GARDEN TO PLATE:

THE EFFECTS OF GARDEN-BASED LEARNING ON STUDENT UNDERSTANDING AND ENVIRONMENTAL ENGAGEMENT

by

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A professional paper submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

July 2012

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July 2012

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ABSTRACT

In this investigation, student participation in the on-campus organic garden project was used to determine whether being part of such a project encouraged student learning and environmental awareness. Students rotated through the garden project on a trimester basis in groups of six or seven and were given responsibility for all aspects of the garden program from choosing which seeds to plant to running the monthly campus farmers' market. Weekly blog posts, survey and questionnaire responses, teacher observations and interview responses were analyzed to determine the effects of working in the garden on the students. Results showed that student interest in gardening increased over the course of the project assignment, as well as knowledge of sustainable agriculture practices. Connections to content learned in the classroom were also strengthened through student involvement in the garden project.

INTRODUCTION AND BACKGROUND

Project Background

Teaching Experience & Classroom Environment

I have taught at Pacific Ridge School in Carlsbad, CA, which is located in North County, San Diego, for four years. We had 431 high school students and there were 34 students taking Advanced Placement (AP) Environmental Science during the 2012-2013 school year. AP Environmental Science was open to juniors and seniors as a science elective. Out of the 34 students enrolled in the course, 25 were juniors and nine were seniors. The school's mission statement helped to foster an overall climate in which academic excellence, engagement in the global world and ethical responsibility in student learning and actions were deemed most important. My students were driven to succeed academically in AP Environmental Science and they were consistently prepared and engaged during class. There was a range of academic ability in the class, which showed on major assessments where the scores ranged from A+ to C. Even with the range of abilities in the classroom, all of the students were interested in succeeding and would seek out extra help outside of the class period when they needed it. My students were primarily Caucasian, with two being of Asian descent and three of Middle Eastern descent (Admissions, 2011).

The students in the AP class were given a choice between three different sustainability projects in September for their trimester-long research project. They could choose composting, sustainable systems, or permaculture for their first rotation. They then rotated through the other two projects during the winter and spring trimesters. Students were placed in their first group based on their first or second choices for projects

and actively worked on their projects during our designated 45-minute block on Friday mornings and at other times, if their project warranted more attention. Twelve students chose to be part of the permaculture research group during the first rotation, and this group was given responsibility of the on-campus garden and aquaculture system. Each of the students in the group demonstrated different interests in terms of the tasks they enjoyed completing with regard to their project.

The students in the permaculture group were consistently engaged in their project and had made quite a deal of progress this year. They built three raised planters and three vertical hydroponic planter systems, planted and cared for a variety of edible plants and ran a monthly Farmers' Market on campus to share their produce with the community. Specific sustainable agriculture practices were highlighted as well throughout the project: organic gardening, seasonal planting, integrated pest management and the use of organic fertilizers. I chose to focus my attention on the permaculture group because of their demonstrated interest in their project as well as their motivation to complete tasks requiring them to work outside of the designated class time. The data collected helped me see the impact this project has had on the students in terms of interest in sustainability as well as their individual senses of pride and ownership of the project.

Focus Questions

My primary focus question was: What effect does participation in the school permaculture program have on student understanding and environmental engagement? The subquestions for this study were:

1. Does working in the garden affect student attitudes in relation to sustainable agriculture practices discussed in class?

2. Does working in the garden deepen student understanding of sustainable agriculture practices discussed in class?

3. How does working in the garden affect a student's ownership and sense of pride?

CONCEPTUAL FRAMEWORK

As we move further into the 21st century, environmental education in school curricula is becoming critically important. Learning about the environment and the problems and crises that many people face is necessary for students so that they are capable of responding and changing their potential future situation (Kadji-Beltran, 2001). In order for students to be prepared for an unpredictable future in terms of environmental conditions, they need to be educated on these topics. Environmental education also gives students the tools necessary to get involved in changing how a person interacts with the environment. In addition, students not only relate what they are learning in environmental education to themselves, but they also have the ability to make connections to their community and the world as a whole as a result of environmental education. In a school curriculum that seems increasingly overcrowded, there exists a need for an infusion of environmental education across the disciplines (Eames, 2008).

Many shortcomings in current education exist to justify a more environmentally focused curriculum. These include the importance of hands-on, interactive lessons, which are important for enrichment of student learning. Learning may progress from experiential hands-on lessons in the elementary grades to more challenging problem-solving lessons in the secondary grades (Eames, 2008). Instead of listening to a teacher lecture on a specific topic, students are able to participate in the implementation, testing

and observation of a concept. This leads to greater student ownership and allows the teacher to be more a guide in the learning process rather than a "sage on the stage" delivering abstract information (Mulder, 2010). Students also begin to understand the social implications of environmental issues and how these can be addressed through the community. It is also important for students to understand the different sides of debates that are anchored in environmental issues so that they can adequately make decisions and value judgments (Eames, 2008). In the end, students may become more concerned about the environmental problems they themselves experience. This may lead to a greater appreciation for the environment and a greater sense of stewardship related to their work (Berns, 2009; Eames, 2008).

One of the most powerful tools for student engagement in the environment is the construction of a garden on the school grounds. Evidence of the use of school gardens in the U.S. to supplement studies in botany and the agricultural sciences dates back to the late 19th century (Desmond, 2002). Desmond believes that "garden based learning has [historically] been viewed as contributing to all aspects of basic education, including academic skills, personal development, social development, moral development, vocational and/or subsistence skills, and life skills" (Desmond, 2002, p.16). Many philosophers throughout history have also posited that interacting with the natural world was the best way for students to learn (Desmond, 2002).

Gardens have historically been installed for a variety of purposes, from the beautification of the school grounds to a tool by which students may gain an understanding of environmental processes. The popularity of school gardens has risen and fallen with trends in education reform, being most popular during times when

progressive education philosophies dominated. As schools changed their focus due to competing educational philosophies, school gardens were removed in favor of fields and multipurpose spaces. Only in the past 20 years, with the resurgence of progressive philosophies along with an increase in environmental awareness, have gardens begun to become more mainstream again as supplements to the curricula (Desmond, 2002).

The rationale for the return of school gardens in the past two decades includes the notion that their implementation affects students positively in a variety of ways. School gardens provide an immediate real world link to the science curriculum for students (Skelly, 2007). Simply being engaged in a hands-on project like a garden allows students to take the concepts they have learned in the classroom and apply them to a real situation (Bundschu-Mooney, 2003; Rahm, 1999). Students can test the effects of altering variables on plant growth and health in the garden, observe interactions between plants, insects, and birds and brainstorm methods for pest control, and master skills necessary to be a successful gardener (Rahm, 1999). Students may also learn more about sustainable agricultural practices and environmental science through their work in a school garden (Heffernan, 1997). School gardens offer an integration point to the biology curriculum in terms of ecosystem interactions and plant growth and development, while also fostering a sense of ownership and stewardship in students (Ozer, 2007).

One argument against the implementation of school gardens in the curriculum is the belief that the school curriculum is already overcrowded. The curriculum is seen as having a finite number of places for disciplines and activities, which are all currently occupied. The addition of a piece like a school garden may be too much and generally unnecessary for the success of the school's overall program (Eames, 2008). However,

the documented effects on student attitudes and behavior that come from involvement in a school garden appear to outweigh the perceived overloading of the school curriculum, based on recently conducted studies (Eames, 2008).

To that end, California implemented a program called "A Garden in Every School" in 1995 through which the state department of education awards grants to schools to help in the initial garden set-up and maintenance. In addition to the promotion of healthier eating habits and links to environmental education curricula, the program aims to connect schools and students with local farmers in an effort to create community ties between the two groups. There are currently over 3,000 gardens in California schools throughout the state, from the elementary to the secondary level (California Department of Education, 2007).

One of the most successful school gardens in California is the Edible Schoolyard at the King Middle School in Berkeley, CA, which was founded in 1995 by chef Alice Waters and former principal Neil Smith. The mission set forth by the garden was to create a garden where students could learn about agricultural practices as well as feeding themselves and each other through the school lunch program. The daily workings of the garden were integrated into the daily schedule. When the program was assessed in 2003, it was found that students were eating healthier, had more positive attitudes in terms of their overall education, and knew a great deal about agricultural practices even while attending an urban school (Murphy, 2003).

School garden programs have been shown to have many positive effects on student achievement, behavior and attitudes. One effect identified by Ozer is the change

in classroom social dynamics during garden work. Because working in the garden draws on different skills than classroom learning and is done primarily in groups, this may influence peer interactions and lead to new relationships forming that may not have otherwise. This may translate into better interactions and cooperation among classmates when back in the classroom as well (Ozer, 2007). These programs also empower students to make critical decisions every day that will affect the outcome of the garden's plants and products. In an education system where few decisions in the curriculum are left up to the students, having this opportunity can be rewarding for students (Brynjegard, 2001).

In addition to supplementing the science curriculum and raising environmental awareness in students, school gardens also have many other intangible effects. These include instilling a sense of responsibility and ownership in students who work in the garden (Brynjegard, 2001; Skelly, 2007). Because the students' actions ultimately affect how the garden grows, students gain a sense that they are responsible for the outcomes instead of merely passive observers. This heightened responsibility eventually leads to a feeling of pride and accomplishment related to their work and positive attitudes towards the environment as a whole (Bundschu-Mooney, 2003; Skelly, 2007). By working in the school garden, older students can also share their newfound knowledge with younger students, extending the effects of the garden experience. Depending on what happens with the produce from the school garden, students may also feel like they are "grow[ing] produce with a purpose" if it is being sold at a local farmers' market, used in school lunches or donated to a local food bank (Reeves, 2010, p.36). During and after working

in the garden, students feel they have mastered a new skill that they can use outside of school at their homes and in their communities as well as later on in life (Rahm, 1999).

There is also evidence that parents are affected by school gardens. Parents who may opt out of participation in other school activities or volunteer opportunities feel more comfortable volunteering their time and effort in the school garden (Ozer, 2007). The different skill set involved in garden work opens the door for more volunteer opportunities. School gardens create opportunities for parents to become more involved in the school and also for the school to build relationships with community members (Ozer, 2007). Many school gardens are supported by community members who may not have children at the school, but are nevertheless interested in supporting such a project. The positive effects of school gardens are far-reaching and go beyond the students themselves to the larger community (Ozer, 2007).

METHODOLOGY

The treatment for this study involved students being assigned to the Permaculture research group for a 12-week rotation during either the fall, winter or spring trimester of the 2011-2012 school year. Students ranked the three trimester-long projects during the first class period in September and then were assigned to their first rotation based on the ranking. Most students placed in the Permaculture group during the fall ranked this project as their first choice. Students in the Permaculture group were then given responsibility for the on-campus garden as well as the hydroponic and aquaculture systems. The group was also responsible for growing edible plants from seeds and selling seedlings and garden produce at monthly on-campus farmers markets. The group

was responsible for maintaining a weekly journal of their project. Progress was checked weekly on Friday mornings, and some guidance was given by the instructor if needed. The results from all three trimester groups were compared to gauge the impact of the permaculture research group's work versus that of the other groups. Each subquestion was answered using different data collection strategies (Table 1). The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained.

Students were given an Environmental Science Research Project Preference Survey to fill out on the first day of class (Appendix A). Students were given three choices on the survey that they needed to rank in order of interest from 1-3, with 1 being their top choice. They also needed to answer a few questions to explain their choices and interests. The purpose of this survey was to gather student preferences on yearlong projects as well as their rationale for the choice they made. This served as some initial data as to why certain students were interested in working in the campus garden.

Once the garden group was formed, they were responsible for maintaining a weekly electronic journal of their project, following guidelines set in the Weekly Journal Entries Guidelines (Appendix B). The journal was updated at least once a week by group members, and was read once every two weeks by the instructor to gauge overall progress. Students also participated in a video component to their journal, recording their thoughts and observations using a Flip camera. These journal entries served as more informal feedback, showing how they felt the project was going from week to week as well as to give the group a chance to develop a digital archive for future garden groups.

Student interviews were conducted with group members at the completion of the project using the Student Interview Questions (Appendix C). The interview consisted of ten open-ended questions that the students were asked to answer in a one-on-one interview with the instructor. The interviews were digitally recorded using a Flip camera and interview notes were also taken. Student answers were used to gauge their overall interest and effort with regard to the permaculture project as well as the impact of the project on student learning and interest.

The students were given Permaculture Student Questionnaires twice during the study to allow students to give feedback on their project as well as for the instructor to determine student learning (Appendix D). Topics covered on the questionnaire ranged from student self-evaluation of effort and participation to specific sustainable agriculture practices such as organic gardening, seasonal planting, integrated pest management and the use of organic fertilizers. The questionnaires were administered in the first week of the project and upon completion of the project. Answers were analyzed to determine whether there were any changes in student responses. Questionnaires were ungraded but commented on to aid in student learning.

Students also completed two Permaculture Student Surveys to gauge their participation, motivation, sense of ownership and other factors affected by their work in the school garden (Appendix E). These surveys were administered during the first week of the project and upon completion of the project before the formal interviews in order to gather information and inform the interview direction and questions. Data collected from the surveys were analyzed to determine the mode for each question, and also whether individual student answers had changed from the first survey to the second.

Student behavior while participating in the garden project was also observed and recorded by the instructor weekly in the Teacher Observation Template (Appendix F). Instructor impressions of student interest in the work being done as well as the ability to work in a group were recorded. Results were analyzed to determine levels of perceived interest and participation for each group member.

Table 1
Triangulation Matrix

Focus Questions	Data Source 1	Data Source 2	Data Source 3	Data Source 4
Primary Question: What effect does participation in the school garden program have on student understanding and environmental engagement?	Questionnaire Responses	Journal Entries	Interviews	Teacher Observation Template
Secondary Questions: 1. Does working in the garden affect student attitudes in relation to sustainable agriculture practices discussed in class?	Survey Responses	Journal Entries	Interviews	
2. Does working in the garden deepen student understanding of sustainable agriculture practices discussed in class?	Questionnaire Responses	Interviews	Journal Entries	Survey Responses
3. How does working in the garden affect a student's sense of ownership and pride?	Survey Responses	Questionnaire Responses	Teacher Observation Template	Interviews

DATA AND ANALYSIS

The treatment for this study began with the administration of the Environmental Science Research Project Preference Survey (Appendix A). Students were given the choice of three options for their first rotation: Permaculture, Composting or Sustainable Systems. Twelve students chose Permaculture as their first choice and were placed in this group for the fall trimester. When asked to explain why they had chosen the Permaculture research project (hereafter referred to as "the project") as their first choice, students wrote a variety of responses. One student wrote, "Taking care of the garden and running the Farmers Market sounds enjoyable. It also seems like a good learning experience because I can learn about the benefits of gardening and growing your own food." Another student wrote that he had seen the students working in the garden during the previous year and that the project looked like fun. Others reported that they have always liked gardening at home or working outside, and so this project would be a good fit for them. When asked what they hoped to accomplish during the trimester, student responses ranged from "I would like to expand the garden and plant new things" to "I hope to learn how to take care of a garden." Another student wrote, "I hope to not kill everything in the garden."

Student Effort and Participation

Students were asked to rank themselves in terms of their effort and participation at the end of the first week of the project and again at the end of the twelve-week project period. Student responses regarding effort (Question 1) and participation (Question 2) both showed overall increases from the pre-treatment questionnaire to the post-treatment questionnaire (Figure 1). While only 15% of students reported that they were performing

at maximum effort at the beginning of the project, 50% of students reported performing at this level at the end of the project. This same pattern was reflected in participation levels. At the beginning of the project, 9% of students reported that they were participating at the highest level. This number rose to 65% of students by the end of the project.

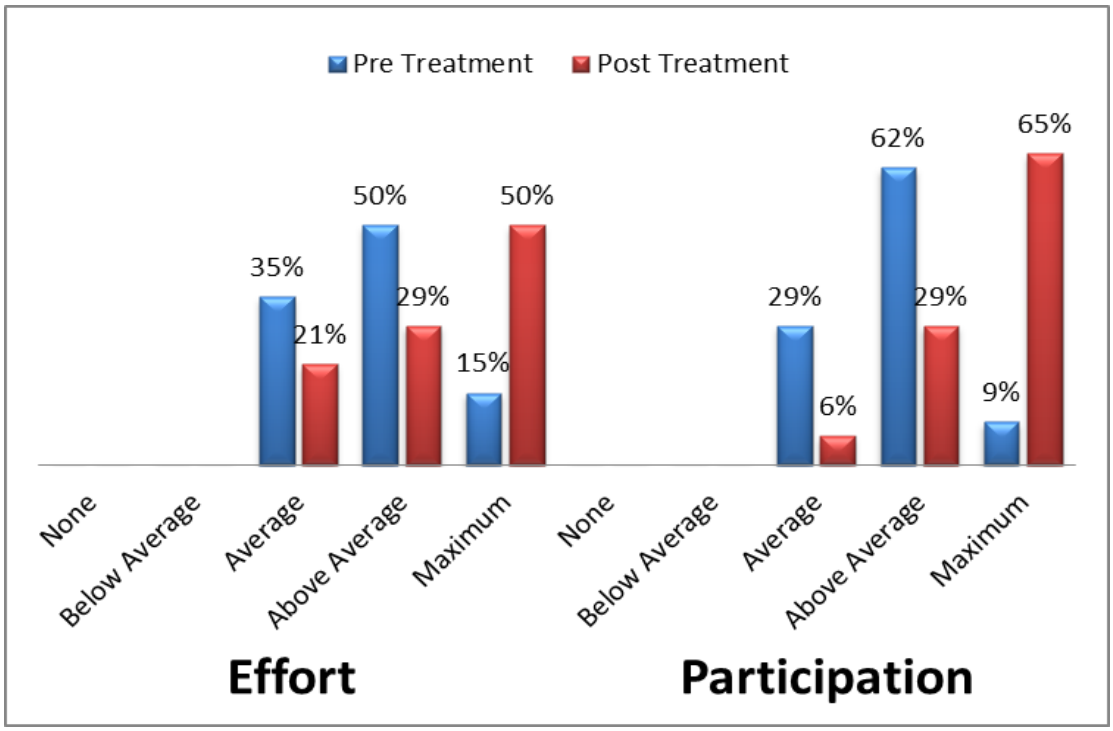

Figure 1. Comparison of pre and post treatment survey responses related to student effort and participation, (*N*=34).

This pattern was reflected in the teacher observations of students being actively involved in the garden project (Figure 2). At the beginning of the project, 59% were actively involved in what the entire group was supposed to be doing for the day and 44% of students did not remain on task for the entire 45-minute project period. Over the course of the 12 weeks, this pattern began to shift, ultimately ending with 100% of students being involved in the group's task and 88% being on task for the project period.

The number of students needing reminders from the instructor to stay on task during the period also decreased from 44% to 12% over the course of the 12 weeks.

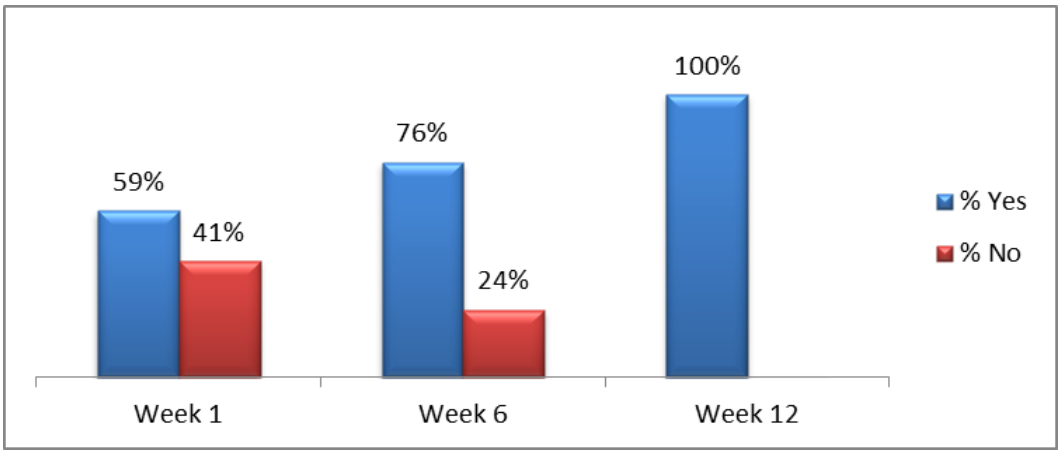

Figure 2. Teacher observations of students being actively involved in garden project during week 1, week 6 and week 12, (*N*=34).

In addition, teacher observations focused on whether students were completing extra work beyond the project guidelines (Figure 3). Students were considered to be completing extra work if they were performing tasks such as watering the garden beds, researching planting methods, collecting materials for the next meeting and other such tasks outside of the allotted time block. While only 6% of students completed extra work during the first week of the project, it was observed that 76% did so by the 12th week. Through my teacher observations, I also noticed that many of the students behaved like group leaders at different moments during the 45-minute work periods, showing their shared feeling of responsibility and ownership for the garden overall. Over the course of the twelve weeks, I also observed that progressively more students had done extra work outside of the dedicated project work times to solve a problem, reset the irrigation or simply to check on the status of the plants.

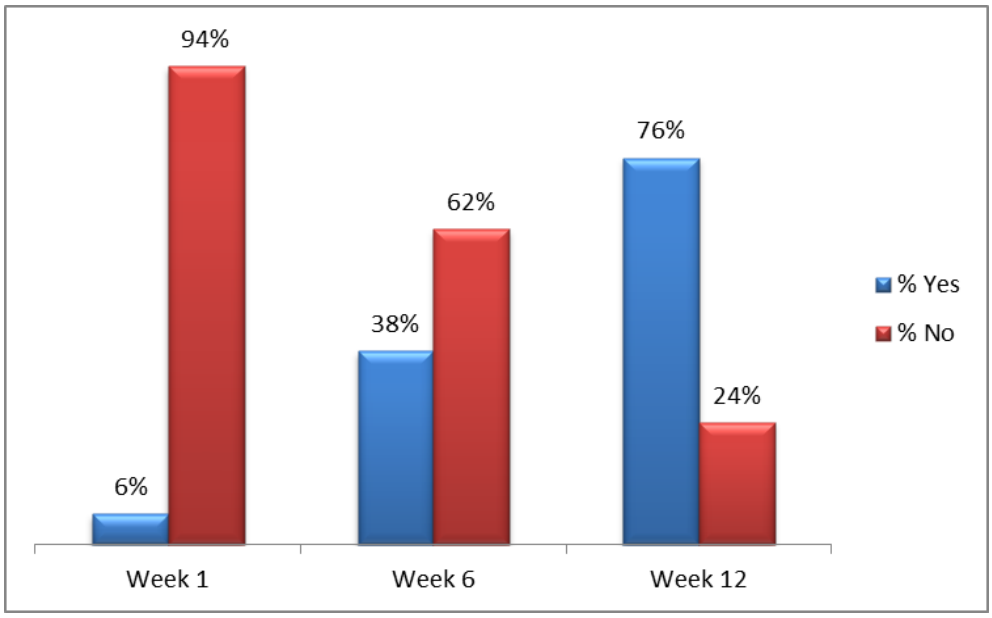

Figure 3. Teacher observations related to student perception of importance of working in the garden during week 1, week 6 and week 12, (*N*=34).

Students were also asked questions regarding to the importance of working in the garden, whether they would make the same project choice again and whether there was significant planning involved in their work. At the beginning of the project, 65% of students reported that they were indifferent when asked if working in the garden was important to them. At the end of the project, 85% of students agreed or strongly agreed with this statement, showing an increase in the perceived importance of working in the garden (Figure 4).

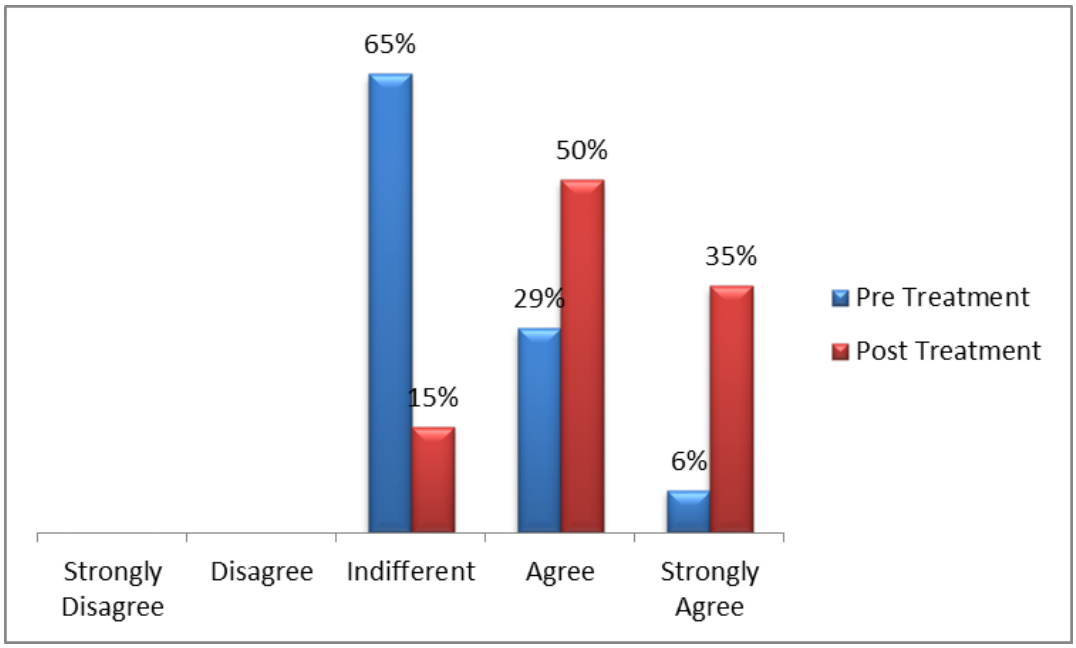

Figure 4. Comparison of pre and post treatment questionnaire responses related to student perception of importance of project, (*N*=34).

Another question designed to determine student participation levels focused on the amount of planning done during the project. Initially, 15% of students disagreed and 62% were indifferent that a lot of planning when into their decisions. By the end of the project, 44% of students agreed and 41% strongly agreed that a lot of planning went into their decisions. Initial journal posts from the first weeks of each trimester show this lack of planning. While students were prompted through the journal guidelines to include what was happening next, this information did not appear until later weeks. The journal posts for the three trimesters also show this switch, though in a more gradual way. Students in the fall trimester began including their next steps after six weeks, while students in the winter and spring trimesters began including this after four weeks. The importance of planning also came up in the interviews. When asked to talk about one challenge encountered during the project, many of the students identified planning as the biggest challenge their group faced. One student said, “At the beginning, we just planted

whatever seeds we wanted and then waited for instructions from [the teacher] the next week. We didn't think about what we should do or plan anything out." Another student explained the evolution of planning in his group. He said, "We learned pretty quickly that we needed to be planning out what we were doing or nothing would grow. Our journal was a helpful place to write down what we were thinking for the next week." Another student discussed how she had noticed that the way the group was planting their seeds started off erratic, so that when the seeds sprouted, no one was sure what kind of plant each was. Because of this, she reported that she had learned the value of planning out where seeds would be planted and perhaps even sketching out the planters for a record of each planting.

When asked whether they would participate in the same project again if given the choice, initially 38% of students disagreed and 59% were indifferent. Only 3% of students agreed that they would participate again in the garden project. When asked the same question again at the completion of the project, 94% of students agreed or strongly agreed that they would participate again in the garden project. Two of the students who had initially disagreed with this statement reported being indifferent at the end of the project. Both of these students had also reported being indifferent to whether their work in the garden was important to them. Students were also asked the same question during one-on-one interviews. One student, who had initially been indifferent to whether she would participate in the project again, said, "At first, I thought that working in the garden was just busy work and I wasn't too excited about that. But now that the project's over, I wish I could keep doing it. If I had to choose again, I would definitely want to be part of the garden project group." This feeling was echoed by most of the students interviewed.

However, two students remained indifferent to this question, even in the interviews. One student, who had worked in the garden during the winter trimester, said that he, "didn't really like being outside in the mornings when it was cold. I guess I didn't really know what the project would be when I signed up. It was OK but not great."

Student attitudes towards sustainable agriculture practices

Three survey questions addressed student attitudes towards sustainable agriculture practices. When asked whether it is important to know where your food comes from, initially the majority of students disagreed or felt indifferent with regard to this concept. This pattern was reversed at the end of the twelve-week period, with 100% of the students stating that they agreed or strongly agreed with the statement. Student responses were more varied to the statement regarding the importance of buying produce locally from farmers in the area. Over the course of the twelve-week period, student responses shifted towards 88% of students agreeing or strongly agreeing that this is important, up from 30% initially. When asked if it is important to learn about gardening, 50% of students were indifferent at the beginning of the project, with 38% agreeing and 12% strongly agreeing (Figure 5). At the end of the twelve weeks, 9% were indifferent, 79% agreed and 12% strongly agreed that learning about gardening is important. The three students who responded with *Indifferent* after twelve weeks had also responded in the same way at the beginning of the project. Similarly, the four students who responded with *Strongly Agree* after twelve weeks had also responded in the same way at the beginning of the project. In interviews, students expressed an appreciation for the challenges faced in sustainable agriculture. One student shared that now she understood "organic growing concepts so much more. It is definitely a lot more work." Four

students replied that they had changed their diets to reflect this consciousness, by choosing more local produce and attending local farmers' markets.

Changes in student attitudes towards sustainable agriculture practices were also seen more informally in their blog posts. After running their first on-campus Farmers' Market in October, the students in the fall garden rotation posted the schedule for other local Farmers' Markets in addition to a review of how theirs had run. Their next blog post a week later discussed how six of them had gone to a Farmers' Market over the weekend and had talked with one farmer about their pest problems in the garden at school, using him as a sort of local expert on sustainable pest management. The students had also wrote about how much fun they had had at the Farmers' Market and how "cool" it was to meet the person who had grown the produce that they bought.

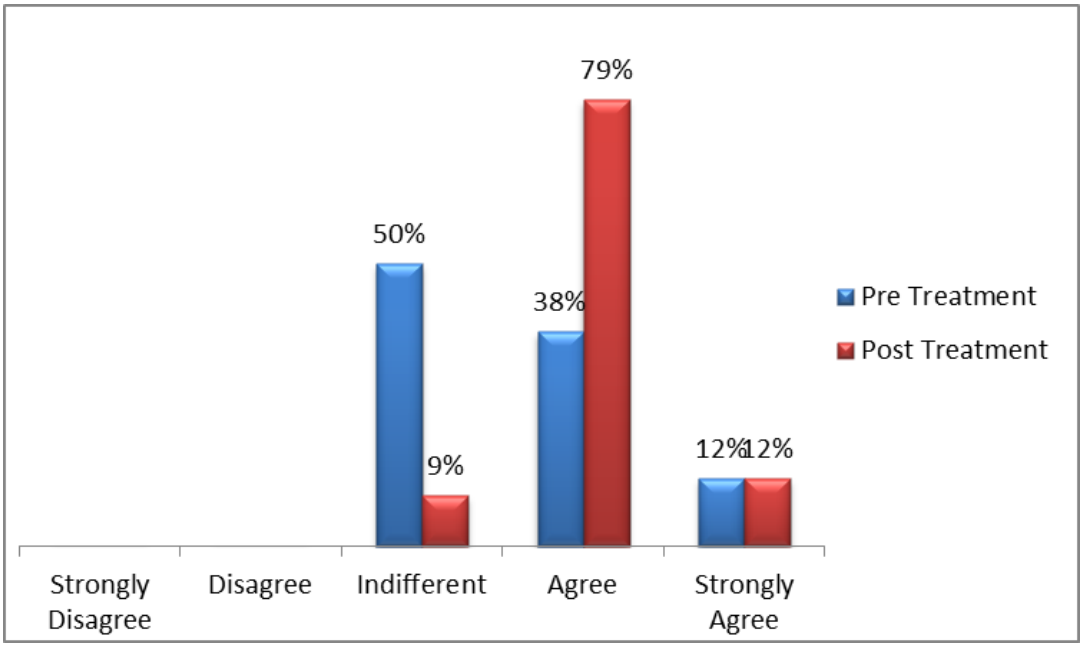

Figure 5. Comparison of pre and post treatment questionnaire responses related to student attitudes towards learning about gardening, (N=34).

Student understanding of sustainable agriculture practices

As this project was integrated into an academic class curriculum, student understanding of concepts was closely tracked. When asked initially if they had learned about running an organic garden from this project, 50% of students disagreed and 50% were indifferent (Figure 6). This was to be expected, since the survey was administered at the beginning of the project, before learning could take place. At the end of the project, 82% of students strongly agreed that they had learned about running an organic garden, while 9% agreed and 9% were indifferent. In the interviews, all of the students said that they had learned about practical applications of class material in terms of sustainable agriculture as well as how to design a long-term project. Students identified concepts such as integrated pest management, seasonal planting and use of organic fertilizers such as compost as ones they learned and used repeatedly during the project. On the student survey, all students were able to provide justification for considering the season when planting. One student wrote, “Stuff doesn’t grow in the off-season. Like tomatoes don’t grow in the winter.” In the online journal, students created a list of plants suitable for each season, so that planting could be more efficient, as well as pest management strategies and types of seeds and fertilizers to use for optimal harvest.

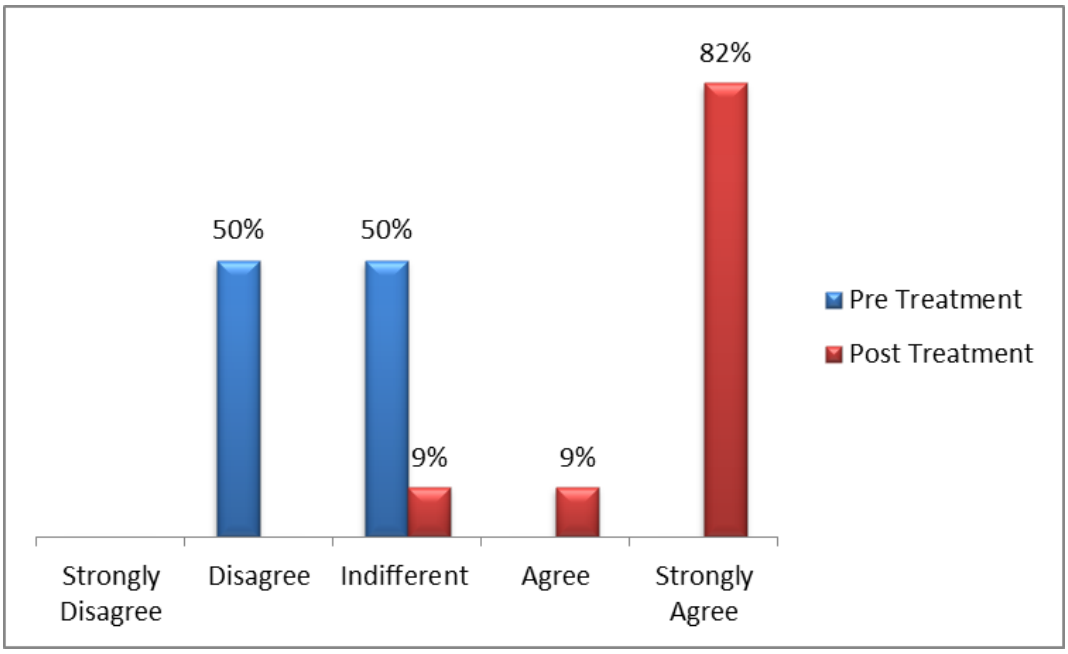

Figure 6. Comparison of pre and post treatment questionnaire responses related to student understanding of organic gardening practices, (*N*=34).

Students also showed a better understanding of organic versus non-organic growing practices at the end of the project. While 71% of students were indifferent about the differences in the first week of the project, 94% of students strongly agreed that they understood the differences after twelve weeks. Students were also asked if they knew ways to manage pests without using chemical pesticides. Initially, 74% of students disagreed, indicating that they did not know how to do this. Additionally, 23% of students were indifferent and only 3% of students agreed that they knew how to manage pests without chemical pesticides at the beginning of the project. By the end of the project, 88% of students strongly agreed with this statement, 9% agreed and, interestingly, 3% disagreed. Students were also asked to explain how they had dealt with pests in the garden. Student responses ranged from, “We bordered the box with copper to prevent snails from eating the plants,” to “We have encountered gophers, but don’t really

know what to do. Maybe the gopher will leave before we figure it out." In the interviews, twelve students identified the pest problem as an area where they felt empowered to find a solution to pest control that was both effective and environmentally friendly. "We did a lot of research when we saw all of the snails. Finally, we decided on a multi-part strategy using seaweed, carnivorous snails and hand-picking them off the plants."

As the project progressed, more students also felt that they could apply what they had learned to other coursework or at their own home (Figure 7). While 20% disagreed and 50% felt indifferent about applying what they had learned at the beginning of the project, 73% agreed and 12% strongly agreed with the statement at the end of the project. In the interviews, all students felt that this project was an integral part of their learning and should be continued in future years.

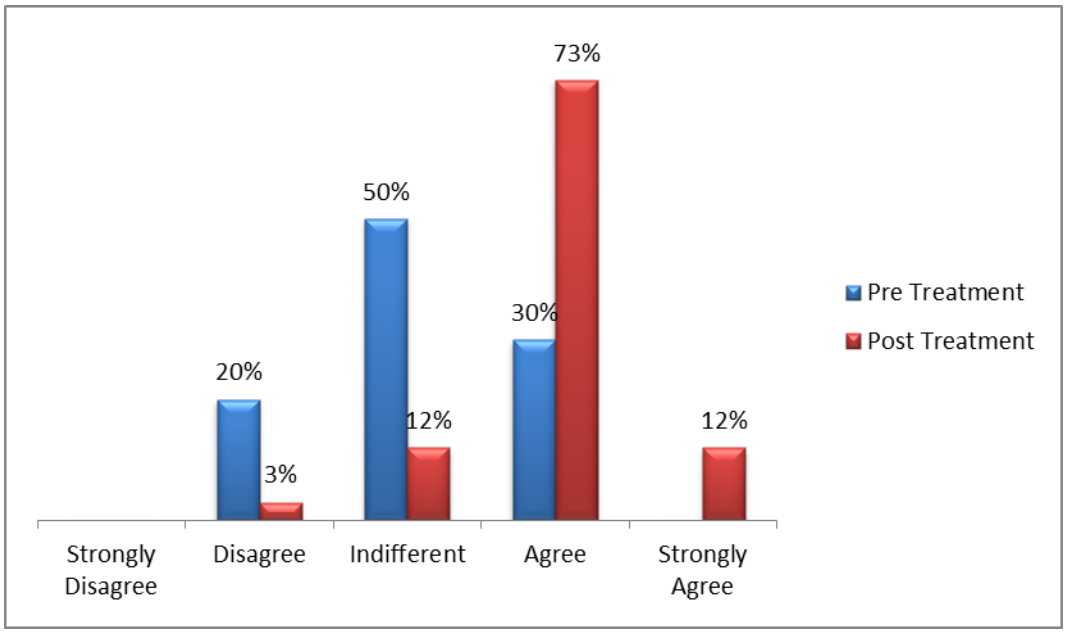

Figure 7. Comparison of pre and post treatment questionnaire responses related to student feelings of applicability of learned material, (*N*=34).

Student ownership and sense of pride towards garden project overall

Two survey questions asked students about their feelings of ownership of the garden and overall sense of pride in the work done. When asked if they felt responsible for the garden, 74% of students initially disagreed and 26% felt indifferent (Figure 8). When asked at the end of the project, only 3% of students still disagreed while 82% strongly agreed and 12% agreed that they felt responsible for the garden.

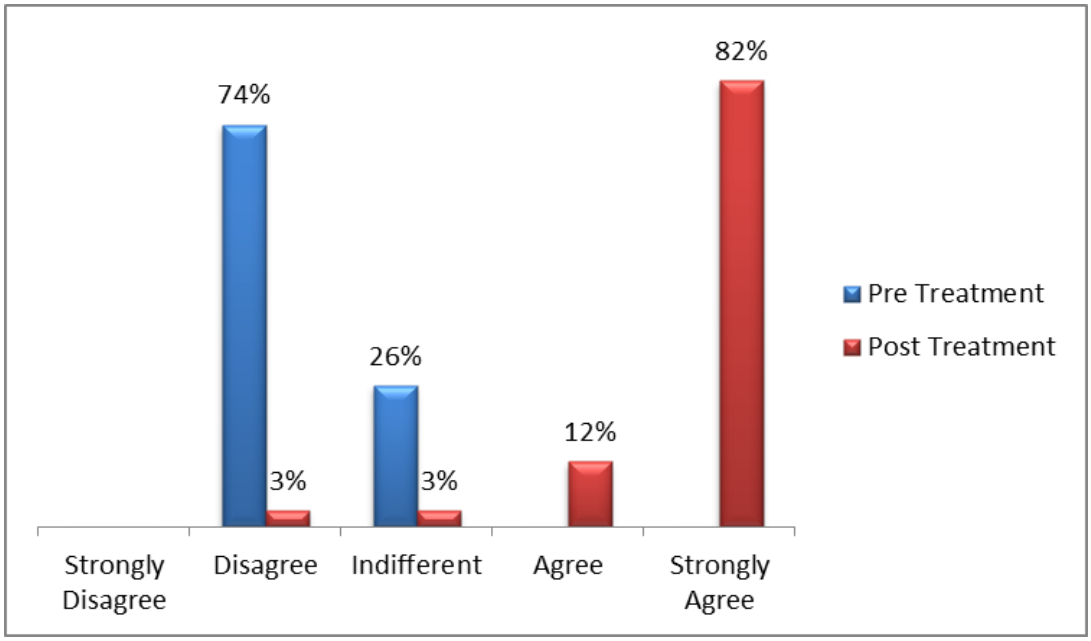

Figure 8. Comparison of pre and post treatment questionnaire responses related to student sense of responsibility, (*N*=34).

The second question asked whether students felt a sense of ownership over the garden at school (Figure 9). In the first week of the project, 74% of students disagreed with this, while 26% were indifferent. After twelve weeks, 47% strongly agreed and 47% agreed that they felt a sense of ownership over the garden. This increased sense of responsibility and ownership were also echoed in student responses on the questionnaire regarding their roles in the group. Seven students wrote that they would consider

themselves leaders in the group, while only one student wrote that she "just did whatever [another student] told [her] to do."

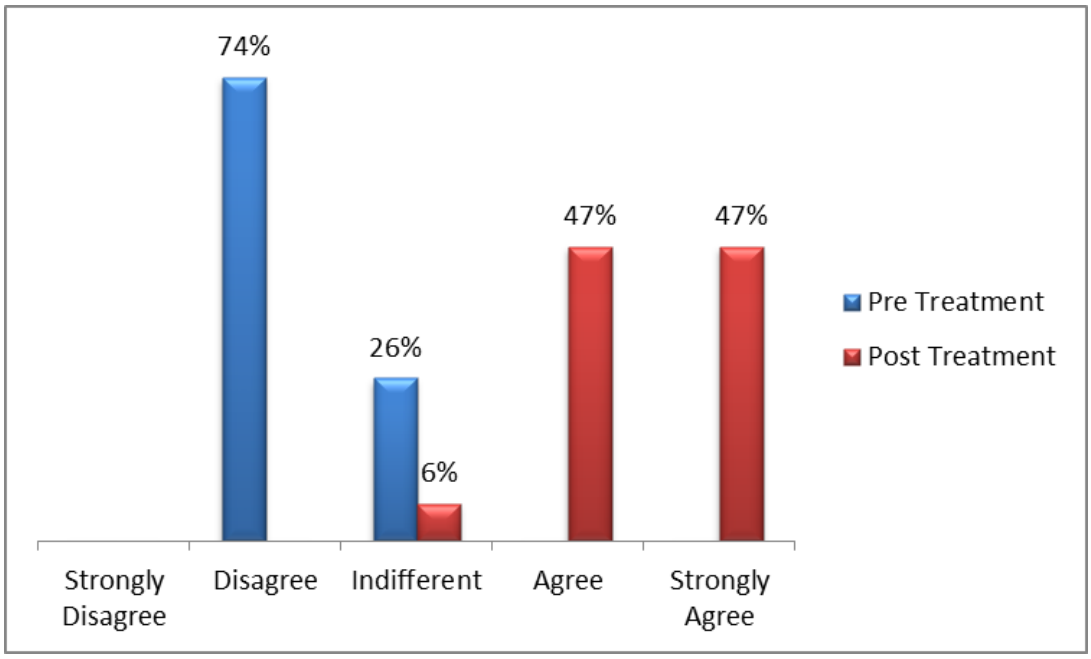

Figure 9. Comparison of pre and post treatment questionnaire responses related to student sense of ownership, (N=34).

INTERPRETATION AND CONCLUSION

As a supplement to the AP Environmental Science curriculum, the Permaculture project appears to change student attitudes towards sustainable agriculture practices and increasing overall feelings of ownership based on the data collected in addition to supporting agriculture topics in the curriculum through practical applications of the material. When the project began, most students wrote that they were interested in the garden project because it looked like fun or they had always enjoyed gardening at home. Very few wrote that they wanted to learn more about sustainable agriculture practices or to put into practice what they were learning in the AP class. These initial responses indicate that students viewed working in the garden as a task and not as a learning

opportunity. Their initial level of investment in the project was understandably low because of this as seen in the data regarding student ownership.

Based on the data regarding student effort and participation, it is clear that students did initially view the garden project as a task. When the project began, only five students reported working at their maximum level with the remainder of the class reporting average or above average levels. Of these five students, three belonged to the fall rotation group and had chosen the project as their first choice. By the end of the project, more than three-quarters of the students reported working at above average or maximum levels with these students being distributed through the three trimester groups. While this does not represent a drastic shift in responses, it is important to note that many students will choose *Average* or *Above Average* on a survey even if it does not accurately represent them. Because this shift in effort was also seen in teacher observations, it is more likely that overall student effort did increase over the course of the project, assuming that the teacher observations were unbiased. The same pattern was observed with regard to student participation.

It is also important to note that there existed the possibility for selection bias while using these questions, as students in the fall rotation had been placed due to preference. One might expect that those students in the fall rotation would participate more and apply more effort to the project since they had chosen it as their first choice. However, upon analyzing the data, no significant difference existed among the data from the three separate trimesters and it was determined that the data could therefore be grouped together for analysis. The same was true for other aspects of the project analyzed later. One area where there was a difference among the three groups existed in

terms of the planning involved and the depth of answers to curriculum-based questions. Students in the winter and spring rotations began planning their next steps much earlier than the fall rotation and their answers to curriculum-based questions were more thorough, perhaps because these students had already learned the material in the classroom.

Another indicator of student effort and participation was whether students viewed the garden project as important or not. Responses to this question showed an overall increase in student perception that the project was important. If students began to think that the garden project was important, and not simply a task to take up 45 minutes, they would begin to participate more and exert more effort. That many students performed extra tasks outside of the guidelines as the project progressed also shows the importance placed on the project. In addition, the amount of planning that went into each week's work increased significantly over the course of the twelve weeks. Each of the three groups began their project without planning the next steps for between four and six weeks. Students may have felt that it was unimportant to plan out next steps, since the project was not important to them at that point. However, all three groups eventually began actively planning their next steps. Interestingly, the second and third groups to go through the rotation did so sooner than the first group. This may be due to some advice being given from those in the first group that planning was actually important. By the end of the project, most students saw the need for planning next steps if the garden and subsequent harvest were to be successful.

When asked if they would choose to participate in the garden project again, students initially disagreed or were indifferent on this question. It should be noted that

only the first group in the fall had marked the Permaculture project as their first choice. The second and third groups rotated through based on their initial preferences, which either put Permaculture as second or third. This may explain the ambivalence or disinterest in the initial responses. However, at the end of the project, the overwhelming response was that students strongly agreed that they would choose this project again, whether or not they had initially chosen it as their first choice. Not all of the students felt this way, though, and two of the students showed a lack of interest in their responses to most questions. One of these students worked in the garden during the winter trimester. While the winters in Carlsbad are not particularly harsh, the weather can be cold or rainy on some days. This may have affected student effort and interest in the garden project during the winter trimester.

Student attitudes towards sustainable agriculture practices changed significantly over the course of the twelve weeks. Student responses to questions regarding the importance of sustainable practices such as locally sourcing produce were initially more negative than positive. Unless students lived in a household where importance was already placed on these practices, students either did not understand why the practices might be important or they did not care. After working in the garden for twelve weeks, though, most of the student attitudes had shifted, becoming more positive towards the sustainable agriculture practices. One practice of note is buying local produce. Six students organized themselves into a group to visit a local Farmers' Market on the weekend to talk with farmers and to buy produce. Their excitement after the experience, evident in their blog posts and informal conversations in class, showed a change in their

attitudes with regard to visiting Farmers' Markets. These students had seen the value in this practice and advocated for their classmates to do the same.

The concept of student participation in gardening on campus had grown out of a need for the potential for the practical application of concepts learned in the AP Environmental Science curriculum. Students learn material more concretely when the concepts are paired with hands-on activities, and so running a garden was a logical fit for the sustainable agriculture unit in the AP class. Therefore, it was important that students were learning through their work in the garden and not simply completing tasks without thinking about them. Certain sustainable agriculture practices were highlighted: organic gardening, seasonal planting, integrated pest management and the use of organic fertilizers. While student understanding of these practices was notably low at the beginning of the project, this was to be expected with every group but the spring rotation. Sustainable agriculture topics were covered in the AP curriculum during the last few weeks of the winter trimester. Therefore, students in the fall and winter rotations would not have previously learned these concepts in class. This lack of understanding is apparent at the beginning of each rotation, as the responses to each question regarding student understanding were initially primarily *Disagree* and *Indifferent*. By the conclusion of the twelve weeks, responses had shifted to be primarily *Agree* and *Strongly Agree*, meaning the students better understood the practice or concept identified in the question. This pattern shows the ability for the garden project to either introduce practices and concepts later covered in greater depth in class or reinforce concepts covered in class through hands-on implementation. While the student answers on questionnaires do show a pattern of learning, a more powerful way to determine whether

the project had this effect would have been to compare assessment scores between project participants and non-participants on these topics. Further research will need to be conducted to determine if the pattern seen in questionnaire responses is repeated in assessment performance.

In terms of student ownership and pride in the garden project, the results again supported the positive effects of the project on the students. None of the students really felt any responsibility for or ownership over the garden when the project began, but this is to be expected since the garden had just become "theirs" one week earlier. In order for students to feel that the garden was truly "theirs" and that what happened to it rested on their shoulders, the students needed to be involved in the project for at least the twelve-week period. Based on teacher observations, students began to act more like they were leaders during their work periods, showing that they perceived that they were in charge of the space during different moments. Students also identified themselves as leaders in their groups, even though this role was never explicitly defined. Acting as and identifying themselves as leaders shows that the students felt a degree of responsibility and ownership over the garden and the weekly progress of the project. The fact that students also did extra work outside of the project period supports this. The student who felt that she just did what others told her had also identified herself as putting in average effort and participation over the course of the twelve weeks. This outlier is important to note, since not all students will naturally or eventually enjoy working in the garden or benefit from this work.

Students in the AP Environmental Science class are a self-selected group of students who are interested in environmental concepts such as sustainable agriculture.

They chose to take this class to further their knowledge of these concepts and many will go on to study Environmental Science in college and may pursue careers related to what they have learned in the AP class. So while the data suggest that the Permaculture project has a significant impact on student attitudes, understanding and ownership, it will be important to continue this research with non-AP Environmental Science students to determine the impacts of such a project on the general student body.

VALUE

I chose to begin an on-campus gardening program at Pacific Ridge after visiting other schools with similar mission statements and seeing their gardens. We had recently completed our permanent high school building, which received LEED silver certification, and it seemed to make sense that our campus should also have an organic garden in an effort to make our campus even more "green." The 2010-2011 school year was also the first year that we offered AP Environmental Science as an $11^{th}/12^{th}$ grade elective in the science department. After looking at the AP curriculum, I decided that encouraging students to start up and work in the garden while enrolled in this class seemed like a good fit.

The practice of having students participate in the Permaculture project as a supplement to the AP Environmental Science curriculum has been a successful endeavor over the past two years. Each student could point to a variety of things that they have learned about themselves and sustainable agriculture through the project. While students would have still learned the same material in the AP classroom, they arguably learned even more through their work on the garden project. The students had to plan a long-

term project, create checkpoints for themselves, apply what they had learned in class, troubleshoot any problems that arose and document their work. Concepts covered in the classroom can sometimes seem irrelevant due to their being learned in a vacuum of sorts. Allowing students a chance for practical application of the concepts helps reinforce the concepts and also helps students develop a deeper understanding of the importance of those concepts.

The data collected from this study caused me to reflect on the value of a project such as this in a science curriculum. When the project began in the fall of 2010, I initially thought that it would be a fun activity for the students to work on and that they might learn skills they could later use to start gardens of their own. I had always enjoyed working in a garden and so I suspected the students might feel similarly. I have seen these effects in every group of students who have rotated through the garden project and have been encouraged to continue this project based on this.

What the data have also shown me is that the Permaculture project has had an effect not only on student interest in sustainable agriculture practices but also on their overall learning of concepts in the AP class. While as a science teacher I have known that experiential learning can reinforce classroom material, this has never been more apparent to me than through observations during the garden project. With this in mind, it seems appropriate to give all AP students the opportunity to work in the garden during or after our sustainable agriculture unit in the winter trimester to strengthen their learning. Many of the challenges students encounter in the garden throughout the year require extensive research and troubleshooting when the concepts have not already been covered in class. I have observed that the winter and spring groups find solutions faster than the

fall group, since our sustainable agriculture unit is either ongoing or already passed. Therefore, the project could be modified to have more of an introductory overview of all projects in fall trimester followed by a more in depth focus on the garden in the winter and spring to reinforce earlier student learning.

The data also suggest that projects like these can build a student's sense of ownership over his or her work as well as a feeling of pride towards something on campus. In high school when students are constantly worried about where they fit in and may also have low self-esteem for a variety of reasons, participation in the Permaculture project may provide the positive feedback a student does not receive elsewhere.

In the future, I believe it would be appropriate to expand the Permaculture project beyond the boundaries of the AP Environmental Science class to better determine the effects of student participation in this type of project. This project has been a meaningful one over the past two school years and one that many students look forward to participating in from week to week. By expanding the program and perhaps also the garden itself, the perceived benefits of garden-based learning may be felt by even more students.

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APPENDICES

APPENDIX A

ENVIRONMENTAL SCIENCE RESEARCH PROJECT PREFERENCE SURVEY

Environmental Science

Research Project Preference Survey

Over the course of the year, you will be engaged in a long-term research project. This project will be student-driven and will require you to work independently as a group to solve a problem and reach conclusions about the sustainable systems found on PRS campus. You will be conducting your research and gathering data daily and during our zero period. Part of the project will also involve community outreach to the PRS community to educate your peers on your area of concern. Your goal will be to synthesize your data and draw conclusions for a final presentation in May.

Important Dates

September 10th—Project Outline Due

September 24th—Project Abstract Due

November 18th—First Data and Progress Check

February 4th—Second Data and Progress Check

May 13th—Final Poster and Lab Report Write-Up due

Resources

I am your first stop to help answer any questions you might have along the way. Please come see me for clarification or for ideas. You should also use your textbook and any credible online resources to guide you. Finally, if you can identify a community expert, this resource can be used to further your project.

Please rank the following choices from 1-3: I will do my best to give you your first or second choice!

_____**Composting on Campus**—Designing and Maintaining the Compost System on Campus; Designing a Compostable Wrapper as a Prototype for Clif Bar

_____**Permaculture**—Organic Gardening and Running the PRS Farmers' Market; Aquaculture Research

_____**Sustainable Systems**—Recycling/E-cycling, Energy and Water Auditing and Finding Solutions to Minimize Our Environmental Impact as a School.

Please answer the following questions in 3-4 sentences:

Explain your rationale for choosing one of the above options as your first choice.

What do you hope to accomplish this year, if you are given your first choice?

Do you enjoy working outside?

Which tasks do you foresee yourself enjoying during your project? Which tasks do you foresee yourself not enjoying?

What goals do you have for yourself in terms of this project?

APPENDIX B

WEEKLY JOURNAL ENTRY GUIDELINES

Environmental Science Research Project Journal Entry Guidelines

The purpose of the journal is for you to reflect upon your research project work and to leave a written record of your progress from week to week. You should be making connections between what is taught in class and your experiences in your journal entries. In addition, the journal is a way for your group to track progress, discuss what has gone well and what could be improved and make suggestions for future groups.

Format

Journal entries should be posted to the research project page on the class Google site every week on Friday mornings.

The entry should begin with the day's date and weather conditions.

You may decide to upload pictures or videos to track progress.

Questions to Answer

What are you doing right now in your research project?

What is going well for your group?

What challenges have you faced? How did you solve them?

What recommendations can you give to future groups?

Are there specific supplies or resources that you are using? What are they called? Where did you get them?

What have you learned?

What's coming up next?

APPENDIX C

STUDENT INTERVIEW QUESTIONS

1. Why did you choose the school garden as the focus of your trimester-long environmental science project?

2. Have you ever planted a garden at home? Have you planted one since beginning this project?

3. Do you think there is a difference between the way you're learning environmental concepts in the classroom vs. in the garden? Can you elaborate?

4. Tell me about one challenge you encountered during the garden project and how you worked in your group to solve it.

5. Have any of your eating habits changed due to your gardening?

6. What have been the two most important things you have learned while working in the garden?

7. Have you learned anything about yourself through this project?

8. If you had to choose all over again, would you still choose the Permaculture project for your project? Can you elaborate?

9. Is there anything you would change about the way the project is structured to make it better?

10. Is there anything else you'd like me to know?

APPENDIX D

PERMACULTURE STUDENT QUESTIONNAIRE

Permaculture Student Questionnaire

Please answer the following questions regarding your work in the garden so far this trimester.

1. Please rank yourself in terms of your effort on the garden project

no effort *below average* *average* *above average* *max effort*

2. Please rank yourself in terms of your participation on the garden project.

no participation *below average* *average* *above average* *max participation*

3. What are two things that you have learned so far about running an organic garden that you did not know at the beginning of the project?

4. Give an example of something you have done well so far in this project.

5. Give an example of something you would like to improve on in this project.

6. Explain what you consider your role is in your group. Where do you fit in?

7. Why is it important to consider the season when planting different vegetables in your garden? Give an example of a plant that you might plant in the summer, and a plant that you might plant in the winter.

8. Explain how you have dealt with pests in the garden. What kinds of pests have you encountered? Are there ways to control the pests without using pesticides?

9. Have you fertilized your plants? What do the numbers mean on the front of the bag?

10. Why might a farmer use compost instead of chemical fertilizer on the crops?

11. How can Ms. Sullivan help to make your project run even better?

APPENDIX E

PERMACULTURE STUDENT SURVEY

Permaculture Student Survey

Please complete the survey honestly. The purpose of this survey is to gather your opinions regarding your work on your trimester research project.

Please use the following scale:

1 (strongly disagree), 2 (disagree), 3 (indifferent), 4 (agree), and 5 (strongly agree)

1. A lot of planning went into our decisions to plant specific seeds. 1 2 3 4 5

2. We always discussed our decisions as a group. 1 2 3 4 5

3. I feel comfortable working in my group. 1 2 3 4 5

4. I feel responsible for the way the garden is running. 1 2 3 4 5

5. I have learned about running an organic garden from this project. 1 2 3 4 5

6. I know about ways to manage pests that do not involve chemicals. 1 2 3 4 5
   Please elaborate:

7. I have a vegetable garden at home. 1 2 3 4 5

8. I have planted a garden at home since starting this project. 1 2 3 4 5

9. I enjoy working in the garden. 1 2 3 4 5

10. I understand the difference between an organic and a non-organic garden.
    1 2 3 4 5

11. It is important to consider the season when planting. 1 2 3 4 5

Please elaborate:

12. It is important to consider sunlight levels when planting. 1 2 3 4 5

Please elaborate:

13. Drip irrigation is good to use in a vegetable garden. 1 2 3 4 5

Please elaborate:

14. My work in the garden is important to me. 1 2 3 4 5

15. I feel a sense of ownership over the garden at school. 1 2 3 4 5

16. If I had to choose again, I would participate in the garden project. 1 2 3 4 5

17. I can apply what I have learned to other aspects of my coursework and at home. 1 2 3 4 5

18. I think it is important to learn about gardening. 1 2 3 4 5

19. I think it is important to know where your food comes from. 1 2 3 4 5

20. I think it is important to buy produce locally from farmers in my area. 1 2 3 4 5

APPENDIX F

TEACHER OBSERVATION TEMPLATE

Teacher Observation Template

Student name:

Date:

Time:

Weather conditions:

Group activity for period:

Student:

Remains on task for entire period	yes	no
Is actively involved in what the group is doing	yes	no
Offers ideas for next steps	yes	no
Has done extra work beyond project guidelines	yes	no
Is in charge of updating the blog for the week	yes	no
Does not need reminders from instructor to stay on task	yes	no
Behaves as a leader of the group	yes	no
Asks for help from group members when needed	yes	no
Works well with group members	yes	no
Seems happy to be working on project	yes	no

Observation notes: