Using a Project-Based Learning Approach to Determine and Extend Students Ideas About Gardening and Interpret Group Interactions in Constructing a Semester Project within a Chemistry Course at a Rural Community College

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Abstract

A community garden project was used to analyze students' beliefs about gardening and social interactions that occur in developing a project. The case study involved 22 students enrolled in a freshman level chemistry course at a rural, community college in the United States. The students in the course were divided into eight teams who participated in a 15-week project in designing a community garden. Recordings were made of nine in-class conversations, two instructor-team consultations, and post-class interviews. Along with student produced artifacts, these data sources were used to determine student beliefs before the project, analyze group interactions in developing the project, and capturing post-project beliefs.

The students enrolled in the chemistry class initial beliefs included viewing gardening as an activity of older adults, a food source, a self-gratification interest, and having associated cost issues. Students demonstrated an individual lack of responsibility in the garden project development, poor collaboration skills, and challenges in effective communication. The social interaction in influencing the project development was inconclusive. The students did report gains in conceptual knowledge and skill recognition. Post-project beliefs included gardens being beneficial for physical and mental health, a food source, and a social center. The general attitude of the students toward gardening also showed a positive change during the project. The findings of this study demonstrate a need to better engage students in developing asynchronous communication and collaborative skills.

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List of Abbreviations

CMS – Classroom Management System

IRB – Institutional Review Board

LSI – Learning Style Inventory

PBL – Project Based Learning

PrBL – Problem Based Learning

STEM – Science, Technology, Engineering and Mathematics

ZPD – Zone of Proximal Development

CHAPTER I

INTRODUCTION

Science, Technology, Engineering, and Math (STEM) courses play a key role in the development of a populace that can help lead and progress the society in which we live. Unfortunately, students attending an American college or university often dread taking a science course. One reason for this apprehension is that for many students the normal curriculum places too much emphasis on low level critical skills, such as recall and copying, without challenging the student (Osborne & Collins, 2000). Engaging students requires a process of action and reflective thinking. However, a reflection on mere facts becomes an inquiry in determining what the instructor wants to hear back and results in educational waste. Waste occurs when the educational environment, curriculum or system does not allow for the full potential gains of the learner.

Educational waste partly occurs through a curriculum that isolates the learner from the contextual relevance in society. To overcome this waste, the learning environment needs to promote an interactive and personal experience through utilization of the learner's social and personal skills. To fully engage students, a curriculum needs to allow learners to participate while observing, gaining new information, and constructing knowledge that connects to the society in which they live.

Educational researchers have studied many ways to enhance the classroom curriculum and make the time more interesting for students. Possible solutions include the use of active learning and narrative texts instead of written responses dealing with mere facts (Swarat, Ortony, & Revelle, 2012), context connections to newsworthy topics

(Dijkstra & Goedhart, 2012), and context connections to students' everyday lives (Cigdemoglu & Ozalp-Yaman, 2012). Project based learning (PBL) instructional methods attempt to do the latter by engaging students in an actual problem within their community.

The use of PBL in STEM courses has been on the increase in recent years. PBL first came to the forefront in modern times as a means to better prepare future physicians by working with actual patients or patient case studies (Barrows & Tamblyn, 1980). PBL instructional methods though have a broader scope in STEM education since they mirror the processes encountered by people working in STEM related fields. The driving questions at the basis of PBL activities engage students in the use of various scientific practices including planning and carrying out investigations, developing and using models, and justifying a position with evidence (Krajcik, 2015).

PBL activities have become one way to engage learners in overcoming the apprehension of STEM courses in general and science courses specifically by making the content contextually relevant. However, studies have shown that the dislike for sciences are not equally distributed. There is a greater dislike being noted with physics and chemistry courses compared to biology courses where students are better able to connect with the content (Whitfield, 1980). Later studies have even gone farther to suggest a preference to physics over chemistry (Harvard, 1996; Osborne & Collins, 2000). Thus, there needs to be more investigation on ways to help students connect more to chemistry within their social context.

Background of the Problem

As a chemistry instructor, I have observed students' fears of taking chemistry and being unable to relate to chemical concepts. Students often look at a particular course as something they have to take for credit and fail to see a larger utilization in the real world or their chosen career field. The low interest and apprehension toward science often comes from an instructional approach that more often than not follows a lecturing format. The students in the chemistry class I teach are from a variety of declared majors, which also becomes a challenge when planning instruction to fit the wide interest of the students.

I have used projects for learning in my chemistry classes for several years. In that time, I have noticed some groups work well with each other and some resort to cooperative learning by just assigning parts to complete the assignment. In reviewing the literature on PBL instructional methods, I kept coming across quantitative data showing the benefits that could be obtained from utilizing PBL to encourage collaborative learning within a class. The PBL approach showed increasing gains in cognitive understanding (Stefanou, Stolk, Prince, Chen, & Lord, 2013) and development in critical thinking, communication, and problem-solving skills (Lee, Blackwell, Drake, & Moran, 2014; Sabag, Trotskovsky, & Waks, 2014). Studies of perceptions following an experience with a PBL showed students evaluating the process as socializing, providing more permanent learning, and creating social connections (Genc, 2015; Lee et al., 2014).

For a practitioner, missing from these research studies is the information concerning the planning of a PBL activity in terms of the group interaction. PBL

instructional methods involve the construction of knowledge from a variety of sources. The intellectual base is increased when heterogeneous groups are utilized for PLB activities (e.g. Apedoe, Ellefson, & Schumm, 2012; deGrave, Schmidt, & Boshulzen, 2011; Webb & Palincsar, 1996). How do these groups work? What does an instructor need to add into a PBL assignment to maintain a collaborative environment where students work together through discussion to complete project parts over a cooperative one in which students divide up the task to be completed? How do groups handle conflict (e.g. finding information sources, personality disputes, non-contributing group members)? Where in the PBL instructional process does learning become deeper?

The PBL process starts with an ill-defined problem with which students must work through various steps that cumulate in a final product. Unfortunately, within the PBL research the interactions of a group are rarely studied (e.g. Lee & Lim, 2012; Skinner, Braunack-Mayer, & Winning, 2015). However, the interactions within a group throughout a project are an important area for researchers and instructors to have knowledge both for curriculum planning, teacher education, and adding to the research on PBL.

Problem Statement

Students often dread taking chemistry classes compared to other science classes (Osborne & Collins, 2000; Whitfield, 1980). As a result, a challenge for chemistry instructors is to maintain interest of the students. Further adding to the challenge on maintaining interest in a chemistry class is the various declared majors of the students that enroll in a freshman level course. PBL activities offer a means for engaging students

of varying majors because of the student-driven instructional approach (Krajcik, 2015). The benefits of PBL are often presented in an after-project manner without providing an understanding of the group interaction and individual contributions in developing a project or in providing an instructor with challenges that could be faced in planning the curriculum. There needs to be a better understanding of the group interaction that takes place throughout a PBL activity to aid in planning and implementing assignments related to the project within the curriculum. This study examined the individual contributions and group interactions through a semester garden themed project for the PBL assignment in a chemistry classroom.

Purpose of the Study

Based on the review of literature, little empirical research has been conducted that focused on the group interactions that occur during the development of a project within a PBL instructional method. Planning PBL instruction requires an understanding of how these interactions might influence the mentoring process that is critical in this student-driven instructional approach. Use of a gardening theme, which students would likely have some familiarity, allows for investigation of how a student's prior beliefs, values, and preferences about the topic might influence the collaboration process and possibly instructional needs that would support the social learning throughout the project development. This study evaluated the role student interactions as well as individual beliefs and knowledge play in developing a group garden project with the following questions in mind:

1. What prior beliefs and knowledge do students have about gardening?
2. How does group interaction influence the process and design of a community garden project?
3. How do students' beliefs and knowledge about gardening change through participation in a garden related project?

This study evaluated student interactions as they socially constructed knowledge about gardens to complete a project within a chemistry course using a PBL instructional approach. Capturing students' prior beliefs and knowledge about gardens was an essential component in understanding the students' potential contributions to the group and individual changes that might occur in their beliefs and knowledge. While the course did use chemical concepts (See Table 1.1), this study was not seeking to define the chemistry concepts understood by students, but sought to determine the knowledge students had of gardening and how students applied their knowledge during a community garden project proposal.

Table 1.1 *Chemistry Concepts Covered in Class as Potential Information Source*

Concepts covered in class	Application to Gardens
pH	Soil chemistry required by plants
Macro nutrients in soil (i.e. N, P, K, Ca, Mg, S)	
Micro nutrients in soil (i.e. Cu, B, Mn, Zn, Fe, Mo, Cl, Co)	
Oxidation-reduction	Composting, fertilizers, photosynthesis
Electromagnetic spectrum	Solar irrigation, greenhouses
Thermochemistry	Benches, walkways
Effects of too little/too much of nutritional elements (i.e. too much Mg can cause low blood pressure)	Plant sources of needed nutrients
Functional groups	Medicinal and aromatic plants
Esterification	Plant oils used in soaps
Experimentation: - Chemicals on seed germination - Natural pH indicators - Environmental pollutants on plants - Soil additives change in soil chemistry	

Significance of the Study

Findings from this study may add to the literature on instruction in using the PBL model to maintain interest in chemistry classrooms, utilizing collaborative group learning, and construction of knowledge. With this study focusing on freshman courses at a community college, this study may also add to the literature on STEM instructional methods at two-year schools. These contributions may be used by current faculty, administrators, curriculum coordinators and professional development planners in improving instruction in freshman science courses at their institution. The utilization of a community garden for the topic of the PBL assignment might also add to the literature on understanding where and how people construct their information about gardening.

Definitions of Terms

- *Collaborative learning* – learning during group work where students actively communicate and discuss aspects of the project to point of agreement before moving forward with the project. (Oxford, 1997).
- *Cooperative learning* – learning during group work where students divide up portions of the assignment and then combine their individual work with little discussion of the individual parts before moving forward with the project. (Oxford, 1997).
- *Conceptual Knowledge* – the acquisition of knowledge related to concepts behind the science and determining how they relate to society.
- *Garden* – for this study garden is defined as a planned space for utilization of plants for cultivation, utilization and/or enjoyment of the community.
- *Learning Style Inventory* (LSI) – a self-reporting survey developed by David Kolb to evaluate ways in which a particular student prefers to acquire knowledge. The styles are broken into four categories: concrete experience, reflective observation, abstract conceptualization and active experimentation. A student will use all four categories in the learning process but generally expresses one as a preferred entry point in the learning cycle. (Kolb & Kolb, 2008).
- *Project based learning* (PBL) – an instructional method requiring social collaboration among peers to *produce a final project.* This approach usually involves a driving question or problem whose solution is used to create the

final product. The overall process thus going a step beyond a simple PrBL (Capraro & Slough, 2013).

- *Problem based learning* (PrBL) – an instructional method usually requiring social collaboration to *arrive at a solution* to a question or problem. (Copraro & Slough, 2013).
- *Procedural knowledge* – knowledge needed to complete certain tasks or participate in activities. Within this study the focus will be on acquisition of knowledge needed to design and carry out an experiment as well as gathering information.
- *PBL Model/Instructional Process* – a model of instruction in which students are presented with a community-based, open-ended problem and asked to produce a final project (e.g. presentation, model, report). The final project is a result of information gathered by the group through class instruction, the group's research, discussions, and collaborations around the concepts of the problem presented (Krajcik, 2015).
- *Science, Technology, Engineering, and Math (STEM)* – an association of related fields that often have interdisciplinary requirements. This study has used the term STEM to refer to courses or students seeking degrees in fields that fall into these general areas of study.

CHAPTER II

LITERATURE REVIEW

STEM faculty face a challenge in freshman level undergraduate courses in maintaining and developing student interest. This is particularly daunting since our global society depends on an educated population to advance technology and scientific understanding. One reason suggested for this lack of interest in STEM courses, and science courses in particular, is the normal lecture-based curriculum places too much emphasis on low level critical thinking skills such as recall and copying that does not challenge or relate to student interests (Osborne & Collins, 2000). Thus, alternative instructional methods must be considered. One such method is project based instruction.

Project Based Learning (PBL) has a long history in education although the terminology and application has morphed through the years. PBL can trace its philosophical roots to the work of John Dewey in the late 19th century. Dewey (2007) believed education should mirror the real world by exposing learners in the classroom to real world experiences the learner would encounter in society. For learning to be relevant to a student the knowledge content must be associated with social applications. Projects as part of the curriculum are a tool to helping make these connections. The term of "project" as a teaching method emerged in the early 1900's when William Kilpatrick published *The Project Method* (Kilpatrick, 1918). Unfortunately, this early definition was vague and broad in scope. Kilpatrick defined a project as any educational endeavor done purposefully by the student (Kilpatrick, 1918; 1921). The broadness of Kilpatrick's

definition of project to include a range from active engagement to passive observation was too general of a term for effective study utilization.

The mid-twentieth century brought an increase in standardization of curriculum across academic institutions resulting in forms of student-centered methods like PBL being abandoned for teacher-centered instructional methods. However, the rapid change in technology and medical advances led to a reemergence of student-driven instruction beginning with transformations in medical schools. Barrows and Tamblyn (1980) documented an approach adopted to help students at McMaster University better relate knowledge to problems patients presented. Their success in changing the instructional approach was adopted by other medical schools around the world and became one of the primary learning methods in medical programs.

The use of PBL in other higher education areas did not follow as quickly. The use of PBL was adopted and studied readily in K-12 instruction (Krajcik, 1994; Thomas, 2000). However, the absence of post-secondary PBL instruction has been well documented (Allen & Tanner, 2003; Helle, Tynjala & Olkinuora, 2006; Savin & Baden, 2000). Studies of the use of PBL instructional methods within higher education and STEM fields in particular have mostly occurred in the last 15 years or so and evaluating the findings of these studies requires background knowledge about PBL in general.

Project Based Learning

The main issue in defining PBL from practice comes from an often-interchangeable vocabulary. Researchers have agreed PBL involves active learning, is

student driven, and has a constructivist approach to learning (Krajcik, 2015; Krajcik & Blumenfeld, 2006; Savery, 2006; Savin-Baden, 2000). However, many similar terms have been used to express the process such as differential learning, research learning, experiential learning, and discovery learning. This confusion in terminology has been manifested most in the terms Project Based Learning (PBL) and Problem Based learning (PrBL). The abbreviation PBL is often used for both which adds to the confusion but PrBL will be used in this paper to distinguish between them. A compiled comparison of PBL and PrBL is provided in Table 2.1 and has been discussed in the following paragraphs followed by the importance of collaboration and group dynamics to a successful PBL project.

Table 2.1. *Comparison of Problem Based Learning (PrBL) and Project Based Learning (PBL) characteristics*

Problem Based Learning (PrBL)	Project Based Learning (PBL)
Learning is linear	Learning is multi-dimensional
Underlying problem or question is ill structured to allow for free inquiry.	Underlying problem or question is ill structured to allow for free inquiry.
Problem or question may have real-life context	Problem or question has real-life context and setting
Often involves one solution but some examples can involve multiple solutions	Multiple solutions are possible
End result is the solution of the problem or question	End result is the production of a product (e.g. presentation, model, legislation, paper)
Involves peer and teacher communication	Communication occurs between peers, teachers, and community members
Learner-centered	Learner-centered
Involves active learning	Involves active learning
Promotes development of life-long learners	Promotes development of life-long learners
Students must identify suitable sources of resources of knowledge	Students must identify suitable sources of resources of knowledge
Students develop or enhance critical thinking skills	Students develop or enhance critical thinking skills
Students develop or enhance collaborative skills	Students develop or enhance collaborative skills

Defining PBL

Krajcik (1994, 2006, 2015), in his body of work, recognized PBL as creating a learning centered environment where students have the opportunity to utilize disciplinary concepts, tools, personal experiences, and technology to solve real-world problems. The distinguishing factor of PBL involved the creation of a project as a final component. Researchers have argued that this final project is the main difference between PBL and PrBL with the focus of latter being in the process of learning (Savin-Baden, 2000). However, the process of gathering the information is also critical to the production of the product in PBL. Both methods require the students to construct knowledge by determining sources of information. The evaluation of the information helps to develop information literacy skills as well as networking skills. Networking skills have been regarded as more important in PBL since the process often involves community members (e.g. church groups, local families, community leaders) within the project.

PBL immerses students in a problem that occurs outside the classroom often within the context of their community as an imbedded part of the curriculum. Krajcik (2015) identified PBL as students, teachers and members of society collaborating on a question or problem in order to find a solution or solutions. The final project then emerges from this collaboration based on those solutions. This networking among various individuals and groups allows for social construction of knowledge by pulling from all available resources; but is the networking unique to PBL?

PrBL involves students working with each other to solve real world based problems developed in the classroom. This perspective has been used to argue that PrBL

methods focus more on helping students construct knowledge in arriving at a solution whereas PBL focuses on the project produced as a solution to the problem (Prince & Felder, 2006; Savin-Baden, 2000). The problems or questions presented often result from course outcomes being used to develop the scenario which require students to make sense of the concepts they are learning through solving the simulated problems (Galvan & Coronado, 2014; Savin-Baden, 2000). The PrBL process from this view does not allow for instructional modification based on student interests or abilities and usually only allows for one solution. The course outcomes are also the driving force behind a PBL activity. The difference in PBL being that a general problem or question is presented that could have multiple solutions with utilization of the same conceptual knowledge.

Collaboration within the student groups is also a shared component of the two methods since social construction of knowledge requires utilizing the diversity in experiences and prior knowledge of the group. However, there is the potential for the interaction to revert to simple cooperative exchanges as the result of a poorly designed PBL/PrBL or as the result of unresolved group conflict. The learning that takes place and the skill development in the two methods often seek the same process outcomes. This indication of more similarity than difference has led some researchers in recent studies to not attempt to separate PBL and PrBL methods (Galvin & Coronado, 2014; Nielson, Du, & Kolmos, 2010). Some studies have even made a deliberate attempt to combine the two methods (Bedard, Lison, Dalle, Cote, & Boutin, 2012; Hanney & Savin-Baden, 2013).

Attempts have also been made to fit one method as a component of the other. Some researchers have concluded that PBL is simply a subcategory of PrBL (Lee et al., 2014). Others have made a case for considering PBL as the larger umbrella under which PrBL exists. Capraro and Slough (2013) claimed that PBL was broader than PrBL and often composed of several problems that the students must solve. Some debate also exists concerning if one method is more beneficial than the other. Studies on comparing these two instructional methods have concluded that the more real-world, ill-defined, open-ended project in PBL appeared to spark higher level-cognitive skills among student (Stefanou et al., 2013) while also noting higher achievement of learning outcomes in PBL compared to a PrBL group (Abdulaal, Al-Bahi, Soliman, & Iskanderani, 2011).

The distinguishing component of PBL is the construction of a product (e.g. model design, presentation, consumer product, analytical report), but when evaluating the process should the two methods be looked at separately? The instructional approach to both PBL and PrBL involves starting with an ill-defined problem and allowing a group of students to construct knowledge in order to progress through the problem. The difference is where the students end. Within a PrBL approach the solution(s) is(are) the expected result while in PBL the solution(s) is(are) used to develop a final project based on those findings. The distinction between the two methods being minimal and the purpose of each being complimentary has cautioned researchers to suggest not spending a great deal of time in classification of an activity as being a project or problem (Burlbaw, Ortwein & Williams, 2013; Savery, 2006). Though PrBL and PBL do have some differences, the basis of construction of knowledge and applying that knowledge to a problem focuses the

methods on the cognitive growth of the student (Krajcik, 2015; Ruangrit, 2009; Savery & Duffy, 1995). Some researchers have concluded in their studies that the two methods really should be merged (Hanney & Savin-Baden, 2013; Prince & Felder, 2006). Of greater importance for this study is to look at the characteristics involved in the process and not on whether the assignment falls in the PBL or PrBL classification.

Characteristics of PBL

One of the early definitions of PBL came from Adderley et al.'s (1975) *Project Methods in Higher Education*. In this book, Adderley identified five characteristics constituting an approach as a project method. These were (p. 1):

- Projects involve the solution of a problem; often set by the student.
- Projects involve initiative by the student or group of students and necessitate a variety of educational activities.
- Projects commonly result in an end product
- Work often continues for a considerable length of time
- Teachers take on an advisory rather than authoritarian role at all stages of the project

The idea of projects involving a problem and the end result being the creation of a product are the heart of PBL methods of instruction. Blumenfeld et al. (1991) echoed this sentiment in stating the essence of PBL is that a problem serves to organize and drive activities. The activities of PBL instruction culminated in a final product to address the driving question.

As a pioneer in the study of PBL methods of instruction, Joseph Krajcik (2015) expressed the characteristics in terms of roles and skills utilized by the students. Krajcik identified five essential features of PBL instructional methods. These essential features may be summed up in that PBL instruction must:

- Investigate authentic questions or problems
- Develop a series of products that address the question or problem
- Engage students in the process of investigation
- Engage students in collaboration with peers, teachers, and community members
- Utilize cognitive tools of learning (Krajcik, 2015)

However, the teacher's role within these features is often challenging as one must transition from traditional instruction and assessment to mentoring processes in a PBL environment. Lee et al. (2014) found in particular the assessment of learning in PBL instruction was something new and challenging for teachers. Thus, a sixth requirement is often added requiring various formal and informal imbedded assessments within the PBL instruction (Markham et al., 2003). This feedback throughout the project is one of the major benefits of PBL instruction in promoting student learning.

In recent years, PBL has become more multidisciplinary in nature with projects often designed to meet standards of the curriculum across disciplines (Krajcik, McNeill, & Reiser, 2007; Zajkov & Mitrevski, 2012) and concentrate on 21st century skills of critical thinking, collaboration, creativity and communication essential for life-long

learning and workforce readiness (Bell, 2010; Jollands, Jolly, & Molyneaux, 2012; Krajcik, 2015). These multidimensional components and outcomes require collaboration between the groups to draw from the experiences and knowledge of the collective. One of the essential points of PBL methods has been the attainment of the skills and content knowledge required to produce the final project (Krajcik, 2015; Ruangrit, 2009; Savery & Duffy, 1995). As students worked through the project they experienced a process that scientist would use in real-world investigations. PBL activities have been shown to exhibit involvement in scientific processes such as model making, engaging in argument from evidence, and communicating scientific ideas (Krajcik, 2015). Accomplishing this interaction within a group requires not just communication but active collaboration. Collaboration is one essential component of PBL that requires more discussion.

Collaborations in PBL

Learning in a PBL activity occurs through social construction of knowledge (Krajcik, 2015; Savery & Duffy 1995). Interaction within the PBL group acts as the conduit for this construction. The group diversity provides a collective expertise, creativity and ideas from various individuals to allow for members of a group to acquire knowledge (Krajcik, 2015). The interaction that takes place could be simply cooperative in nature or involve a more social collaborative approach. The latter is the preferred method to encourage maximum gains of knowledge and skills by all group members.

Cooperative and collaborative work within the group are not the same. Oxford (1997) compared cooperative and collaborative communication noting that both encourage involvement by high input inclined students while allowing restrained students

to feel more willing to communicate. Groups only engaging in cooperative interaction may do so from following a provided structural format from the teacher as to student roles in the group (Matthews, Cooper, Davidson & Hawkes, 1995). This definition of cooperative interaction goes against the intent of PBL learning methods. Unfortunately, when the problem is more defined in this manner, students may simple assign various parts of the PBL activity to individuals without gaining the full acquisition of knowledge available from the group (Dillenbourg, 1999; Skinner, Braunack-Mayer, & Winning, 2015).

The more ill-defined problems or questions that drive a PBL allow the students to control the interaction. There may still be a tendency to revert to assigning roles, but there is also the possibility for more exchange of ideas, experiences, and knowledge to occur from collaborative interactions. Collaborative learning evolved from the philosophical, theoretical and political discussion of issues which are socially constructed through the community and focus on social relationships in the group (Oxford, 1997). This open discussion lies at the heart of PBL methods of instruction. Many studies have supported this by showing successful PBL methods require stimulation of joint construction of knowledge, encouraging student generation of questions, reasoning and conflict resolution through a collaborative interaction (Krajcik, 1994; Visschers-Pleijers, Dolmans, de Leng, Wolfhagen, & van der Vleuten, 2004). Planning a PBL activity that encourages collaboration becomes a critical factor for practitioners.

This importance of planning instruction for social interaction is well documented. Dewey (2007) and Vygotsky (1978), among others in early education theory, noted that

knowledge is socially constructed and ideas have social origins. This social interaction helps to push learners to greater depth of cognitive gains within the context of their society. Vygotsky's *zone of proximal development* sums this up by stating that the realm of potential learning occurs under optimal circumstances and with the best possible support from the teacher and others in the environment. While Vygotsky's theories focused primarily on adolescent learners, Knowles (1968) *adult learning theory* suggested individuals had more experience from which to draw and see connections to gain further cognitive knowledge. Thus, the social learning occurs throughout life and becomes even more prominent as the learner moves more into societal interactions. Other characteristics of adult learners include being more interested in immediate application of knowledge and being more motivated by internal rather than external factors (Knowles, 1980) which are well supported in PBL environments. Adults are life-long learners that continually build their knowledge base through learned skills.

As mentioned above, collaboration is an essential component in PBL activities and an essential skill in the development of life-long learners (Bell, 2010; Krajcik, 2015). Unfortunately, students are accustomed to the lecture approach especially in post-secondary science classes. Studies that have shown students in PBL groups have a consumption, or being provided information, conception of learning (Skinner et al., 2015) with most of the interaction time spent on statements of information (Visschers-Pleijers, Dolmans, de Leng, Wolfhagen, & van der Vleuten, 2006). This mind set acts as a challenge to adoption and integration of PBL.

Another essential component for learning in the context of the group is for cognitive conflict to be present. Through the discussion students should be exposed to additional information that might contradict their current understanding. As Mezirow (2000) pointed out, learning occurs through complex institutional and interpersonal settings that must be understood in cultural frames of reference. The gain of new knowledge occurs as students evaluate new information and determine the assimilation worth from their own reflective analysis. PBL groups engaging in collaborative learning should experience this cognitive conflict. In contrast, self-reports by students have shown that cognitive conflict involved in social construction of knowledge is often lacking in PBL groups (Visschers-Pleijers et al., 2006). While PBL instructional methods are a tool of providing exposure to cognitive conflict within the learning environment in higher education, the group interactions must be understood better in order for practitioners to incorporate PBL activities that encourage cognitive conflict.

Collaboration is also a central part of science investigations and is essential to finding solutions to challenging questions and problems (Krajcik, 2015). Helle et al. (2006) supported the importance of collaboration by suggesting one of the main strengths of PBL and PrBL instructional methods was allowing students to work to a solution through the student's idiosyncratic way. The current practice of information presentation does not allow for students to gain and assimilate new information. For example, many undergraduate labs generally verify chemical principles rather than allow the student to discover the knowledge concepts (Schoffstall & Gaddis, 2007). Improvement in science education requires the student experience accurate science processes through the post-

secondary curriculum (Robinson, 2013). The group interaction within a PBL activity thus needs to be looked at in greater depth.

Groups in PBL

Groups are the heart of a PBL activity. Oxford (1997) noted that the group is richer in resources than any single individual resulting in potential for greater confidence and satisfaction from the group interaction. The diversity within the group allows for more cognitive gain than instruction coming from a single individual or the student's personal background. Group discussion has been concluded to enhance cognitive development because of stimulation of an individual's prior knowledge through integration, retention and information recall with the collaborative interactions (de Grave, Schmidt, & Boshulzen, 2001; Lee, Huh, & Reigeluth, 2015). Achieving this gain of knowledge is based on the premise of valid collaboration within the group.

Some studies have suggested that the skills of collaboration such as addressing knowledge conflict, reasoning, and argument development are absent from the PBL activity (de Grave et al., 2001; Lee et al., 2015) or students do not recognize the value of these skills in the learning process (Dillenbourg, 1999; Lee & Lim, 2012; Skinner et al., 2015). Understanding how the group operates within a PBL activity thus becomes an essential need for practitioners and curriculum developers.

The successful use of groups in PBL requires some preparation in determining group makeup, size and preparation. Early work on groups has suggested two members as the optimal size because each student has an increased opportunity for active participation (Lohman & Finkelstein, 2000). Though heterogeneous groups bring more

diversity of thought, intellectual backgrounds, experiences and viewpoints with groups of three or four working best for general classes (Apedoe, Ellefson, & Schunn, 2012; Webb & Palincsar, 1996) allowing critical evaluation of both majority and minority statements in terms of evidence and justification (Wiley & Jensen, 2006). However, Barab et al. (2000) noted that pairs of students tended to work collaboratively while one member tended to dominate in groups of three. Thus, a need exists to better understand the engagement of individuals within a group as a project develops.

The collaboration within the group as being an important aspect of PBL projects has prompted several studies to be conducted. Student perceptions through questionnaires, surveys or interviews have captured viewpoints of benefits and challenges within PBL activities (Bilgin, Karakuyu, & Ay, 2015; Genc, 2015; Jollands, Jolly, & Molyneaux, 2012; Lee et al., 2015). Teachers using PBL projects have also been evaluated through surveys, interviews, and evaluation of student artifacts (Guo & Young, 2012; Schneider & Krajcik, 2002). While capturing post reflective perceptions helps to support benefits and challenges of PBL activities, the full emersion of the students is not captured.

The student interaction within the project needs to be evaluated. This area has been examined by only a handful of studies. In online or hybrid courses using PBL activities, the electronic exchanges between students have been evaluated (Hou, 2010; Lee & Lim, 2012) as well as peer evaluations during phases of the project (Lee & Lim, 2012). A study by Visschers-Pleijers et al. (2006) did use recordings and observations to evaluate group interaction but for only one discussion session part way through a six-

week project. Skinner et al. (2015) used one of the few qualitative studies by means of a naturalistic approach to observe students through the first-semester of a multi-semester PBL curriculum with unstructured interviews conducted the second semester. Thus the group interaction within a PBL requires further study to add to this body of knowledge on PBL methods. Such a study would potentially provide greater information for planning and implementing of PBL activities by practitioners particularly in post-secondary applications.

PBL in Post-secondary STEM Courses

While the reemergence of PBL as an educational tool started in teaching students in medical school in order to prepare them for future work as physicians, very little about the utilization of PBL has been studied in post-secondary courses. Thomas's (2000) metacognitive study of PBL noted that most of the research in PBL had occurred within the last few years of the 1990s and uncovered the majority of that work took place within the K-12 system. The absence of PBL studies in higher education was also noted by Savin and Baden (2000) who claimed PBL should play a more essential role in post-secondary education. While Pascarella and Terenzini (2005) concluded that collaborative and constructivist teaching methods were becoming more common in higher education but the lecture model remained the dominant format. Helle's (2011) studies of PBL in higher education noted that "research is lagging behind practice despite the fact the topic certainly is not a new one" (p. 15).

Helle et al. (2006) noted most literature in PBL use in higher education were primarily reports of the implementation of projects within the instruction. The result was

that most of the literature in PBL could be classified as course descriptions rather than evaluating educational merit of PBL use. Helle et al. (2006) were only able to find five studies showing clear indication of authoring for research on PBL instruction. I came to similar findings in that many articles represented course descriptions more than educational research on several recent studies of PBL in higher education (e.g. Hall, Palmer & Bennett, 2012; Kalivas, 2008). Some of the PBL studies conducted within higher education have focused on pre-service and current teachers in STEM instructional areas (Frank & Barzilai, 2004; Guo & Yang, 2012; Mennin et al., 2013) rather than students in STEM fields. For purposes of this current study, we will look at a few of the educational studies that have been conducted in STEM fields in higher education.

Many studies have involved pre-service teachers who plan on teaching in a STEM subject area. Frank and Barzilai's (2004) study involved 25 pre-service teachers enrolled in a methods course taught in the department of education whose design was based on national science and technology curriculums for junior high schools. These pre-service teachers were also completing Bachelor degrees in one area of science or engineering. The authors found several benefits of the PBL immersion including gains in interdisciplinary knowledge acquisition, increase in motivation and responsibility, and importance of utilizing formative assessment throughout a PBL activity. A study by Wilhelm, Sherrod and Walters (2008) was also conducted with pre-service teachers in a science and mathematics methods course. This study involved 24 pre-service teachers making observations of moon appearance, azimuth angle, and altitude angle through an entire lunar phase. The pre-service teachers compared observations with peers enrolled at

similar courses in two geographically different institutions. The authors found an increase in mathematical understanding of the students within the science based project.

A study by Bilgan, Karakuyu, and Ay (2014) followed 66 science education students enrolled in an educational theory class taught either through a PBL or traditional approach. The same instructor taught both classes and the students learned the same content. The difference was in the method of content presentation. The students reported positive benefits of the PBL method as application of knowledge gained, learning science process, more permanence of knowledge gained and collaboration. Some of the negatives reported included information pollution (e.g. misinformation, incomplete information, irrelevant information), lack of time, and the student's adjustment to the PBL method. Genc's (2015) study of 39 pre-service teachers in an environmental course used PBL activities to measure impact on student attitude toward the environment. The students reported positive effects on environmental attitude and that the PBL process enhanced creativity, encouraged research, and provided more permanent learning.

Some of the studies in teacher education have had a direct impact on students in STEM areas. Mennin et al.'s (2013) longitudinal study followed 54 mid-career faculty from health-related fields in designing and implementing projects into their instruction while participating in a mentoring program. Mennin et al. (2013) found collaboration, relevant societal context of work, and organizational skills among important factors of teacher implementation and students' involvement in PBL activities. Lee et al. (2014) followed eight faculty from different disciplines who attended PBL professional

development. The study reported on challenges and successes the faculty observed in communication, student engagement, assessment, and faculty understanding of PBL.

The study of STEM students using PBL in core courses (e.g. those within biology, chemistry, physics, engineering, math) is more limited. Bedard et al. (2012) studied determinants of engagement and persistence of undergraduates in engineering and medicine through a PBL program curriculum. This study followed a quantitative approach using surveys after PBL activities to find major factors that impacted student engagement and persistence in engineering programs. Jollands et al. (2012) surveyed 10 engineering graduates to see if the PBL based program had been beneficial. The graduates reported the PBL process helped them gain interdisciplinary knowledge, acquire knowledge through active learning, improve communication skills, and handle challenges of interpersonal conflicts. Students also commented on the benefit of formative feedback throughout the projects. Robinson's (2013) study involved 60 undergraduates in an analytical chemistry course using PBL methods. Students had to work with two companies in the area. Students reported the authenticity of engaging in the project with real clients as motivating and engaging and drove the students to work more carefully on performing analyses.

While the benefits of using PBL methods in higher education have been documented (e.g., Bedard, 2012; Genc, 2015; Helle et al., 2006; Mennin et al., 2013) areas still remain that are not well understood that could benefit practitioners and curriculum developers. One of these areas is that group interaction and development should occur as an integral part of the PBL process through collaboration and pooling of

resources (e.g. prior experiences, individual knowledge, contacts) of the individuals in the group. However, most studies of PBL in higher education have focused on the post perceptions of the PBL process or the academic and skill gains from the PBL process. There has been limited study on the interaction of the group itself throughout the PBL activity. This study hopes to add to this area of the PBL literature.

The majority of the studies in higher education have occurred at the university level (e.g., Baysura, Altun, & Yucel-Tot, 2016; Frank & Barzilai, 2004; Robinson, 2013 or at specialty schools (e.g., Fuertes et al., 2015; Hall, Palmer, & Bennett, 2012). This study focused on community college students to further add to the PBL literature within a niche that has not been well studied. Community college students often have obligations that prevent them from being a full-time student (e.g. family commitments, full time job) or are underprepared for the rigor of college level courses. Studying community college students thus allows for comparisons with university studies for application of project-based instruction.

In addition, a PBL should involve a topic that incorporates the community and can engage the students. A community garden is a topic that can accomplish this dual task within a freshman chemistry class.

Gardens as Sociocultural Centers

Gardens in various forms have become an integral part of modern society for many. As society moved away from family farms into more urban areas, gardening became a means to provide food for the family. Researchers have documented this development from the vacant-lot cultivation movement of the 1890s through school

gardens, victory gardens and community gardens (e.g. Hanson & Marty, 2012; Lawson, 2005). The history of various gardens has also become an online virtual exhibit at the Smithsonian Institute titled “Community of Gardens”. While the exact purpose associated with each garden type has a slightly different meaning in context, within this paper I look at the garden as a collective association of these various styles. One thing the various types of gardens all have in common is the benefits to the community in which they are utilized.

The main purpose of a garden has been to provide food for the community. Community gardens started with vacant lot gardens during the 1890’s economic recession and has progressed through to current movements focused on providing better nutritional food sources for low-socioeconomic neighborhoods (Adelman & Sandiford, 2007; Lawson, 2005). Some gardens have been used as social learning environments. For example, high school students engaged in creating gardens for low-income housing neighborhoods (Bahng, 2015) or growing food for local food banks (Roubanis & Landis, 2007). Some government programs have been directly associated with garden interaction and have provided indirect encouragement through education on gardening methods for mothers in the Women, Infants, and Children (WIC) program (Flannigan & Varma, 2006), developed as a solution to urban degradation (Poulsen et al., 2014) or for promotion of cultural awareness (Benton, 2015).

A garden also provides many health benefits beyond nutritional needs. Carney et al. (2012) followed 42 Hispanic farm worker families in planting and working an organic garden over a year growing season. The authors of the study noted that gardening

activities showed a direct relationship with stress reduction, increased relaxation and self-confidence. Poulsen et al.'s (2014) qualitative study of the perceived benefits of community gardening in Baltimore involved 28 participants from 13 different gardens in the city. The authors reported an increase in the physical and mental health of the participants as well as for those less mobile community members who enjoyed the aesthetics of the garden even if they were not able to physically participate. The community garden also provides a means of creating social bonds within neighborhoods (Firth, Maye, & Pearson, 2011; Poulsen et al., 2014).

The complex nature of gardens in terms of variety of garden type, purpose, plants, and layout design lends well to education in both formal and informal settings. Dewey (2007) saw a school garden as an integral part in preparing a child for the society in which they would function. Dewey's school design was based on the idea that gardens, and other public spaces, could serve as a place to pool ideas and share experiences thus increasing the opportunities for discussion and learning. How then have gardens been used in education? The use of gardens for education will be discussed in the next session.

Gardens in Education

Gardens associated with schools have become popular in the last few decades with state entities encouraging their integration into the curriculum through programs to promote school gardening (Culin, 2002; Smith & Mostenbocker, 2005) or providing curricula and evaluative research to schools for consideration of building a school garden (Dirks & Orvis, 2005; Ozer, 2007). The purpose of these gardens has included science learning, improving academic performance, developing ecological and environmental

awareness, increasing knowledge about food systems and nutrition, and social development (Berezowitz, Yoder, & Schoeller, 2015; Blair, 2009; Skinner & Chi, 2012). Thus, gardens have a wide potential for utilization within the educational classroom.

Unfortunately, while gardens have many benefits in education at every grade level, the largest documented use of gardens within education since the early 1990s has been at the elementary and middle school levels (Blair, 2009). One of the largest school garden initiatives has been in the California school system with over 4000 gardens being grown in schools (California Department of Education, 2010). When Graham, Beall, Lussier, McLaughlin, and Zidenberg-Cherr (2005) did a study of utilization in the California system, the schools reporting garden based instruction included only 11% high schools compared to 56% elementary, 9% kindergarten through eighth grade, and 13% middle schools. One possible reason given for the large number of elementary schools using garden based instruction was that generally students in those grades were in the same classroom throughout the day and therefore state standards would be easier to meet.

Draper and Freedman (2010), in a review of the literature on community gardening in the United States, found that over one-third of the studies focused on youth gardening activities. The articles they reviewed with adult participants focused on a certain population based on race, socioeconomic standing, prisoners, or currently gardening. One study did focus on older adults where an increase in social connectedness and emotional health was reported (Austin, Johnston, & Morgan, 2006) while other studies have shown that older adults were more likely to be involved in community gardens (e.g. Glover, Shinew, & Parry, 2005; Kurtz, 2001).

The educational application of the gardens in the school curriculum has followed the needs of the grade level related student learning outcomes. Using the gardens to teach science has been the predominant utilization, followed by environmental studies and nutrition in the K-8 levels (Graham et al., 2005). In their review of the literature on garden based instruction in elementary schools, Berezowitz, Yoder, and Schoeller (2015) also found significant improvements being reported in daily fruit and vegetable consumption due to educational garden experiences in these early grades. The social interaction associated with these garden based programs has also showed development of personal interactive skills, inclusion and intrinsic motivation (Rye et al., 2012; Skinner & Chi, 2012).

The curricular applications of gardens tend to become more focused in higher grade levels. High schools tended to use gardens primarily for agriculture studies with science taking a distant second in application focus (Graham et al., 2005). Gardens have also been used for specific applications with high school students, such as developing an irrigation system for a community garden (Farinde, Tempest, & Merriweather, 2014) and building a pergola in the garden to enhance garden-based instruction (Dorrel & Berkeishiser, 2014). Garden based learning has also been used successfully as a means to motivate high risk students to stay in high school (Ruiz-Gallardo, Verde, & Valdes, 2013).

Only two studies with college age students were included in the Draper and Freedman (2010) review of the literature. Hoffman, Knight, and Wallach (2007) studied 32 students in an introductory psychology course at a community college. The students

worked in a community garden for a three-week period. The students in the study showed lower levels of ethnocentrism and higher self-esteem scores compared to a control group who did not work in the garden. Roubanis and Landis (2007) reported on results of garden project developed to fulfill curriculum needs of nutrition and family and consumer science programs at the college. The program fostered student engagement on sustainable food practices and prompted changes in attitudes and beliefs about organic farming, food consumption, and resulting dietary changes. The project also provided food for a local food bank.

Within the postsecondary level, educational applications and use of gardens outside of the agricultural sciences becomes even more limited in focus but tend to follow societal needs. Some gardens have been used to return to the focus of providing fresh, healthy food for a community (Gorneau, 2016; Manase, Nkuna, & Ngorima, 2009: Sorenson, 2011) or producing for local food banks (Roubanis & Landis, 2007). Other gardens have been used to showcase various plants for public education by presenting culturally relevant species (Benton, 2015; McKinne & Halfacre, 2008) to plants that can be used as natural insecticides (Innocent et al., 2014). Plants that can be grown within these gardens have been studied for nutritional and medicinal applications (Charoenkiatkul, Thiyajai, & Judprasong, 2016; Vollmer & Rosenson, 2004; Williams et al., 2014; Zhang et al., 2015) and as a method to measure potential ingestion of environmental pollutants (Servin et al, 2013; Stoykova, Yankovska-Stefanova, Yotova, & Danalev, 2015). The flexibility of gardens through variety in type (e.g. fruit/vegetable, herb, heritage, botanical) allows for various instructional applications.

Studies involving garden-based instruction have mostly reported changes in health, diet, academic performance, and development (e.g. social relationships, respect for other cultures). Physical and mental health benefits of gardening were reported in over half of the studies reported in Draper and Freedman (2010) and have been common in studies since (e.g. Carney et al., 2012; Poulsen et al., 2014). Studies on perceptions and beliefs have usually been specific. For example, Lineberger and Zajicek (2000) looked at attitudes towards fruits and vegetables. Fancovicova and Prokop (2011) studied students attitudes towards plants in an outdoor learning environment. A study of college students on general beliefs about gardens before exposure to garden instruction was not found in the review of the literature

The multifunctional use of gardens for sociocultural applications makes them a good choice as a basis for a project within a PBL instructional process. The project should be student driven in design. With the variations on gardens for vegetables and fruits, herbs, medicinal plants, flowering plants, and so forth; students have many choices to make their garden fit the societal needs of the community. The various needs of the garden (e.g. soil nutrition, sunlight, fertilizer) and potential nutrient and medicinal composition also allows for curriculum content to be covered. For this reason, a community garden was chosen as the topic for this study of interactions in a chemistry based PBL instructional method.

PBL provides a student driven instructional method that allows for learning to take place through student collaboration of prior experiences, knowledge, and resources. The social process allows students to construct knowledge from their fellow students,

family, community members, and classroom instruction. The wide array of types and commonality of gardens would probably have some familiarity with most students. Therefore, the garden was chosen as the primary topic for the PBL to be used in this study to evaluate how groups might communicate and utilize their peers to help progress a project.

CHAPTER III

RESEARCH DESIGN AND METHODOLOGY

Project based learning (PBL) follows a constructivist approach to learning where students slowly add to their own level of knowledge through gathering and analyzing new information. Student gains in knowledge, critical thinking, and positive perceptions have been documented in the literature as reported in Chapter II. However, most of these studies have utilized a post-activity analysis of data or perceptions usually following a quantitative methodological approach and have often focused either on the products created in the PBL or on the performance gains in content knowledge. This study will add to the literature by capturing a naturalistic analysis of the student interactions within the moment of the PBL activity.

Theoretical Framework

The framework for this study was drawn from the sociocultural theory of learning. A central assumption of this theory has been that learning and mentoring can be viewed as a form of socialization into a community of practice (e.g. classroom, gardeners) (Erickson, 1982; Rogoff, 1990). This assumption has implied that instruction involves both social and cognitive construction and can occur in both formal (e.g. classroom, student labs) and informal (e.g. home, museums) environments. Vygotsky (1978) explained this process within his *zone of proximal development* (ZPD) as the difference in a learner's independent task performance and his or her potential performance with assistance from others. Helping learners to gain knowledge involves an

immersion in an activity where involvement is mediated, scaffolded and supervised through guided participation (Rogoff, 2003) within the learner's ZPD.

When applied to educational settings, the ZPD suggests that learning may occur in peer groups where each student possesses some of the knowledge but requires the other group member's contributions in order to progress. For example, one student may come from a family who maintains a medicinal herb garden. As a result, the student would have acquired some information from home about the types of herbs, care, and utilization. The student then would share this knowledge with the other group members to help plan an herb garden. While Vygotsky's work dealt primarily with children as the focus of these peer groups, learning is a lifelong process that can be assisted by others at all ages in this manner (Rogoff, 2003; Wennergren & Ronnerman, 2006). Project based learning methods rely on this group interaction at their core, with the final outcome being driven by the student knowledge and gathering of information (Helle, Tynjala & Olkinuora, 2006; Krajick, 2015). Instruction, whether from a mentor or peers, within the ZPD entails a negotiation of meaning. This negotiated meaning is often deeply personal as it includes the individual's values, beliefs, and goals (Forman & McCormick, 1995).

The negotiation of meaning occurs within the group collaboration. Forman (1989, 1993, 1995) within her body of work on collaborative problem solving noted that interactions created a bi-directional ZPD where both parties of the interaction, whether student-student or student-teacher, learn from the other. Through these interactions students were able to coordinate their different perspectives in order to progress through a problem. Group collaboration allowed students to complete a project within a PBL

learning model by building on the knowledge of the group as a collective. Complex social relationship and differing cultural values influence this co-construction of knowledge and the sources of information used (Forman & McCormick, 1995; Wennergren & Ronnerman, 2006).

Brown et al. (1993) noted that the active agents within the ZPD "can include people with various degrees of expertise but it can also include, artifacts, such as books, videos, wall displays, scientific equipment and a computer environment intended to support intentional learning" (p. 191). Accordingly, the growth of the group within a sociocultural framework depends not only on the individuals collaborating but on external sources they utilize. These sources could be community members, experts in the field, and available technology (Lantolf & Thorne, 2006; Wennergren & Ronnerman, 2006).

Studying group interactions throughout the duration of a project from a sociocultural framework embraces the complexity of the group interactions, thereby allowing for a more holistic understanding of how group members interact to complete a project. Thus, a sociocultural perspective is particularly valuable in gaining insight into student learning during PBL (e.g. cognitive gains, sources of knowledge, collaboration), as well as illuminating instructional necessities in planning a project (e.g. sources to use, identifying community members, time for group interaction dedicated to project). A project based on a community garden provides a wide variety of past sociocultural experiences (e.g. gardening techniques with grandparents, mom using aloe vera for

burns) and sources of information for students to utilize in gaining cognitive understanding within their individual zones of proximal development.

Methodology

This study followed an interpretive case study approach within the sociocultural framework. Yin (2014) stated "the distinctive need for case study research arises out of the desire to understand complex social phenomena" (p. 4). However, exactly what constitutes a case study is not as clear. Yin noted that a case study "allows investigators to focus on a case and retain a holistic and real-world perspective—such as studying individual life cycles, small group behavior, organizational and management processes, school performance" (p. 4) among others. When Merriam (1998) was giving rationale for her definition, she noted that Stake focused on "trying to pinpoint the unit of study" (p.27). This study uses Merriam's definition of a case study as "the product of an investigation [that] is an intense, holistic description and analysis of a single entity, phenomenon, or social unit" (p. 34).

In addition, Merriam (1998) noted that by their nature qualitative cases studies are "particularistic, descriptive, and heuristic" (p. 34). The particularistic nature of case studies indicates the need to concentrate on set conditions to evaluate the way groups of people handle specific problems or task. The descriptive nature of case studies according to Merriam means "the end product is a rich, thick description of the phenomenon under study" (p. 29). The third characteristic of case studies, heuristic, Merriam defines as "illuminat[ing] the reader's understanding of the phenomenon under study" (p. 30).

Merriam (1998) further defines case studies by dividing types into two categories: disciplinary oriented or overall intent. Disciplinary includes ethnographic, historical, psychological, and sociological case studies, which often focus from different views on analyzing "specific issues or problems of practice" (Merriam, 1998, p. 34). While this current study has the potential to help in curriculum planning, I was more focused on the group interaction within this case and the study did not fall under disciplinary criteria. As Stake (1995) noted the purpose of case study research is to understand the current case first and not to study a case in order to understand other cases. Merriam's second categorization of case studies based on overall intent are divided into descriptive, interpretive, and evaluative types. A descriptive case study provides a detailed account of the case and is useful when presenting basic information while an evaluative case study "involves description, explanation, and judgement" (Merriam, 1998, p. 39). Interpretive case studies gain as much information as possible to allow the "investigator to take the data and develop a typology, a continuum, or categories that conceptualize different approaches to the task" (p. 38). The intent of this study was to understand student interactions and the meaning of those actions in the development of a semester community garden project. Thus, an interpretive case study approach was selected for this study.

The case for this study was a chemistry class that used a PBL instructional method. Merriam (1998) noted that a case study must be bound. The bounds for this case were the groups enrolled in the class and completing the project. Merriam (1998) also noted that the case study approach is particularly suitable for looking at process. The

main focus for this case study is analyzing the process of how students learn during a PBL activity. The intent was to interpret the meanings of the experiences of students as they interacted to complete a project.

I was the instructor of record for the chemistry classes being used in this case study and have been on faculty for 18 years at the institution where the course was taught. The course was designed to be project oriented but this often presented a challenge in planning instruction because of a lack of the students' abilities to construct knowledge from each other. In my dual role as course instructor and researcher, I sought to determine how group interactions develop throughout a PBL activity within this freshman level chemistry course. The chemistry course involved a semester long PBL activity with predetermined in-class discussions occurring related to progression of the PBL activity. The activity itself has been briefly described in the section entitled Context of the Study. For further information about the chemistry course, see Appendix A for the general course outline and Appendix B for the specific project instructions provided to each student.

Context of the Study

The study took place within two sections of a freshman level chemistry class at a small, rural community college in the Midwest United States. The researcher taught both classes. The researcher has attended workshops on active learning techniques in addition to formal education classes as part of continual professional development. The instructor has also used project based activities as embedded parts of the class curriculum. The

college president granted permission for the research at this institution (see Appendix C) and Institutional Review Board (IRB) permission was obtained.

The instructor gathered data that was created during the normal operation of the freshman chemistry courses he was teaching. The IRB approval of the research project stipulated data obtained from students in the courses would be de-identified upon the students' completion of the course and grades having been submitted and prior to any analysis of data.

Participants

The participants in this study were students enrolled in a freshman level, non-STEM majors, chemistry course at a small, rural community college in the Midwest region of the United States. The students in the course had a wide variety of declared majors and interest, so a project involving gardens was used to accommodate their interests while also providing content knowledge.

The freshman level chemistry course had an open enrollment with two sections offered. Each of these sections had an enrollment cap of 24 students. The chemistry course met every day for a weekly total of seven hours in an integrated studio type environment where lab and lecture are mixed. Typically, the age of the students in these classes ranged from 18 to 25. However, because of Institution Review Board requirements, the registrar of the college checked the age of the students to verify that all students in both classes were over the age of 18. All student participants were age 19 or older. Students were informed via a statement in the syllabus (see section below) that

student produced artifacts for the class (e.g., normal classwork assignments and activities) might be used as part of a research project on PBLs.

> **Educational Research:** Educational research is an ongoing process to help improve student learning within both the classroom and the institution as a whole. For purposes of research, some of your class work may be used. In these cases, your name will be removed so as to de-identify any artifact collected. If you do not wish your work to be used for research, please notify the instructor. You will still be responsible for completing all assignments since these artifacts involve normal classroom work, the work just will not be used for research purposes.

Initially 28 students were enrolled in the two different sections of the class. Only 22 students (17 females, 5 males) completed the course and have been included in the study (see Appendix D). The participants included 11 student athletes representing three sports at the institution. The students were initially divided into 9 teams for the project in the course. This was later reduced to 8 teams because of some students dropping class.

Qualitative studies in general utilize three main collection techniques: conducting interviews, observing, and analyzing documents. Merriam (1998) noted that many other types of qualitative studies may only use one of the methods. This should not be the method in case studies. Merriam (1998) stated:

> In qualitative case studies, all three means of data collection are frequently used. Understanding the case in its totality, as well as the intensive, holistic description and analysis characteristic of a case study, mandates both breadth and depth of data collection. (p. 134)

This study utilized all three methods to gather data.

Interviews occurred both formally and informally. The groups participated in 10 in-class team discussions where they were supposed to gather information from each other. The teams had two consultations meetings with the instructor where they were

interviewed about team progress on components of the project. Individuals also had to use interviews as a means of gathering information.

Real time observations occurred during the in-class time as well as through exchanges through the online components of the class. Reflective observations were also noted in the researcher's journal immediately after classes and during the transcription phase. Several documents were utilized throughout the class for data sources. These included weekly discussions, student reflective journals, regular exams, and the project.

Using all three techniques provided the sources required for a case study. In addition, many of the sources relied on social interactions of the students. The case study approach allowed the researcher to analyze the data sources within the theoretical framework. A detailed description of each of the data sources has been provided in the order in which they were introduced into the class.

Surveys

The Learning Styles Inventory (LSI) was used with permission of the Hays Group who held the copyright to the survey (see Appendices E and F). The LSI is a self-reporting tool that assists students in identifying their preferred method of learning new information. Students were asked to rank four potential endings to a question from the one they agree with most to the one they agreed with the least. This survey was used in this study to help identify students preferred methods of learning and create learning groups whose members had a variety of methods of learning. Since one component of the study was on group interactions, LSI was a screening tool also to document each student's preference in regard to methods used to gather and assimilate new information,

which would also ultimately impact the groups' ability to learn with and from each other. The findings of the group interactions were also used to determine if the students' preferred method of learning had any influence on the group interactions or direction of progress through the project.

A self-reporting survey was also given to the students during the first week of the freshman chemistry class in order to capture the students' background of experiences in science courses, familiarity with PBL, and experience with keeping a reflective journal (see Appendix G).

Grouping

Heterogeneous groups of three to four have been shown to provide the most productive number for group size in studies of diversity of thought and experiences (Apedoe, Ellefson, & Schunn, 2012; Webb & Palinscar, 1996). The LSI given during the first week of classes was intended to aide in determining group assignments. However, due to an unexpectedly large number of student athletes (11 out of 22) and incorrectly filled surveys, the LSI was not used for purpose of grouping.

The grouping of students was accomplished by evaluating involvement in athletics and the students' prior course level completion of math (e.g. Intermediate Algebra, College Algebra, Calculus). Chemistry is a heavy math application type course. Including at least one individual within the group, who has stronger math skills, allowed for the group to better address questions or problems that might arise during the PBL activity. One other consideration affected the creation of student groups, that of student athletes often missing several classes because of games. Limiting the number of athletes

in a group allowed for the other group members to keep the student athlete caught up on the progress of the project and related assignments.

The researcher intended to selectively create heterogeneous groupings that would remain intact for the entire semester of the course. As a result, the information concerning the math skills of the individuals and knowledge of the types of sports in which the student athletes were engaged, were used to make the nine initial groups. Two groups were combined just before mid-semester because several students had dropped the class. The groups were also given team names based on elements to serve as identifiers for assignments. All members of the class were assigned to a group allowing for normal class demographics to be represented within the study. Appendix D shows student information and groupings.

Audio Recordings

As part of the course norms for group work, audio recordings were required of group conversations during class time involving the PBL activity. An Olympus WS-852 Digital Voice Recorder was labeled with the number designated for each group. This numbered audio recorder was placed at each corresponding group's table during the class in order to capture group dialogue. A pseudonym was assigned to each person during the transcriptions in order to de-identify the participants. The pseudonym was then used for the same person through each weekly recording and for all other work by that student. A total of nine in class conversations were captured along with two team-instructor consultation meetings for each group. A tenth in-class meeting took place with the teams

at the very end of the project. This meeting addressed determining what could be finished in the proposals and focusing on those components.

As typical of many institutions, the students in the course could work on the project outside of class. When this happened, students were encouraged to audio record these sessions as an extension of the class operation. Students were reminded to audio record these external sessions through assignment instructions (See Appendix B) and continual verbal reminders throughout the project. Students in the chemistry courses had the option to checkout a digital voice recorder for planned meetings outside of the class time or to use a recording app on their phones. Only one team submitted an out-of-class recording of their conversation, although several teams talked about out-of-class meetings during other conversations.

Observations

As instructor of the course, I made informal observations of the students during the class. Real-time observations made during the class time focused on, but were not limited to, seating positions, non-verbal communication, participation, attendance, contributions to group work, and PBL activity decisions. My observation notes were recorded in my researcher's journal for comparison and triangulation of data with the other sources of information when data analyzation began after the conclusion of the semester long chemistry course.

Journals

As a requirement of the class, the chemistry students maintained a reflective journal in a word document. Scientists in varying fields keep detailed lab notebooks

concerning elements of the scientific process, materials, procedures, and results; however, the journal maintained by the students also recorded additional information. The ongoing journal, with each week entry labeled, was submitted to the class instructor on a weekly basis via a classroom management system (CMS) (i.e., Canvas). The students were asked to write a general reflective statement on the past week but were also provided some additional questions to address in their journal. The instructor initially used these reflections during the course to address conceptual misunderstandings, interpersonal conflicts, and other items that needed to be addressed as part of the course. The analysis of the journal content for this study did not take place until after the completion of the course, per IRB procedures. The journals were kept in the password protected CMS program during the duration of the course. The final journal files were then downloaded, de-identified, and transferred to a password protected file on the researcher's personal computer for analysis.

In my dual role as course instructor and researcher, I also kept a researcher journal throughout the course. Journal entries included my perspective throughout the duration of the class from both an instructor and researcher point of view. The instructor component contained perceived issues with the implementation and completing a PBL instructional activity. The researcher entries consisted of observations and reflections about the group interactions throughout the semester. Entries from this journal also allowed for comparisons of sociocultural interactions within the groups.

Student Artifacts

Student work submitted as part of the class was maintained either within the password protect CMS or in a locked file cabinet in my office. Work submitted within the CMS could be viewed by the individual students, course instructor, and system performance personnel at the college. At the conclusion of the course, student artifacts to be used for the research study were de-identified, coded and transferred to a secured file on the researcher's computer. Artifacts collected included, but were not limited to, exam questions related to the project, student performance notes, discussion comments, essays, and final projects.

Interviews

Informal consultation interviews were conducted throughout the course. These were required when groups strayed from the project guidelines or internal conflict within the group required intervention. Consultations also provided the instructor an opportunity to acquire a clearer idea of the group's thoughts on particulars of the project or group interactions. The informal consultation interviews were an integral part of the normal operations of the course and not an added component because of the research study although the recordings of these consultations, as mentioned earlier, were for research purposes.

After the completion of the course and posting of final grades, requests for volunteers from the course to participate in interviews were sent out via e-mail. Four students volunteered for these interviews. Those who volunteered were asked to participate in a semi-structured interview of approximately 20 minutes in length (see

Appendix H). The semi-structured interview format allowed participants to provide detailed responses about the garden project as well as the group interactions and the acquisition of knowledge during the project.

Data Analysis

All data sources were assigned a code for analysis and data organization and facilitated the development of an audit trail. The beginning of semester survey was designated "S" and an individual three letter code for the student. For example, the survey for Ariel would be S-ARI. Weekly audio recordings were coded by "R" with session number and team symbol, thus team Iron's fourth discussion would be coded R-4-Fe. The student journal was coded "J" with entries additionally marked by week and student code. Interviews were coded with "I" and the participant's individual code number. Open ended questions related to the garden project were on three of the chemistry exams. These questions were coded with an "E" followed by exam number and participant code. Thus, Patty's response on Exam 2 would be coded E2-PAT. Weekly discussions done through the CMS system were coded with D<week>-student code. The researcher's journal was designated as "RJ" and student general artifacts from class were given the code of "SA."

The data was used to answer the research questions through an analysis process outlined below. The relationship of the research questions to potential data sources has been outlined in Table 3.1. The question correlation to specific data sources became clearer as data was de-identified and analyzed including what additional student classwork might be used for data sources.

Table 3.1. *Correlation of Research Question to Data Source*

Research Question	Data source (* indicating a variable in week or student code)
1. What prior beliefs and knowledge do students have about gardening?	S, R-1-*-*, R-2-*-*, SJ-1-*, SJ-2-*, RJ, E1-*
2. How does group interaction influence the process and design of a community garden project?	R-*-*, SJ-*-*, RJ, SA-*, I-*, D*-*
3. How do the student's beliefs and knowledge change through participation in a garden related project?	R-*-*, SJ-*-*, RJ, SA, I-*, F-*

Data Analysis

Coding of data is a means of discerning themes, patterns, processes and other comparative analogies in relationship to the framework of a study (Glesne, 2011). An inductive constant comparative method of data analysis was utilized for this study. Merriam (1998) noted that in a constant comparative method "the researcher begins with a particular incident from an interview, field notes, or document and compares it with another incident in the same set of data or another set" (p. 159). The transcriptions of the weekly recordings were the main data source since this study was looking at social construction of knowledge within the individual students ZPD. For this reason, these were analyzed first using open coding.

Open coding of the transcripts from both the group discussions and interviews began upon completion of the course. Merriam (1998) noted two criteria for data to meet at this stage of analysis. First, the data must reveal information relevant to the study and second, the data should be the smallest piece of information that can stand by itself. Following the constant comparative method, the codes were analyzed and compared to

other data sources throughout the analysis process and reevaluated periodically. This process allowed for the construction of a "primitive outline or classification system reflecting the recurring regularities or patterns" (Merriam, 1998, p. 181) within the study.

These codes were used and reflectively reevaluated to code the narratives associated with the student journals, student artifacts, researcher's journal and post-course interviews. Data were documented in a computer spreadsheet to indicate source, location in which data was obtained, type of data (e.g. interview, transcription, observation, student journal), and episode (e.g. week 3, week 4) as a code paired up with the data. The codes were then evaluated for similar characteristics that could be placed into more general categories.

Prior to transcribing, pseudonyms and participant codes were established for all students. I decided to use the first three letters of the pseudonym to identify the student from which a particular set of data was obtained. After creating a source coding table for potential artifacts, I had a peer evaluate the coding table to ensure source codes would be unique. There was one problem that emerged with the student codes when noted that Jacob and Jaclyn would have the same first three initials. I modified this duplication by using JAC for Jacob and JAK for Jaclyn (See Appendix D for students in study).

The open coding began by analyzing the transcriptions of the first two in-class discussions for each group through an inductive process with research question one and the theoretical framework in mind. Portions of narratives within the discussion that could reference existing knowledge or beliefs of the students about gardening were copied into a spreadsheet and assigned a code. This initial analysis yielded 25 codes (See Table 3.2).

These codes along with the matching narratives were printed and placed on individual pieces of paper, each paper included only one narrative. The narratives with the same code were initially placed together in a stack. The narratives in a stack were then reread and compared to each other. Some narratives were similar across codes and some that were coded under one term did not match others in the stack resulting in a need to recode.

Table 3.2. *Initial Open Coding and Reduction*

Codes on first analysis	Codes after reevaluation
Acquaintance to gardener	Benefits and Cons
Benefit	Experience-Self
Care in cold	Experience-Others
Compost benefits	Garden type
Contrasting	Gathering Information
Expanding garden	General Care
Garden concern	Historical classification
Gathering information	Intergroup communication
Initial attitude	Soil Additives
Initial belief on why	
Initial belief on needs	
Initial classification	
Interaction	
Interview experience	
Interview influence	
Interview interest	
Other class (gardens used)	
Other communications	
Personal interest	
Prior experience (at a garden)	
Prior experience (at home)	
Reading	
Soil additives used	
Subservient behavior	
Wants	

The codes were reevaluated and new codes were established. Some codes encompassed similar areas and were combined into one category. For example, ‘other

class', 'personal interest', 'prior experience (at garden)', 'prior experience (at home)', and 'acquaintance to gardener' were moved to the code 'experience-self'. 'Interview interest', 'interview influence', and 'interview experience' were found to contain information related to the person being interviewed and were recoded as 'experience-others'. 'Subservient behavior', 'other communication', 'interaction', and 'contrasting' were re-coded under 'intergroup communication'. 'Initial belief on why', 'benefit inquiry', and 'compost benefits' showed a wide arrange of opinions about why people gardened while demonstrating both benefits and challenges associated with gardens that could not easily be separated. I decided to code these under "benefits/cons" with some initial thoughts noted in my research journal on potential sub-codes.

After the modified codes were established at this point in the analysis, the narratives attached to the code were re-read to ensure a match to the new code. The narratives that did not match a new code were set aside for later analysis if a code emerged under which they would fit. The transcriptions were also re-read looking for narrative phrases that might have been missed that would fit under the new codes and contribute to answering a research questions using a deductive coding approach.

Data analysis then continued with the third and fourth in-class discussions and student artifacts (e.g. student journals, on-line discussions, exam) from the first four weeks of class related to the garden project. The codes established were used in a deductive-inductive evaluation of the data for additional narratives of the students. Leaving open the emergence of additional codes helped ensure the data led the analysis. This phase of the analysis firmed up some sub-codes under 'benefits/cons' and the rules

of inclusion were written (See Table 3.3). After the rules of inclusion were determined all phrases and narratives were reread to ensure they fit the rule of inclusion for which they were coded. The codes and rules of inclusion were then analyzed with research question 1 in mind. Three categories were identified that most of the coded data were grouped under. The exception being 'gathering information' which was felt to be important but fell under the second research question and was set aside for later categorization.

At this point, I approached a peer and colleague to review my data analysis. The reviewer has been an instructor of Biology for over 20 years, has a doctorate in educational research, and has served as director of research and assessment at the college. I provided the reviewer with my rules of inclusion, codes, sub-codes and access to the deidentified data. After this review, the coded phrases and narratives were printed and cut into individual papers with one phrase/narrative per paper. Narratives with the same code were filed together.

The inductive coding process was then repeated with all remaining transcriptions of the in-class conversations. Codes established from the transcriptions were then used in a deductive-inductive coding process of all remaining data sources for weeks five through sixteen. A constant comparative approach was used to read and re-code, if needed, the data following the process outlined above for the analysis of the first four weeks of data. The final categories, sub-categories, codes, and sub-codes are provided in Table 3.4.

Table 3.3. *Initial Classification of First Four Weeks of Data*

Category	Codes	Sub-codes	Rule of inclusion	Examples
Pre-Project Experience	Self		Indicates a direct involvement or exposure to a garden	I did the health and wellness class. We had to go to a garden and we did that. (R-1-Al_MAR)
	Other		Participant has a communicable relationship with someone who works with plants	Over the past ten years my mother has developed a love for growing plants and different types of herbs (J-PAT)
	Types grown		Identify either personal or through interview what gardens they are familiar	my parents have like different flowers and stuff. They had one (garden) where it was like a vegetable (R-2-Al-ARI)
Initial thoughts	Benefits/Cons	Time	Garden occupying time or used as a hobby	kind of like to get away. Some place that can go and just kind of hang out and just be outside for a little bit. (R-2-Pb-JAC)
	Benefits/Cons	Food	Garden is a source of food	wants to have fresh and not go to a store and (people) not know what they did to that food (R-1-Ni-DAL)
	Benefits/Cons	Cost	Related to cost savings or expenditures of gardening	Probably in the long run, [garden cost] will save up. Like when you get [the garden] started and everything (R-2-Al-KAT)
	Benefits/Cons	nature	Filling a love of nature or nurturing	my grandma she gardens because she likes to take care of it and to make it grow (R-2-Fe-MOL)
	Care		Conveys the students' belief about care of garden	Have the amount of soil, water, sunlight (R-1-Al-ARI)
Initial Knowledge	Classification		The students' knowledge or lack of knowledge about garden classification	victory /community I feel that it's just like for fruits and vegetables. Stuff like that (R-2-Ca-NAT)
	Soil Additives		The students' knowledge or lack of knowledge about what is added to soil	I know for like the huge farms and stuff they use manure but that is just nasty. (R-2-Mn-TAN)
Not categorized	Gathering information		Represents the means the student uses to gather information	I mean like it seems your mom is pretty well into it and so is mine, that we could always ask them more (R-2-Ca-Tab)

Table 3.4. *Organization of Categories, Subcategories, and Codes Used in this Study*

Research Question	Category	Codes
Q1. What prior beliefs and knowledge do students have about gardening?	Initial thoughts	Benefits/cons>cost
		Benefits/cons>age/time/hobby
		Benefits/cons>nature
		Benefits/cons>food
		Benefits/cons>water
		Historical classification
		Soil additives
		Care
	Pre-project experience	Self
		Others
		Garden type
		Advice given by interviewee (not used)
Q2. How does group interaction influence the process and design of a community garden	Gathering Information	Gathering information
	Intergroup communication > project development	Project Development>Design
		Project Development>experiment
		Project Development>community
		Project Development>plant varieties
		Project Development>care of garden
		Information retention/transference
	Intergroup communication>group interaction	Discussion>direct communication
		Discussion>asynchronous
		Avoiding conflict
		Collaboration/Cooperation
		Lack of contribution
		Ignoring team members
		Out of class communication
	Motivation and Procrastination	Homework>completion
		Homework>belief of heavy load
		Other commitments
		Easy-experiment
		Easy-project
		Procrastination

Table 3.4. Continued

Research Question	Category	Codes
Q3. How do students' beliefs and knowledge about gardening change through participation in project?	Project>Beliefs	Benefits/cons>social Benefits/cons>food Benefits/cons>concerns Benefits/cons>health Benefits/cons>beautification Benefits/cons>environment Benefits/cons>education
	Project>Knowledge	Methods/care Types Knowledge related to plants Self-reflection-knowledge Self-reflection- skill
Not related to question	Composting (not used in paper)	Knowledge>researched Knowledge>experimental
	Food source of student	Food source
	Attitude	Attitude toward gardening

Themes and categories were determined through an inductive process. An inductive process is a means of constructing meaning from the heterogeneous data from the study (Erlandson, Harris, Skipper, & Allen, 1993). The codes from all study data sources of a similar nature were used to determine a category. Merriam (1998) listed five guidelines for determining efficiency of a category. They were:

- Categories should reflect the purpose of the research by answering the research questions.
- Categories should be exhaustive by being able to encompass all relevant data
- Categories should be mutually exclusive meaning the data should fit in only one category
- Categories should be sensitizing meaning an outsider should be able to read the categories and get a sense of their nature
- Categories should be conceptually congruent or be at the same level (p. 184)

When the categories stopped emerging, a rule of inclusion was written for continued analysis. Individual data was then reevaluated to be sure that the data fit this rule of inclusion and to reclassify as needed.

Categories were then organized under each of the corresponding research questions. The research questions followed a chronological order through the project allowing for a finite time-period of the first four weeks of the class for the first question with only appropriate personal reflective statements from later in the semester considered for inclusion. Data corresponding to weeks 4 through sixteen of the class were analyzed for research questions 2 and 3. The trustworthiness of this data is discussed in the next section.

Trustworthiness

Qualitative studies involve multiple realities as a result of capturing the participant perspectives. Thus, no single truth exists to compare the trustworthiness of a

study. The corresponding values for establishing trustworthiness were devised by Lincoln and Guba (1985) to include four areas: credibility, dependability, transferability, and confirmability. These were each looked at in turn to their relationship with this study.

Credibility. Prolonged engagement, persistent observation, triangulation of data, and peer debriefing were used to establish credibility (Lincoln & Guba, 1985). Since this case study followed a participatory method, the researcher was engaged with students for the entire semester. The course interaction required seven hours of in class time weekly along with formative assessments and discussions between the instructor/researcher and the students. This allowed the researcher to detect distortions that might be present, such as retrospective biases and selectivity of responses (Lincoln & Guba, 1985). Student data were collected as part of regular class work to limit situated motives where students might expect something additional as part of the study.

In addition, triangulation of the data occurred between the collected data (i.e. S, RJ, SJ, D, E, F, R, I) to further add credibility. Lincoln & Guba (1985) indicated four modes in which triangulation can occur: using multiple methods, sources, investigators and theories. In this study, the researcher used different methods for data collection including recordings, observations, surveys, student journals and student in class work. The use of multiple groups also allowed for a variety of sources within the study.

Member checks may also be used to help establish credibility (Erlandson et al., 1993). After the end of semester, the hope was that at least one member from each group would volunteer for the follow-up interviews. Volunteers were asked to read over the transcripts of group discussions for verification. This process allowed participants to

recall additional things or actions that may not have been included during the recorded time. The member check also provided for further clarity of intent or meaning by the participant during the conversation.

Peer de-briefing uses a peer outside of the context of the study to help build credibility (Erlandson et al., 1993). Two colleagues of the researcher who have familiarity with both gardens and qualitative research were used in this study. This process helped the researcher to maintain objectivity and initiate additional insight within the study.

Dependability. Lincoln and Guba (1985) argued that the process of triangulation used to establish creditability also supports the establishment of dependability. This overlap method works on the principle that creditability cannot exist without dependability. The triangulation process was used to establish dependability for this study.

A dependability audit was also used for meeting this requirement. During a dependability audit, an "external check can be conducted on the processes by which the study was conducted" (Erlandson et al., 1993, p. 34). All documentation regarding the audit trail was made available.

Transferability. According to Lincoln and Guba (1985) the qualitative researcher does not provide the index of transferability but the description of the data provides the basis to make transfer judgements. The researcher has included thick description within the data to allow for other researchers to evaluate the findings for transferability. A

purposeful sampling of student population was also used to provide the widest range of information for inclusion within the thick descriptions.

Confirmability. An audit trail was kept for the purpose of confirmability. Lincoln and Guba (1985) identified six items that can be kept for an audit trail. Raw data was kept in a secure location in which only the researcher has access. Data reduction and analysis products were kept in a secure file on the researcher's computer. Data reconstruction, synthesis products and process notes were maintained in researcher's journal. Materials relating to intentions and disposition were kept in a secure file or the researcher's journal depending on format of materials. Finally, instrument development information was maintained in the researcher's journal.

Assumptions

The researcher believed freshmen students would enter the chemistry class at different skill levels and backgrounds, even those within the same major. The zone of proximal development supports that students will construct knowledge through the sociocultural interactions within PBL activities to build their own knowledge based on their own level of understanding and within the context of their world. The researcher believed that the students would not follow a set time table in completing goals or necessarily arrive at the same level of knowledge at the end, but perhaps a level above that of the student upon entrance into the course.

Limitations of the study

This study involved a small group of students and a single instructor within a qualitative study. The study cannot be generalizable as a single study, but the findings

could be compared to similar studies to evaluate transferability of results. The students were evaluated during one semester of a science course. The variety of offerings as well as the sequence of successive courses may have affected student perceptions and interactions. However, due to time limitations for this study, these considerations were not assessed.

Students within this study attended a local community college whose courses must meet competency standards for transfer to a university. This constrained the instructor of the chemistry courses in what concepts could be taught and may have impacted the in-class time allowed for PBL activity discussions in order to cover the required competencies.

Projects in the class involved some collaboration between students. Recordings of class discussions, student journals and the final group project were available to the researcher. However, the groups worked outside the classroom. Audio recordings were supposed to be submitted for these discussions as part of the class, but not all discussions were recorded. There also was no ability for observation by the researcher to occur.

Context of the researcher

The researcher of this study was the instructor of the student participants. The researcher was thus a necessary participant in the study, which was as expected in qualitative research. However, the researcher did not have access to the private thoughts or group conversations that might have occurred outside of the class environment. The students in the study while in the instructor's class followed normal class activities.

Summary

PBL inherently follows a constructivist approach to learning (e.g. Krajcik, 2015; Savery, 2006). Using sociocultural theory as the framework for this study allowed for the evaluation of student interactions throughout the project and the social construction of knowledge by individual students. Krajcik (2015) noted that the basis of PBL learning is for the students, teachers, and members of society collaborating to meet the needs of the project. The involvement of students, teachers, family members, and community members in the garden project used for this study allowed for breadth of potential collective expertise for the students to utilize both in socially constructing knowledge and in applying that knowledge to complete the project.

Oxford (1997) noted that diversity in the groups allowed greater cognitive gain. Researchers have also noted that the best heterogeneous groups consist of three or four members (Apedoe, Ellefson, & Schunn, 2012; Webb & Jensen, 2006). The groups for this study were thus set at three for the average number of members. The social collaboration of the groups both internally and externally with potential resources became an integral part of the methods used in this study.

The topic for this study, community gardens, was chosen because of the predicted familiarity the students would have with gardens. This familiarity was evaluated the first two weeks of the semester as covered in Chapter 4. Since community based gardens have served different purposes over the last 120 years (e.g. Hanson & Marty, 2012; Lawson, 2005), this allowed the students some leeway in construction of the community garden

proposal through collaboration within the group and interaction with community members.

While the project allowed for a range of variables for social construction of knowledge, the bounds of the classroom made this study an appropriate candidate for case study analysis (Merriam, 1998). The 22 students, who completed the course and whose course submissions served as data sources for this study, provided a normal representation of the student population who are not majoring in STEM areas at the research site institution. As this group progressed through the project, data sources were collected to capture the social interactions of the students and their self-reflections throughout the project. This data is analyzed in Chapter 4.

CHAPTER 4

FINDINGS

The literature has shown that students in general often fear taking a chemistry course (e.g. Harvard, 1996; Osborne & Collins, 2000; Whitfield, 1980). Project based learning (PBL) is an instructional method used to help students better connect classroom knowledge to their daily real-world interactions. This instructional approach showed great success in medical schools (Barrows & Tamblyn, 1980) and in K-12 instruction (Krajcik, 1994; Thomas, 2000). However, absence of PBL instruction in post-secondary education has been well documented (Allen & Tanner, 2003; Helle, Tynjala, & Olkinuora, 2006; Savin & Baden, 2000). The research studies of PBL in higher education have been even more limited (Helle, et.al, 2006; Savin & Baden, 2000).

PBL establishes a connection to the community by involving students in a community problem that is imbedded in the classroom curriculum. This type of learning requires the social construction of knowledge by the students through interactions with their peers, teachers, family, and community members (Krajcik, 2015). The teacher assumes more of a mentoring role through constant formal and informal assessments during the project (Markham, et al., 2003). The social interaction with in PBL instruction allows learners, particularly adults, to draw on prior experiences and knowledge to see connections and gain further cognitive understanding (Knowles, 1968; Vygotsky, 1978). However, this interaction has been seldom studied. The few studies conducted have involved snap shots within the project (Visschers-Pleijers et al., 2006) or student self-

reporting (Lee & Lim, 2012) as discussed in Chapter 2. This study was designed to follow the students through the entire project.

Gardens in various forms have been an integral part of society for many people. Gardens have been used for sociocultural learning environments (Bahng, 2015) and population needs (Carney et al., 2012; Flannigan & Varma, 2006). Gardens also have a long history within the classroom setting. Unfortunately, many of the studies with gardens have been focused on applications in the elementary and middle school levels (Blair, 2009). The course content in higher grades becomes more conceptually focused such as for agricultural studies (Graham et al., 2005), developing an irrigation system (Dorrel & Berkeishiser, 2014), and building a pergola in the garden (Dorrel & Berkeishiser, 2014).

Using a sociocultural framework, this study focused on the group interactions and development of knowledge as students developed a community garden proposal using a PBL instructional approach. The students were divided into heterogeneous teams for the semester. The teams had 10 in-class discussion days devoted just to the project, two-formal instructional consultations, interaction with family members and acquaintances, interactions with teachers and gardeners, and group interactions outside of the classroom.

Within the sociocultural framework, this study was driven by three research questions:

1. What prior beliefs and knowledge do students have about gardening?
2. How does group interaction influence the process and design of a community garden project?

3. How do students' beliefs and knowledge about gardening change through participation in a garden related project?

The questions follow the chronological development through the project and were studied through a qualitative case study approach. The type of data collected followed what Merriam (1998) suggested for case studies: interviews, observations, and documents. Research question 1 was addressed through informal interviews both within the groups and gardeners familiar with the students, observations, and student created documents within the first four weeks of the course. Questions 2 and 3 analysis used much of the same types of data but were focused on weeks 5 through 16 of the course. The different focus of the questions determined where particular data was placed. The data is organized in the following sections around each question's focus.

Establishing Baseline Knowledge and Potential Student Resources

In doing this community garden project, some of the first data gathered was to determine any prior experience with gardens and any acquaintances of the students that had gardens. The information was gathered to assist in the interviews that the students had to complete before the project as well as to analyze potential sources of information for the group as the project developed. Twenty of the participants indicated either a family member or knew an acquaintance who had a garden. The students then interviewed these gardeners as part of a pre-project assignment. This information is provided in Table 4.1. An acquaintance included a teacher/advisor, coach, neighbor and a manager.

Table 4.1 *Relationship of Gardener Interviewed to Student*

Parents	Personal friend	Grandparents	Acquaintance	None
Ariel	Kate	Molly	Karissa	Alexia
Nate	Cortez	Suzanna	Cynthia	Dallas
Tabitha	Blanche	Jaclyn	Mary	
Patty		Tania	K'Lan	
Bailey		Manuel		
Jacob				
Irene				
Judy				

For many of the participants, their mother was the one that gardened. Nate noted that his mother "started (gardening) when we moved here and I have lived here for close to 15 years … She learned from her mom because she does a lot of gardening too" (R-2-Ca-NAT-50). Patty wrote "over the past ten years my mother has developed a love for growing plants and different types of herbs" (J-PAT-1). Tania's mother gardened "for my whole life and as long as I can remember. She has many different types of plants like flowers and basil and things she uses to cook" (J-TAN-1). Tabitha recalled how her parents started gardening by stating her mom has "been gardening since like her early twenties and my step dad said he started (gardening) when he met my mom" (R-2-Ca-TAB-48).

Jacob originally did not know anyone who had experience with gardens but reflected in his journal, "because my group was talking about how their female elders may have gardened in the past, I figured my mom would have as well" (J-JAC-18). After using his mother for the initial interview, he found his mother's family "did garden for like 2 years but not very long. Her dad wanted to when they were growing up as kids" (R-2-Pb-JAC-33). Tabitha mentioned her step-dad as having a garden with her mom.

However, Bailey was the only participant in the study to talk about her dad at this point having the garden when she stated “my dad has like a greenhouse. He has like plants and stuff in there” (R-1-Fe-BAI-20). Alexia only mentioned her dad at the very end of the semester saying “my parents have a garden in the backyard because my dad loves to garden” (F-ALE-13) but did not share this information before the project began.

Manuel (R-1-Ni-MAN-12), Irene (R-1-Pb-IRE-34), Tania (R-2-Mn-TAN-38), and Suzanna (R-1-Fe-SUZ-22) claimed their grandparents as gardeners. Tania (R-2-Mn-TAN-39) noted her grandmother had been gardening her whole life. Suzanna, in talking about her grandparents, reflected in her journal a foreshadowing of one thing that would come up during the project when she wrote “I thought of my grandparents. They are real old fashioned and came to mind quickly. They grow jalapenos and stuff like that” (J-SUZ-13).

A few of the participants in this class indicated some direct involvement in gardens at home. Jaclyn stated that “we always grow gardens and so my family always used to grow stuff” (R-1-Pb-JAK-14). Tania (R-1-Mn-TAN-29) indicated her family has a potato farm but that she also has hanging tomato baskets. Kate noted “my experience with gardens is little plants in my house” (R-1-Al-KAT-43). Patty (R-1-Co-PAT-9), Karissa (R-1-Cu-KAR-19), and Nate (R-2-Ca-NAT-50) recalled accounts of minimally helping their mothers when they were younger. Team Calcium shared their experience:

> Nate "Yeah, I know one thing like my mom would always tell me like whenever I had to water her flowers or stuff. Like she would always get mad at me because I would always overdo it. Like I would always put way too much water because I don't know why but I was always think that..."
> Tabitha "the more water the better"
> Nate "yeah, and it can harm the flowers and plants"

Tabitha "yeah that's the way I was." (R-2-Ca-58)

Other students mentioned a personal experience with either growing a plant or exposure to a garden as part of a class. Tania (R-1-Mn-TAN-12) recalled planting bean sprouts in elementary school and a tree as part of an environmental science class in middle school. Two students noted visiting a garden as part of a class. Mary stated "I did the health and wellness class. We had to go to a garden" (R-1-Al-MAR-17). Molly noted "the only time I've been to a garden was probably (at the school) when we did the tour" (R-1-Fe-MOL-31). Two students did indicate some prior exposure to community gardens. Tania stated:

> My high school that I went to was like a really, really small school so there was an actual community garden on the school grounds. That was cool because the community could come there but then it was also like the school took care of it. (R-2-Mn-TAN-67)

Kate recalled an experience working at a garden associated with the community shelter when she stated "I would go do my community service hours for school there and they made me pick tomatoes, jalapenos, and onions. They had all kinds of stuff there" (R-1-Al-KAT-58).

Twelve students indicated either a lack of experience or that gardening was not for them. Irene (R-1-Pb-IRE-6), Jacob (R-1-Pb-JAC-13), K'Lan (R-1-Co-KLA-5), Cynthia (R-1-Cu-CYN-21), and Karissa (R-1-Cu-KAR-22) all indicated that they had no gardening experience. Jacob stated his thoughts on gardens more firmly by saying "I don't dabble in gardens" (R-1-Pb-JAC-30). Judy simply stated "I kill plants" (R-1-Zn-JUD-7) about her ability to keep a garden alive. Tabitha elaborated "My mom has tried to

get me into gardening before and I kill everything. Like I killed an air fern…. I'm like a hospice worker for plants. I ease their transition" (R-1-Ca-8, R-2-Ca-110).

Having learned some about the prior exposure of the participants in this study to gardening in general, the analysis turned towards addressing the research questions. The first focus was to evaluate the students' beliefs and knowledge about gardens in general. Gardens were not defined as this was left open to the students. The first research question is addressed in the next section

Pre-project Analysis

In establishing some beginning factors for the groups to consider, the students were asked to interview someone they knew that gardened. Information gained from these interviews and reported by the students to the group, as well as the students' own thoughts, were analyzed for pre-project beliefs and experiences. The first research question asked what prior beliefs and experiences students had with gardens. Four categories emerged when analyzing the data: garden type, reasons for a garden, knowledge on terminology associated with garden classification, and soil additives.

What is a garden?

The first theme was what the students believed made a garden. The students were almost evenly divided on a garden being either a flower or a vegetable garden. Only three students mentioned any other type. Tania indicated her grandmother had a herb garden. She stated:

> [her grandmother] first start[ed] off with like flowers and stuff because it made it look nicer like in the front and the back but now she does like some... Not like

> vegetables but what are those things you put in... Something you put in soup or something to make it taste better. (R-2-Mn-TAN-27)

Mary mentioned in the future "I want to get like a Japanese garden you know with a little waterfall and bridge" (R-1-Al-MAR-49). Bailey encouraged her team to think beyond the traditional by noting "there are like flower gardens, vegetable gardens, weed gardens, rock gardens…freaking everything" (R-1-Fe-BAI-19).

Blanche (E1-BLA), Kate (R-2-Al-KAT-52), and Jaclyn (R-1-Pb-JAK-90) noted a friend or relative as having a flower garden. Nate provided specifics about his mom's garden stating she "just gardens like flowers and stuff not like vegetables and fruits. It is something like Chrysanthemums or something like that. Those were her favorite" (R-2-Ca-NAT-38). Tabitha noted that her mom has "like flower gardens and a couple of fruit trees. She likes growing flowers" (R-2-Ca-TAB-28). Mary stated a preference for flower gardens by noting "I think people like flower gardens better because it is pretty and smells good" (R-2-Al-MAR-61).

The students who went to vegetable gardens observed the types of vegetables grown. Dallas noted "they always use tomatoes because tomato plants are basic" (R-5-Ni-DAL-55). Tomatoes were common to all who broke a list out for the vegetable garden. Patty stated the person she interviewed had just tomatoes and squash (R-2-Co-PAT-23). Cynthia (R-2-Cu-CYN-108), Jacob (R-2-Pb-JAC-35) and Irene (R-2-Pb-IRE-26) knew people who had tomato, squash, pepper, and okra. Suzanna in looking at vegetable gardens reported to her group the most diverse garden containing jalapenos, tomatoes, watermelon, and sugarcane (R-2-Cu-SUZ-45).

A few students did recognize a combination of flower and vegetable gardens. Patty stated, “I guess there is like flower gardens and vegetable gardens so you could have one for like pretty flowers or for food” (R-1-Co-PAT-19). Ariel interviewed a person that had done both but noted “they do flowers more than vegetables because the vegetables they didn’t take care of them very much and it makes a mess if you don’t” (R-2-Al-ARI-156). Blanche stated a transition in gardens in that people “plant different trees or flowers and like back in the day they used to have vegetables, like for vegetables. So the whole community could go and get food and stuff” (R-4-Mn-BLA-22).

The analysis provided an idea of what the students considered as a garden leading into the next two categories. The first being what beliefs do the students have about why people garden. The second theme analyzed the students’ knowledge of how gardens have been used over the last 130 years in the United States. I have shared the students’ beliefs on why people garden in the next section.

Initial Beliefs on Why People Garden

The participants discussed their thoughts on why people garden in the first in-class team discussions. During the following week, the students interviewed the person they identified in Table 4.1 with one of their questions asking why that person gardened. The students then discussed their interviews at the second in-class discussion session the following week. Both of these discussions occurred before the project was introduced and gardens were presented as part of the class curriculum. The conversations during these first two weeks identified four categories related to why people garden: time, food, nurturing, and cost.

The initial comments from some of the students were that gardening was something older people did to pass the time. Nate (R-1-Ca-NAT-15), Jaclyn (R-1-Pb-JAK-37), Ariel (E1-ARI) and Kate (R-2-Al-KAT-248) all mention gardening as a time-consuming activity because the gardener has nothing to do. Suzanna claimed, "older people have gardens because it is easier for them" (R-1-Fe-SUZ-37). Jaclyn elaborated that "my grandparents just don't like going places, so it is easier for them to like walk out to the garden then it is to go drive to the store" (R-1-Pb-JAK-56). Tabitha commented similarly with "my parents are retired. [Gardening] gives them something to do" (R-1-Ca-TAB-17). Irene (R-1-Pb-IRE-58) looked at gardening as a future goal for when she was old.

Similar comments were reported back for the second week, Tania reported her grandmother "just started growing stuff because she was bored" (R-2-Mn-TAN-25). Tabitha stated her parents "started gardening [because] there is really nothing here for them to do and they find it relaxing" (R-2-Ca-TAB-43). Her team partner, Nate, reported similar results from his mom stating "she just kind of needed something to do. She says [gardening] is kind of addicting. Like once she started, she wanted more things to garden. [Gardening] is a hobby of hers" (R-2-Ca-NAT-21). Jaclyn reported the garden was not just for something to do but more as a place to "go and just hang out and be outside for a little bit" (R-2-Pb-JAK-79) for her grandparents.

The second category concerned food. The garden being both a source of food in general but also free of additives and sprays. Only two students mentioned a personal

connection to food from the garden. Bailey talked about her dad "grew tomatoes so we always had a source of some vegetables" (E1-BAI). Mary recounted her trip to the gardens as the school saying:

> We were at the garden and we were like that is a nice strawberry and [the manager] was like eat it. So they were really good stuff. It was probably the best strawberry I have had in my life. It was so good. (R-1-Al-MAR-33)

Patty viewed the garden as a food source in terms of a historical issue stating

> You know back in the day [gardens] were needed. It wasn't just for something like looks or for this or that. It was something that was like essential for daily life but now you can just go the grocery store and buy it. (R-2-Co-PAT-101)

Many of the first discussion comments that centered around food did recognize that gardens could provide more natural foods. Patty mentioned to the group:

> [Food grown is] more natural. They don't have like all the hormones...or if you know how they spray that stuff on vegetables. So the bugs don't get it at night in the supermarket and stuff. If you can do all that on your own, it's going to be fresh (R-1-Co-PAT-17)

Mary expressed to her group that people garden because they "want to have fresh and not go to the store and not know what they did to that food" (R-1-Al-MAR-65). Suzanna was concerned about peoples' attitudes stating, "some people get mad if you spray pesticides and stuff on all the vegetables and fruits" (R-1-Fe-SUZ-83). Manny commented simply "fresh garden products are fresh and rich. It is organic" (R-1-Ni-MAN-17). However, K'Lan was the only student to report back that chemicals added to foods was a reason the interviewed person had a garden (R-2-Co-KLA-63).

The third reason the participants initially gave as to why people garden was self-gratification. Karissa simply commented in her group "I think you have to have a passion

for gardening in order to raise a garden" (R-1-Cu-KAR-37). Blanche saw gardens as "mak[ing] something look better like a yard or a house" (E1-BLA). Molly (R-2-Fe-MOL-39) and Bailey (R-1-Fe-BAI-39) reported that generally gardeners like to watch things grow. Tabitha, in reporting on an interview, gave a more maternal reason stating "I think it is just the mom in her. She just likes to make things grow and nurture them and she said it is like addicting to her" (R-2-Ca-TAB-26).

The fourth category of cost, was the most divisive with students expressing both sides within their group conversations. Manny (R-1-Ni-MAN-15) and Jaclyn (R-1-Pb-JAK-42) both initially commented gardening was cheaper than buying food. Blanche, Tania, and Suzanna all reported back to the groups that their interviewees gardened to save money. Tania stated, "you save money and you don't put as much waste out into the community" (R-2-Mn-TAN-125). Irene took the historical necessity when sharing with her group. "My grandparents went through the Great Depression and did have to have that kind of food. I mean they couldn't go to the store and buy anything" (R-1-Pb-IRE-44).

Irene's report back to her group on her interview suggested lack of savings with gardening stating "[the garden] wasn't cost effective. It cost a lot more. Store bought is cheaper but they did [garden] because they enjoyed it" (R-2-Pb-IRE-29). Jacob reasoned that if you grow in "bulk it would be cheaper but I kind think if you grow it in small amounts it is more expensive" (R-1-Pb-JAC-48). Mary provided the most vocal response about cost of raising your own food in a garden stating

> Everything is much easier to buy. Think about it like building a garden. It is just like expensive. You have to buy seeds, buy soil, and so people buy

> more…(Google) is saying that a basic bag of Miracle Grow at Wal-mart cost at least $12. You can buy like freaking apples with the $12. (R-2-Al-MAR-243)

Knowledge of Historical Classifications Associated with Gardens

What constituted a garden was left open to the interpretation of the students in this course. Vacant lot, school, victory, and community gardens were presented for students to provide their initial thoughts within the team discussions. Vacant lot, school, and victory gardens could have been community gardens as well but they had specific purposes. The groups were provided with some discussion point prompts. For many of the discussions, as have been addressed later in the paper, one person would state their thoughts on the prompt and the team would merely move on without everyone in the group commenting.

Several of the students did express not knowing what a victory garden was (e.g. R-2-Cu-KAR-134; R-2-Fe-SUZ-68; R-2-AL-(all)-173). For some of the other garden names the students tried to just play off the words. For example, Karissa simply replied "school gardens are at the school. Community gardens at the community" (R-2-Cu-KAR-134). Suzanna commented "school garden, obviously, like for agriculture classes and community garden for the community" (R-2-Fe-SUZ-71). Comments on specific terms are provided in Table 4.2.

Table 4.2 *Student Comments on Garden Classification*

Garden type	**Student responses**
Vacant lot	"to fill up space" (R-3-Ni-DAL-35) "mainly for scenery" (R-3-Ni-MAN-36)
School	"I think the school garden they use some of the food they grow in the cafeteria" (R-1-Fe-MOL-40) "Gardens teach the kids like gardening is good, healthy, and all that kind of stuff" (R-2-Al-MAR-168) "are to show students like hands on how to grow their own stuff and like what goes into making your own garden" (R-2-Ca-TAB-124) "are for learning" (R-2-Co-PAT-74) "for learning and also sometimes to try make the school look better" (R-2-Co-COR-91) "the garden here is to give food to the Caff" (R-2-Cu-KAR-137) "they want like kids to see if they would like gardening when they grow up" (R-2-Fe-MOL-73) "teach kids like responsibility" (R-2-Fe-BAI-92) "I feel like they are mainly like flowers, not gardening for those at school" (R-2-Pb-JAC-73)
Victory	"Are just like big mansions with stupid gardens, bushes, and stuff like that. They don't really get anything out of them" (R-2-Mn-Dal-32) "maybe just like hobbies or awards" (R-2-Co-PAT-74) "for hobbies and people who actually want and like that area to kind of have their own "garden" (R-2-Co-COR-96) "It is just like a good garden" (R-2-Fe-SUZ-68)
Community	"like to look neat and stuff" (R-2-Al-KAT-178) "makes like the community look pretty for someone to actually like move in there" (R-2-Al-ARI-179) "I feel that it is just like for fruits and vegetables. Stuff like that. Maybe like to plant and sell later somewhere" (R-2-Ca-NAT-121) "for design to look good like with flowers. It could also be like a community coming together to do something" (R-2-Co-PAT-74) "make the community look better for people who just visiting tourist and also try to do something good for where they live" (R-2-Co-COR-94) "feed like the community" (R-2-Fe-BAI-92) "helping people out that kind of need it" (R-2-Pb-JAC-78) "if people do need food they can just go to the community garden and take what they need to eat" (R-2-Mn-TAN-75) "I know they are for show, for prettiness, but I don't know if that is the actual reason for them" (R-3-Zn-CYN-37)

Soil Additives Used in Gardens

In preparation of some investigative parts of the project, students were asked to include in their first interviews a question asking, "what were some items that the gardener added to the soil and why?" These interviews were supposed to be done between the first and second group meetings. The interview results were reported to the respective teams during the second in-class group discussion coded as R-2-<team>-<individual speaking>.

Most of the team members reported that nothing special was added to the soil (e.g. R-2-Ca-NAT-99, R-2-Pb-JAC-92, R-2-Fe-MOL-49, R-2-Al-MAR-80). Kate (R-2-Al-KAT-85) and Suzanna (R-2-Fe-SUZ-46) both reported that the person they interviewed just purchased Miracle-Gro garden soil from the store. Patty had a similar response but with an additional comment "they use pre-packaged soil but they kept a close eye on the pH level because they said that made a difference on what they were growing" (R-2-Co-PAT-29).

Several of the students did not recognize fertilizer as an additive. Irene reported her interviewee "only used fertilizer. They didn't use any soil additives. They use cow manure and mulch" (R-2-Pb-IRE-27). Jaclyn stated her grandmother "didn't use like additives or anything. She just used fertilizer" (R-2-Pb-JAK-49). Tania speaking from her own experience injected "I know for like the huge farms and stuff they use manure but that is just nasty" (R-2-Mn-TAN-94).

A few of the students did either report on some specific additives or injected some of their thoughts on possible additives. Patty's interviewee used "eggshells, potato skins,

and bad lettuce" (R-2-Co-PAT-32). Tabitha noted her parents "use diapers. I guess there is like crystals in there that expand or something and they put it in their potted plants. It holds more moisture and so they don't have to water as often and it like makes them grow faster" (R-2-Ca-TAB-100). Cynthia's interviewee "likes to put Epsom salt on the tomatoes because it makes them sweeter" (R-2-Cu-CYN-186). K'lan noted the person she interviewed added coconut water (R-2-Co-KLA-121).

Only a handful mentioned compost in these early conversations, but as personal observations and not reported from interviews. Tabitha noted that compost could also be added and "that is just like the junk that is leftover like from your fruits and vegetables. So you are just basically recycling that back into the ground, but I don't know how" (R-2-Ca-TAB-153). Dallas stated compost could be added then explained "usually if you leave your plants, like if it dies in the same spot. It helps your other plants grow better" (R-2-Mn-DAL-60). Tania also brings a personal recollection of soil additives by stating

> I have heard tea like once you have used tea. I guess that is the same as like coffee grounds but I have heard when you're done with your tea if you keep it…like all your tea together and then like…even with the tea bags. You don't take away the tea bags you leave them in. (R-2-Mn-TAN-100).

Suzanna did express some knowledge of compost on a question during a regular exam but as a cultural difference writing "my grandfather is Hispanic. He uses natural compost to put in his garden compared to an American who goes to the store and gets chemicals" (E2-SUZ).

During the reporting of these additives, most of the students did not report on why the substance was added. The two exceptions were mentioned above. Cynthia reported on Epsom salt being added to make tomatoes sweeter and Tabitha using beads in diapers for

water retention. Students were asked to do some additional research on how the additives they came up with in their discussion, and some additional suggestions, changed the soil. The results were discussed the following week in the in-class discussion coded as R-3-<team>-<individual>. Individual reflections were also analyzed in weekly journals coded R-<individual>.

During the third discussion, the groups presented their thoughts on composting. When Cynthia indicating no knowledge of composting her partner explained composting as "like eggshells, banana peels that they put in barrels and then it like breaks up and turns into soilish like stuff" (R-3-Zn-JUD-26). Tania expressed compost as "basically like the remainders of food, like orange peels and stuff. You just put it in a box and wait until it kind of gets all icky" (R-3-Mn-TAN-21). Nate characterized composting in his group as being "like a mixture of different types of decaying matter or substances like leaves, manure, and that is used to fertilize soil" (R-3-Al-NAT-51). Bailey (J-BAI-59) and Cynthia (J-CYN-26) both reflected in their journals as composting being a way to enhance the garden soil and save money in terms of waste disposal and purchasing soil additives from the store.

The reasons as to why certain items might be added to soil varied from speculative to researched reporting. Karissa wrote in her journal that adding banana peels "will go into the soil and help the plants to smell better and grow stronger" (J-KAR-114). Nate commented adding banana peels "because of the potassium helps the plant grow" (R-3-Al-NAT-11). Jacob suggested "oranges and apples have like high nutrients in their

rind and stuff like that. So we could probably do that (for our experiment)" (R-3-Pb-JAC-113).

Eggshells were the most common additive, however this was one of the items suggested for research by the instructor the prior week. Nate noted in his journal that "eggshells bring in calcium to the soil and slightly raise the pH level" (J-NAT-92). Patty commented similarly within her group stating, "eggshells help to increase calcium in the soil and they also help with the pH level of the soil" (R-3-Co-PAT-5). Kate also noted the addition of eggshells as building up calcium (R-3-Al-KAT-8). Jacob chose a more general comment of "I know eggshells put some nutrients back into the ground that the plants may need or may not need but I do think [eggshells] help [the soil] out" (R-3-Pb-JAC-8).

Jacob continued this vagueness in his weekly reflective journal writing "some common items could be animal manure and fruit and vegetable leftover pieces because all of those objects will help the plant grow and produce a good product in the long run" (J-JAC-69). Blanche in her reflection indicated a choice had to be made writing "some of the different compost will be old vegetable or fruit peels and animal waste. I believe the one that can be used in a garden would be the vegetable and fruit peels" (J-BLA-74). Irene had a similar reflection writing "with home compost anyone can use whatever they may bring and my thoughts instantly go to the icky and idiotic in some people. (think manure)" (J-IRE-92). Bailey commented in team Iron's discussion about a dual-purpose stating "eggshells balance out pH. Coffee grounds I think is for pH as well. The manure

and compost and stuff is the base for whatever you are growing because (plants) need to have the nutrients" (R-3-Fe-BAI-8).

Some specific reasons for certain soil additives were noted. Judy commented "I was told if you put sugar in (soil), it makes the soil more compact" (R-3-Zn-JUD-7). Tania commented that "eggshells add calcium and help deter slugs…You can open up old tea bags and sprinkle damp leaves around the base of your plants to fertilize the soil and deter garden pest like mice" (R-3-Mn-TAN-80). Mary explained to her team that "ashes from a fireplace will slowly increase the pH of your soil" (R-3-AL-MAR-28). Tabitha included this in her journal entry noting "coffee grounds can be added to soil to provide nitrogen, potassium, and magnesium. Ashes from a fireplace will give (soil) potassium and calcium. Both of these will increase the pH of the soil." (J-TAB-40).

After the groups had identified items that could be added into soil or compost, the groups then planned an experiment to test the claims of these additives. This was the second experiment done related to this project as the first was an experiment to test seed germination. Another experiment carried on at the same time as the student's soil manipulation experiment was a test on the effects of environmental pollutants (e.g. acid rain, brine, bleach water) on plants. These were all intended to give suggestions in developing the garden proposal. The actual project was introduced in week 5. The next section has analyzed the groups' interactions during the project development.

Group Interaction During Project

The second research question for this study was 'how does group interactions influence the process and design of a community garden project?' This data addressing

this question is presented in this section. The major categories that emerged involved ignoring team members, lack of collaboration, communication with the group, gathering information, and project development. However, I will first recap the group assignment and scheduled in-class interactions.

The original plan was to use the LSI and math course completion to establish groups. However, because of a large number of athletes in the course, involvement in athletics and math course completion were used to establish groups. All the athletes in the course were involved in spring sports (i.e. baseball, softball, tennis) and missed class days as a result of participating in games. Every team had at least one athlete in the group. Teams Aluminum, Cobalt, and Lead each had two athletes in the group.

The number of members absent on discussion and consultation days has been indicated in Table 4.3. There were also absences on instructional and investigation days. The intent of organizing the groups with athletes split was for the team members to communicate and keep everyone current on the various steps of the project if a person did have to miss a scheduled class day. Attendance was good for the first two team discussions then began slacking as season games began.

Table 4.3 *Absences of Team Members at In-class Team Discussions and Consultations*

Meetings (in order occurred)+	Team (Number of members in group)								
	Al (3)	Ca (2)	Co (3)	Cu (3)	Fe (3)	Pb (4)	Mn (3)	Ni (3)	Zn (3)
R1	0	0	0	0	0	0	0	0	0
R2	0	0	0	0	0	1	0	0	2
R3	1	1	0	2	0	1	0	1	2
R4	1	1	0	2	1	2	1	1	2
R5	0	0	1	1 *	0	1	0	1	--
R6	0	1	1	0	0	0	0	0	--
C1	0	0	1	2	0	0	2	3	--
R7	0	2	0	1	1	1	1	1	--
R8	0	1	1	0	0	1	1	1	--
R9	1	1	1	1	1	2	1	1	--
C2	0	1	2	1	1	1	1	2	--

*Teams Zinc and Copper were combined when Zinc dropped to one member remaining in class.
+R = recording of in-class discussion, C = consultation meeting with team and instructor

Each team also had a Google Doc page in addition to the daily class meetings. However, the groups did not keep all the team mates up to date on the project. When Patty showed up as the only representative for team Cobalt for the second consultation, she replied to an instructor inquiry on where they were with “I am not for sure what they (team mates) want to do” (C-2-Co-PAT-65). She also mentioned this in the fifth in class discussion stating, “I feel like one day we should get together and try to like organize because I have no idea on (the project)” (R-5-Co-PAT-74). An entire team not being kept up to date was also noted in Team Manganese. Blanche stated during the eighth in class meeting “I don’t know what you guys talked about (last week). I wasn’t here” (R-8-Mn-BLA-101). In the second consultation of Team Manganese, the instructor asked about where the group was in a section of the project. Blanche, who did not know, asked a teammate and was told “Tania has all that” (C-2-Mn-BLA). Jaclyn also mentioned not

being kept informed as an excuse during the fifth week discussion stating “I don’t really remember doing that. I probably wasn’t here” (R-5-Pb-JAK-135).

The inability to keep team members involved was one challenge during the project. However, communication was an issue within the groups even when all were present in the classroom. This lack of communication emerged in three categories during the data analysis: ignoring team members, lack of collaboration, and motivation. These will be addressed in the next few sections.

Ignoring Team Members

For a few groups, a definite disconnect was noticed. Members of Team Aluminum best represented this disconnection. During the third in-class discussion Mary was on her phone throughout most of the conversation. She tended to miss parts of the conversation and her teammates had to catch her up (RJ-127). In a later in-class discussion, Mary was again observed on the phone for over 5 minutes only rejoining the conversation when the instructor came over (R-7-Al; RJ-324). During the second consultation meeting at the end of week 13, Mary showed up and presented her layout for the garden. Her two teammates have no idea about the proposal being presented and have not seen the layout (C-2-Al-MAR-5). Items that were discussed and agreed upon by the team were also missing from Mary’s layout (C-2-Al-ARI-207). When Mary’s two teammates would text her about work on the project between classes, they were completely ignored (C-2-Al-ARI; I-KAT).

While Team Aluminum had this issue throughout the semester, similar isolated incidents were noted from other groups. During the fourth discussion, the students were

to discuss a homework assignment over the Smithsonian's online presentation on history of gardens. Cynthia did not do the homework and when Judy started explaining about the exhibit, Cynthia asked a random question to a person in another group (R-4-Zn-CYN-13). Teams Lead and Iron both had members that would not talk to the others in the group. Molly when she was present would merely sit and not answer direct questions. Her teammate Suzanne was constantly telling Molly "you have to come up with your half, because if not we are going to like fail" (R-7-Fe-SUZ-88) or "that is why we are trying to wait for you to get your plants" (R-8-Fe-SUZ-59; C-1-Fe-SUZ-90). Alexia, a member of team Lead, would be present for most of the conversations but would say very little except for the time there were only two members present on an in-class discussion day (e.g. R-1-Pb; R-4-Pb; R-6-Pb).

The groups were set up to try to keep all members caught up with the project specifically and overall class in general. The diversity within the groups was also to allow for a breadth of prior experiences for the members to pull from and collaborate toward completing the project. The lack of collaboration emerged as a category and is discussed next.

Lack of Collaboration

The ignoring team members did partly contribute to lack of collaboration within the groups. Kate from Team Aluminum in her weekly reflection wrote:

> Ariel and I are the only ones that have been working on [the garden project]. Mary has not helped at all. I tell her we each need to work on [the project] because we have so little done and she always says she will but doesn't. We did not have a steady plan over our project and how it was going to be set up because when we tried talking about it, Mary would always be on her phone and not help

> out. She also always seems to be in a rush to leave class so we could never really agree on much. (J-Kat-12)

Ariel expressed similar frustration in her weekly journal noting "I also learned that working in group projects can be hard. People saying that they will do it but doesn't do much, do a few paragraphs here and there" (J-ARI-15). Ariel and Kate at one point even discussed Mary while she is on her phone with Ariel saying to Kate "I know that last discussion (Mary) wasn't here but we did terrible on it. Make her read it. Remember we were supposed to read the articles and we didn't?" (R-5-Al-ARI-110).

Patty also noted lack of contribution in her post class interview stating:

> I think people just not doing (their part of project). So we would like say just do this and then it wouldn't happen. My problem was that sometimes they didn't understand what I was talking about but they didn't give any suggestions about what to do. So I just kind of said do this but they didn't really understand what I was talking about. So then I would just end up doing it. (I-PAT-74)

In the one in-class meeting of Team Cobalt where Patty was not present, the other two group members tended to be very vague in their responses to discussion prompts. Nate from Team Calcium was with the group for this discussion and shared some ideas from his group's interaction but this did not incite additional dialogue (R-4-Co-ref).

Jacob from Team Lead recorded in his journal writing "it becomes frustrating when there was only two people in our group who were putting in time to create our paper and seeing the other two sit back and reap the benefits" (J-JAC-15). Irene acknowledged Jacob's taking charge of this group. During the third discussion she told him "you are doing great" (R-3-Pb-IRE-20) while Jacob was the only member of the team responding to prompts on the prior week's homework. Irene also stated on the out

of class discussion “Where are we starting at? You usually do most of the talking.” (R-OC-Pb-3).

The in-class discussions were intended to encourage collaboration and sharing of ideas. The groups usually tried to rush through them and not involve all members, as shown in an excerpt from Team Nickel’s fourth in class conversation.

> Dallas reads question 3
>
> Dallas "it was a good exhibit"
>
> Dallas reads question 4
>
> Dallas "From what I got it was a stress reliever type thing."
>
> Manuel "Man, I would see it as food."
>
> Dallas "or food sometimes"
>
> Manuel "I see it as an agricultural since it is.."
>
> Dallas "Old people do it to just like pass the time"
>
> Manuel "Teaches you math, geography, nutrition"
>
> Dallas "true, that is true"
>
> Manuel "agriculture"
>
> Dallas reads question 5
>
> Dallas "so pretty much the articles says that people use them for different things. They will use them to teach people how different chemicals do things. They will use it as their main source of food and stuff like that."
>
> Manuel "Composting is cool"
>
> Dallas "yeah. Composting"
>
> Dallas reads question 6
>
> Dallas "it can like help people sometimes. If they don't have the space for it."
>
> Manuel "I say it keeps kids off the street"
>
> Dallas "yep. It gives old people a time passer"
>
> Manuel "it brings the community together"
>
> Dallas reads question 7 (R-4-Ni-8)

Kate stated in the post-class interview:

> I was writing it down and Mary was the one that got the whole thing. You know how she puts everything on her phone? And she was like okay I will text it to you guys. And here comes the next day, I think it was...I don't know what day it was, Friday that we were going to have a discussion over that again. And she hadn't texted it and I messaged Ariel and she messaged her (Mary) and I kind of texted her too and she never answered. She was like...no, at last she did answer after I texted her a few times. She was like I will send it to you here in a bit. And she never sent it to me and I was like ugh. (I-KAT-88)

For a couple of the groups, there was a member who would not participate to allow collaboration. During the third discussion, the instructor reflected that Molly seemed to be out of the conversation and just eager to leave. Baily and Suzanna introduced some good leads but did not follow through with them on the recording (R-3-Fe-ref). The struggle of this group was further seen in the sixth in-class discussion. A portion of the in-class conversation from team Iron demonstrated how members worked co-operatively, but not collaboratively.

> Suzanna "I think she just wrote down the ones from last time."
>
> Molly "yeah"
>
> Suzanna "So we are still waiting on yours though because it is 20 of them."
> Molly "Well I looked them up but at least I have these ones."
> Suzanna "There has to be more vegetables. Like 20 and 20. You need 10 flowers, 10 vegetables."
> Molly "That looks like a lot of flowers."
> Suzanna "I know but we have to have more than...like ours together is going to be 40. We need 20 more from you. That is 60 altogether.
>
> Molly "Does it matter what it is? Does it have to be.."
>
> Suzanna "It has to be vegetables or flowers. Because that is our thing we said we are going to do."
> Molly "Can I do vegetables?"
> Suzanna "Oh, wait. You have to do 10 vegetables, 10 flowers" (R-6-Fe)

The teams had class together daily allowing for constant interaction. During the class, there were 10 days devoted to just group discussions on the project. Each group also had a Google Doc on which to communicate. This communication was vital link for the instructor to aid the students in progressing on their project and to study the group interactions. The next section examined other communication utilized by the groups.

Communication within the Group

The course project was designed so that the instructor could follow the interactions of each of the teams. This was accomplished through the in-class discussions, the team-instructor consultations, and a Google Doc embedded into Canvas. The Google Doc permitted the instructor to see who was posting what information and any comments or questions that were posed to the rest of the group. The groups were also instructed to provide recordings for any out of class meetings.

Some students recognized the importance of the Google Doc as a method for asynchronous communication. Karissa commented to her partners "whenever I type you guys can see it. So like we can basically talk through [Google Docs] too you know" (R-8-Cu-KAR-54). Patty noted that communication was important for the project and "it was difficult communicating my ideas and thoughts over Google Docs, but after a few discussions everything was communicated better" (J-Pat-15).

Several students mentioned either meeting outside of class or communicating external to the class provided methods. In the post-class interview, Patty stated "we had like a Facebook group that we messaged on a lot. We talked about anything about the

garden project. That was pretty much the main way we communicated" (I-PAT-51). Patty's partner, K'Lan, wrote in her journal "we communicated through Facebook messenger when we were not in the classroom" (J-KLA-15). Irene from Team Lead similarly stated "we work on it through Facebook" (C-1-Pb-IRE-176). Karissa mentioned that team Copper has "group messages on phones" (R-8-Cu-KAR-57).

Jacob, in conversing with Nate in another group, stated he "made another Doc so we could all go in there and add to it" (R-8-Ni-JAC-101). The instructor reminded the team members to use the Google Doc in the Canvas shell, but during the second consultation in week 13 the group members indicated they were still using a separate Google Doc (C-2-Pb-JAC-7). The teams also did meet outside of class. Jacob noted in the same conversation "we are probably going to try to meet up in a couple days and probably get through that other stuff" (R-8-Ni-JAC-94). Alexia also mentioned Team Lead "get[ting] together out of class and do[ing] work … we are getting together on Tuesday of next week" (R-9-Pb-ALE-7). Irene, a member of Team Lead, reflected after the project "I feel like when my group got together to work on our project outside of class, we were better able to communicate ideas with each other and got much more done, rather than getting on our Google Doc and working independently while using a chat box" (F-IRE-18). Bailey from Team Iron asked her teammates "can you [meet] Tuesday at like 2:30?" (R-7-Fe-BAI-269). Tania suggested a meeting with her group saying, "maybe one day we can get together like in the study lounge and work on it or even the Library" (R-7-Mn-TAN). Patty from team Cobalt also suggested "one day we should get together" (R-5-Co-PAT-74).

Despite the team members having class every weekday and the 12 days devoted strictly to the project, several students noted a lack of communication as a problem. Kate stated

> [the biggest issue] was lack of communication. We didn't talk much about the project. We kind of did it, I guess. Kind of one on one because either we would try to get together and somebody always couldn't. We couldn't like meet up. We tried contacting each other and there was always that person that wouldn't answer. Like, we didn't really talk about the project. (I-KAT-52)

Tabitha, a member of the only team of 2 for the entire semester, revealed

> We didn't really talk. The only time that we communicated was like right when something was due. Then we would e-mail each other. I would do like a big part of it and give to him. Then he would do his half, he would add his stuff. We didn't really communicate at all. (I-TAB-58)

Karissa expressed the importance of communication to the project writing in her journal

> Another big thing I learned about this project is how important group work is. You really can't do anything to finish the project on your own. You have to rely on others and do your part because the rest of the group is relying on you as well. (J-KAR-15).

While Team Lead met several times outside of class, Alexia noted the importance of that interaction. She wrote "It takes a lot for the whole group to meet and get on the same page but it is good to have more than one head so that way if you don't think of something then someone else will" (J-ALE-15). Cynthia from Team Copper/Zinc, who had the most absences of all the groups, reflected "something that was huge in my group was lack of communication" (J-CYN-15).

Dominant team member. Of the eight groups that finished the semester, a dominant person was noted in five of the teams (RJ). For team Aluminum, this was Mary.

In the first group in-class discussion, the teams were constructed interview questions for the next week. Part of the conversation was:

> Kate "Yeah, but there should be a different way shouldn't there? I mean how to people … "
> Ariel "so do we answer question E"
> Mary "I don't see a question"
> Kate "No, I think this is for ... Is this for an interview. Like each one of us?"
> Mary "I think we are done"
> Kate "yeah" (R-1-Al-78)

Kate initially questions what was intended with constructing the interview questionnaire but did not challenge Mary when she suggested that they were done. During the second consultation, Mary brought a layout to the meeting that the other two had not seen, even though the group had discussed the basic ideas in the prior two in-class discussions. Mary and the instructor conversed:

> Instructor "So the other two, have you seen the layout she has written down?"
> Mary "Well, I just did that yesterday. So they didn't see it (garden layout). It was in study hall. But I made this layout."
> Instructor "Share it with them real quick."
> Mary "Never mind. <Turns around and drops her notebook on the table> this is what we are going to do. Here is the opening. We have daisies on both sides. We have a park bench. Then when you first walk in we are going to have a map of the garden. So we have like …" (C2-Al-MAR-107).

> After Mary left the classroom, the instructor visited with the other two members.

> Instructor "So no comments on her layout? Are you fine with it?"
> Ariel "Except for the greenhouse. She forgot the greenhouse. We had specified a greenhouse."
> Instructor "Did you tell her to put it in there?"
> Ariel "Yeah. I didn't even know about it. She was talking about it and I was like what is she talking about."
> Kate "yeah, I was kind of surprised. But I mean it seems okay." (C2-Al-206)

In the post class interview, when asked about the interaction, Kate replied

> One of my partners did their own thing and would surprise us. We would kind of … whatever she would put down, we would try not to say anything but just start from there. Like see what we can do from there. (I-KAT-56)

When asked why they did not stick up for their ideas, Kate responded

> I feel bad saying something. So me and Ariel would kind of start from there. Like kind of put our ideas to what she had put and see what we could work from that. But that kind of messed up a few things because she would change it a lot. (I-KAT-62).

Patty initially dominated team Cobalt interactions. In several of the in-class discussions, Patty would state her ideas and the others merely agreed or would say "that is what I got, too" (e.g. R-2-Co, R-3-Co, R-6-Co). For the one in-class discussion where Patty was not present, the other two merely blurted a quick, generalized response to the prompts and moved on to next prompt (R-4-Co). This particular in-class discussion for the group was considerably shorter than the other groups at 5 minutes and 34 seconds compared to an average of just under 16 minutes for all the other groups' discussions on this date. After an intervention by the instructor for the group to rotate who spoke first on each prompt, the conditions improved (e.g. RJ, R-5-Co, R-6-Co). Dallas, from Team Nickel, also tended to dominate the in-class discussion. He would read all the prompts first, then turn on the recorder and give quick responses to each question with little opportunity for his teammates to respond (RJ). For example, in the fourth in-class discussion, the groups were to discuss their thoughts about the on-line Smithsonian's Garden History exhibit. Dallas replied, "was a good exhibit" (R-4-Ni-DAL-9) and then read the next prompt.

In Team Lead, Jacob was the dominating person in the group. Irene commented "where are we starting at. [Jacob] usually does most of the talking" (R-Pb-425-IRE-3) and another time when leaving the room, she told the instructor "Jacob is just going to do what he wants as usual" (RJ). Jacob self-justified his actions commenting in his journal how frustrating it was when he and Irene were doing the work and the others were just sitting back and doing nothing (J-JAC). In one of the open-ended questions on the course final, Jacob wrote:

> It takes the whole group to present a perfect final copy of whatever we are working on so when someone isn't on board with putting the same amount of time, it negatively correlates and can result in lesser grades and performance. I slowly figured out that some people want to have a better grade and will focus on contributing much more than others in the group. I would say it wasn't a fun time just on the fact that it really wasn't a 'group' project. (F-JAC-18)

Avoiding conflict was also observed in a conversation in team Iron where Suzanna tried to dominate the group. The conversation was about developing interview questions for community members.

> Suzanna "Should we give them like certain vegetables?"
> Bailey "No, because then they would just pick the ones with the most answers because they are going to be similar"
> Suzanna "But if they are too diverse then you can't get like everything."
> Bailey "I don't care." (R-5-Fe-90)

Bailey correctly questioned doing a survey which provided the community only a few choices to select from instead of asking what the community members would like to have in the garden. As a result, the group only had the community representatives they ask choose between five vegetables and realized the mistake later. However, unlike members in other groups, Bailey does become more vocal in the development of the project (RJ).

Lack of motivation. An overall lack of motivation was also observed in several of the groups with communication problems. This theme of lack of motivation warranted exploration in a separate section.

Throughout the project, the students had a few homework assignments between in-class discussions that were related to the project. The lack of completing this homework was noted across the groups. For discussion prompts that concerned an assigned reading, the normal response was to skip them and move on to the next prompt (e.g. R-4-Al; R-4-Co, R-4-Fe). Blanche represented the general trend by stating "I did nothing. So move on to the next question" (R-4-Mn-BLA-8). Suzanne wrote in her journal "my group didn't discuss because they didn't read the articles" (J-SUZ-6).

Readings were not the only assignments that were not completed. Cynthia stated "I didn't interview anybody" (R-6-Cu-CYN-20) for the required community member questionnaires. In Team Lead's presentations that week, Jacob was the only one sharing information about the survey/questionnaire that was done the prior week (R-6-Pb-ref). Even the written assignment for the project was not looked at by Mary who, while discussing the guidelines during a consultation, stated "let me write this down because I am pretty sure I am never going to look at that paper ever again" (C-1-Al-MAR-23). Tania in her group's discussion stated "honestly, I don't know what we are supposed to do for [the project]. I haven't read the requirements" (R-5-Mn-TAN-26).

Several of the students were verbal about having to do work. Cynthia stated "I wish it wasn't so much. I am so tired" (R-7-Cu-CYN-119). Alexia quipped "that is a lot already" (R-5-Pb-ALE-134). Irene simply expressed "this is hard" (R-7-Pb-IRE-123).

Karissa stated her disapproval first to her group saying “Screw this part right now. We will do that later. Just take that one to the side. This is way too much work in one day. I can’t handle it.” (R-5-Cu-KAR-134) Later in the conversation the group members expanded stating:

> Karissa "This is stressful. Like I am never here so I don't know what is going on half the time and you just put way too much work on us and it is just...lets slow down a little bit."
> Instructor "Just tell coach you need to be here a little more"
> Karissa "just calm down a little bit. We don't need to stress this whole week out with 5 million things to do. Okay? Just give us one assignment at a time, instead of seven. Because I can't do all seven at once."
> Instructor "That is why you work on the garden project a little bit at a time."
> Cynthia "I wish we had one journal due and then the next week we have one discussion and then the next week journal.."
> Judy "I just wish it wasn't due on the weekend"
> Karissa "i just wish we didn't have to do it at all."
> <All laugh>
> Cynthia "You are right. Yeah! Can we go with her idea?" (R-5-Cu-196)

K’Lan was frustrated about the method of submission proclaiming “I suck at the journals. I need to get it together. I mean I am caught up on them but I am just not a Canvas … like turning in homework on the Internet type of person” (R-5-Co-KLA-102). Tania excused herself from discussion by stating “I don’t know. I can’t think right now. Today is not a good day” (R-5-Mn-TAN-91).

Procrastination. Several students did note that they needed to get to working on the project. Cynthia in week 10 stated “we need to step our game up. We have been slacking a lot” (R-7-Cu-CYN-75). Karissa trying to justify this noted “I think every group is [slacking]. I was talking to a lot of other groups and they are like no we haven’t written anything either” (R-7-Cu-KAR-76). However, the researcher noted at the time that “team

copper is one of the lagging groups in the project" (RJ-3-24). Mary, on a prompt during week 13 that referred to an assignment that was due in week 8, stated "we didn't fully get to that part yet and we need to do that still" (R-9-AL-MAR-23). Tania urged "I think we should just start" (R-6-Mn-TAN) in reference to an assignment on the Google Doc that was due four weeks earlier. In the week nine discussion, Dallas asked and replied "What do we need in our group writing for our proposal? Everything!" (R-6-Ni-DAL-78). Cynthia mentioned procrastinating as a regret in her post project final stating "I only wish I would've tried harder in the beginning because my group slacked so much" (F-CYN-16).

Taking the path of least effort also extended into the project itself. Tabitha asked "what garden would be easier to make? (R-5-Ca-TAB-71). Jacob wanted an easy community population stating "just to make it easy we could just say college students" (R-5-Pb-JAC-60). Suzanne told her partners "I am trying to do not a lot, you know what I mean?" (R-5-Fe-SUZ-172). She used this as the reason for placing specific choice responses on the survey for the community members on what they wanted in the community garden. Suzanne stated "Do we want to do just like three flowers [on survey]? Because we are going to have to do research on all the responses" (R-5-Fe-SUZ-161).

The groups tried to find the easiest route in making plant selections. For the project, the groups were supposed to survey representative members of the community and determine what kind of plants they would like in a garden. Most of the groups

gathered this information but then did not incorporate those selections in the project. Jacob told Nate

> I looked up flowers that grow in Kansas during the spring and this website popped up and it was like a chart of when flowers bloomed and stuff. There is like hundreds of them. I took like 20 off there and I typed the same thing in for vegetables and there was a chart. We ended up getting probably 70 [plants]. (R-8-Ni-JAC-67).

Tania wanted "like simple things that don't require too much work and don't take too long to grow" (R-7-Mn-TAN-98). Karissa suggested "let's just do cherry tomatoes" for an easy plant. Some plants were also eliminated because of extra work on research or care. Bailey and Suzanna discounted roses because "the pH balances for roses was weird" (R-7-Fe-BAI-119). Irene suggested removing vegetables and "just do plants and bushes because they are a lot easier to maintain." (R-7-Pb-IRE-70). Team Lead decided to add herbs when the instructor reminded the class that there needed to be at least 40 different varieties of plants in the garden (R-6-Pb-47-62).

While planning the layout for the garden was a challenge for all the groups, Team Iron discussed taking an easy route out. Bailey noted

> [Ace] could probably give us a freaking layout. That is what they do … I have been thinking about that for so long. I am like I am just going to fucking do that because they have to know something. Steal Wal-mart's garden layout. We get an A. (R-8-Fe-BAI-117)

The students were told to use the garden centers, acquaintances that gardened, sustainable agriculture instructor, among others as references. However, most did not consult those resources other than for specific assignments. The next section briefly discusses the students claimed sources of information for this project.

Gathering Information

Manuel was the only one in the recorded discussions to mention "we should go to the agriculture building, to ask them questions. Like what grows here?" (R-8-Ni-MAN-23). Karissa asked about type of garden grown making a difference. She noted

> The people that grow gardens are like … and I'm from Colorado so a lot of my friends have like Marijuana gardens. Could I still ask them about it? I mean coming from Colorado it's really all there is to do there now. Like that is all they talk about. (R-1-Cu-KAR-162).

Tabitha noted her team members' mothers were a good source of information. She stated "I mean like it seems your mom is pretty well into [gardening] and so is mine, that we could always ask them more" (R-2-Ca-TAB). Tabitha also mentioned some regional experience in planning her interview questions stating "Like my mom since they lived all over … how has one place been different from another? Like they lived in Kansas, Oklahoma, Texas, and Florida. I'm sure like the garden is different" (R-1-Ca-TAB-39).

For most of the students, their source was Google. K'Lan stated "I can Google it really fast" (R-7-Co-KLA). Mary stated to her team members "just go out, look it up, and do research on it. Look it up on Google" (R-2-Al-MAR-236). Tabitha proclaimed "I just go on Google and type in whatever he wants us to look for. Then I scroll and read and pick pieces out of each one. I mean research is kind of easy now days with the Internet" (R-5-Ca-TAB-171). Tania summed up the general attitude about gathering information, "I mean you could ask other people but I feel like Google is honestly just the ideal and the easiest, convenient" (R-2-Mn-TAN-111).

Nine students did mention their specific searches. Bailey noted she "would Google natural household or natural additives for gardens" (R-2-Fe-BAI-117). In a later

discussion, she mentioned “I Googled flowers that grow well with each other. It brings up lists of like what works and what doesn’t. Some of them even tell you what do not grow with them” (R-7-Fe-BAI-99). Patty used images to define her initial thoughts on community gardens by stating “When [Google] showed pictures, it would show like more than one person growing [garden] in an area and [the garden] wasn’t always flowers” (R-3-Co-PAT-34).

The students did not seem to search many websites but instead concentrated on one. Mary noted “I only looked at one [website] because it had so much. I was like okay I am just going to look at this one” (C-2-Al-MAR-66). Patty stated in her team’s discussion “I am going to look up on one website that we have already looked at and then there is another website that my mom always went on for flowers that has like all the chemical stuff about it” (R-7-Co-PAT-297).

Group Interactions in Project Development

The communication methods among the team members and means of gathering additional information within this study have already been discussed. Additionally, the social interactions of the groups in developing the project throughout the semester warranted investigation. Communication has been noted as a key for a collaborative interaction, however this was a problem for students in this study as their tendency was to just divide up the work but then never discuss the findings.

The cooperative approach to this project was mentioned by several students in their reflective journals. Patty wrote “my team and I have all been working on our

individual research. Each one of us has our own section to gather information on" (J-PAT-12). Patty's teammate, K'Lan, noted "we still have been sticking to our contributions we assigned for each member" (J-KLA-13/14). Nate mentioned "we also talked about our collaboration page and how we would split up the work for that and finish the composting section this week" (J-NAT-7). He later reiterated "we can just split it up" (C-2-Ca-NAT) during the second consultation when discussing some sections that still needed to work on for the project. In the post lab interview, Tabitha, Nate's partner, mentioned "we didn't really talk … I would do like a big part …then he would do his half" (I-TAB-58).

Suzanna suggested a cooperative approach in Team Iron stating "[Bailey] do half the vegetables and I do the other half. Then [Molly] can do the flowers" (R-6-Fe-SUZ-89). This was the approach that Bailey had started the week before when she mentioned "I will do number 2. Do you want to do it like that? You want to each take something?" (R-5-Fe-BAI-36). Cynthia also mentioned splitting the plants up with each taking 12 that were then put directly into the Google Doc without discussion (R-8-Cu-CYN-34). Tania, a member of Team Manganese noted the problems this cooperative approach had. She stated:

> In the beginning of the year we had 3 members in our group. All splitting up the work evenly but at the end of the year right before our final project was due one of our team members dropped the class and we then had to figure out how we were going to make up the work that she didn't do. It was hard when we had to do the final project with one less person in the group because we had everything planned out with three people. (F-TAN-18)

The design and type of garden counted on the social learning of the group from each other, those they interviewed/surveyed, and collaborative research. While the type

of community was left to each team to discern, they had to interview representatives of that population to see what they wanted in a community garden. Manuel reported "everybody was really hype about food" (R-7-Ni-MAN-13). Blanche recalled "one of the person's I interviewed said the flowers was the main thing they see in a community garden" (R-8-Mn-BLA-86). Jacob reported "some people wanted fruit. Some people would like to see just a vegetable garden. Then you would have the occasional people that did just want a flower [garden]" (R-7-Pb-JAC-98).

A few students even commented on the importance of designing the garden content towards the needs of the community members. Patty telling her group:

> This [survey] will help us to know what the majority is going to want and actually use and what they are actually going to like. So if we do a bunch of stuff that they are not going to like, it is going to be like … no one is going to use [the community garden] and they are not going to appreciate it. But if we can figure out exactly what they are going to like and how they are going to contribute, then if will be more effective in the neighborhood. (R-5-Co-PAT-47)

Jacob also expressed this concern with his team noting "before we decide what we are going to put in the garden, we could just go around and ask people what they think they needed the most. What they are going to eat the most or use the most" (R-5-Pb-JAC-79). Manuel in creating questions for the population questionnaire for Team Nickel stated "I am trying to think what they would want in a garden" (R-5-Ni-MAN-26).

Through discussion some groups came up with elements of their design. Jaclyn suggested since the garden was for the students "we will do like spring plants. Then when we come back for fall, we can have fall plants" (R-7-Pb-JAK-45). Patty suggested "a little section of fake [plants] for like kids to pretend they are [gardening]" (R-7-Co-PAT-54) that was added into the final project. Dallas brought to the group a means of

composting using a three-row cycle that ended up driving the eventual layout of their proposed garden (R-3-Ni-ref).

However not all suggestions were presented in the final project. The most drastic difference came from Team Aluminum. Kate suggested a garden that was "all pretty and stuff with a greenhouse so people can walk inside" (R-7-Al-KAT-123). The group agreed to include the greenhouse in the garden. The feature was part of the regular discussions up until Mary presented her layout at the second consultation and the greenhouse was no longer there. This team had also originally discussed planning a vegetable or fruit garden for the community.

> Mary "What kind of plants do you want to grow? If I was to do flowers … well I don't even like flowers"
> Ariel "I don't like flowers either"
> Kate "I don't know because I would grow a vegetable garden"
> Mary "Legit. I would rather do like a fruit garden because those are so cool." (R-6-Al-126)

However, when Mary brought her layout to the second consultation, as previously addressed, the entire garden was flowers. The initially discussed and final garden components for the various teams are presented in Table 4.4.

Table 4.4 *Type of Garden: Comparison of Initial and Final*

Team	Garden type-Initial plan	Indicated purpose	Garden type-final
Aluminum	Vegetable, fruit	Educational	Flowers
Calcium	Fruit, vegetable	Foodbank	Fruit, vegetable
Cobalt	Flower, vegetable, fruit	----	Vegetable, fruit, herb
Copper	None specified	----	Vegetables, herbs <incomplete>+
Iron	Vegetable, flower	School	<plagiarized>*
Manganese	Vegetables, fruit	----	Vegetable, fruit, herb <incomplete>+
Nickel	1/10 flower, 9/10 food	----	Vegetable, fruit, herb <incomplete>+
Lead	Vegetables, fruits	Students on campus	Flowers, herbs, vegetables, fruit

+ Final project submitted was missing one or more major required sections.
* For the final project submitted, this group did not design the layout and plants included from their research but pasted and copied verbatim one directly from a source they found on-line.

The requirements for the project indicated including a minimum of 40 different varieties of plants (see Appendix B). The instructions stated that different types of the same species counted as different varieties. The example given was that of tomatoes; they could have Cherry, Brandywine, and Beefmaster. Those counted as three toward the 40 minimum varieties of plants. Five students had knowledge of varieties they shared with their teams. Tania stated:

> I work at this place that is like a fruit and vegetable thing. Like all around where I live and then they bring [produce] to like a packing house. Then they send it around the world. They have yellow zucchini and there was purple cauliflower at one point. Then they have like these peppers and they are all different colors. You know how there is like the typical green. They had like a light yellow, these dark purple, and a black. It was really cool. Oh, they had purple carrots at one point. So we can have like stuff like that so that it is a really cool garden. (R-7-Mn-TAN-67)

Patty mentioned to her group “there are different types of tomatoes. There are different types of peppers. So that could make [plant numbers] more” (R-7-Co-PAT-24). Bailey brought up the varieties from her research noting “the beets, [the site] said to pair with bush beans only. So what kind of beans are we using?” (R-7-Fe-BAI-69). The varieties also came up in an exchange in Team Copper with Karissa stating “there is only one kind of tomato” (R-6-Cu-KAR-67) and Judy responding “No, there is not. There is a lot. There is like Roma, Cherry …” (R-6-Cu-JUD-68).

Most groups decided to add herbs to increase the count number for plants as can be seen in Table 4.4. Despite Tania’s experience and Patty’s mentioning varieties, neither team includes varieties of a type of plant in their final proposal. Only teams Calcium and Nickel use varieties within their proposal. The other six teams all just increased the number of different plant types.

Transfer of information was not limited to the varieties of plants. Within class the instructor discussed the chemical process of decomposition. The students also had a two-week threaded discussion in Canvas over plant sources for essential nutrients. A lecture was done over the essential nutrients needed by plants from the soil. Experiments were conducted on soil additives and effect of environmental pollutants. The students were instructed to include these various concepts in their proposal.

Despite the chemistry of composting being a required section, only three teams included the chemical process in their proposal. Only Team Copper did not include any information about soil requirements of the plants they were proposing for the garden. Nickel was the only team to present plant specific soil nutrients. The remaining teams

only provided the soil pH needs of the plants. As for chemicals produced or provided by the plants, only team Calcium and Cobalt included these in their proposal.

The procrastination on working on project throughout the semester could be one factor for these elements not being present. As noted in Table 4.4 some groups were missing entire sections of their proposal that were not completed. Others had the general sections in the proposal but lacked the detail required. Only team Calcium presented a nearly complete proposal. All four participants interviewed after the conclusion of the class commented one of the biggest challenges was not procrastinating.

Patty stated:

> I think it was more like, oh we have lots of time. No need to start it yet. Well we never said we don't need to start it. It was more like okay do this and then that. A week will go by and you will get caught up doing other stuff because it is not like the top priority yet (I-PAT-41)

Her teammate Cortez in a separate interview elaborated:

> I mean we did it like two weeks before we start actually working on it. I remember you tell us this is going to be a huge project and we were discussing about it. We say we don't have to leave it until the last time but I forget it and Patty forget about it. So actually when we came and we started talking about, we were like 'oh my God this is for two weeks.' We probably missed some information we didn't put that probably would be important. We could actually do it better. (I-COR-113)

Tabitha shared advice for other students stating:

> Communicate with your partner. Not to wait on them to take the initiative of the project because then you will have late nights. That was kind of our downfall. Not put it off until the last minute. If there is a deadline, do it. Don't think you are going to have time to do it at the end of the semester when there is a lot of other stuff piling up. (I-TAB-107)

Kate's comment was "don't slack off. Don't do none of that and I think meeting up with your partners is very important. So you can all be on the same page and decide what you are going to do or what is needed" (I-KAT-30).

The groups overall did not communicate well and work collaboratively as intended. Attendance was a large contributing factor to the lack of communication, along with an overall lack of motivation to work outside of class. As a result, group members did not engage in the full social interaction with the potential resources (e.g. community members, family members, gardeners) to gain from their experience. This in turn led to groups falling behind on deadlines and not completing the project completely. Only one group had almost all the requirements addressed in their project.

While collaborative learning was not seen to the fullest extent in the project, the third research question involved what the students learned during the project. The prior beliefs and knowledge concerning the benefits of collaborative learning were discussed earlier in this chapter. The learning of concepts and skills that took place from the project is covered in the next section with a comparison to look at changes that might have occurred.

Learned from Project

The pre-project beliefs on why people garden, as reported earlier in this chapter, fell into four categories of to pass time, fresh food, self-gratification, and saving money. Part of the third question was to investigate if a change in beliefs occurred as a result of participation in this project. The recordings of the in-class conversations (R-<discussion occurance>-<student code>) after the project began were analyzed as well as the

students' reflective journal (J-<student code>) and open-ended questions on the final exam (F-<student code>).

While a source of fresh, healthy food remained as a high benefit belief among the students, physical and mental health emerged as a more often cited benefit to gardening. This theme began to emerge in week 5 of the course. Tabitha noted in her weekly reflection "I never really considered the physiological benefits [gardening] can have and the benefits of becoming healthier in a sense for some people" (J-TAB-5). Alexia wrote "the health of the people and the perception of obesity" (J-ALE-39) as reasons for community gardens. On the final exam health was mentioned as a benefit by 12 of the students compared to only 10 mentioning food.

Molly (F-MOL-14) and Jaclyn (F-JAK-14) both wrote that exercising while gardening can result in weight loss, stress reduction, lower cholesterol, and decrease depression. Bailey recalled "with my Dad, that [gardening] is good for mental health" (F-BAI-14). Nate noted "gardening can improve your flexibility and strength. Gardening is a great stress reliever. It allows you to unwind and it's always great to see hard work pay off" (F-NAT-14). While Irene (F-IRE-15) mentions the mental and physical benefits, Tania stated more elaborately "the hands-on experience of gardening is helping your brain, there are studies that show that gardening can boost your brain power and can be used as natural therapy" (F-TAN-14). Cortez declared "health benefits are the most important" (F-COR-12).

The second benefit of gardens was as a food source. This was the only theme from the pre-project attitudes to remain. However, many still tied into the health aspects

when discussing food. For example, Cortez wrote “veggies and fruits have a lot of health benefits such as vitamins and minerals that for us as humans are very important to keep living” (F-COR-12). Cynthia also noted the healthier option noting “[gardening] will benefit your health because most of these plants have a lot of nutrients especially when no additive is added” (F-CYN-14). Alexia stated “the benefits of gardening to me are vegetables, herbs, and fruit are always fresh. They grow naturally” (F-ALE-14). Patty (F-PAT-14) and Blanche (F-BLA-14) made similar notations about growing one’s own food as the most natural and environmentally friendly method. The self-reliance in growing your own food was the focus for Suzanna (F-SUZ-14) and Tabitha (F-SUZ-14).

The third theme that emerged as to why people garden was social interaction. Manuel simply recognized the garden as being “great for bringing people together” (F-MAN-13). Ariel wrote “adults can become more involved if there is a community garden. There would be more communication between people. Getting to know new people, spending time with people instead of just being indoors all day” (F-ARI-14). Irene noted the garden “can be a good way to spend some time with your family and teach your kids the value of hard-work, responsibility, and the importance of not being wasteful” (F-IRE-14). Suzanna suggested that one benefit would be gardening “with your kids and grandkids to create special memories and teaching them how to garden” (F-SUZ-14). Tabitha also believed the garden as being socially educational. She stated, “I learned that people use [gardens] to help preserve part of their culture and pass down a little bit of their traditions to each person that gets involved” (F-TAB-13).

Education was named specifically as a benefit by four people (F-ARI-14; F-MAN-14; F-PAT-14; F-SUZ-14). Informal education through social interactions was mentioned in the prior paragraph but formal school education was also included as a benefit by the students. Other minor themes mentioned were environmentally friendly (F-JAK-14; F-KAR-14; F-PAT-14), self-reliance (F-IRE-13; F-MAN-14), beautification (F-JAK-14), and learning patience (F-NAT-14).

Knowledge Gained

The students in the project self-reported on their learning during the project through open-ended questions on the final (F-<student code>). Analysis was also done one the weekly reflective journals (J-<student code> and recordings of in-class conversations (R-<occurance>-<team>-<individual code>) The knowledge codes developed, document the members in the class acquired both concepts and skills. A summary of the concepts reported is provided in Table 4.5 and a few select comments have been provided in the upcoming section.

Table 4.5. *General Topics Self-reported by Students as Gained from Project*

Type	Topic
Conceptual	Companion Plants
	Composting
	Soil Requirements
	Garden types
	Plant requirements (non-soil)
Skills	Communication
	Teamwork

The two main science concepts of soil requirements and composting were required sections for the paper. In addition, the soil additive experiment was related to

composting. The variety in types of gardens was what students were the most communicative about. In the fourth in-class discussion Suzanna stated "Since we are from America, everyone just assumes that you [garden] one way but there are multiple ways of doing it" (R-4-Fe-SUZ-69). Kate noted "I didn't know there were tea gardens. Like they grow their own herbs or whatever and make their own tea" (R-4-Al-KAT-64). The herb garden was also new to Cynthia. She wrote "I learned that it is popular to grow herb plants" (J-CYN-24). Tabitha reflected "I don't really know too much about gardening so I was kind of shocked when I found out there was so many different types of gardens" (J-TAB-55)

The soil additives and requirements of plants also seemed to surprise some students. Tania commented:

> I learned that there is a lot more to gardening than I expected as I said before I am not a very good gardener and I thought it was just because I am forgetful and don't water them but I realize now that it could also be the fact that I'm using the wrong soil and not adding nutrients (F-TAN-17)

Jaclyn wrote "I learned that there was a lot more to gardening than just putting seeds in the ground and watering them. I learned about the Nitrogen-Phosphorus-Potassium in the soil and how certain plants need different levels of these" (F-JAK-17). Irene also commented on the soil chemistry. She recalled "I learned that different plants grow better or worse in soils with certain pH levels and how the NPK (Nitrogen, Phosphorus, and Potassium) levels can affect growth. I never understood what the numbers on fertilizer bags meant. Now I know" (F-IRE-17).

Learning about light requirements of plants seemed to be a new concept to a few students. Suzanna noted "I honestly thought you could grow whatever together as long as

you gave them water and soil … The amount of sunlight each flower and vegetable [need] are all different" (F-SUZ-17). Ariel learned about both light and water needs. She wrote:

> I learned that most summer flowers need full sun but there is also some that just need minimal sunlight a day. The thing that was very interesting to me was that some flowers were drought resistant and they didn't need much water to survive and grow. (F-ARI-17)

Karissa and Molly learned about seasonal plants. Karissa wrote "I learned each flower has their own timing. There are summer flowers, spring flowers, and fall flowers" (F-KAR-17). Molly reflected "I learned that certain plants and vegetables grow in different seasons. I thought you could plant any type of flowers and vegetables any time you wanted" (F-MOL-17).

One of the suggestions made in planning the garden was to look at plants that could be grown together. Several of the students commented on learning about these companion plants. Blanche noted the space and light requirements stating, "we can plant tall plants like corn next to a plant like watermelon that need a lot of sunlight" (F-BLA-17). Manuel noted a change in taste that can occur when certain plants like tomatoes and peppers are planted next to each other (F-MAN-17). This was a topic Tabitha spent a good amount of time on in Team Calcium and she provided a detail of her learning on the final. She wrote:

> Carrots cannot be paired with tomatoes, although a lot of websites state that it is okay. One of the reasons is the carrots do not do well in soils rich with nitrogen. Well tomatoes need that extra nitrogen to be able to grow properly so if the carrots are paired together, then the carrots will have heavy green leafy tops and small carrots (F-TAB-17)

Problems in communication were covered earlier in the paper. However, the students in their final reflections recognized the importance of communicating. Blanche stated “this type of project requires a lot of communication and commitment. Some of the time my team members didn’t have either making it difficult to work on this project” (F-BLA-18). Bailey commented “I learned that everyone needs to be on the same page to accomplish a goal together” (F-BAI-18). Karissa expressed:

> working as a team can be challenging. Not everyone will want to participate. Not everyone has the same thoughts as you. Some students are in the class to actually learn and others are just there because they need to take it. When having a project this big, it takes a lot of communication and a lot of group meetings to see what we need and where we stand. (F-KAR-18)

Cynthia commented:

> I know that miscommunication happened so much during these past four months, but I do wish that for one, we all weren’t so busy with life and work and school. It was honestly so hard for my group to meet outside of class because our schedules were always off. [It] just got difficult to stay connected. (F-CYN-18)

A change in beliefs and gains in knowledge were observed for the students who participated in the project. Beliefs changed in what student’s perceived as the purpose of a garden with only ‘as a food source’ remaining in the pre-project and post-project categories. Students did self-recognize gains in knowledge in several areas but they also gained a better understanding of social skills. After the project, students were asked if they would ever have a garden of their own. Their responses to this inquiry have been shared in the next section.

Willingness to Garden

After the project, the students were asked about whether or not they would have a garden of their own. Most commented they would when they were older. A few claimed they would not personally but supported those who wished to have a garden. Two of the students were against having anything to do with a garden.

Jacob stated during the first in-class discussion "I don't dabble in gardens" (R-1-Pb-JAC-30) and reflected, as mentioned earlier, that most of the female elders were the ones who gardened. His initial attitude carried in his reporting during the sixth in-class discussion when reporting on community member surveys. He stated "most of the people that did see interest in [a community garden] were women. Most men said they probably would not be spending their time in a garden" (R-6-Pb-JAC-6). On the final, Jacob wrote "I probably wouldn't be looking to have my own garden anytime soon. It really isn't something I am interested in doing" (F-JAC-1).

While some students stated they would not have a garden, the students were supportive of those that could. K'Lan noted:

> At the beginning, I didn't really have high hopes on learning about plants and gardens. I had my mind set that I wasn't going to enjoy learning about different plants, fruits, and other things that are grown in a garden. My views have changed now that this project is over. I probably will never grow my own garden simply because it is not my thing nor do I have the patience for it. However, I do see the beauty and purpose in garden (F-KLA-1)

Patience was also the reason Tabitha gave. She stated:

> I probably will not ever grow my own garden unless I absolutely have too! I do not have the patience to grow a garden or the time to maintain one. I do definitely have a new-found respect for people who do grow their gardens. (F-TAB-13)

Ariel also commented on a change in her attitude towards garden. She stated:

> My first thought of people gardening was like me thinking "why do people like to do that?" I thought it was just a waste of time. But now I do not think like that. I think that people can benefit to garden in many ways … I would not like to have a garden of my own because I feel like I would not have time to take care of it as I should. The garden would probably die on me as I am busy most of the time. (F-ARI-13)

Alexia (F-ALE-13) and Tania (F-TAN-13) both commented about currently having gardens and using the information form class to better maintain their gardens. Blanche stated, "I would have a garden of my own, now that I know the processes of creating a garden, it will be a lot easier to have one" (F-BLA-13). Cynthia was getting married the last week of class and commented "I honestly am thinking of starting my own garden when [fiancé/husband] and I have our own house because I know that it is going to benefit my family" (F-CYN-13).

Several students that thought they would have a garden, felt that it would be later in their lives. Suzanna stated, "I personally would not have a garden now but maybe in the future when I have time" (F-SUZ-13). Jaclyn noted

> my point of view has changed a lot because I honestly thought that old people were really the only ones to garden at first but I realized that gardens can be a learning experience as well as a community project. When I have kids, I am going to have a garden so I can teach them about agriculture and what you can achieve when you work hard for something (F-JAK-13)

Karissa commented "I think from what I have learned I would plant a garden later on in life. I actually want to test out some composting items to see how good they work" (F-KAR-13). Irene was more committed to the idea stating "I would like to have a garden at some point in my life when things calm down. My garden would consist of vegetables and herbs. Lots of herbs" (F-IRE-13).

Overall most of the students reported they would have a garden. The idea that gardening was something that 'old people did' as reported in the pre-project beliefs was no longer present. Most of the students who claimed they would not have a garden of their own did claim a deeper understanding of gardening and supported those who chose to have a garden. The students in general were glad to have engaged in the garden project now that it was over and having gained more knowledge. Some of the favorite parts of the projects were the tiny details that they struggled with during the project.

Summary

The students in this project had limited knowledge of gardens. The students in general believed gardening was something old people did to pass time, to watch something grow, were for food, or to save money. The students were also initially split on what they believed constituted a garden with about half thinking vegetable garden and about half flower garden. The students were not knowledgeable on additives to improve the soil and only partly were able to gather additional information from their interviews.

The collaborative intent of the project was not observed to the full extent. Some social interaction and learning did take place. However, the students tended to move to cooperative approach to the project instead of building from each other's backgrounds and information gathering to create a cohesive project. Several problems did emerge within the groups from one member taking complete control and doing most of the project to a member not contributing at all.

The groups deciding to communicate outside of class or using other Google Docs did prevent the instructor from doing a complete analysis of the group interactions. While

the project was designed to provide access to several people (e.g. community members, family members, faculty) for the groups to use as resources, the majority of the students chose to look things up on Google. The class experiments, discussions, and lectures that were designed to go along with this project were seldom incorporated by students into the project design. The students did share prior knowledge and experiences during the discussions. However, a lack of transfer of this information into the final project was also noted.

A change in beliefs about the purpose and benefits of gardens developed from the group interactions. The students no longer looked at gardening as just something to pass time, but believed the mental and physical health benefits along with supplying food were top benefits of gardening. The students did gain knowledge related to gardens from the social interactions as well as class instruction.

While not fully utilized during the project, the students did report recognizing the value of communication for this type of project. The majority of the students also expressed an interest gardening at some point in the future.

CHAPTER 5

DISCUSSIONS, IMPLICATIONS, AND CONCLUSION

This study followed 22 students who completed a class project to create a proposal for a community garden. The students were enrolled in a freshman level chemistry course for non-majors at a small, rural community college in the mid-west United States. The students were divided into heterogeneous groups by the instructor using athletic involvement and math level completion as contributing factors in assigning groups. The community garden topic was used within a Project Based Learning (PBL) instructional method for the course. A PBL approach involves active learning, is student driven, and has a constructivist approach to learning (Krajcik, 2015; Krajcik & Blumenfeld, 2006; Savery, 2006; Savin-Baden, 2000). While the project, the community garden proposal, was the final outcome of this class, the social interaction the groups engaged in was the primary focus for this study.

This study used sociocultural theory for the framework. The community garden project needed the students to build on their individual backgrounds and through interaction with others (e.g. peers, gardeners, family members, teachers) to expand their procedural and conceptual knowledge. This student development followed the idea of Vygotsky's (1978) zone of proximal development within sociocultural theory as the difference in a learner's independent task performance and his or her potential performance with assistance from others. Learning is a lifelong process that can be assisted by others at all ages (Rogoff, 2003; Wennergren & Ronnerman, 2006). The

community garden project required this social interaction in order for the students to complete the proposal.

This research involved a qualitative case study using the sociocultural framework. Merriam (1998) defined a case as "the product of an investigation [that] is an intense, holistic description and analysis of a single entity, phenomenon, or social unit" (p. 34). The case must also be bound for a study (Merriam, 1998). The bounds in this study were the groups enrolled in the class and completing the project. The groups interacting throughout the project met the definition of a case while requiring social learning as expected in the framework.

Using a community garden as the theme for this project allowed for some prior familiarity with the topic. The theme thus allowed for investigation of how the students' prior beliefs, values, and preferences might influence the collaboration process in designing the proposal and identifying instructional needs that would support the social learning throughout the project. This study evaluated the interactions that occurred within the teams over the semester long project with the following questions in mind:

1. What prior beliefs and knowledge to students have about gardening?
2. How does group interaction influence the process and design of a community garden project?
3. How do students' beliefs and knowledge about gardening change through participation in a garden related project?

There were numerous data sources for this study. The students were involved in 10 in-class discussions, conducted interviews of family and community representatives,

and had consultations with instructor on progression of project. Recordings were made and transcribed of each teams' in-class discussions and the formal consultations with instructor. The students also maintained a weekly reflective journal through the classroom management system (i.e. Canvas), participated in on-line discussions, had an investigative notebook, and student artifacts created for class related to the project. The instructor was also able to interview four of the students after completion of the class.

Merriam (1998) noted that in case studies the researcher needs breadth and depth of data through conducting interviews, observing, and analyzing documents. The instructor of the course was also the researcher for this study and met with the students every weekday for 16 weeks. This prolonged engagement allowed the instructor to make real-time, after class, and reflective observations throughout the study. Formal interviews were conducted both between students and instructor and students and community or family members. Informal interviews were collected through the in-class discussions, class interactions, and open-ended questions on student artifacts.

Data for the study were analyzed using a constant comparative method. This process started with the in-class discussions since the primary focus of this case study was to evaluate the sociocultural interactions of the group members in completing the project. Open coding was implemented with the transcription of the first in-class discussions and codes compared and reevaluated before the next transcriptions were analyzed. When new codes stopped emerging, rules of inclusion were developed. Other data sources (e.g. student journals, researcher journal, class artifacts) were then analyzed

using these codes. A summary of the findings has been included in the next section. A more in-depth analysis was covered in Chapter 4.

Major Findings

The analysis of the study followed a chronological order through the semester as students worked on the project and in alignment with the research questions. Thus, the analysis was divided into pre-project, during project, and what students self-reported learning through the project both during and after completion. These are summarized in the following sections.

Pre-project

The pre-project analysis started with collecting information from students about prior experience with gardens and identifying potential people they could use for personal resources throughout the project. The majority of the students were familiar with at least one family member who gardened. Only two of the students in the class were not able to identify someone they knew that had a garden. Although one of these, Alexia, stated her dad had a garden at the very end of the project. Only a few of the participants indicated a personal experience with gardening.

The garden project was introduced in week 5 of the course. Class assignments and discussions in the first four weeks were used for the pre-project analysis. The categories that emerged in the pre-project analysis were garden type, reasons for a garden, knowledge on terminology associated with garden classification, and soil additives.

A garden was never defined by the instructor but was left for the students to identify. The students were about evenly split on a garden being either vegetables or flowers. Only three students identified other types of gardens including herb, Japanese, and rock. A few students identified gardens as being a combination of flowers and vegetables.

The reasons a person might garden fell into four themes: time, food, self-gratification, and cost. The students felt gardening was something older people did to pass time because they had nothing better to do. The students recognized gardens as being a source of healthy food for some people. The idea that some people garden just for the satisfaction of watching something grow or being able to eat something you produced yourself also emerged. While the theme of cost did come up through the conversations, both sides were represented. Some students believing that growing your own food would save money while others thought it would be more expensive.

Gardens have often been classified by purpose through periods of U.S. history. Most students were not familiar with the terms of vacant lot, victory, or community garden. Some students were able to relate to a school garden. A community garden also being a vacant lot, victory, or school garden was discussed in the lecture.

The fourth category in the pre-project analysis was additives people add to enhance the soil. While some of this data was presented from the students' perspectives, this was also reported to the groups from the individuals the student interviewed who had a garden. The students then planned an experiment to test claims of how the additive

affected the soil. This investigation was one of the items that led into the semester assignment and the interactions during the project are summarized next.

Group Interaction During Project

This study was designed to examine how students socially obtained information and incorporated these new concepts into the community garden. Overall within the groups there was a lack of collaboration; the groups tended to want to work in a cooperative manner and would assign sections of project to different members. The teammates then would add their parts to the document without much discussion taking place.

Several categories emerged as to why there was not better communication within the groups. For some groups, there was a dominating member that tended to control the in-class meeting conversation. This individual either responded to all the questions or rattled off quick responses to the discussion prompts and moved on without the entire team discussing them. Several team members also seemed to be absent from the conversation even though they were physically present. This was the result of being on phones, chatting with people in other groups, or not participating in the dialogue.

Other issues that impacted the groups' ability to fully collaborate involved some students not completing assignments. These could have been articles the students were to read, particularly for the next in-class discussion, or interviews they were to conduct and report back to the group. Without this information, the students were not able to communicate ideas with their teammates and incorporate them into the project. An

overall attitude of procrastination also kept many students from fully completing the community garden proposal.

The students had multiple sources of information available to them. These included the gardeners they interviewed, instructors on campus, peers at the college, local garden experts in community, and results of their own investigations in class. However, the students chose to complete most of their project from information available on-line.

Learned from Project

While students did not fully utilize collaborative methods and their social resources, the students did report gains in knowledge and a change in beliefs about gardening. The students' recognized gardens as having both physical and psychological benefits for those involved. The belief in a garden being for food did remain, but there was more recognition of providing healthier food choices. The students also believed that gardens provided a place for social interaction.

Students self-reported a better understanding of composting, determining soil requirements for various plants, learning about companion plants, and recognizing the variety in garden types. The students also recognized a need for more communication among the team members and not procrastinating in their post-project class assignments and interviews.

Discussion

This study focused on answering three questions using a sociocultural framework that involved prior beliefs and knowledge, influence of group interactions during the project, and changes in beliefs and knowledge as a result of participating in a garden

project. A discussion of the findings concerning these three questions has been presented in the following sections.

Prior Beliefs and Knowledge

Research question one concerned the students' beliefs and knowledge prior to starting the project. The study captured information that included both the students' personal beliefs and knowledge as well as what had been acquired from their one interview of a gardener before the project started. Capturing both perspectives was important to understand what the student might bring into the team discussion and possibly the project. Beliefs and knowledge are covered separately in the next two sections.

Beliefs. This study captured two main categories on students' prior beliefs about gardens to address the first research question. The first belief was what constituted a garden and the second belief addressed why people garden. The first belief emerged through an analysis of what the students in this study thought would constitute a community garden. The students' beliefs as to the purpose of a garden could influence the design and was important to capture for this reason.

The students in this case study generally believed gardens as comprising a single classification of plant, primarily vegetable or flower. While some students were general in their comments, a few shared specifics about the gardens of those they interviewed. Nate mentioned his mom's love for Chrysanthemums (R-2-Ca-NAT-38). Suzanna noted that her grandparents grew jalapenos among other things (J-SUZ-13). Dallas commented about all vegetable gardens having tomatoes since it was a basic staple (R-5-Ni-DAL-55).

Tomatoes were also included in the list of vegetables reported by Cynthia, Jacob, Irene, Patty, and Suzanna.

Only three students mentioned a garden other than a vegetable or flower. Mary expressed wanting to have a Japanese garden, Tania described a herb garden, and Baily noted the wide array of possibilities. Patty, Ariel, and Blanche commented on more than one category of plants could be in a garden.

In translating their beliefs about gardens to the final project proposal, multiple categories of plants were prevalent in the teams' designs. Only Team Aluminum proposed an all flower garden. The dominant person in this group, Mary, stated in the beginning "I think people like flower gardens better" (R-2-Al-MAR-61) and it is possible her beliefs influenced the group in this direction. The other teams all proposed combinations of fruits, vegetables, flowers, and herbs. However, based on the findings of this study, this variety of plants was more of an issue of including the minimum 40 varieties to meet the assignment rather than addressing community needs or personal preferences.

The second belief was what would be the purpose of having a garden. There were four purposes identified: pass time, food, self-gratification, and cost. The students in this study believed that gardens were something old people did to pass time or as a hobby. The students referred to gardening as "old-fashioned" (J-SUZ-13) or something done "back in the day" (R-4-Mn-BLA-22; R-2-Co-PAT-101). The students believed gardening was not something in which their generation would be involved. Jacob even went farther to note that gardening was something "the female elders in the family" engaged. Most of

the gardeners used for the interviews in this study were mothers, grandmothers, aunts, or a female acquaintance. Jacob also carried his belief through the project noting in his surveys of community representatives that the men were not keen on helping with a community garden. Jacob also stated post project that he would never have a garden. Facovicova and Prokop (2011) found that females did have better knowledge of plants but exhibited a less positive attitude towards plants during an outdoor educational program.

A second belief concerning the purpose of the garden was as a food source. Several of the students claimed the gardens produced chemical free food but from the students' reports back to their teams only one person interviewed grew a garden for this reason. Using gardens for providing fresh, healthy food was the focus for many studies on gardens (e.g. Gorneau, 2016; Manase, Nkuna, & Ngorima, 2009; Roubanis & Landis, 2007). Some researchers have reported on gardens providing food for lower-income families (Adelman & Sandiford, 2007; Flannigan & Varma, 2006). Carney et al. (2012) reported a garden provided more nutritional food for temporary farm workers. Therefore, the emergence of this theme of the purpose of a garden is to provide food was not unexpected. However, the food source theme was the only pre-project belief that carried through to the post-project beliefs on uses of gardens by the students in this study.

The belief of self-gratification that emerged from the students involved in this study has been considered as speculative in nature by the researcher. A belief held by a few of the students was that gardeners liked to watch something grow. As Tabitha stated "I think it is just the mom in her. She just likes to make things grow and nurture them"

(R-2-Ca-TAB-26). Other students noted that there was something gratifying in eating something you had grown yourself. Some of the students thought growing gardens was to make something like your yard or house look better.

The last belief was the cost of gardening and students expressed beliefs that were on both sides of the issue. Some students believed people gardened to save money over buying from the grocery store. Tabitha even shared that her grandparents went through the Great Depression and had to grow their own food since they could not afford to go to market. Other students focused on the short-term cost versus long-term stability. Jacob noted that gardening might be cost-effective in bulk but not for small amounts (R-1-Pb-JAC-48). Mary focused on the cost of purchasing soil versus buying food directly (R-2-Al-MAR-243). While cost emerged as a category in the prior beliefs, no team incorporated the cost of the garden in their final proposal.

The two beliefs of why people garden and what constitutes a garden also did not transfer to the final projects in this study. The community garden proposals tended to encompass multiple categories of plants rather than the singular (e.g. vegetable, flower, herb) many associated with gardens in the beginning. The belief of gardens as something for old people did not show up at all in the final projects. The belief of the cost for a community garden also did not appear in the final proposals. However, the belief of using the garden for a food source was integrated into several of the final proposals in this study.

Knowledge. Two areas were examined for pre-project knowledge. The first was recognition of terminology and the second addressed additives people add to the garden's

soil. Community gardens have served many purposes over the last 130 years. Sometimes the gardens have been called by a specific name based on that purpose. The students in this study were evaluated for their knowledge on what a vacant lot, victory, school, and community garden were. Most of the students did not know the applications of these types of gardens. These types of gardens were then covered in the class curriculum in preparation for the project.

Identifying the additives people might add to soils allowed for students to plan an investigation that could be used in helping with the final project. The soil additive information was obtained from both group discussion and gardener interviews. While the students did identify some soil additives (e.g. coffee grounds, eggshells, coconut water, Epsom salt) they often did not identify the purpose of the additive. A few that did mention the purpose (e.g., Epsom salt for sweetness or beads for water retention), did not test for those properties. Many of the students noted that people added fertilizer or manure to the soil but did not recognize these as soil additives.

Six of the 9 groups mentioned soil additives in their final proposals. However, the information presented was generalized from an Internet research and not from either their laboratory investigation or interviews. However, the idea of what to search for on the Internet cannot be ruled out as having come from these sources as this was not specified in the project proposals. The lack of transfer of information from the class activities and discussion to the project has been noted under the discussion of project development, which appears later in this chapter.

Group interaction

The second research question looked at how the group interaction influenced the process and design of the community garden proposal. In this study, there was a problem with the students' motivation, collaboration, and completing project.

Motivation and procrastination. Gardening, as mentioned earlier in this chapter, was believed by the students to be something for "old people." This disconnect initially caused some lack of interest in the project. Skinner and Chi (2012) observed students were relatively engaged in garden-based learning but recommended for future studies to evaluate the sense of relatedness or belonging in the garden. As Knowles (1980) pointed out a characteristic of adult learners included being more motivated by internal rather than external factors. Graham, Beall, Lussier, McLaughin, and Zidenberg-Cherr (2005) found that of the gardens used in education, only 11% were at the high school level indicating there is little exposure to gardens for college age students. In this study, the students showed an initial disinterest in the project that could be attributed partially from a generational disconnect. While their attitudes did change as the project progressed, the initial disinterest in the topic could account for some of the reluctance to fully participate.

Other factors (e.g., involvement in school athletics, work schedules) contributed to the students' lack of completion of assignments in a timely manner. For many of the in-class discussions, the attendance of all teammates was rare. In fact, all the students were present only for the very first discussion (see Table 4.3). The external communication needed to keep everyone up to date on the project was not observed in most of the groups in this study. Karissa noted "I am never here so I don't know what is

going on half the time" (R-5-Cu-CYN-202). Blanche stated "I don't know what you guys talked about. I wasn't here" (R-8-Mn-BLA-101). The absences then became a reason for not having to complete work even though all homework was available 24 hours a day through the CMS and the class met every weekday. There was ample time to acquire notes from classmates between the in-class discussions.

The students lack of completion of assignments between in-class discussions negatively contributed to acquiring the knowledge needed for project completion. Mary from Team Aluminum noted "we didn't fully get to that part yet." Blanche in an in-class discussion stated "I did nothing. So move on to the next question" (R-4-Mn-BLA-8). Skinner, Braunack-Mayer, and Winning (2015) noted that exchanging information was observed as a vital component in completing PBL projects. The students in Skinner et al.'s (2015) study reported that "adequate contributing at any stage was related to providing information and knowledge" (p. 27). In this study, the lack of completion of homework did not allow for the full sharing of ideas. Lee, Huh, and Reigeluth (2015) also observed members not doing their part of a PBL project. The authors referred to this as 'social loafing' in their study. The researchers noted that "social interdependence theory suggested that lack of individual accountability may reduce feelings of personal responsibility, and accordingly social loafing behavior increases" (Lee et al., 2015, p. 578). Frank and Barzilai (2004) concluded that PBL immersion resulted in an increase in motivation and responsibility, but this was not observed in this study.

A portion of the graded assessment for the project included an individual score. However, this grade came at the end of the course. There was not any intermediate

grading through the project just formative assessments and mentoring by the instructor. A summative grade was given at the end of the project. While the lack of a formal individual grade throughout the project development portion may have contributed to not completing work, the lack of work completion also limited collaboration.

Minimal Collaboration. Collaboration is an essential component in PBL for the groups to create a finished project (Bell, 2010; Krajcik, 2015). However, in this study, the students tended to follow a more cooperative approach to most of the project by dividing sections among teammates. Skinner et al. (2015) concluded that most students in their study "focused on knowledge gain and obtaining information and answers, rather than learning in and from the group and PBL process, such as discussing uncertainties" (p. 27). Similar group interactions were noticed in this study, with teammates choosing to divide up gathering information for the project.

Visschers-Pleijers, Dolmans, de Lang, Wolfhagen, and van der Vleuten (2006) found that 80% of group session time focused on the content of the learning task. However, they assigned roles to members of the group, a practice which Matthews, Cooper, Davidson, and Hawkes (1995) found contributed to students moving towards cooperative interactions. The students in Visschers-Pleijers et al.'s (2006) study spent two-thirds of their group time on statements of information and cumulative reasoning with much less time spent on exploratory questions. Similarly, in the current study, groups did meet for 10 in-class meetings during which the teammates mostly shared information and only occasionally discussed additional information or components to enhance their garden proposal.

Groups of three were used for this study to help bring the multiple backgrounds to the project. This number is supported by findings from Apedoe, Ellefson, and Schunn (2012) who concluded that diversity of thought, intellectual backgrounds, experiences and viewpoints was best with groups of three or four in general classes. However, in this study a dominant individual tended to take over discussion and influence the project. Barab et al. (2000) noted pairs tended to work collaboratively while one member tended to dominate in groups of three. Dominant members were noted in five of the eight teams. In some instances, the dominant member limited the discussion that took place during the in-class discussions and thus hindered collaboration. For example, in the case of Team Aluminum, the dominating person controlled the direction of the final project.

Project Development. While the lack of collaboration among the groups did not allow for the full utilization of the sociocultural experiences and knowledge of the participants, some of the exchanges did help develop the proposal while others were ignored.

Some of the elements of the final design emerged from ideas of the individuals within the teams. Jaclyn suggested the seasonal plants for their group and Patty proposed a section of fake plants for children to play. Dallas' research on composting methods led to Team Nickel's garden layout. Mary's initial belief that people preferred flowers drove a change to the final proposal to a strictly botanical community garden.

Some prior experiences that were present in the social exchanges among the groups were not incorporated into the final project. For example, several of the individuals noted different varieties existing among a particular species of plant.

However, the final garden proposals of the groups with these individuals only contained the species without an identification of variety. Bailey from Team Iron and Kate from Team Aluminum stated that they did not want to create conflict and just let their ideas be ignored. This went against the sociocultural learning that the project required.

Although the gardening project was designed to involve the social construction of knowledge from multiple sources, the students chose to merely relay information from their online research into the final proposal. Participants in other studies have also viewed community members as having limited resources and were not fully utilized in community gardening educational programs (Langhout, Rappaport, Simmons, 2002). Clayton (2007) noted students' primary source of information was the Internet. However, in her study students reported garden center and state agriculture research and development centers as closely following as information sources. In this study, two groups did mention using garden centers as information sources but there is no evidence that they followed through to visit. Many of the students noted the division of information gathering, a practice which supported the method of cooperatively producing the product. Following a cooperative approach limited the scope of the community garden proposal and application to their specific community.

Many of the teams waited until a couple weeks before the due date to seriously start compiling major parts of the proposal. Cortez noted they procrastinated until about two weeks before the project was due. Tabitha from Team Calcium and Kate from Team Aluminum both commented on their teams slacking off until last minute. Hou (2010) also noted an increase in activity among the group dialogue the last few days for online

students doing a project. He also concluded a reason for this was students often procrastinate about their studies.

A Google Doc was used to collect the teams' work and document individual member contributions. This did not encourage all members to participate as a tool of accountability. Lee et al. (2015) indicated the need for participants to have a means of checking in with each other and each member's progress. Some students in this study did recognize the Google Doc as a communication tool and a way of checking on members. However, the use of this tool in the course did not overcome the procrastination.

This study sought to study the impact of the group interactions on the design of the project. Almost all of the teams in this study (7 out of 8) did not complete the project. This was partly due to a lack of collaboration and lack of incorporation of socially gathered knowledge into the project. While the group interactions did influence the type of community garden and some select features, the contributions from the individual group members were not fully addressed. Whether this is a matter of procrastinating and pushing to finish at the last minute or actually the lack of using individual experiences and knowledge to enhance the project cannot be determined based on this study.

Learned from the Project

The third question in this study concerned what changes in beliefs and knowledge students might gain from participation in a gardening project within a freshman, chemistry class. While teams did not fully complete the project, the students did report gains in individual conceptual knowledge and skills. Some knowledge was socially learned through interactions with teammates. Most studies on PBL instruction have

looked at the gains in conceptual knowledge or disciplinary knowledge (e.g. Bilgan, Karakuyu, & Ay, 2014; Frank & Barzilai, 2004; Wilhelm, Sherrod, & Walters, 2008).

The students in this study reported an increase in understanding of knowledge areas such as composting, soil nutrient requirements of plants, light requirements of particular types of plants, types of gardens, and companion plants. This finding was consistent with similar studies. Wilhelm, Sherrod, and Walters (2008) reported increases in mathematical understanding. Jollands et al. (2012) reported students perceiving gains in interdisciplinary knowledge associated with engineering.

The students also reported gains in skills or recognition of the importance of skills. Primarily this was reported by the students in the need to communicate and work more effectively as teams. All the students interviewed post-course indicated recognizing a need for better communication. Jollands et al.'s (2012) as well as Bilgan, Karakuyu, and Ay's (2014) reported on improvement in communication skills from using a PBL approach. Even though in this study communication was not utilized to the fullest extent, the students were able to gain value of the importance associated with this skill.

Changes in Beliefs. Students attitudes towards gardens did change during the project. At the end of the project all but two of the students in this study stated they would either have a garden or would support those who had one. Genc (2015) observed an increased positive attitude towards environment through use of PBL. The pre-project beliefs on why people garden changed over the duration of the course, with only the belief of gardening as a food source remaining at the end the course.

The students began to look at gardens in general as promoting a healthy lifestyle. The students reported gardening as providing exercise, relieving stress, and improving mental health. This finding is in agreement with gardeners who reported spending time outdoors, relaxation, and working with their hands as reasons for gardening (Clayton, 2007). The students also believed food from a garden could be more nutritious and healthier than store bought produce. Carney et al. (2012) showed an increase in the health of the participants in their study who were involved in a community garden. Carney et al. (2012) specifically noted stress reduction, increased relaxation, and self-confidence. Poulsen et al.(2014) reported an increase in physical and mental health of their studies participants.

Gardening as a food source remained a belief of the students throughout the project. The garden as a food source has been the most commonly studied theme (e.g. Bahng, 2015; Flannigan & Varma, 2006; Lawson, 2005). The students in this study were also exposed to cases where the community garden was used for cultural foods and medicinal plants. However cultural varieties of food plants were not included in the final proposals. Thus, a garden was viewed as providing food in general terms by the students.

After participating in the project, the students in this study also believed gardens could be social centers. The creation of social bonds has been reported in other studies (Firth, Maye, & Pearson, 2011; Poulsen et al., 2014). The community cleanup and social interaction was reported as the main driving force for the creation and longevity of many community gardens (Kurtz, 2001). The social nature of gardens has been used for

instructional studies as well (Dorrel & Berkeishiser, 2014; Ruiz-Gallardo, Verde, & Valdes, 2013). This belief of the garden as a potential social center is thus in agreement with the literature.

Changes did occur in students' knowledge and beliefs through involvement in the community garden project. Whether the changes occurred as a result of the social interactions or through normal studies is inconclusive based on this study.

Implications for Practice and Future Research

This study captured pre-existing beliefs on why people garden. The students reported a belief that gardening is something for 'older people' and was not relatable to the age group of participants in this study. The review of literature has shown most studies have focused on younger students in formal educational settings or individuals who already show an interest in gardening for informal education. This points to a need for greater communication and community education about the potential for community gardens prior to implementation with young adults.

The findings of this study provided some insights on group interactions and how they might be used for development of project. The students in this study demonstrated challenges that are faced by instructors and team-members in a group project. While some group interactions contributed to some details of the project, other socially shared experiences were ignored. Additional studies should focus on evaluating methods of communication and type of information exchanged in developing a semester-long project.

The review of the literature has shown that PBL instruction often leads to an increase in knowledge. The findings of this study illustrate the need to identify the method of learning during a PBL project. Does learning occur through being able to associate concepts to society on an individual basis or does learning occur through group interactions?

This study was to look at the group interactions during the process of completing a project using PBL instructional method. Overall the teams demonstrated procrastination and a lack of motivation, which resulted in most teams not completing the project. This finding suggests some potential changes for the instructional side of this study. First, having students reporting to community members periodically instead of at the end of the semester could be utilized as a motivating tool. This suggestion has also been supported by the findings of a study by Robinson (2013) where students reported their engagement in the project with real clients motivated the students during the project.

Second, student groups should design a 'consequences of a non-contribution' contract at the beginning of the project. This would be a smaller project associated with the larger that would allow the students to practice collaboration skills. This could also be used by the instructor as a means of determining whether additional collaborative scaffolding assignments are needed. This would potentially motivate students to stay engaged throughout the semester in contributing to the project.

The findings of this study also suggested some areas for further investigation. First, what are the beliefs of members of the general population on why people have gardens? As well as what do members of the general population believe is considered a

garden? Understanding these two areas would be beneficial for both formal and informal education. Second, a similar study should be completed with science majors. This would allow for a comparison between science and non-science majors in terms of motivation and integration of socially acquired knowledge and experimentation into the project. Third, future research should follow a select few students through a semester long project in an ethnographic focused study. This type of study would potentially add to the literature by capturing the challenges and benefits as seen by an individual participating through the process.

Conclusion

The findings of this study demonstrate the difference between theory and practice concerning PBL instruction. The initial beliefs of students concerning what the benefits of gardening and garden type were captured. The pre-project discussion also revealed an age disconnect between this group of students and gardening in general. The cultural integration of the Internet as an information source was shown to be preferred over social acquisition of knowledge from teammates, community members who gardened, or gardening centers. Even when exposed to valid information from teammates or community members, the garden related concepts seldom made an appearance in the final project presented. Although some components of the project did develop from the group discussions, the final group project consisted of parts of the proposal being completed by individuals and shoved together to meet the minimum requirements rather than a cohesive proposal created from collaborative dialogue. In response to the third question, and in agreement with what has been reported in the literature, students did report gains

in conceptual knowledge, recognition of importance of skills, and changes in beliefs on reasons for gardens.

The class met every day and students had access to on-line communication through Google Docs. However, the students in general noted the lack of communication was a problem, which was magnified by the number of student athletes and other individuals who missed the class meetings. The significance of this study is that more attention needs to be paid to teaching students to communicate asynchronously and engage in collaborative conversations. As our society moves more to a digital exchange of information among teams that often are in different geographical locations, being able to communicate asynchronously will become a more essential skill.

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Appendix A

Week	Assignment	In Class discussion (Class time was scheduled within the course. These discussions were audiotaped.	Weekly Reflective Journal (submitted electronically by students by midnight every Saturday)
1		(Fri)Within your group share: - Your experiences with gardens - Who do you know that raises a garden? - Why do you think they have a garden? - What might they do special to prepare for the garden? - Develop an interview questionnaire for each member of the group to ask of a person they identified as having a garden.	- Critically reflect on what you learned over the past week - Reflect on your team's Friday discussion. How did you decide on your interview person?
2	- Students conduct interviews of family members/friends who garden. - Begin effect of environmental pollution on plants experiment (2 weeks for plant germination, then pollutants added over 4 week period) - Experiment over seed germination under different conditions	(Fri) - Discuss your interviews with group members. What did you find out in common? Different? - What were/are victory gardens, school gardens, and community gardens? What do you believe was the purpose for each? What social issues today might influence the creation of a community garden? - What additives do people add to the soil for plants? Why? - Which of these additives come from regular household items?	- Critically reflect on your experience over the last week. - Look up vacant lot gardens, victory gardens, school gardens, and community gardens. What do they have in common? How are their focuses different? What social issues today have resulted in the renewed interest in community gardens? - What did you learn about the varied purposes of gardens? - What were some common household substances that might be added to soil for composting? What is the claimed purpose for adding these substances?

		- How could you research additional soil additives and their purpose? - How might some of these additives help reduce household waste?	
3	- Lab on process of adsorption, soil pH, and Nitrogen, Phosphorus, and potassium (N-P-K) requirements of plants.	(Fri) - Discuss findings on items people add to soil and why. What claims are made about these items benefit? Which of these additives come from regular household items? How might some of these additives help reduce household waste? - What is composting? How does the information you found follow a composting style? What are the types of composting? - What are some of the purposes of community gardens? Does the intent differ from vacant lot, victory, or school gardens? - How can composting also be a means of recycling? What else could be recycled from waste into a community garden? - Design an experiment to be carried out in lab to verify the soil additive claims.	- Critically reflect on your experience over the last week - What new have you learned about the classifications of gardens (i.e. vacant lot, victory, school, community)? How were the purposes similar/different? - What did you learn about gardens in general? About their societal associations? How can household compost be used in maintaining a garden? Etc. - What are the types of composting? Which would work best in a community garden?
4	- Begin soil manipulation	- None scheduled this week due to an Exam	- Critically reflect on what you learned over the past week

	experiment (ongoing for duration of project) - EM spectrum discussed (e.g visible, UV, gamma)		- What are your expectations for your soil lab experiment? - Were changes made to the experiment from the original plan? Explain.
5	Assigned Readings: - Smithsonian online exhibit on history of community gardens - Heritage plant preservation as purpose of community garden - Perceived benefits of community gardening Semester Garden project introduced Online discussion of chemicals that are beneficial for human health and plants sources of these chemicals	(Fri) - Discuss the Smithsonian online exhibit on the history of gardens. - What have you in the past claimed as the purpose of gardens? - Discuss the other articles you read this past week and identify how the purpose of the gardens within these articles meets your prior definition or compliments your definition. - What are your initial thoughts for a community garden? - What are differences/similarities between fruit/vegetable gardens, botanical gardens, apothecary gardens, heritage, and herb gardens? - How do greenhouses and cold frames aid in plant growth? - What parts of the EM spectrum are involved in plant growth? - Is this the same for various types of plants? Explain.	- Critically reflect on what you learned over the past week - Provide an update on your garden project. - Elaborate on discussion of ion sources from plants and their needs by humans - Discuss the online exhibit from this week's readings - We have been looking at the different classifications of gardens (e.g. vacant lot, community, school) and are now looking at types of gardens (e.g. herbal, fruit/vegetable, heritage). What are some examples of each type, or combination of types within respect to community gardens? - How are parts of the electromagnetic spectrum utilized by different plants? - Expand on your definition of compost types and the chemical process of composting. By next week your team should be able to write a 2 to 3 page summary on this topic. - Discuss the readings for this last week. - What is the function of greenhouses and cold frames? - How do you think the information from this week could be used in planning a community garden?

6	- A day was spend introducing how to use Google Docs for collaboration while visiting the online Cambridge Botanical Garden. - A day was spent on redox reactions in nature. This included groundwater iron deposits, cellular respiration, nitrates in water from fertilizers, anaerobic decomposition Based on results of prior week, assign readings over: - Prior week's readings weren't done by most and told to finish for this week - Solar powered irrigation of rain water. - Geothermal warming of plant beds	- No in class discussion was done because all three sports teams were gone for games on the scheduled discussion day.	- Critically reflect on what you learned over the past week - Provide an update on your garden project. - Provide an in-depth review of the articles you read last week and discussed with your team. - What were some of the plants at the Cambridge Botanical Garden used for? - Work with your team on our collaboration page for the composting section.
7	- Instruction and labs covering corrosion and surface modification.	(Fri) - What are some essential nutritional elements and compounds needed by humans? What were the results of too	- Critically reflect on what you learned over the past week - Provide an update on your garden project. - What are some social/cultural applications of surface modifications

	- Online discussion of environmental erosion of statues, bridges, and buildings. A second part of this discussion dealt with conservation of historical artifacts made of metal, stone, etc.	much or too little? What plant sources can these be found in? - What is your target population in the neighborhood for your community garden? - Develop a questionnaire/survey for your target population. - How will your questionnaire and own research be used to help determine what type (or combination of types) of garden should be presented? What types of plants to incorporate? - What stage is each team member at in putting their initial thoughts on your Google Doc page regarding composting? - Discuss the teams progress or future progress towards the semester garden project - Develop a plan next week to research solar rainwater systems and geothermal heating? (note: keep this in your research composition book along with your earlier research on cold frames and greenhouses)	- Explain chemically the decomposition of limestone. - What differences/similarities exist in chlorinated water, acid rain, and natural rain water? How does each impact plant growth?
8	Assigned reading over plants as natural insecticides.	No discussion due to Exam	- Critically reflect on what you learned over the past week - Provide an update on your garden project.

			- Report on surveys/questionnaires administered that you developed in last Friday's discussion day.
9	-online discussion of what soil nutrients are best for a vegetable garden and why? (Team's chose this week's discussion topic)	(Tue) - Discuss the results from your survey or questionnaire with your representative community members (each person needs to include the responses you gathered as Appendices in the back of your Google Doc with the name of the person that collected that set.) - Based on your questionnaire/survey what type of garden does your target population want? - What is the purpose of the garden they indicated? - Use these results and your information from earlier discussions on benefits of different types of plants to start planning the content (e.g. plants, landscape features) of your garden proposal. - What does your group need to do next in writing up your proposal (the composting section should be done and probably started the benefits of a community garden section based on your own	- Critically reflect on what you learned over the past week - Provide an update on your garden project. - Reflect on how your group decided on the type of garden. Was it a single type of garden or combination of types (think back to the fruit/vegetable, herb, botanical, heritage, etc.) - How will the plants to be included be decided upon? - What did you learn from your survey/questionnaire?

		research and feedback from surveys/questionnaires)	
	Spring Break		
10	Lecture and lab on solar cells	(Fri) - Based on consultations yesterday, discuss what you each thought about overnight and where the project needs to go next. - Discuss plant choices for the garden and how you are going to research chemical properties associated with them (e.g. soil chemistry, nutrients provided, aromatic chemicals) - Begin thinking about and discussing the garden layout (e.g. compost bins, containers, plots, accents). What you include is going to vary by group and the feedback you received from your population surveys/ questionnaires.	- Critically reflect on what you learned over the past week - Provide an update on your garden project.
11	Discussion of plant oils for soaps	(Wed) No discussion prompts were provided to students	- Critically reflect on what you learned over the past week - Provide an update on your garden project. - Explain the classes of oils. Which are good for soaps? What properties of the oil result in these differences?
12		Exam, graduate assessments, and two teams gone one day this week. No in class discussion took place.	- Critically reflect on what you learned over the past week - Provide an update on your garden project

			- What has been the contribution of each of your team members to the garden project? - What are your team's goals for the next week in terms of the garden project?
13	- Finish environmental pollution impact on plants lab - Online discussion on common classes of chemicals found in fragrant flowers and types of solar cells. (Team choice topic)	(Wed) - What does each member think the team has done well towards completing project over the last two weeks? What still needs to be done? - What chemistry was included in the composting section? - What chemistry has been researched in regard to other parts of your team's garden project? - What have you learned about gardens so far? - Develop an outline of parts of project to complete over the next week (Easter Break)	- Critically reflect on what you learned over the past week - Provide an update on your garden project - How is your garden going to benefit the community? - What new have you learned from your research during the garden project?
14		No in class discussion	
15	Groups will make final measurements on soil manipulation experiment.	(Fri.)- Teams were discussing final parts of the project and the presentation. Presentations were May 2nd and final paper turned in by May 8th. The original plan was to actually have various community members come in to hear the presentations but none of the groups had the full proposal to be at that level. Instead was changed that other groups were to give written feedback to the presenting group on what was done well	- Critically reflect on what you learned over the past week - Provide an update on your garden project - What did you learn by working on the community garden project? - How do you think your thoughts changed, if at all, about the benefits of gardening? - How will you use, if at all, the information you learned in this project in the future?

		and what they needed to add to the proposal. (Note: copies of these reviews were made and the originals given to the presenting group the next day, May 3rd)	
16	Presentations of complete proposal for community garden done on Tuesday. Other teams provided comments for improvement. Final document was completed by the following Monday. Individual research composition books submitted.		

Appendix B- Assignment instructions

As a representative of ACME chemical solutions, you have been hired to put together a proposal for the community of Harmony. The community is wanting to become more environmentally friendly and self- sustainable. They have asked you to propose a community garden plan that involves composting and reusing materials while meeting the needs of the community (which you will need to determine). The garden should have a variety of plants to provide for the community members. There are two locations for potential location: the rooftops of two adjacent apartment complexes or an old empty lot nearby.

Product: you will produce a report and presentation for the community members detailing the chemistry involved in various aspects of your planned solution. A written report of at least 15 pages will be provided along with a presentation to community members. The proposal must at a ***minimum*** include 40 different types or varieties of plants (note: brandywine, cherry and Beefmaster tomatoes would count as 3 different varieties), a section on the chemistry of composting and how to incorporate in soil, a section on chemistry of soil manipulation (e.g. pH, nitrogen, magnesium, iron, etc.), and a section on chemistry produced by chosen plants (e.g. nutrients, aromatics)

Composition book: you will keep all written notes and lab related investigations in your composition book. These will be handed in at the end of the semester.

Reflective Journal: You will have a reflective journal due every Saturday as part of the regular class work. ***One part*** of this journal should include a reflection on your group interactions in relation to this project, what you learned and how you believe this information might be incorporated into your project.

Collaboration page: Each group will have a collaboration page set-up using Google Docs. These can be accessed through Canvas. Use this page for discussion (asynchronous and synchronous) and to mutually construct your written report.

Oral recordings: All group conversations regarding the project shall be audio recorded. If meeting in class these will be on a digital voice recorder. If meeting outside of class, a member of your group may check out a recorder or record the conversation on a phone app that can be saved as a media player file.

These documentations are needed in order for the instructor to guide you when needed. This could be suggesting some other variables to consider or there may be a need to address a misconception that might lead you off track.

These documents will also be used in educational research in the field of project-based learning curriculum design.

Appendix C

Letter of Site Access

SEWARD COUNTY COMMUNITY COLLEGE
1801 N. Kansas Ave., P.O. Box 1137, Liberal, KS 67905-1137 620-624-1951 or 1-800-373-9951

Texas Tech University
Human Research Protection Program
Administration Building, Room 357
Box 41075 | MS 1075
Lubbock, TX 79409-1075

August 7, 2016

Dear Human Research Protection Program Committee,

This correspondence serves as a letter of full confidence and support for Mr. William Bryan's research study involving the evaluation of how group interactions among students develop through a semester-long Science, Technology, Engineering and Mathematics (STEM) project.

Per institutional policy, Seward County Community College follows the research sponsoring institution's IRB process and application. We request that an approved copy of the IRB from Texas Tech University be delivered to Dr. Todd Carter, Vice President of Academic Affairs at Seward County Community College (SCCC).

Conducting a study involving the evaluation of how group interactions among students develop through a semester-long STEM project poses no known threat or harm to student subjects. Mr. Bryan's course policy clearly states that *any student work may be collected for research and institutional assessment purposes and that any such works would be de-identified before being released*. Further, Mr. Bryan's research plan is to notify, in writing, qualified participating students that their work on this assignment will be used for a research study. Additionally, Mr. Bryan will request that SCCC's Register Office notify him directly, in writing, of any students enrolled in the class that are under the age of 18. These students would still complete the same class assignments but these particular data would not be used within the study involving the evaluation of how group interactions among students develop through a semester-long STEM project.

Please contact Dr. Todd Carter at todd.carter@sccc.edu or at 620.417.1012 with any questions. We wish Mr. Bryan success completing his research.

Sincerely,

Dr. Ken Trzaska
President

Appendix D
Breakdown of Participants in the Study

Team	Pseudonym	Classification	high math	Gender	ethnicity	Major	sports
Iron (am)	Molly	Freshman	beg. Algebra	female	hispanic	dentistry	softball
Iron (am)	Bailey	Sophomore	col. Algebra	female	hispanic	liberal arts	
Iron (am)	Suzanna	Sophomore	int. algebra	female	hispanic	behavioral science	
Cobalt (am)	Cortez	Sophomore	beg. Algebra	male	hispanic	sports med	tennis
Cobalt (am)	K'Lan	Sophomore	beg. Algebra	female	black	photography	cheer
Cobalt (am)	Patty	Freshman	Calculus	female	caucasian	business administration	softball
Manganese (am)	Tonia	Sophomore	beg. Algebra	female	caucasian	criminal justice	softball
Manganese (am)	Blanche	Sophomore	col. Algebra	female	hispanic	behavioral science	
Calcium (am)	Nate	Sophomore	col. Algebra	male	caucasian	business	baseball
Calcium (am)	Tabitha	Sophomore	int. algebra	female	hispanic	computers	
Aluminum (am)	Ariel	Sophomore	int. algebra	female	hispanic	behavioral science	tennis
Aluminum (am)	Mary	Freshman	beg. Algebra	female	asian	behavioral science	softball
Aluminum (am)	Kate	Sophomore	col. Algebra	female	hispanic	business admin	
Zinc (pm)	Judy*	non-traditional	trig	female	caucasian	accounting	
Lead (pm)	Jacob	Sophomore	trig	male	caucasian	sports management	baseball
Lead (pm)	Irene	Sophomore	beg. Algebra	female	caucasian	education	
Lead (pm)	Alexia	Sophomore	int. algebra	female	hispanic	nursing	
Lead (pm)	Jaclyn	Freshman	int. algebra	female	caucasian	biology	softball
Copper (pm)	Karissa	Freshman	col. Algebra	female	caucasian	accounting	softball
Copper (pm)	Cynthia	Sophomore	col. Algebra	female	hispanic	education	
Nickel (pm)	Dallas	Sophomore	col. Algebra	male	caucasian	sports management	
Nickel (pm)	Manuel	Sophomore	col. Algebra	male	hispanic	computers	

* was moved to Team Copper half way through semester because of students dropping class.

Appendix E

Letter of approval from Hay Group

Hi William,

Congratulations! Your LSI research has been approved! Attached you will find the following documents:

- MCB200C - This is a copy of the LSI 3.1 test. You may print of copy this as needed for your research.
- MCB200D - The profile sheet contains the answer key for the test as well as the profiling graphs for plotting scores. This document may be produced as necessary for your research. The AC-CE score on the Learning Style Type Grid is obtained by subtracting the CE score from the AC score. Similarly, the AE-RO score is AE minus RO.

These files are for your data collection only. This permission does not extend to include a copy of the files in your research paper. It should be sufficient to source it.

We wish you luck with your research and look forward to hearing about your findings. Please send a completed copy of your research to Joe.McDonald@haygroup.com or you can mail a hardcopy to:

LSI Research Contracts
c/o Joe McDonald
Hay Group, Inc.
399 Boylston Street
4th Floor, Suite 400
Boston, MA 02116

Please let me know if you have any questions.

Kind regards,

Joe

Appendix F

Conditional Use Agreement

For good and valuable consideration, the receipt and legal sufficiency of which are hereby acknowledged, I hereby agree that the permission granted to me by the Hay Group ("Hay') to receive and utilize, without charge (paper version, $3 per participant fee for online version), the Kolb Learning Style Inventory Version 3.1 ("LSI") is subject to the following conditions, all of which I hereby accept and acknowledge:

1. I will utilize the LSI for research purposes only and not for commercial gain.
2. The LSI, and all derivatives thereof, is and shall remain the exclusive property of Hay; Hay shall own all right, title and interest, including, without limitation, the copyright, in and to the LSI.
3. I will not modify or create works derivative of the LSI or permit others to do so. Furthermore, I understand that I am not permitted to reproduce the LSI for inclusion in my thesis/research publication.
4. I will provide Hay with a copy of any research findings arising out of my use of the LSI and will cite Hay in any of my publications relating thereto.
5. To translate the LSI, I need specific permission from Hay. If permission is granted, I will use the translation for my research only, and I am not permitted to include this translation in my thesis/research publication.
6. Hay will have no obligation to provide me with any scoring services for my use of the LSI other than the Algorithm used to score results.
7. Hay will not be deemed to have made any representation or warranty, express or implied, in connection with the LSI, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose.
8. My rights under this Agreement are non-transferable and non-exclusive and will be limited to a period of two (2) years from the date of this Agreement.
9. Hay may immediately terminate this Agreement by giving written notice to me in the event I breach any of this Agreement's terms or conditions.

10. The Agreement will be construed in accordance with the laws of Massachusetts without recourse to its conflict of laws principles.
11. The Agreement may not be assigned by me without written consent of Hay.
12. Failure by Hay to enforce any provisions of the Agreement will not be deemed a waiver of such provision, or any subsequent violation of the Agreement by me.
13. This is the entire agreement with Hay pertaining to my receipt and use of the LSI, and only a written amendment signed by an authorized representative of Hay can modify this Agreement.

Agreed and Understood:

_____

Signature Print name Date

Appendix G

Student Pre-activity Survey

1. For each of the following statements, place an "X" in the box that you agree with most.

Statement	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
I understand concepts better when I can relate to them					
I am interested in science					
This chemistry course relates to my major					
I have difficulty in understanding how science concepts affect me					
Chemistry consists of many disconnected topics					
Understanding a scientific concept in chemistry means being able to recall something I have read or have been shown.					
When studying chemistry, I relate the important information to what I already know rather than just memorizing the content the way it is presented.					

2. How would you rate your attitude toward chemistry?

Strongly negative	Slightly negative	Neutral	Positive	Strongly positive

3. Referring to your last lab science class, give an example of how a scientific concept was related to a real-world application.

4. Referring to your last lab science class, give an example of how a science concept was used to discuss a cultural issue.

5. Have you ever completed a project in a prior science course? If yes, please explain what you did?

Appendix H

Semi-structured Interview

Researcher: Thank you for agreeing to meet with me today. Let me just cover the purpose of the context of this interview. I am doing a study on group interactions while participating in a PBL activity. Your participation in this interview is strictly voluntary and you can skip any questions you do not want to answer. This study will help to understand group interactions to allow for better curriculum development and utilization of PBL activities. You will be given a pseudonym for reference in all work including the transcription of this interview.

Researcher: Do you have any questions for me at this time?

May I audiotape this interview? (yes turn on audio recorder and continue, no ask if can take notes during interview).

Some example questions:

1. Would you give me a little background about yourself in terms of classification (freshman/sophomore/non-traditional), declared major, etc.?
2. Would you tell me a little about your prior experience with science classes?
3. Have you ever enrolled in a course that uses a PBL activity? If yes, explain.
4. What were your overall thoughts about the PBL activity in this class?
5. What did you find most beneficial about the PBL activity?
6. What did you find least helpful about the PBL activity?
7. What issues do you feel your group had to address?
8. How did your group decide to seek out new information?
9. How did the interdisciplinary nature of the project help you understand concepts?
10. What would you say to other students in doing a PBL activity? Other faculty?

Researcher: Do you have any questions for me about the research or the questions I have just asked you?

Thank you very much for your time. Your responses will be very helpful for this study. Please do not hesitate to contact me if you have any questions or concerns about this interview.