

THE EFFECT OF USING PROBLEM-BASED LEARNING IN MIDDLE SCHOOL
GIFTED SCIENCE CLASSES ON STUDENT ACHIEVEMENT AND STUDENTS'
PERCEPTIONS OF CLASSROOM QUALITY

by

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Dedication

This dissertation is dedicated with all my heart to my beloved husband, David, whose unconditional love has made all of the difference in my life. Who has always made me feel like my greatest flaws are my greatest strengths. Who, whenever I asked, always answered “yes.” And who has given so much, but has so much more to give. In him, I have found my compass and a sense of direction that comes from the absolute certainty of how extraordinary it is to share a completely ordinary life with someone who fills all of the corners of my heart.

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In Memoriam

Anthony “Ken” Umina

December 28, 1942-October 27, 2011

Over the past year or so since I have lost my father, I have been thinking about his legacy in the ways he contributed to the person I have become.

Had he not taught me a sense of humor is a good coping strategy; I might not have developed the resiliency to carry me through this journey. Had he not taught me it is better to persevere than feel sorry for myself; I might not have kept perspective of the bigger picture as I went. Had the story of his life not included the pride he took in the ambition he had to make something of himself beyond what was expected of the boys where he was from; I might not have discovered in myself the same drive and determination. Had he not shared the enthusiasm for the big adventure of his life that he set off at 17 to find; I might not have felt the same support, respect and understanding for my own big adventure that carried me far from home, family, friends and everything I knew.

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Table of Contents

	Page
List of Tables	ix
Abstract	x
Chapter 1: Introduction	1
Background of the Problem	6
Purpose	10
Significance	10
Summary	12
Chapter 2: Literature Review	14
Conceptual Framework for PBL	14
Distinctions of PBL	20
Problem-Based Learning (PBL)	21
PBL vs. Case-based and Project-based Learning	22
PBL vs. Inquiry-based Learning	23
PBL and Problem-Based Learning Instruction (PBLi)	24
Curriculum and Instructional Components of the PBL Model	25
Problem Engagement	26
Inquiry and Investigation	26
Problem Definition	27
Problem Resolution	27
Problem Debriefing	27
PBL and Traditional Instruction	28
Ill-structured problem	28
Teacher as meta-cognitive coach	28
Students as stakeholders	29
Summary	31
Research on PBL	32
Research on PBL in Medical Schools	32

Non-cognitive outcomes of PBL	33
Cognitive outcomes of PBL	39
Effectiveness of PBL	42
Research on the effectiveness of problem structure	43
Research on the effectiveness of the tutor/coach	44
PBL in P-12 Settings	52
Effects of PBL	53
Cognitive Outcomes of PBL.....	57
Content Acquisition.	58
Conceptual Understanding.....	61
Problem-Solving	68
Questioning	73
Non-cognitive Outcomes of PBL	79
Social Skills.	79
Students' Perceptions.....	88
Summary.....	93
Student Perceptions of Classroom Quality.....	94
Chapter Summary.....	96
Chapter 3: Methods.....	98
Setting.....	98
PBL Group.....	99
Comparison Group.	100
Participants.....	102
Teacher Professional Development.....	103
Statement of the Research Questions	104
Hypotheses	104
Procedures	104
Treatment.....	105
Instrumentation and Data Collection.....	110
Fidelity of Implementation.....	111
Dependent Variables	112
Measures.....	112

Student Achievement.....	112
Students' Perceptions.....	113
Data Analysis.....	113
Pilot Study.....	113
Chapter Summary.....	116
Chapter 4: Results	117
Cognitive Factors Results.....	117
PBL Group Pre/Post-Test.....	118
Comparison Group Pre/Post-Test.....	119
PBL and Comparison Group Pre/Post Test Results.....	120
PBL and Comparison Group Gain Score.....	121
Non-cognitive Factors Results	122
Correlations of the SPOCQ and Gain Score.....	124
Correlations of the Constructs.....	125
Chapter 5: Conclusions, Discussion and Implications.....	128
Discussion of Findings	129
Academic Achievement.....	130
Perceptions of Classroom Quality.....	132
Summary.....	136
Implications.....	137
Implications for Future Research	137
Implications for Teachers	139
Implications for Students.....	143
Summary.....	144
Limitations	145
Chapter Summary.....	146
References.....	168

List of Tables

Table	Page
Table 1 Membership and Staffing of the Schools for the PBL and Comparison Groups	100
Table 2 2011 Grade 8 Science Standardized State Test Scores for Center Program Students.....	101
Table 3 Paired Samples <i>t</i> -test for PBL Group and Comparison Group Pre/Post-test.....	120
Table 4 PBL and Comparison Group Pre/Post-test Comparison of Means.....	121
Table 5 PBL and Comparison Group Gain Score.....	121
Table 6 Students' Perceptions of Classroom Quality Means.....	123
Table 7 Summary of Correlations between Gain Score and SPOCQ total and Constructs for PBL Group	124
Table 8 Summary of Correlations between Gain Score and SPOCQ total and Constructs for Comparison Group	125
Table 9 Summary of Correlations on Appeal and Self-Efficacy Constructs for PBL Group	126
Table 10 Summary of Correlations on Appeal and Self-Efficacy Constructs for Comparison Group.....	126

Abstract

THE EFFECT OF USING PROBLEM-BASED LEARNING IN MIDDLE SCHOOL GIFTED SCIENCE CLASSES ON STUDENT ACHIEVEMENT AND STUDENTS' PERCEPTIONS OF CLASSROOM QUALITY

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The purpose of this study was to explore the impact of the Problem Based Learning (PBL) units developed by a large suburban school district in the mid-Atlantic for the middle school gifted science curriculum on: a) students' performance on standardized tests in middle school Science, as measured by a sample of relevant test questions from a district-managed test bank; and b) students' perceptions of classroom quality according to the constructs of: meaningfulness, challenge, choice, self-efficacy, and appeal as measured by the Student Perceptions of Classroom Quality scale (SPOCQ) (Gentry & Owens, 2004). A group of students taught using PBL and a comparison group of students taught using traditional instruction were studied. Between the two groups, a total of 457 students participated in the study. Pre and post student achievement data were collected using a 25 item multiple choice test that aligned with state and local objectives. It was hypothesized there would be no significant differences in gain scores

or perceptions between a group of students taught using PBL in comparison to the group taught using traditional methods. Data analysis indicated statistically significant gain scores in both of the groups with a higher gain score in the PBL group. Data analysis also revealed statistically significant differences in the total score on the SPOCQ in favor of the PBL group. This study found positive effects for well-implemented PBL instruction with these students. However, much more remains to be known. Future research should include longitudinal studies expanded to different subjects, grade levels and populations of students.

Chapter 1: Introduction

“What we resolve to do in school only makes sense when considered in the broader context of what the society intends to accomplish through its educational investment in the young.” (p. ix-x)

Jerome S. Bruner,
The Culture of Education

Many educators continue to struggle with the classroom implications of the implementation of the Elementary and Secondary Education Act known in its most recent form as the No Child Left Behind Act of 2001 (NCLB). NCLB’s signature achievement as it relates to classroom instruction is a more intensive focus on the assessment of academic content standards, which has resulted in local accountability regimes. Although the goal of the law is to ensure a rigorous curriculum for all students, its major influence has been the creation of a culture of accountability geared towards improving the scores of low-performing students and narrowing achievement gaps among majority and minority students. As a result of this focus, it has failed to promote the implementation of appropriately differentiated lessons for all learners, including those identified as gifted and talented.

This culture of accountability has created pressure on teachers to deliver teacher-directed test-preparation lessons void of adjustments and modifications for the wide range of ability levels they encounter (Abrams, Pedulla, & Madaus, 2003; Brown, Avery,

VanTassel-Baska, Worley, & Stambaugh, 2006; Moon, Brighton, & Callahan, 2003). As a recent report from the Fordham Foundation (Duffett, Farkas, & Loveless, 2009) found, teachers are much more likely to indicate that struggling students, not advanced students, are their top priority. In this way, the law puts educators at odds with the increasing diversity and heterogeneity of the student populations they face and all but ignores the needs of gifted and talented students who enter school already having mastered basic content and who are ready for extension of the curriculum.

In a recent report from the Center for Evaluation and Educational Policy (Plucker, Burroughs & Song, 2010) the authors show that according to national and state assessments, since NCLB's enactment, progress has been made toward closing achievement gaps among different demographic at the basic and proficient levels of educational attainment. However, although there has been a general improvement in academic performance, evidence suggests achievement gaps are widening at the highest levels of student achievement. Plucker, et al. (2010) call this phenomenon, the differences between subgroups of students performing at the highest levels of achievement, the Excellence Gap. The purpose of their report was to review national and state data for evidence of an Excellence Gap. Their report from the Center for Evaluation and Educational Policy shares that while achievement gaps between racial groups have steadily declined, little attention has been given to the Excellence Gap. According to the report, this oversight calls into question the success of state and federal governments to provide equitable educational opportunities particularly for students performing at the highest level of achievement tests. The report provided some preliminary data to illuminate the issue for policymakers.

Regardless of the method used to analyze the data, evidence from the National Assessment of Educational Progress (NAEP) showed inconsistencies in progress on a state-by-state basis. Very few Excellence Gaps are shrinking, and some evidence strongly suggests that Excellence Gaps on most NAEP tests are growing at both Grade 4 and Grade 8. There are multiple ways to measure Excellence Gaps such as by race, socio-economic status (SES), English Language Proficiency and gender. Plucker, et al. (2010) show the NAEP results at the national level suggest that the excellence achievement gaps among all these groups have widened in the era of NCLB. In mathematics, there has been a substantial increase in the percentage of white, affluent, English-language proficient speakers scoring at the advanced levels while conversely, the performance of the other groups has remained relatively stable. In reading, the data is even more homogenous in that there has been little change in the percentage of students performing across all groups. In particular, there has been low performance in reading across all groups in Grade 8.

An analysis of the scores at the state level is consistent with the results at the national level. In most states, the NAEP data suggest the excellence gap has widened. Over-represented groups continue to represent a disproportionate number of high-performing students. Few states are successfully reducing excellence gaps while concurrently improving academic performance across subgroups on both the reading and mathematics exam. This lack of consistent results in any one state may suggest state education policy initiatives have a differential effect on achievement.

Another common method for analyzing changes in the size of the achievement gap is the proficiency level approach. Plucker, et al. (2010) describe how the proficiency

level approach to analyzing gap trends can lead to misleading outcomes. Because student performance on exams tends to cluster around the mean, the selection of the cut score will have an effect on the magnitude and direction of the trend depending on whether the cut-point selected is closer to or farther away from the mean. Additionally, trends can vary from positive to negative, in terms of the change in gaps between groups, based on where the cut-point is placed. This variability affects the validity of using proficiency scores to measure the change in the excellence gap.

Alternately, percentiles are not subject to the same statistical problems as proficiency levels. Given that students have equal ability, a percentile score should indicate the same achievement. An analysis of data using this method at the national level would suggest modest improvement in Mathematics scores for all groups and in Reading Grade 4 for most groups. However, the goal of NCLB is not only to reduce the size of the gap, but to also produce increased achievement in all groups. This scenario is true for the Mathematics Grade 4 scores, but is not consistent in the subgroups in the Mathematics Grade 8 and Reading Grade 4, nor at all in Reading Grade 8. Results of an analysis of the NAEP data at the state level reflect similar trends in that progress is slow and inconsistent. Excellence gaps are closing in many states for most subgroups and exams, except for English Language Learners on Reading tests and gender gaps on Grade 8 Mathematics exams. In summary, there is evidence of excellence gaps whether measured by the percent scoring at the advanced level or by percentile.

Plucker, Burroughs and Song (2010) summarize the data regarding excellence gaps on state assessments. According to their analysis the majority of states experienced increases in the percent of students performing at advanced levels on state assessments.

However, given the wide variation in the definition of advanced among states, these increases are difficult to attribute to actual improvement in advanced performance. Even so, the majority of states also experienced widening excellence gaps. This analysis was based on state developed assessments from 43 states during 2005-2007.

There is a wide discrepancy of content and rigor on state tests. Along with this, state tests use different scales than the NAEP. As such, a direct comparison between the NAEP and state tests would not provide valid information. Furthermore, when trends in excellence gaps on the measures are compared, the correlation does not approach statistical significance. However, there is evidence in the state data supporting the existence of an excellence gap. In the states for which 2008 data was available, all indicated an excellence gap in elementary, middle and high school for all subgroups suggesting that the increase in students performing at advanced levels on state tests is not being shared by all subgroups of students.

Preliminary results of data analysis suggest that focusing on minimum competency gaps does not reduce excellence gaps. The size of the NAEP excellence gaps is moderately correlated with achievement gaps at the NAEP basic and proficiency levels though these correlations are weaker with the Grade 4 mathematics data. Bivariate correlations of state data between the size of achievement gaps between 2003 and 2007 at the basic, proficient, and advanced levels do not show large, positive and statistically significant results suggesting that helping underrepresented students reach basic competence seems unrelated to scores of their peers at higher levels of achievement which is indicative of the need for further research.

In summary, the federal role in addressing excellence gaps has been very small and policy at the state and local levels has been highly inconsistent. As such, addressing differences in educational opportunities for the highest achievers may require a unique response that is part of an intentional effort by national and state policymakers targeted towards potentially high achieving students. There is some evidence to suggest state gifted education policies can influence the size of excellence gaps. Therefore, among their recommendations, Plucker, et al. (2010) suggest making the closing of the Excellence Gap a national and state priority by conducting more research on advanced learning and talent development in an effort to acknowledge that both minimum competency and excellence can be addressed at the same time and determine the appropriate mix of federal, state, and local policies and interventions.

Background of the Problem

In an extensive literature review, Hockett (2009) argues that the distinctions of a challenging and advanced curriculum specific to gifted learners are difficult to describe. However, according to Hockett (2009) experts within the field agree on five key principles:

- High quality curriculum for gifted learners uses a conceptual approach to organize or explore content that is discipline based and integrative;
- High-quality curriculum for gifted learners pursues advanced levels of understanding beyond the general education curriculum through abstraction, depth, breadth, and complexity;
- High-quality curriculum for gifted learners asks students to use processes and materials that approximate those of an expert, disciplinarian, or

practicing professional;

- High-quality curriculum for gifted learners emphasizes problems, products, and performances that are true-to-life and outcomes that are transformational;
- High-quality curriculum for gifted learners is flexible enough to accommodate self-directed learning fueled by student interests, adjustments for pacing, and variety.

In a 2010 position paper titled “Redefining Giftedness for a New Century: Shifting the Paradigm” the National Association of Gifted Children (NAGC), the largest advocacy organization in the field of gifted education, states that the development of talent is a lifelong process. Beginning in early childhood, the optimal development of these children requires differentiated educational experiences in order to match their rapid rate of learning (NAGC, 2010). Such differentiated educational experiences consist of adjustments in the level, depth, and pacing of curriculum and that may require additional and unusual interventions. In the repertoire of current teaching practices accessible in the general curriculum of schools, Problem Based Learning (PBL), a method which originated in medical schools (Barrows, 1994), can be used to teach extended content while concurrently reflecting the key principles of high-quality curriculum for gifted learners.

PBL is built heavily upon the work of educational psychologist Jerome Bruner (1962) whose educational philosophies had a foundation in discovery through problem solving. Bruner contributed to the philosophy of education with his cognitive learning theory, which is based on conceptual and constructivist learning. Problem-solving can be

defined as having four signature steps: a) students forming an initial representation of the problem; b) planning potential sequences of actions to solve the problem; c) executing the plan; and d) checking the results (Qin, Zhining, & Johnson, 1995). This approach to problem solving gave rise to the problem-based learning method of instruction originally designed at Canada's McMaster University in the 1970's for their graduate program in medicine (Barrows, 1994).

As many researchers have noted, PBL is most importantly, a student centered, not a teacher centered method of instruction (Ertmer, & Simons, 2006; Hitchcock & Mylona, 2000; Lehman, George, Buchanan & Rush, 2006; Wetzel, 1996). According to Wetzel (1996), during PBL students are expected to raise questions about an ill-structured problem, the development of which springs from the content in the curriculum, and then to propose hypotheses, present data from independent study, set and prioritize the study agenda, and work in groups to question and teach each other. The nature of problem solving requires students to draw on skills such as elaborating, evaluating, and innovating.

According to Stepien and Pyke (1997), in a PBL unit there are five phases: (a) Problem Engagement; (b) Inquiry and Investigation; (c) Problem Definition; (d) Problem Resolution; and (e) Problem Debriefing. Gallagher (1997) states that during these phases, PBL instruction has the following clearly articulated goals:

- helping students develop flexible knowledge,
- fostering effective problem-solving skills,
- improving self-directed learning skills,
- developing effective collaboration skills, and intrinsic motivation,

- enhancing acquisition, retention and use of knowledge,
- understanding problems from multi-disciplinary viewpoints and the integration of information from many different sources,
- emphasis of learning for understanding rather than learning for recall.

Though the literature on PBL in the K-12 arena is sparse, the limited research available shows there are several benefits to using PBL. Primary-age students who were exposed to [Problem-Based Learning] units showed significant growth in critical thinking when compared to those students who used the regular science curriculum (VanTassel-Baska, Bracken, Stambaugh, & Feng 2007). Additionally, teachers and students both found PBL more engaging than typical science units (VanTassel-Baska, et. al. 2007). In other studies, positive academic achievement effects were significant for all groups of learners, regardless of socioeconomic status, ability level or ethnicity (Feng, VanTassel-Baska, Quek, O'Neill, & Bai, 2005; VanTassel-Baska, Bass, Ries, Poland, & Avery, 1988; VanTassel-Baska, et. al., 2007). Finally, the continued use of the problem-based learning science curriculum over a 3-year period resulted in continued academic growth for students (Feng et. al. 2005).

Considering the potential of PBL as a curriculum model and instructional method intended to teach higher-order skills, a better understanding of several elements of the curriculum model may be valuable to the experts in the scholarly community of gifted education. Specifically, those scholars may benefit from a better understanding of the effects and effectiveness of this inquiry oriented method of teaching on student achievement, and an understanding of gifted adolescents' perceptions of classroom quality, which leads to the purpose of this study.

Purpose

The purpose of this study was to explore the impact of the Problem Based Learning (PBL) units developed by a large suburban school district in the mid-Atlantic for the Advanced Academic Program middle school curriculum on: a) students' performance on standardized tests in middle school Science, as measured by a sample of relevant test questions from a district-managed test bank; and b) students' perceptions of classroom quality according to the constructs of: meaningfulness, challenge, choice, self-efficacy, and appeal as measured by the Student Perceptions of Classroom Quality (Gentry & Owens, 2004).

This study is guided by the following research questions:

- a) What is the effect of PBL on advanced academic students' achievement on common assessments in comparison to a matched group of students taught in a traditional lecture/discussion format?
- b) What is the effect of PBL on advanced academic students' perceptions of classroom quality in comparison to a match group of students taught in a traditional lecture/discussion format?

Significance

As the Bruner quote above suggests, the education we want for our children can include many skills. He speaks to the more robust set of skills our schools could and should be teaching. He is quite consistent with the recent work of the Partnership for 21st Century Skills (2012), who argue that the demands of the global society require an education system that will help ensure the United States remains competitive in a global

economy. As such, the Partnership for 21st Century skills presents a framework for learning in the global economy. The framework reflects focus on student outcomes such as a blending of specific skills, content, knowledge, expertise and literacies. This framework includes learning and innovation skills, information media and technology skills, and life and career skills (see Appendix A).

Learning and innovation skills are defined as using a wide range of idea creation techniques, creating new and worthwhile ideas, and elaborating, refining, analyzing and evaluating ideas in order to improve and maximize creative efforts. Students are expected to work creatively with others and implement innovations (Partnership for 21st Century Schools, 2009). Information media and technology skills include information literacy, media literacy and information, communications & technology literacy. Life and Career Skills describe the ability to be flexible, adaptable, self-directed, socially aware, accountable and responsible. The profile of these learning and innovation skills is in sharp contrast to the profile of the skills, such as identify, recall and retain information, which the typical learner accumulates in the average classroom in the United States.

Even the Association of American Colleges and Universities (AACU) embraces this vision. As the global economy ushers in an era of increasing interdependence, it is anticipated some of the skills required to function in this time will be skills such as real world problem solving skills, analytical reasoning, communication skills, and cross disciplinary knowledge skills (Association of American Colleges and Universities [AACU], 2007).

One large, suburban mid-Atlantic school district has contributed time, money, and effort to develop PBL units, for its middle school gifted program. For the past seven

years, gifted program staff has been involved in writing, pilot testing and revising PBL units using a collaborative expert-practitioner model of curriculum development. Care has been taken to ensure strong alignment to the state standards and to incorporate techniques of enhancing depth, complexity and rigor for gifted students (Gallagher & Horak, 2011). However, while there is substantial anecdotal evidence that the units are popular and appropriate, this does not substitute for more objective evaluation of whether the units are filling their intended mission of delivering content and nurturing students' potential for advanced scholarly work. Given the anecdotal evidence as well as the lack of investigation specifically regarding how PBL is applied in the K-12 educational arena, it will be useful to know whether PBL curriculum, when implemented, meets the needs of gifted learners while fulfilling the intended mission of delivering content and advancing students' preparation for scholarly work.

Summary

This chapter focused on background of the problem, the significance of the problem and the purpose of the study. The introduction began by describing how many educators continue to struggle with the classroom implications of the implementation of the Elementary and Secondary Education Act known in its most recent form as the No Child Left Behind Act of 2001 (NCLB). Next, the introduction examined the key principles of quality curriculum, the theoretical framework for PBL and the Stepien and Pyke (1997) model of PBL. Finally, the purpose and the significance of the study were explained. Chapter Two will describe the relevant literature. The first section will discuss Bruner's cognitive learning theory (1962), which forms the theoretical background for PBL. A second section will discuss the connection between

constructivist learning and constructivist teaching practices. A third section will discuss the current literature. In this section, research literature in both the medical field and P-12 education will be discussed.

Chapter 2: Literature Review

The purpose of this study was to explore the impact of Problem Based Learning (PBL) units developed for the Advanced Academic Program middle school curriculum by a large suburban school district in the mid-Atlantic region of the United States. The intended outcome measures include student performance on standardized tests aligned with state standards in middle school Science and students' perceptions of classroom quality, as measured by the Student Perceptions of Classroom Quality (Gentry & Owens, 2004) survey. Given this purpose, a discussion of the theoretical framework of the PBL curriculum model and Problem Based Learning instructional method (PBLi) is necessary. The first section of this literature will review Bruner's cognitive learning theory (1962), which forms the theoretical background for PBL.

A second section will review the connection between constructivist learning and constructivist teaching practices by establishing a continuum between PBL as a curriculum model and PBLi as a teaching method. A third section will review the current literature on PBL and PBLi. Research literature on PBL and PBLi is limited as it pertains to the P-12 continuum, however, it is abundant in the medical sciences, and therefore this review will be considered from an interdisciplinary standpoint.

Conceptual Framework for PBL

The conceptual framework for PBL is built upon the work of educational psychologist Jerome Bruner (1962), whose cognitive theory of learning provided a

foundation for discovery through problem solving. Bruner's theory centers on the act of discovery, which he characterizes as "finding out" something and not knowing it. In his view, discovery is dependent upon having some knowledge and then ultimately expanding that knowledge by rearranging or transforming evidence in such a way that it leads the student to the discovery of new insights. One component of this discovery may be additional evidence, but discovery is not dependent on new information.

Constructivism, derived from the work of cognitive psychologists such as Bruner, extends the philosophy of John Dewey whose perspective on education includes experiential learning. Several themes emerge throughout Dewey's work (1938), including a belief that education and learning are social and interactive processes, the teacher should act as a facilitator or guide, and education is an instrument for creating social change and reform. Dewey advocated for an educational framework that balances the interests and experiences of the student equally with the pedagogy for delivering content and is therefore credited with influencing experiential models of education such as Problem-Based Learning.

According to Bruner (1962), discovery is conducive to two kinds of teaching: expository mode and hypothetical mode. Expository mode is for the most part teacher-directed. Decisions regarding the pace and style of learning experiences are determined by the teacher and the student takes on the role of listener. The role of the listener is to anticipate and manipulate the content of the material given by the teacher. However, in the discovery mode, which he labels the hypothetical mode, the roles shift. In this case, the teacher and the student are in a more cooperative position relative to one another.

The student is not relegated to the role of a listener, or passive recipient of content, but rather has a more active role in the pace, style of delivery and content of information received. This hypothetical mode, Bruner asserts, characterizes teaching that encourages discovery.

The principal benefits derived from the hypothetical mode of learning through discoveries are: (a) an increase in intellectual potency; (b) a shift from extrinsic to intrinsic rewards; (c) the learning of heuristics of discovering; and (d) the aid to conserving memory (Bruner 1962). The increase in intellectual potency results from the active attitude assumed by the learner as problem-solver when completing a task through discovery. In this case, the development of thinking is affected by the learner's attempt to process information efficiently in order to utilize it effectively. This is the difference between episodic empiricism, in which the learner attempts to solve a problem by becoming a "potshotter," or one who strings together hypotheses non-cumulatively one after the other, and cumulative constructionism, which is an organized persistence, in which the learner attempts to solve a problem by intentionally organizing her/his questioning to locate the problem's constraints as a technique in forming a preliminary hypothesis. Bruner further posits that a learner attempting to solve a problem employs constraint location by asking questions that eventually give way to a hypothesis. For example, if a child were attempting to determine the cause of a car accident, the "constraint locating" child would ask, "Was there anything wrong with the driver?" as opposed to, "Was the driver tired because he had worked all day and he fell asleep at the wheel?" The persistence results in more valuable information through the learner's cycles

of questioning and summarization.

In terms of the shift from extrinsic to intrinsic rewards, essentially, Bruner (1962) suggests learning by discovery leads to a child having increased autonomy over learning, and that when a child has autonomy over learning, the discovery itself is the reward. The intrinsic reward of mastery therefore, becomes the goal of the learner as opposed to extrinsic rewards. Success indicates the learner is on the track to mastery and failure indicates the learner needs to try a different approach. The experience of success is influenced by the degree to which the desire for competence controls behavior. As this desire increases, it has an inverse relationship to the influence any external rewards, e.g. grades, have in shaping behavior.

Bruner (1962) describes one of the benefits of the hypothetical mode of learning as the heuristics of discovery. He explains this as the process of inquiry and research. Bruner elaborates by commenting that too much time is spent learning what is known and too little time is spent finding out what is not known. There are, according to Bruner, several attitudes and activities related to pursuing inquiry as a way of life; one of them is knowing to avoid immersion in irrelevant variables. He notes that an important skill to develop in order to be able to avoid immersion in irrelevant variables is accurately judging the significance or severity of said variables. Another important skill is the ability to recast a challenge encountered in the process in a different form. Only through the exercise of problem solving and discovery is it possible to invent and develop effective models or “puzzle forms”. The more practice the learner has in the heuristics of discovery, the more likely the learner is to generalize what he or she has learned into

the style of problem solving or inquiry that serves any kind of task that can be encountered.

Finally, Bruner (1962) describes conservation of memory as a benefit of the hypothetical mode of learning characterized by discovery and problem solving. While the human brain is capable of storing large amounts of information, retrieving that information is dependent on effective organizational systems and structures. When a person imbeds material in a cognitive process he or she has independently constructed, that material will be more accessible for retrieval. In essence, when material is organized in terms of a person's interests and cognitive structures, it is more likely to be placed along routes that are connected to one's own ways of intellectual travel and therefore available "on demand".

Savery and Duffy (1995) characterize the philosophical view of constructivist learning in terms of the following three primary propositions: (a) understanding is in our interactions with the environment; (b) cognitive conflict or puzzlement is the stimulus for learning and determines the organization and nature of what is learned; and (c) knowledge evolves through social negotiation and through the evaluation of the viability of individual understandings. The core concept of constructivism is that which we understand is a function of the context of the learner. Cognition is a part of the learner's context. Additionally, learning begins with a puzzlement. The learner's curiosity about the puzzlement is the stimulus for learning and the puzzlement is the purpose for undertaking the learning process.

This purpose determines what the learner attends to, what prior experiences the

learner uses in constructing comprehension and what is ultimately understood. Finally, knowledge is dependent on the social environment. The social environment is a mechanism for testing our own understanding by examining the understanding of others. Other people help us to evaluate and challenge our current understandings because they are the source of alternate views. Integrating these alternate views into our individual schema leads to expanding the body of understanding called knowledge (Savery & Duffy, 1995). The social environment also provides tests of our own understanding and is a mechanism for enriching, interweaving and expanding our understanding. Concepts that are considered to be knowledge are considered so because they have been tested in the social environment many times over and are stable across these contexts.

According to Savery and Duffy (1995) eight instructional principles derive from constructivist teaching practices. The eight principles are: (a) anchor all learning activities to a large task or problem; (b) support the learner in developing ownership for the overall problem or task; (c) design an authentic task; (d) design the task and the learning environment to reflect the complexity of the environment in which the learner should be able to function at the end of the learning period; (e) give the learner ownership of the process used to develop a solution; (f) design the learning environment to support and challenge the learner's thinking; (g) encourage testing ideas against alternative views and alternative contexts; and (h) provide opportunity for and support reflection on both the content learned and the process. These principles can be applied to a variety of learning environments however, in the scope of instructional practices, there is one application that captures these principals more succinctly than others and that is Problem-

Based Learning.

Distinctions of Problem-Based Learning

There are many teaching models in the constructivist tradition, including concept attainment (Bruner, 1969), concept formation (Taba, 1966), and reciprocal teaching (Palincsar & Brown, 1984), among others. Another example of Bruner's cognitive learning theory, which is both cooperative and constructivist, is Problem-Based Learning (PBL). The widespread adoption of the PBL instructional approach has produced a range of instructional practices referred to as PBL that vary from implementing specific instructional strategies, to using certain teaching methods, to a comprehensive curriculum model that incorporates specific instructional strategies and includes research-based curriculum components (Savery, 2006). This widespread adoption has led to some misapplications and misconceptions of PBL (Maudsley, 1999). Certain practices that are called PBL exist on a continuum derived from Brunerian constructivist practices but for a variety of reasons are distinct from PBL and therefore may lead to different learning outcomes than the ones anticipated for PBL. Boud and Feletti (1997, p. 5) described several possible sources for the confusion:

- Confusing PBL as an approach to curriculum design with the teaching of problem-solving;
- Adoption of a PBL proposal without sufficient commitment of staff at all levels;
- Lack of research and development on the nature and type of problems to be used;
- Insufficient investment in the design, preparation and ongoing renewal of

learning resources;

- Inappropriate assessment methods which do not match the learning outcomes sought in problem-based programs; and
- Evaluation strategies which do not focus on the key learning issues and which are implemented and acted upon far too late.

Since there is overlap in the range of practices referred to as PBL, a discussion of the differences among practices within this range, specifically to distinguish the definition of PBL from other forms of inquiry based instruction is necessary.

Problem-Based Learning (PBL). Currently, PBL is used widely in medical schools, more so than in P-12 education. More than 80% of the medical schools in the United States use PBL as a primary instructional strategy (Jonas, Etzel and Barzansky, 1989). In the context of medical schools, Hallinger and Bridges (1997) state there are five defining characteristics of PBL:

1. The starting point for the learning is a problem.
2. The problem is one that students are apt to face as future physicians.
3. Subject matter is organized around problems rather than the disciplines.
4. Students assume a major responsibility for their own instruction and learning.
5. Most learning occurs within the context of small groups rather than lectures.

Aside from medical schools and within the context of P-12 education Savery (2006) states three clearly identifiable characteristics of PBL: (a) the role of the tutor as a facilitator of learning, (b) the responsibilities of the learners to be self-directed and self-

regulated in their learning, and (c) the essential elements in the design of ill-structured instructional problems as the driving force for inquiry.

One example in the range of practices typically referred to as PBL from the field of P-12 education is the curriculum model proposed by Stepien and Pyke (1997). This model is adapted from the one used in medical schools and includes five phases: (a) Problem Engagement; (b) Inquiry and Investigation; (c) Problem Definition (d) Problem Resolution; and (e) Problem Debriefing. Additionally, Gallagher (2001) distinguishes three key defining features of PBL instruction. These three key defining features are important teaching methods for instruction: a) the ill-structured problem; b) the teacher as meta-cognitive coach; and c) the student as stakeholder. These components, while distinct as teaching methods for instruction, occur within the implementation of a PBL curriculum model unit and are critical to its success. For the purposes of this study, the Stepien and Pyke (1997) curriculum model will serve as the stipulated definition of PBL.

PBL vs. Case-based and Project-based Learning. Two other examples of constructivist practices often confused with PBL are case-based learning and project-based learning. Both of these approaches are similar to PBL in that they promote active learning and engage learners in higher-order thinking.

Case studies differ from PBL in that they may or may not be done as a group project whereas a key component of PBL is the interaction of the students in the small group or tutorial. Also, cases may be used to assess student learning after instruction or as a practice exercise to prepare learners for a more authentic application of the skills and knowledge gained by working on the case while PBL is used as the method for the

delivery of instruction and acquisition of content (Savery, 2006).

The project-based learning instructional approach was described as the Project Method by Kilpatrick (1921). Subsequently several other researchers have elaborated on this method, including Blumenfeld, Soloway, Marx, Krajcik, Guzdial, and Palincsar (1991). Project-based learning differs from PBL considerably in that learners are usually provided with a specific desired end product and the learning process is organized around following correct procedures to produce the project (Savery, 2006). In PBL, the nature of the ill-structured problem leads to many possible resolutions to the problem that vary from each other. Additionally, in project-based learning the role of the teacher is that of an instructor which is more similar to traditional instruction than that of the meta-cognitive coach in PBL.

Cases and projects are strong examples of learner-centered instructional strategies. However they differ from PBL meaningfully in that the learner's role in setting the goals and outcomes for the problem is diminished (Savery, 2006). One important outcome for PBL is not only the ability to develop a solution to a problem, but also to identify and define a problem.

PBL vs. Inquiry-based Learning. There is a great deal of overlap between these two approaches. Inquiry-based learning is a student-centered, active learning approach focused on questioning, critical thinking, and problem solving (Savery, 2006). Similar to PBL, inquiry-based learning activities begin with a question or problem and is followed by investigating solutions. Inquiry-based learning is frequently used in science education

and emphasizes a hands-on approach where students practice the scientific method on authentic problems.

The primary difference between PBL and inquiry-based learning approach is the role of tutor as both a facilitator of learning and a provider of information. In a PBL approach the tutor functions as the meta-cognitive coach who supports the learning process, however, the students are expected to take responsibility for making their thinking clear. Additionally, in PBL the students are responsible for providing information about the problem.

PBL and Problem-Based Learning Instruction (PBLi). Problem-Solving is another common instructional practice derived from Brunerian practices that is often referred to as PBL. However, for the purposes of this study, instructional practices, such as problem-solving, that encompass problem-solving processes and any instructional strategies implemented in association with problem-solving will be referred to as Problem-Based Learning Instruction (PBLi). According to Qin, et al. (1995) problem-solving is defined as a three-step process which includes: a) forming an initial representation of the problem; b) planning potential sequences of actions to solve the problem; c) executing the plan and checking the results.

Accordingly, while there is overlap between PBL and PBLi, it is important to note that in this context, PBL refers comprehensively to the curriculum model, its teaching components and instructional strategies. Conversely, in this context, PBLi is a subset of PBL and though subsumed by PBL is also applied independently in different contexts. Therefore, PBLi will refer to independent applications of these components either in part

or in their entirety. Since this study intends to explore the impact of the curriculum model, a discussion of the five phases and three key components of the Stepien and Pyke (1997) PBL model follows.

Curriculum and Instructional Components of the PBL Model

Problem-based learning was designed to create change simultaneously in curriculum and instruction (Barrows, 1988; Barrows & Tamblyn, 1980). The model proposed by Stepien and Pyke (1997) describes the curriculum components that distinguish PBL from other curriculum models. Gallagher (2001) elaborates on the key instructional differences of PBL from traditional instruction that are defining features of PBL instruction. These key instructional components, while distinct as instructional methods for instruction occur within the implementation of the PBL model during all of the curriculum phases and are critical to its success.

As mentioned previously, there are five phases of PBL curriculum. The five phases to be used in the present study are: (a) Problem Engagement; (b) Inquiry and Investigation; (c) Problem Definition; (d) Problem Resolution; and (e) Problem Debriefing (Stepien and Pyke, 1997). This order reflects the flow of the problem and the sequence of each phase as it occurs during implementation in the classroom.

This sequence reflects how the design of the curriculum matches the way learning takes place in the real world as proposed by Alfred North Whitehead (1929) in his theory of education. This theory outlined three fundamental stages of growth: a) romance, b) precision and c) generalization. According to Whitehead (1929) the first stage of intellectual growth the student encounters is that of romance. This stage is characterized

by the vividness of the novelty and breadth of knowledge. It arouses curiosity by exposing students to some information while other information remains unknown. The second stage, precision, is characterized by the development of skills and knowledge. Learners gain new knowledge that leads to the exactness in the formulation of their understanding. The breadth of knowledge is replaced by the depth of knowledge. The final stage of generalization is characterized by the synthesis of romance and precision. During this stage the learner applies knowledge in order to produce and share the outcome of the effort undertaken. Therefore, the discussion of these five phases will follow the same progression as the list above and will explicitly connect to Whitehead's (1929) theory.

Problem Engagement. According to Stepien and Pyke (1997), during the problem engagement phase, students are introduced to the authentic problem. Learning begins when students encounter a scenario or situation containing an ill-structured problem, meaning it needs more information before it can be solved. The scenario contains some emotional "heat" and provides a timeline for completion. The problem has been crafted carefully to align with learning outcomes and course standards, benchmarks and indicators. During this initial phase, students explore the problem and generate a list of questions reflective of the gaps in their knowledge. This list of questions serves as a blueprint for further investigation and lesson planning.

Inquiry and Investigation. The inquiry and investigation phase of PBL involves in-depth research in the areas relevant to the problem presented in the scenario or situation presented to them during the problem engagement. This research constitutes the

majority of the content acquisition stage of the learning process. This phase also requires students to cycle through the reasoning process until they are able to define the problem (Stepien & Pyke, 1997).

Problem Definition. The problem definition phase of PBL is a distinct phase that occurs within the inquiry and investigation. In this phase, students directly address the problem they are attempting to solve by articulating a problem statement such as, “How can I [decide which programs to give funding to] so that [the needs of the community are met equitably] (Stepien & Pyke, 1997).”

Problem Resolution. In this phase of PBL, students develop their solution product. The solution product reflects the student’s resolution to the problem, complete with rationale or justification. The solution product is produced as an authentic product for the stakeholder role the student has held during the unit (Stepien & Pyke, 1997).

Problem Debriefing. After the solution products have been completed, the problem debriefing phase of PBL takes place. At this time, the teacher helps students to deepen their understanding of concepts and skills, reviews any gaps in content acquisition, and facilitates reflection on meta-cognitive skills (Stepien & Pyke, 1997).

The flow of the problem in PBL mirrors the stages in Whitehead’ (1929) theory. During the Problem Engagement, students are immersed in a problem that contains emotional heat and gives some information but leaves holes. This reflects the romance stage. Next, students begin to uncover information about the problem during the Inquiry and Investigation. This inquiry and investigation leads to the refinement of their understanding of the problem which ultimately informs their resolution. This reflects the

precisions stage. The resolution is the application of their knowledge which is then shared with the community of learners. This reflects the generalization stage.

PBL and Traditional Instruction

There are three key instructional differences between PBL and traditional classroom instruction. While traditional classroom instruction may include some of some of these key differences at different times, PBL uses all of the key differences concurrently throughout the duration of the PBL curriculum phases. The first of those key differences is the ill-structured problem, the second is the teacher as the meta-cognitive coach, and third is the students in the stakeholder role (Gallagher, 2001). Each is explained below.

Ill-structured problem. An ill-structured problem is a problem that needs more information before it becomes clear, can be solved in more than one way, has more than one acceptable resolution, sometimes changes with new information and is ambiguous and unclear. Another important aspect of the ill-structured problem is that students are given the problem at the beginning of instruction (Gallagher, 2001). Virtually all problems in life are ill-defined (Qin, et al. 1995). An example of an ill-structured problem would be deciding whether or not to drill for oil in Alaska. Another example would be evaluating the merit of stem cell research. By grappling with an ill-structured problem, students are mirroring the way learning takes place in real life.

Teacher as meta-cognitive coach. The second key component of PBL is the teacher as the meta-cognitive coach (Gallagher, 2001). Meta-cognition is the process by which we think about our thinking and reflect on what we know and do not know in order

to plan a strategy for producing needed information . It is the act of being conscious of our own steps and strategies during the act of problem solving in order to evaluate the productiveness and effectiveness of our own thinking (Costa & Kallick, 2000). Meta-cognition is a form of reflection that is one component of growth that can influence increased self-direction in learning.

The nature of PBL is by and large directed by the students, which is why the teacher's role as the meta-cognitive coach is so significant. As the meta-cognitive coach, the teacher's role is to prompt students' own thinking by answering questions with questions and giving students the opportunity to assume control of the direction of instruction while maintaining responsibility for the content and objectives being covered. Additionally, the role of the teacher is to follow the discussion of the students closely and consider when and how he or she might contribute to their learning (Wetzel, 1996). Specific teacher activities include: planning, preparing, listening, encouraging critical thinking, challenging assumptions, giving feedback, guiding, and facilitating learning. During Problem-Based Learning, teachers ideally are restrained in the transmission of information, concentrating more on making a considered decision when to interject and when to hold back, never interrupting productive discussion (Wetzel, 1996). This is a departure from traditional practices and beliefs and allows for students to test ideas, collaborate, and innovate.

Students as stakeholders. Finally, the third characteristic of PBL which differs from the traditional classroom is the student taking on the role of a stakeholder in the problem. Gallagher, (2001) states, in PBL, the stakeholder has authority, responsibility

and accountability in the problem scenario. This means that the overall objective is to increase the students' ownership in the resolution of the problem while increasing their awareness that real-world problem solvers have perspective, or in other words, are not objective, and that problems must be considered from multiple perspectives. By maximizing students' investment in this way, they are highly motivated to work together to develop a creative yet plausible solution to the problem presented to them.

PBL draws on many different branches of learning theory, joining together the areas of content acquisition, problem-solving, motivation and higher order thinking. In order to teach higher order thinking skills, a broad knowledge base is critical since many effective problem-solving and reasoning skills are embedded in discipline-based content knowledge (Chi, 1978; Chi, Glaser & Rees, 1982; Glaser, 1984). Modern research on learning says that it is essential for students to make connections in order to learn facts. Effective connections are established when students actively seek associations and form relationships in order to form a solid network of information (Resnick & Klopfer, 1989; Voss, 1989). The nature of presenting content through an ill-structured problem provides students with support for content acquisition and retention by providing a meaningful context for information, opportunity for active discourse and connection with prior learning (Gallagher, 2001).

In most disciplines, problem-solving is a fundamental activity and serves as an important bridge between content knowledge and higher order thinking. However, not all problems provide this link. Ill-structured problems support the kind of thinking and skill development students will need after schooling is complete to solve real world problems

(Carter, 1988; Chand & Runco, 1993). Furthermore, discovery, inherent in the investigation of an ill-structured problem, is one variable which seems to assist students in the transfer of concepts and skills to new analogous experiences (Gallagher 2001).

Additionally, when a curriculum is based on problems of significance and thoughtful questions, learning and motivation both increase (Brown, 1990; Wiggins, 1989). It is critical for students to acquire positive dispositions towards learning if there is any inclination for them to use critical thinking skills (Gallagher 2001). The attributes of the positive dispositions towards learning associated with life-long learning include perseverance, tolerance of ambiguity and intellectual courage (Ennis, 1962; Newmann, 1990; Wilkinson & Maxwell, 1991).

The combination of these dispositions, along with rich content and thinking skills, is increasingly considered to be the components of good reasoning (Ennis, 1986; Paul, 1992; Perkins, Jay, & Tishman, 1993). Immersing students in the discipline, rather than just teaching content, provides an effective foundation for long-term information retention by orienting content around significant concepts (Bransford & Vye, 1989; Rabinowitz & Glaser, 1985). The design of PBL immerses students in a stakeholder role of a practitioner in the field. In order to solve the problem as the stakeholder, students must consider not only the content knowledge needed by the practitioner, but also the ethical codes and thinking dispositions associated with the practitioner as well (Gallagher 2001).

Summary

As can be seen, PBL is an example of a constructivist method of teaching that has roots in discovery and inquiry based learning. Bruner's theory of learning provides a foundation for learning through discovery and problem solving. The principle benefits of learning through discovery include more effective problem solving, a shift to intrinsic reward for learning, more efficient memory and recall of information, and the development of the skills and attitudes of inquiry that transfer and generalize to learning in many different contexts. There are many different teaching models in the constructivist tradition. One model of PBL, proposed by Stepien and Pyke (1997) reflects the principles of Bruner's theory of discovery and problem solving. This model is characterized by five distinct phases: (a) Problem engagement, (b) Inquiry and Investigation, (c) Problem Definition, (d) Problem Resolution, and (e) Problem Debriefing. It is also characterized by three key differences: (a) the problem should be ill-structured; (b) the teacher should serve as a meta-cognitive coach; and (c) the students should be treated as stakeholders in their own learning. This discussion will now turn to a review of the research on PBL.

Research on PBL

Research on PBL is more extensive both in process and in variables studied in medical education than in P-12 education. Therefore, this section will begin with a review of the research relevant to the questions examined in this study drawn from the medical school literature.

Research on PBL in Medical Schools

As noted, PBL has not been widely applied in the P-12 education arena.

Although some efforts are underway to change that trend, and the literature in P-12 is rapidly growing, medical schools have made the greatest use of PBL in the preparation of physicians; as such, the medical literature is saturated with literature on the use of PBL and this section will begin with a review of that literature.

Non-cognitive outcomes of PBL. Vernon and Blake (1993) conducted five separate meta-analyses of 35 studies representing 19 medical schools. They used the following criteria for including studies in their meta-analysis: (a) the study of clinical cases, either real or hypothetical; (b) small discussion groups; (c) collaborative independent study; (d) hypothetico-deductive reasoning; and (e) a style of faculty direction that concentrated on group process rather than imparting information. Studies were identified from standard online abstracting and indexing services for the time period of 1970-1992, prior literature reviews, personal communications with investigators, and bibliographies of research reports and continuous examination of several journals. Quantitative research reports comparing PBL with more traditional methods and that measured outcomes of an evaluative nature were also considered. Separate effect-size analyses were done for each of the most common types of dependent variables reported in the results.

Results showed no sample in which student attitudes did not favor PBL to some extent. Effect-size values could be calculated for eight samples, the mean was $d_w +.55$. The results of the vote-count analysis suggested a favorable effect of PBL ($z=3.87, p <.0001$). These results were supported by the studies of class attendance and student mood or distress. Results exploring academic achievement used the National Board of

Medical Examiners Part I (NBME I) examination. Eight studies were included in this analysis. Effect-size data suggest a significant trend favoring traditional teaching methods ($d_w = -.18$, $CI_{.95} = -.10$ to $-.26$). On the other hand, vote count, which included the results of five additional samples showed no difference between PBL and traditional measures.

A group of reports also presented data on academic processes, meaning students' approaches to learning and their use of various learning resources. The findings suggested PBL programs place more emphasis on understanding rather than rote learning and memorization in comparison to traditional programs that did the opposite. The effect-size values in these samples ranged from $+0.44$ ($N=85$) to $+0.79$ ($N=204$). Data on the use of various learning resources by students in PBL and in traditional programs were reflected in four studies. Results supported differences in the use of learning resources between the two groups. PBL students placed more emphasis on journals and online searchers and made greater use of the library as measured by a cumulative-use index ($d = +0.41$). PBL students made greater use of self-selected reading materials ($d = +0.41$). These findings suggest a greater degree of independent study in PBL (Vernon & Blake, 1993).

In sum, Vernon and Blake (1993) found that the students reported PBL as more enjoyable, more motivating, more engaging and more satisfying than traditional instruction. The results of the analyses also indicated the comparative value of PBL with respect to measures of students' clinical performance, thereby leading Vernon and Blake to conclude the PBL approach superior to more traditional methods of instruction.

In a study of 341 students at two universities with nearly identical admission criteria, curriculum organization and implementation were examined for the effects of PBL on non-cognitive outcomes. (Lancaster, Bradley, Smith, Chessman, Stroup-Benham, & Camp, 1997) These researchers compared students taught in a traditional lecture-based setting to students taught in a PBL setting. Of the 341 students, 56 were enrolled in the PBL curriculum and 258 were enrolled in the traditional lecture based curriculum. The students from the two schools, the Medical University of South Carolina College of Medicine (MUSC) and University of Texas Medical Branch at Galveston (UTMB), were administered the 55-item Medical School Learning Environment Survey (MSLES). The MSLES consists of seven scales: flexibility, student interaction, emotional climate, nurturance, meaningful learning experience, organization, and breadth of interest. They found that the PBL students were significantly more likely to find more enjoyment from their learning, a more meaningful learning environment ($F=51.53$), more nurturance from faculty ($F=11.36$), more and better student-to-student interactions ($F=24.68$), and stimulation of a greater breadth of interest than traditionally instructed students ($F=13.66$), ($p<.05$). Additionally, PBL students reported the learning experiences exceeded their original expectations, while traditionally instructed students reported the learning experiences to be inferior to what they anticipated. The researchers found no significant differences in age, gender, or ethnic composition when the data were compared.

The results of the study showed at orientation, all students matriculated with the same baseline expectations for each aspect of the learning environment in the MSLES,

except for flexibility ($F_{(2,338)}=9.29, p<.05$). By the end of the first year, the PBL students were significantly different from the lecture-based students in that the PBL students felt the learning environment provided a more meaningful learning experience, more flexibility, allowed exploration of special interests, was more nurturing, encouraged more student-student interaction, and provided a more positive emotional climate than they had anticipated a matriculation. On the other hand, the traditionally lecture-based students, as measured by these six scales, perceived their learning environment to be worse than anticipated.

Researchers have also addressed the self-directed study feature of PBL. Rankin (1992) conducted surveys at two medical schools with PBL tracks and traditional tracks and one school with only a PBL curriculum. At the schools with a PBL track and a traditional curriculum track, a control group of students who were enrolled in the same school in the traditional track served as the comparison group. At the third school with an exclusively PBL curriculum, a control group was drawn from a school with a similar mission, size and geographic location and data published in the Association of Academic Health Sciences Library Directors (AAHSLD) *Annual Statistics of Medical School Libraries in the United States and Canada*. Second year medical students at the four schools were selected to participate in the study. The study design attempted to control for descriptive characteristics that affect library use by students such as gender, age, education, class level in school, academic standing, and prior library experience by collecting data related to these factors.

Generally, library use is measured as a dichotomous variable, meaning either use

or non-use, or as a continuous variable measuring frequency or intensity (D'Elia, 1980). However, in an experimental study of three PBL schools as well as one conventional school, Rankin (1992) measured library and information use in both dichotomous and continuous components. The rates of response varied by institution; however, overall the response rate was 34% (97 of 287). Of the 97 responses, 30 were from PBL students and 67 were from traditionally instructed students. Results showed that no difference was found in the range and variety of resources chosen by the PBL students and the traditional instructed students. For issues related to clinical problems, students generally chose three out of a possible six information resources. Conversely, differences were found between the PBL students and the traditionally instructed students in the type of information resources selected ($p < .05$). Both groups identified the textbook as the first choice for their preferred resources. However, for their second choice of their preferred resource, the groups differed in a statistically significant way. PBL students ranked medical journals and articles as well as medical databases as their second choice for preferred resources while traditionally instructed students chose a faculty member.

Another interesting finding emerged from Rankin's (1992) study related to resources medical students would use to support a clinical practice. In this case, both PBL students and traditionally instructed students ranked consulting with a practicing physician among their first choice to support a problem in clinical practice. However, among PBL students, an equal number of respondents selected online databases along with consulting with a practicing physician as their first choice while traditionally instructed students clearly placed a lower value on online databases by ranking online

databases among their third and fourth choice for resources to support a clinical practice. These results reflecting the choice of information resources medical students use to support a clinical problem and a problem in clinical practice appear to reflect a more independent approach to learning and problem solving.

No significant difference was found between the groups in information-seeking competencies however, the results also showed support the notion that PBL promoted higher degrees of self-directed learning. A one-way ANOVA indicated a statistically significant difference ($p < .05$) between the two groups in terms of self-selected as opposed to faculty-recommended library materials to support learning.

Rankin (1992) found significant differences between PBL students and traditionally instructed students in terms of their library use. Survey results indicated that PBL students were the more frequent library users, used information resources that supported the independent learning process, acquired information seeking skills at an earlier stage in their medical education, and reported greater ease in using these skills although the difference between the two groups was not statistically significant.

In a qualitative two-case critical study case design study of 30 full time occupational and physical therapy students enrolled in a small faith-based University in a suburban community in the Northeast for 2005-2006 school year, Bortone (2007) examined PBL strategies and how they guide critical thinking as well as how they facilitate the use of evidence based practices by students in PBL tutorials. A quantitative instrument, the *California Critical Thinking Skills Test (CCTST)* (Facione, 1990) was used to select the sample from the population of students. Students who showed

significant advancement in critical thinking as demonstrated on the CCTST were interviewed for the study. The two case study design included students and PBL facilitators from two programs, the occupational and physical therapy programs.

The occupational therapy (OT) program is a two-year, full time graduate program and the physical therapy (PT) program is a three-year, full time graduate program. Both programs use PBL as the primary method of teaching. Additional coursework, laboratories and clinical fieldwork are also a part of the program. The participants were a purposeful, criterion-based convenience sample of 30 first-year, second-semester, entry level OT and PT PBL tutorial groups who were invited to voluntarily participate. There were 12 OT students and 22 PT students.

The data were triangulated by using multiple sources such as observations, interviews and documents. Data were coded according to themes that emerged from the participants responses, the researchers own perceptions, and from the theoretical literature. Using a constant comparative method for data analysis, Bortone (2007) found students reported beneficial changes in their critical thinking such as no longer accepting information in textbooks at face value. The students also reported that they found themselves asking more questions about information, asking what made the source they were using credible and how the information applied to the case they were studying.

Cognitive outcomes of PBL. While satisfaction, interest, and motivation to learn are important outcomes of any learning experience, often the criteria by which curriculum and teaching practice are deemed effective is content acquisition. Much of the literature on teaching for content acquisition generally shows an advantage for

teacher-centered instructional practices. However, with the rise of 21st Century skills, (see Appendix A) there is interest in instructional strategies that require students to be more than passive recipients of content. Currently, PBL is one of the more popular of these indirect strategies; however, one concern is that indirect strategies, such as PBL, do not teach for content acquisition as well as those direct strategies.

In a three-year study, Eisenstaedt, Barry, & Glanz (1990) studied sophomores in medical school. A total of 59 students voluntarily participated in a PBL tutorial in lieu of a traditional lecture-based hematology-transfusion course while the remainder of the class participated in the traditional lecture-based course. Eisenstaedt, et al. (1990) found students in PBL environments scored lower on a content based test at the conclusion of the course than the students in the traditional lecture-based course who took the same exam ($p < .001$). However, results showed that two years later, retention remained constant for the PBL students while for a randomly selected sample of the remaining class who took the same exam retention declined significantly ($p < .001$).

All students who participated in the PBL tutorial took the objective examination at the conclusion of the course and 54% completed a second exam administered two years later. The 107 members of the class who served as controls had all taken the initial exam, and 54% returned the second. Students in the PBL tutorial scored significantly lower on the initial exam however, performance of those in the tutorial remained fairly constant over a two-year interval, while scores of the students in the control group dropped significantly on a delayed post-test. In their discussion of the results, Eisenstaedt, et al. (1990), suggested that the advantage of lecture-style preparation is

short-lived while the overall learning from PBL participation sustains.

Similarly, Dolmans, Gijsselaers, Schmidt, and van der Meer (1993) report findings in three studies of 120 second-year students and 12 faculty tutors in a six-week course on normal pregnancy, delivery, and child development at the medical school of the University of Limburg in The Netherlands in 1990-1991. The three studies were all conducted using the same participants; all were designed to determine what learning issues did and did not arise for the students relative to what the professors were expecting. The first study was used to link course objectives with various student learning issues. In this study, 12 pairs of expert raters judged the match between faculty objectives and student generated learning issues. The second study determined why some groups experienced more learning issues than others. In this study, faculty objectives not identified by one or more tutorial groups were ranked in a list. The faculty member who designed the course then categorized the list. The third study explored how and why students created their own learning issues, one of the components of PBL. In this study, student generated objectives considered not to correspond to any objectives identified by the faculty were judged for their relevance by the faculty member who designed the course.

Results of the first study showed faculty objectives identified by the 12 tutorial groups averaged about 64% ($F_{(11,143)} = 6.84, p < .000$). Results of the second study showed that 30 of 51 faculty objectives were not identified by one or more tutorial groups. Results of the third study showed the 12 tutorial groups generated 520 learning issues for the 12 problems. Of these, 32 learning issues definitely did not correspond to

any faculty objectives. Of the 32 learning issues not corresponding to faculty objectives, eight were then judged fairly irrelevant, nine neutral, 14 fairly relevant and one relevant thus, 47% of the unexpected learning issues were congruent with the course content.

In their discussion of the results, Dolmans, et al. (1993) note students in PBL learned on average 64% of the expected learning objectives. This result is in line with typical results from traditional teaching methods suggesting that students in a PBL curriculum are able to determine what they need to know. Furthermore, this result suggests students in a PBL curriculum are able to determine what is relevant to learn and how to modify their learning to satisfy their own needs and interests.

In summary, several studies in medical schools have explored the cognitive outcomes of PBL. Of major interest is the retention of content. In retention of content, results show that PBL may yield less retention in the short term, but higher retention in the long term. Furthermore, in terms of cognitive outcomes of PBL, studies from medical schools reveal students acquire a better understanding and a more comprehensive grasp of the subject matter. Finally, related to cognitive outcomes, studies reveal that students in a PBL curriculum are more meta-cognitive about their learning in that they are able to determine what they need to know, what is relevant to learn, and how to modify their learning to satisfy their own needs and interests.

Effectiveness of PBL. There is a body of research in the medical literature addressing the question of how to maximize the effectiveness of PBL. Studies in this area seek to provide clarification on how PBL should be implemented to result in the maximum benefit. Gallagher's (1997) three key features of PBL, the ill-structured

problem, the tutorial, and the teacher as meta-cognitive coach, are the primary focus of these studies. It must be noted, however, that in the medical literature, group collaboration in the tutorial takes the place of the students as stakeholders and the teacher as meta-cognitive coach is referred to as the tutor. So in this research stream, Gallagher's three features are: (a) an ill-structured problem, implemented in (b) a group collaboration learning environment with (c) the coach becoming a tutor.

Research on the effectiveness of problem structure. Because PBL is a complex instructional model that includes a series of interrelated steps and components, it is a challenge to isolate its individual influences and effects. However, one group of researchers has isolated results related to problem construction and design. For example, there is some evidence that the problems can be too structured or too ambiguous to be effective. But, when problems are designed around well-articulated goals and objectives that are clearly communicated to the tutor, both novice and expert tutors are able to achieve the same level of achievement with their students (Davis, Oh, Anderson, Gruppen, & Nairn, 1994).

Davis et al. (1994) studied 211 students in the University of Michigan Medical School. The purpose of their study was to explore the efficacy of a carefully designed and highly focused case problem to remove the influence of the group facilitators' content expertise on students' learning outcomes. The students were randomly assigned to 28 groups, each led by a faculty facilitator, in a microbiology and immunology course. However, complete data were only available from 27 of the groups. Experts led 13 of the groups and 14 of the groups were led by non-experts. Data collection included the

observers' codings of interactions between the students and the facilitators (interaction analysis), test scores and students' ratings of the experience.

The results showed that the content expert group leaders devoted significantly more time to teacher-directed activities than did the non-content expert leaders ($p < .05$). This was an unexpected outcome. The researchers expected that group leaders with less content expertise would revert to teacher-directed behavior to explicitly teach the content. Overall, 62% of the time was devoted to student-initiated activity. In regard to the results of the multiple-choice test, there was no significant difference between the two groups' performances on the items related specifically to the goals of the case. Additionally, all students gave consistently high ratings for student satisfaction with the experience. This finding supports the notion that PBL influences positive student attitudes towards student learning. In the discussion of the data, the researchers noted that careful design of the case and increased focus on the content to be learned are significant variables affecting students' learning.

Research on the effectiveness of the tutor/coach. Investigations of tutor behaviors have also shed some light on the skills and attitudes that maximize the benefits of PBL. The studies in this area are concentrated on three areas: tutor expertise, tutor instructional skill, and tutor attitude.

Eagle, Harasym, & Mandin (1992) sought to determine the effects of tutors' levels of content expertise on learning issues generated within problem-based learning (PBL) tutorials. The 70 students in the class of 1992 at the University of Calgary Faculty of Medicine were divided into ten small groups for an integrative course taken prior to

clinical clerkships. The course consisted of 24 ill-defined problems, each considered to be a separate case. These cases followed various formats including, book, microcomputer and simulated patient. The major focus of the courses was 12 simulated-patient cases in which actors were hired to play the roles of the patient. There were a total of ten small groups and 17 tutors. Of the tutors, 14 faculty members each tutored a small group for a two-week period and three had one group for the entire period. Tutors were deemed to be experts under the conditions that they were the case author and/or the case was typical of those they encountered in their clinical practices. Therefore, depending on the topic of the case, tutors were identified as experts for some cases and as non-experts for others.

Eagle, et al. (1992) found that when the groups had tutors with expertise in the clinical cases studied, the groups generated approximately twice as many learning issues per case ($t=3.46$, $df=12.8$, $p < .01$), and these issues were approximately three times more congruent with case objectives ($F=21.29$, $df=1.33$, $p < .01$). Overall, the students experienced 43 simulated-patient cases, of which data were collected for 35. Of the 35 simulated-patient case encounters for which data were collected, 24 were led by non-expert tutors and 11 were led by expert tutors. In addition, groups with expert tutors spent approximately twice as much time per case overcoming identified learning issues, meaning a question, comment or gap in knowledge that needed to be addressed in order for the group to progress with the resolution of the case. These results suggest that it is important for tutors to be well informed about cases and case objectives and to be well versed in the PBL tutoring process.

There is some inconsistency in the results on expert tutors in that Silver and

Wilkerson (1991) found evidence that suggests expert tutors do not always work to the students' advantage. Their study took place during an 11-week, interdisciplinary course in pathology, immunology, and microbiology for first-year students at Harvard Medical School in 1988. Four randomly selected tutors were chosen to participate in the study. Two sessions on two separate cases were audio taped for each of the four tutors, a total of eight tutorial sessions. Data analysis included the development of a series of categories related to the direction of the tutorial process in order to code individual verbal contributions. The contributions included the types of tutors' comments and the relative use of each; amounts of time taken up by the comments of the tutors and students; and the pattern of exchanges during the tutorial and tutorial agenda-setting.

Data analysis, using t-tests for paired samples, revealed significant differences in the nature of the tutors' comments ($p < .0001$), length of tutor comments in seconds ($p < .001$), the patterns of tutorial interaction ($p < .0001$), and agenda-setting behaviors ($p = .002$), when the tutors were and were not experts on the subject being discussed (Silver & Wilkerson, 1991). Expert tutors were found to be more directive than novice ones. They spoke more often and for longer periods, provided more direct answers to the students' questions, and suggested more of the topics for discussion. Tutor-to-student exchanges predominated, with less student-to-student discussions. The development of students' skills in active, self-directed learning is an important goal of PBL; therefore these results reveal that when problem-based tutorials use faculty tutors with expertise, their knowledge and authority may be more of a drawback than an advantage.

The relationship between tutor expertise and student achievement seems to also

relate to problem structure. Schmidt (1994) investigated the impact of tutors on achievement in problem-based learning environments. The study included 1,800 students enrolled in Health Sciences from the University of Limburg. Each student participated in an average of 4.1 tutorial groups. The researchers analyzed: a) students' achievement scores as a function of tutor's knowledge and student's prior knowledge; b) students' achievement scores as a function of tutor's levels of subject matter expertise and levels of structure; and c) differences in achievement between students guided by tutors of different levels of expertise in high or low structure units. Results showed the level of subject-matter expertise of tutors had a positive influence on student achievement ($F_{4110.2}=12.30, p < .0001$). The effect of student prior knowledge was also statistically significant, ($F_{4110.1}=14.98, p < .0001$). Students who indicated they had limited prior knowledge performed less well on the achievement test. This finding is important in the context of other results that indicate a relationship between tutors' expertise level and students' prior knowledge. The two-way interaction between tutor's expertise and students' prior knowledge revealed statistical significance ($F_{4110.2}=5.79, p < .003$). This finding supports the conclusion that when students had limited prior knowledge, tutor expertise was an important influence on student achievement, but when students had advanced prior knowledge, tutor expertise was less influential.

Results also emerged indicating a relationship between tutor expertise and the structure of the problem. The two-way interaction between expertise level and structure was also statistically significant ($F_{4099.2} = 3.25, p < .05$). Hence, expert tutors were necessary to provide guidance and assistance when the problem was vague or when the

student did not have extensive prior knowledge about the problem. This finding suggests expert tutors compensate for weaknesses in the curriculum. On the other hand, tutor expertise was not a significant factor that contributed to student learning or success when the problem had sufficient cues to guide student learning ($p < .10$), the students had encountered similar problems previously, or when the students had ample prior knowledge ($F_{322.2} = 1.31, p < .28$).

The literature reveals tutor expertise contributes to successful PBL tutors. However, tutor expertise and student oriented characteristics do not comprise the comprehensive skill set required of successful PBL tutors. PBL reflects a pedagogy that includes specific instructional skills. The instructional skills required for PBL are reflected in a schema developed by Shavelson & Stern (1981). Based on a review of the literature on P-12 teachers' pedagogical thoughts, judgments, decisions and behavior, Shavelson & Stern (1981) formulated a schema of teachers' judgments, planning decisions and interactive decisions.

According to this model teachers' judgments, decisions and behavior are a part of a cyclical pattern in which antecedent conditions such as information about students' ability, participation and behavior, the nature of the instructional task, and the classroom environment are influenced by teacher characteristics such as their beliefs, their conceptions of the subject matter, and cognitive complexity. Teacher characteristics are in turn influenced by teacher cognitive processes such as inferences and information selection and integration. Teacher cognitive processes in turn influences instructional planning and interaction with students which cycles back to the antecedent conditions.

This schema is consistent with the instructional skills in the literature on PBL that tutors need to ensure both student interest and achievement. The characteristics of effective

PBL tutors include:

- balances student-direction with assistance,
- stimulates discussions when necessary,
- provides feedback to students,
- respects pace of the group,
- contributes knowledge and experience,
- creates a pleasant learning environment,
- helps group set learning issues by asking thought provoking questions,
- listens to students; allows students to fumble, and
- stimulates critical evaluation of ideas (Barrows, 1988; Holmes & Kaufman, 1994; Wilkerson, 1996).

These student oriented attitudes alone do not comprise the comprehensive skill set of successful PBL tutors. In addition to these characteristics, Moust (as cited in Schmidt & Moust, 1995) identified effective tutor behaviors that synthesize not only these student friendly characteristics but also important instructional skills such as: (a) use of subject matter knowledge; (b) use of authority; (c) achievement orientation; (d) orientation toward cooperation within the tutorial group; (e) role congruence; and (f) cognitive congruence.

In an extension of this work, to test and further develop a causal model of the influence of tutor behaviors on student achievement and interest in the context of

problem-based learning Schmidt and Moust (1995) analyzed data from 524 randomly assigned tutorial groups involving students participating in the four-year undergraduate health sciences curriculum at the University of Limburg. Students responded to a program evaluation questionnaire at the end of each course prior to administration of an examination measuring student achievement. The program evaluation included items about the quality of different elements of the course. Students responded using a three-point Likert scale ranging from 1, “not present,” via 2, “some-what present,” to 3, “present”. Student achievement was measured by 100 to 10 true-false items and short essay questions. Essays were rated on a scale of 1 to 4 with 3 being the pass score. Correlations among tutors’ social-congruence, expertise-use, and cognitive-congruence behaviors, small-group functioning, and students’ self-study time were analyzed using a structural-equations model. Results indicated a statistically significant correlation between expertise use and social congruence, $r=.55$ ($p<.01$), cognitive congruence, $r=.77$ ($p<.01$), tutorial-group functioning $r=.26$ ($p<.01$), academic achievement, $r=.10$ ($p<.05$) and intrinsic interest in subject matter, $r=.16$ ($p<.05$). There was not a statistical significant correlation between expertise use and self-study time, $r=-.07$. The negative influence of expertise on self-study time suggests that the more content expertise a tutor contributes to the discussion, the less likely it is students will spend on self-directed study time. The results suggested that affective and intellectual qualities such as subject-matter expertise; a commitment to students’ learning and their lives in a personal, authentic way; and the ability to express oneself in the language used by the students all influence the effectiveness of tutors and consequently student learning.

In summary, the extent of the literature in medical school on PBL is prodigious, continues to grow, and provides the foundation for transfer and application of PBL into P-12 education. Evidence from the medical literature suggests that PBL students found PBL more enjoyable, more motivating, more engaging and more satisfying than traditional instruction; PBL and traditionally instructed students had equivalent achievement test scores, and demonstrated no difference in short term recall, but significant difference in long-term recall; and PBL promoted higher degrees of self-directed learning among students.

While satisfaction, interest and motivation to learn are an important element of any learning experience, acquisition of content knowledge often remains the criteria by which curriculum and teaching practice is deemed effective. The literature in this area shows PBL and traditionally instructed students have equal achievement. Other advantages to PBL include the development of self-directed learning and problem-solving skills.

The medical literature also addresses the question of how to maximize the effectiveness of PBL. One element in this area that has been widely addressed in the literature is the role of the tutor. The studies in this area are concentrated on three areas: tutor expertise, tutor instructional skill, and tutor attitude. Data revealed significant differences in the nature of the tutors' comments, the use of tutorial time, the patterns of tutorial interaction, and agenda-setting behaviors when the tutors were and were not experts on the subject being discussed. However, the relationship between tutor expertise and student achievement seems to hinge on the problem structure. Another area of study

relates to PBL students learning teacher-designated objectives. Studies pursuing this question showed that students are able to identify teacher-directed objectives.

Researchers have also looked at the tutorial feature of PBL. Tutorial discussions or group collaboration was identified as the most important factor leading to self-study. Self-directed learning is one of the primary goals of PBL though it takes time for the tutorial discussion to become a powerful source of motivation. The tutorial is supported by tutors with effective tutor behaviors. Effective tutor behaviors in a PBL tutorial included student-oriented attitudes as well as important instructional skills.

Given the results from research conducted in medical schools, PBL is an influential curriculum and instructional model. While implementation is limited, recognition of the benefits of PBL has led to its incorporation into P-12 classrooms. Results from studies in P-12 settings report similar findings to those in the medical schools.

PBL in P-12 Settings

Problem-based learning was designed to create change simultaneously in curriculum and instruction (Barrows, 1988; Barrows & Tamblyn, 1980). While as an educational model, it has been researched in the medical literature, research in P-12 has been sparse but is rapidly growing. Gallagher (2001) reviewed the available literature in the P-12 education arena where PBL has been used. In her extensive review, Gallagher (2001) found it challenging to provide definitive conclusions. This is in part due to the diverse goals PBL aspires to achieve, and in part due to the various perspectives contributing to the question of efficacy. However, there are some indicators of the

strengths of PBL and how to maximize the effectiveness of PBL in both non-cognitive and cognitive domains.

Effects of PBL. There is a body of work that comes out of the Center for Gifted Education at the College of William and Mary in Virginia that focuses on testing the effects of PBL. Many of these studies are either quasi-experimental or research conducted by teachers as action research. As such, the generalizability of these studies is limited, but in each instance, the advantages favor PBL over traditional instruction.

In an experimental study designed to assess student growth on integrated science process skills after being taught a 20-36 hour PBL science unit on the Integrated Curriculum Model (ICM), results indicate small, but significant, gains for students in integrated science process skills when compared to equally able students not using the units ($F=32.86; p < .001$) (Van Tassel-Baska, 1986). The ICM is comprised of three interrelated dimensions, advanced content, higher level processes and product development, and interdisciplinary concepts, issues and themes. The ICM is designed to respond to gifted learners' affective needs as well by using these dimensions to address their precocity, intensity and complexity (VanTassel-Baska, 1986). The ICM has been translated into a set of PBL units in the areas of language arts, social studies, and science.

The subjects totaled 1,471 students in forty-five classes in 15 school districts in seven states. The volunteer teachers were prepared to use the problem-based unit Acid, Acid Everywhere. Students in grades 4-6 comprised forty-five experimental and 17 comparison classrooms. Of the 45 experimental classes, 12 were self-contained gifted, 10 were pull-out, 11 were heterogeneous with a gifted cluster, and 12 were

heterogeneous.

The student outcome measure was the Diet Cola Test (DCT), which was originally developed by Fowler (1990) to identify promising science students. The DCT is an open-ended test that cues students to demonstrate their ability to design experiments. Also, a teacher questionnaire, using Likert scales and open-ended items, was constructed for the study. The teacher questionnaire assessed the extent to which teachers found the curriculum materials appropriate, usable, and effective with students. Validity was not reported for the teacher questionnaire. Alternative forms of the DCT were administered to 1,471 students across 62 classes for the pre- and post-test. Additionally, 42 teachers completed an implementation questionnaire. Data reflected teachers' satisfaction with the units, especially in terms of student interest and motivation. Additionally, the results on the pre- and post-test strongly suggested that the use of the William and Mary Problem-based science units enhances learning and contributes positively to student motivation to learn. (VanTassel-Baska, Bass, Ries, Poland, & Avery, 1988)

Similarly, Feng, et al. (2005) found positive academic achievement effects in a mixed methods study of 973 students in grades three to nine from one northeastern suburban school district over a three year period,. Results were significant for all groups of learners, regardless of socioeconomic status, ability level or ethnicity. Among the participants were 116 third-graders, 106 fourth-graders, and 109 fifth-graders, most of whom were exposed to the William and Mary language arts and science units over a 3-year period.

Between 1996 and 2002, the students were tested using the corresponding performance-based assessments. Inter-rater reliability on the performance based assessments used to measure student learning was .90, based on the use of outside trained observers. These researchers used a pre/post literary analysis and writing assessment along with a stakeholder survey instrument and a student survey. Validity for the pre-post literary analysis assessment and pre-post writing assessment was reported in earlier studies. Surveys were returned by 367 parents, 110 educators and 732 students. The stakeholder survey consisted of between 28-31 multiple-choice, Likert-type items, and two open-ended questions. Key sections were derived from the National Association for Gifted Children (NAGC) standards. Separate forms were administered for parents and educators.

Data analysis, using t-tests for paired samples showed statistically significant gains from pre- to post-assessment in literary analysis, persuasive writing, grammar, and scientific research skills ($p < .001$). The effect sizes using Cohen's d index ranged from .52 to 1.38 suggesting to the researchers that student learning at grades three to five was enhanced at significant and important levels. Moreover, repeated exposure to the curricula demonstrated strong increasing achievement patterns.

The majority of the students in the study were repeatedly exposed to the William and Mary Units. The fifth grade language arts assessments results for repeated exposure affect analysis revealed statistically significant mean differences in all target areas ($p < .001$). The fifth grade scores were selected because there was a range of curriculum exposure from 1 to 3 years among those students thus allowing for repeated exposure

affect to be calculated. Additionally, there was a constant increase not only from pre-posttest in literary analysis, persuasive writing and grammar but also in frequency of usage ($p < .001$) suggesting to the researchers a positive effect resulting from repeated curriculum exposure. The study was limited by the lack of a comparison group due to comprehensive implementation of the curriculum with all of the gifted students in the district. The study was further limited by the low response rate on the stakeholder survey.

Bland, Coxon, Chandler, & VanTassel-Baska (2010) reported research highlights from Project Clarion, a 5-year Javits project funded by the U.S. Department of Education. Project Clarion included 3,462 students in 48 experimental classrooms and 43 comparison classrooms in six Title I schools in three school districts. Students were exposed to eight science PBL curriculum units for K-3 learners and pre-post curriculum-embedded performance-based assessments. The research findings indicated Project Clarion produced positive gains and improved critical thinking. Gains for students participating in Project Clarion were observed in conceptual understanding, science content attainment, and the scientific process on the curriculum-embedded performance-based assessments. There were no ceiling effects for gifted students observed on the performance-based measures leading the researchers to conclude they were effective assessments for that population. No p -values were reported in this article. The Project Clarion units were most effective when implemented as a comprehensive unit as opposed to isolated activities. Science teachers' instruction was improved by the structure, professional development and support provided by Project Clarion. Additionally,

teachers and students both found Problem-Based Learning more engaging than typical science units.

The Project Clarion findings highlighted by Bland et al. (2010) included the following results. Primary-age students who were exposed to PBL units showed significant growth ($p < .005$) in critical thinking in the second year of repeated exposure and significant growth ($p < .001$) in critical thinking in the third year of repeated exposure as measured by the Test of Critical Thinking (Bracken, Bai, Fithian, Lamprecht, Little, & Quek, 2004) when compared to those students who used the regular science curriculum. Additional results from this study included, repeated exposure to Project Clarion units resulted in statistically significant ($p < .001$) higher scores on standardized measures of science content than students who were exposed once (Kim, Van-Tassel-Baska, Bracken, Feng, Stambaugh & Bland, 2011).

Beyond the work conducted at William and Mary, Hmelo-Silver (2004) summarizes the body of work related to PBL in P-12 education. In her review of PBL she affirms that much of the research is conducted predominately in higher education and most frequently in medical schools. Hmelo-Silver elaborates to say that the research within P-12 is characterized by case study, pre-posttest or quasi-experimental designs as opposed to controlled experiments. The results of the meta-analysis revealed evidence that converged on a few key points. These points are reflected in the research that examines cognitive outcomes of PBL such as knowledge construction, problem-solving/problem findings, questioning, and critical thinking skills.

Cognitive Outcomes of PBL. P-12 PBL researchers have been concerned with

content acquisition, content retention, depth of understanding, and transfer of content by students instructed with PBL. In this area, researchers have found that PBL and traditionally instructed students had equivalent achievement test scores, retained more complex information, and demonstrated no difference in short term recall, but significant difference in long-term recall (Dods, 1997; Gallagher & Stepien, 1996; and Hmelo, Holton, Allen & Kolodner, 1997).

Content Acquisition. Due to the common concern that implementing curriculum fostering higher order thinking skills inevitably results in lower levels of content acquisition, Gallagher & Stepien (1996) conducted a pre-post experimental study of 167 students at a three-year state-supported residential school for students talented in mathematics and science to test this assumption. All of the students in the study were high school sophomores enrolled in American Studies. There were 93 males and 74 females. Prior to the students' arrival at the school, they were randomly assigned to one of four American Studies instructors. One of the four American Studies instructors used problem-based learning. Problem-based learning was used approximately 50% of the school year.

In an experimental mixed methods study Diggs (1997) addressed whether PBL affects student attitude toward achievement in science. Participants for the study were selected from a mid-Missouri junior high school for grades 8-9. This school was chosen specifically because of the different types of 9th grade science classes offered to students, one a self-selected optional Technology and Science 9 block course taught using PBL and the other was a regular Science 9 course and a technology course. The study focused

on 9th grade students ($n=127$) enrolled in a science and technology course with the PBL group totaling 78 and the comparison group totaling 49. The total number of girls in the study was 10 and the total number of boys in the study was 117. The study took place over the course of an academic year so student absences and mobility were factors that created slight variations in the numbers from measure to measure. Data included teacher interviews, an entry assessment of students' attitudes toward science survey, an exit assessment of students' attitude toward science survey, the Missouri Mastery and Achievement Test (MMAT), student science grades for semester 1 and semester 2 of the academic year, student perception surveys, and student interviews with randomly selected participants in the PBL group.

Data analysis was conducted to address each of the research questions. Descriptive statistics were analyzed to explore whether or not there was a significant difference in student science achievement. Dependent t-tests were used to examine differences within each group and between groups on the two administrations of the MMAT science achievement scores and semester science grades. A two-way ANOVA with repeated measures was used to determine the relationship between the mean scores on the two administrations of the MMAT and semester science grades for the two groups. Descriptive statistics were used for analysis of student attitudes as measured by the entry and exit attitude toward science survey. Dependent t-tests were used to examine differences between and within groups and a two-way ANOVA with repeated measures was used to determine the relationship between mean scores for the two groups. Initial descriptive statistics were analyzed to determine differences in student perceptions.

Independent t-tests were also used.

All students took the MMAT in 1994 prior to PBL instruction. The results of this showed no statistical significance in achievement scores. After coursework was completed, the students took the 1996 MMAT. During this administration of the test, the PBL group's science scores on the second administration of the MMAT were higher when compared to the comparison group of students and results of the data analysis showed the difference to be statistically significant ($p < .01$). A repeated measures analysis of variance on the 1994-1996 MMAT test scores showed a significant interaction. The PBL group showed an increase in scores from the first administration to the second administration of the test while the comparison group showed a statistically significant decrease in scores over the results from the first administration of the test ($F = 36.41, p < .01$). The results of the analysis of the student semester 1 and 2 grades over the academic year of study revealed a statistically significant difference between the two groups ($p < .05$). Students in the PBL group had a higher science grade point average, than the comparison group for semester 1 and 2. For semester 1, the mean semester grade point average for the PBL group was 2.80 and for the comparison group the mean grade point average was 2.18. For semester 2, the mean semester grade point average for the PBL group was 2.67 and for the comparison group the mean grade point average was 1.35. Analysis of the exit-attitude measure at the end of the academic year revealed a statistically significant difference in the student attitudes toward science. The PBL group reported a more positive attitude towards science at the end of their academic experience than at the beginning. The mean score on a 5-point Likert scale where "5" is highest and

“1” is lowest for the PBL group was 3.57. The mean score for the comparison group was 3.15 ($p < .01$).

In the discussion of the results Diggs (1997) suggests that the results of this study provides strong evidence that PBL students learn more and are more positive about their learning experience than other students. Additionally, the researcher asserts that the results of this study provide evidence that student attitudes toward science might be attributed to the design and delivery of instruction.

Conceptual Understanding. Gallagher and Stepien (1996) administered a 65 item multiple-choice test that was constructed from a computerized database of American studies test items. The test items covered a span in American history from European exploration of North America to the Nixon presidential administration. The test was intentionally designed to replicate a typical end-of-year high school exam. The test scores of students in the traditional and problem-based learning classrooms were compared at the beginning of the school year and at the end of the school year. The results did not support the assumption that curriculum fostering higher order thinking skills inevitably results in lower content acquisition (Gallagher & Stepien 1996).

A one-way ANOVA was conducted and revealed no significant differences in academic aptitude among the four classes. A one-way ANOVA was conducted and revealed no significant differences among the four classes in terms of prior knowledge. The results of a multiple comparisons analysis using the Tukey *b* showed that even though the PBL students had the highest gain, the gain was only statistically significant in comparison to one of the other classes ($p < .05$). This supports the assertion that students

in the problem-based learning course retained as much factual information as students in other classes and that problem-based learning does not have a detrimental effect on content acquisition. Additionally, in their pre-post experimental study of 167 students at a three-year state-supported residential school for students talented in mathematics and science at the high school level, Gallagher and Stepien (1996), found PBL students to consider more perspectives on the problem of ending the war in the Pacific when studying a unit on that topic. These findings suggest that PBL students engage in more complex thought even if evidence suggests traditionally instructed students retain more content.

Dods (1997) conducted an action research study in which he proposed a question about whether content encountered in a PBL experience was better understood and retained longer than content encountered in a traditional lecture format. The study was conducted in a bio-chemistry course at a 3 year residential high school for students with talents in mathematics and science with 30 students. There were 15 male and 15 female participants in the course. The majority of the participants were seniors, only one of the participants was a junior. Portions of the course were delivered as lecture and portions of the course were delivered as PBL. The researcher had taught the course for the previous six years and was an active member of the Illinois Mathematics and Science Academy Center for Problem-Based learning.

The students were required to complete five surveys designed to rate their understanding of specific content terms. The survey was administered prior to and after the lecture and PBL portions of the course. Each survey consisted of content that was

new to the students, content that students encountered in a traditional lecture, a PBL or both. Content that had been encountered by all 30 students in previous courses served as control-content items on the survey. Some terms were repeated in several surveys to assess retention over time. Students were instructed to respond to each term in writing to reflect their most in-depth understanding of the term. A one-way ANOVA revealed significant differences for the three different types of instruction $F(2, 87) = 30.135$, $p < .0005$) suggesting that in the case of this teacher action research project, lecture tended to widen content coverage while PBL promoted depth of understanding and retention of content.

Hmelo, et al. (1997) conducted a mixed method study of two sixth grade life science classrooms in suburban Atlanta using PBL to teach content about complex systems found in natural and physical science such as the human respiratory system. Forty-two students participated in the study. All of the 42 students were taught using PBL. A subset ($n=20$) were selected randomly to participate in pre- and post- instruction interviews. A comparison class ($n=13$) from the same school was used as a control.

Several types of data were collected to examine the students' pre- and post-instruction understandings of the respiratory system including, classroom observations, student projects and anecdotal records. Twenty of the students were interviewed and asked to draw a diagram about their understanding of the respiratory system prior to instruction. This included open-ended questions and questions that required the students to make inferences. All of the students were given a 12-item true-false test that asked them about dynamic processes and identified their misconceptions.

Students in the comparison classroom were taught about the human respiratory system using traditional methods, such as by reading their textbooks and participating in teacher-directed activities such as lectures. Students in the PBL classroom learned about the respiratory system by attempting to solve a design problem. Specifically, the students were asked to plan the design of a practical artificial lung and build a model of some piece of their design. Students worked on the problem project for 13 class periods over two and a half weeks.

Hmelo, et al. (1997) found that the children instructed in the PBL classroom increased their scores on the conceptual knowledge test from pre-to post-test ($F(1,32)=6.23 p < .05$), and were significantly different from students in the comparison classroom. However, the children's drawings and clinical interviews proved to provide better information to the researchers regarding the students' conceptual knowledge than the pre/post-test. From the drawings five types of models were identified and these models could be characterized as increasingly systemic and sophisticated. The most common model represented on the pretest by the PBL students was Model Two which reflected the understanding that the lung is composed of parts but without a clear indication that students understand that the structures are related to each other.

For the comparison class, the most common model represented on the pretest was the lowest level of understanding, Model One, which reflected a general understanding that lungs are structures in the chest but no evidence of an understanding that lungs have connections to other structures or systems. An analysis of the drawings indicated that PBL students had demonstrated statistically significant improvement (in their models

while the comparison students did not (Sign Test, $p < .005$). These results indicate the PBL students' understanding was more complex because they were able to construct models that reflected human respiratory functions as a system connected to other structures.

Transcripts of the students' clinical interviews were coded for evidence that students understood the lung as a system in terms of structure, function and behavior and whether or not this understanding was developed as a result of the PBL experience. The PBL students showed a statistically significant increase in identifying the number of structures of the lung such as "alveoli" ($F(1,17)=625; p < .05$), behaviors of the components of the lung system such as "gas passes from high concentration to low across semi-permeable membrane" ($F(1,17)=5.78 p < .005$), part-whole relationships such as "component-of lungs, works-with capillaries" ($F(1,17)=6.16 p < .005$). The results of this study showed that students did achieve a more systemic understanding of the respiratory system.

In an experimental study of sixty-one 10th grade students from two full classes instructed by the same biology teacher, classes were randomly assigned as either the experimental or the control group and were pre- and post-tested to determine their academic achievement and performance skills before and after the treatment. The experimental group was taught with problem-based learning and the control group received traditional instruction in a biology class including the use of lecture and questioning methods to teach concepts. In the experimental group being instructed using PBL, students worked in small groups with ill-structured problems.

The Pre/Post Human Excretory System Achievement Test was developed by the researchers to align with the literature related to the curriculum. The test included 25 multiple choice questions and one essay. This format was intended to concurrently measure students' academic achievement and performance skills. The Problem Based Learning Feedback Form was adapted from the end-of-course evaluation and consisted of two parts. The first part included 14 Likert-type items and the second part included seven open-ended items surveying their opinion regarding PBL. This instrument was deployed after the treatment of the PBL unit.

The advantages of the PBL instruction were revealed in the results which showed PBL instruction influenced a significantly better acquisition of scientific concepts than the traditional instruction ($p < .000$). Additional benefits of PBL over traditional instruction included results showing the students to be more proficient in the use and organization of relevant information, in constructing knowledge and moving toward better conclusions. Conversely, there was no apparent advantage to PBL in comparison to traditional instruction in terms of items requiring simple recall. In this case, the mean scores revealed no apparent difference between the two treatments. (Sungur, Tekkaya, & Geban, 2006)

Wirkala & Kuhn (2011) sought to examine the effectiveness of PBL and whether the social component is an essential element of the PBL method. In an experimental study of sixth-grade students at an alternative urban public middle school, between- and within-subject comparisons were made of students' learning the same material under three instructional conditions: lecture/discussion, characteristic small-group PBL, and

solitary PBL. Incoming students were assigned to one of three equivalent classes based on gender, ethnicity, standardized test scores, essay responses on the school's admission exam, and previous academic record. Ninety-nine students participated in the study. The student population at this school was highly diverse, composed of African American and Caucasian ethnicities in approximately equally proportions. Socioeconomically, the majority of students, 60%, qualified for free or reduced-price lunch. Previous achievement of the students varied from superior to low average, but all students functioned at or above grade level as indicated by standardized tests.

Nine weeks after instruction, assessments showed that the PBL groups defined a higher number of concepts than the lecture/discussion groups ($p < .001$). These results demonstrated a higher yield of comprehension and application of new material for the PBL students. Since the effects were the same for the group PBL and the solitary PBL, the researchers concluded the benefits of PBL are not dependent on the social aspect of the model. In their discussion, the researchers suggested that based on the results of this study, the superiority of PBL may be related to providing a potentially motivating, goal-based activity. Although the study did not provide direct independent evidence to support this claim, they offer that there are reasons to believe motivation was a contributing factor.

In a pretest-posttest design of two eighth grade gifted and talented science classes in a Midwest public middle school, using focused observations, interviews, test score analyses, and document analyses, results indicated students in a teacher-directed classroom learned factual content at a higher rate than students learning via a PBL

instructional approach ($p < .001$) (Nowak, 2011). However, the students engaged in PBLi had better retention than those who learned under a teacher-directed instructional approach. Results from the qualitative data indicate that students favored learning via PBL. Interview analyses revealed that students suggested embedding teacher-directed lessons within a PBL unit would benefit the students more than an exclusively PBL-based curriculum. Statistical significance was not reported for the qualitative results of the study. Nowak also reported other benefits of PBL that included social skill development, critical thinking and problem solving skill development, collaboration and enjoyment of ideas, increased student ownership, increased motivation, and transfer of concepts and knowledge.

Problem-Solving. One value PBL has to the field of P-12 education is the effect it has on the development of problem-solving skills. Pedersen & Liu (2003) addressed the idea of problem-solving in an experimental study of three sixth grade science classes taught by the same teacher. There were 66 participants in a school located in the suburb of a medium-sized city in the southwestern United States. Three classes were exposed to the hypermedia program *Alien Rescue*. In *Alien Rescue*, students act as a scientist onboard a newly operational international space station where they are part of a worldwide effort to rescue alien life forms.

In each of the three classrooms, a different version of expert support was used as the treatment variable. The three conditions were: (a) the modeling condition, in which an expert modeled two general tasks: tool functionality and his cognitive processes during problem-solving activities; (b) the didactic condition, in which the same expert

explained tool functionality and offered tips and examples of useful strategies to use while working on the problem, but did not model his application of these strategies to the tasks at hand; and (c) the help condition, in which the expert explained tool functionality outside of the context of their use in problem-solving activities but did not offer any advice about how students should work. The dependent variable was a problem the students were asked to solve following completion of their work in *Alien Rescue*.

Upon the completion of their work on *Alien Rescue*, students were asked to solve a novel problem. This problem required them to function by performing the same type of tasks necessary to solve the problem in *Alien Rescue*. Student responses to this problem provided the data for this study. The problem the students were presented with revolved around determining which of three locations would provide the most viable alternative habitat for a species of salamander that is threatened by growing pollution. To respond to the problem students needed to determine what information they needed, compare that information to what was already available and generate a list of questions designed to elicit the remaining information.

Students' responses were scored by classifying each of the questions they generated as either appropriate or inappropriate. An appropriate question met the following criteria: (a) it had to request information about the locale relevant to the salamander; (b) it had to be related to the needs of the salamander; (c) the question had to request information the students did not already have; and finally (d) the question had to request specific information so that it could be answered by data the scientists could collect. The second part of this measure required students to provide a rationale for the

solution they developed for the problem. This data were scored with a rubric by four different raters, three of whom were unaware of the students' treatment conditions. Inter-rater reliability for this measure was .97.

A one-way ANOVA was conducted to determine whether there was statistical significance to the difference in scores by treatment condition. Analysis using Tukey's HSD revealed statistical significance to the modeling group producing more appropriate questions than the help group ($p < .05$). The difference between the modeling group and the didactic group was not statistically significant although the effective size was moderately large ($d = .69$), nor was there statistical significance between the didactic group and the help group. There was no statistical significance to the difference in total number of questions asked by students in each condition. Additionally, an analysis of variance was conducted for the second part of the measure examining students' rationales for the solutions they developed. Results of this analysis revealed statistical significance ($F = 11.363, p < .01$). In this case, the modeling group performed better than both the didactic and help groups. It is important to note the effect sizes, which were also considerable. The modeling group was more than one standard deviation higher than the means for both the didactic group ($d = 1.51$) and the help group ($d = 1.14$).

This evidence suggests students were able to transfer the problem-solving strategies that were modeled for them during the PBL to their work on a similar problem on an unrelated topic. Additional results supporting the use of PBL for transfer of learning include the finding that expert support is more effective through modeling rather than through intervention as the didactic group received since the modeling group

performed significantly better than either of the other two groups on one part of the problem-solving measure (Pedersen & Liu, 2003).

In an experimental study of 98 seniors taking an interdisciplinary problem-based course, Science, Society and the Future (SSF), at a 3-year state-supported residential school for students talented in mathematics and science, Gallagher, Stepien & Rosenthal (1992) found quantitative and qualitative evidence from P-12 classrooms that suggests problem-solving is a skill PBL students do obtain. The students in the study attended a competitive entrance 3-year state-supported residential school for students talented in mathematics and science. There were 42 students enrolled in the experimental class during the first semester and 52 enrolled in the class during the second. All of the students were seniors. The comparison group consisted of students not enrolled in the experimental course. There were 12 seniors and 31 juniors enrolled in the comparison course. The experimental and comparison groups were compared to determine if there were significant differences between their scores on certain measures. On the measures of Academic Comfort, Introversion, Research, Inventive, Enterprising and Conventional scales on the Strong-Campbell Interest Inventory the groups were similar. The groups were also similar on total scores of the Cornell Critical Thinking Test.

The experimental and comparison groups were given a pre-test on problem-solving. This was administered on the first day of class. The test consisted of an ill-defined problem. The intervention was a one semester course Science, Society and the Future (SSF) course designed to elicit three process-oriented goals: (a) to lead students to discover the interdisciplinary character of most real-world problems, (b) to require

students to engage in the process of solving an ill-structured problem, and (c) to improve students' problem-solving skills. Over the course of the semester, two problems were presented to the students. The students were tasked with (a) determining if a problem existed; (b) creating an exact statement of the problem; (c) identifying information needed to understand the problem; (d) identifying resources to be used to gather information; (e) generating possible solutions; (f) analyzing the solutions using benefit/cost analysis and ripple-effect diagrams; and (g) writing a policy statement supporting a preferred solution. Following the course, the students were administered a posttest similar to the pre-test.

The data for both groups were analyzed for evidence of problem-solving schemas. Pre-posttest comparisons were conducted using McNemar's statistic for comparing dichotomous variables. Chi-square analyses were conducted within the SSF group to control for previous problem-solving experience. The results showed no significant difference in problem-solving patterns between groups prior to their enrollment in SSF. Additionally, differences between instructors' skills and characteristics were not a factor affecting the results. SSF students and a group of comparison students were tested to determine changes in their spontaneous use of problem-solving steps as they consider an ill-structured problem. The results of the study showed some significant changes for the SSF group not observed in the comparison group. The rate of including problem-finding as a step in problem-solving increased by 43.62% with the SSF students ($p < .01$).

In their discussion of the results, Gallagher, et al. (1992) note that while an increase was found in the use of problem-finding as a problem solving step, there was not

consistency in the increase of other steps in problem-solving. These results suggest that a refinement in the tutorial process may make improvement across the steps more consistent.

Questioning. Another benefit PBL has for P-12 education is the potential for developing student questioning. In an experimental pre-post study of 175 students Kang, DeChenne & Smith (2012) sought to examine the degree to which students in a high school in an affluent suburb of a city of about half a million people located in the Pacific Northwest improved their inquiry capabilities in relation to scientific literacy through their experience with a problem-based environmental health science curriculum. The total population of the high school was about 2,400 students with about 33% minority population (7% English language learners). Two teachers taught a total of 129 high school students a 10-week long inquiry curriculum. An additional group of 46 students, taught by one of the two teachers, served as a comparison group and learned an alternative curriculum. The students in the inquiry curriculum group wrote responses to an environmental health issues question at the beginning and end of the 10-week long inquiry curriculum.

Kang, et al. (2012) used a chi-square test to compare the students' pretest results between the eight classes taught by the two teachers. Although one teacher's students scored lower than the other, there was no significant difference between the classes. Analysis of the pre-test was also used to determine whether there was a statistically significant difference between the students in the inquiry curriculum and the additional students in the comparison group. The analysis determined there was no statistically

significant difference in terms of prior knowledge and achievement. The results showed students using the inquiry curriculum performed significantly better than those using the alternative curriculum in posing active inquiry questions and generating hypothesis-driven approaches to inquiry into their questions, but again, the findings did not reach significance. The inquiry curriculum students also improved significantly from the pretest to the posttest in both measures of inquiry capacity. In their discussion of the results, the researchers suggest these results support the notion that a curriculum specifically planned to improve students' scientific literacy is more effective than a general curriculum that teachers encounter in regular teaching settings.

In an interpretative case study of grade 9 students taking a biology course and learning about food and nutrition, Chin and Chia (2004) investigated how students generated their own problems and questions for study in a PBL unit, how students' questions guided them in knowledge construction and the kinds of questions that students asked individually and collaboratively. This 18-week study took place at an all-girls secondary school in a class of 39 students where the second author was the science teacher. Data sources included observation and field notes, students' written documents, audiotapes and videotapes of students working in groups, and student interviews. Data from multiple sources were analyzed in relation to each other and coded using a constant comparative method.

Chin and Chia (2004) found that the sources of inspiration for students' problems and questions asked collaboratively could be classified into four main categories: cultural beliefs and folklore; wonderment about information propagated by advertisements and

the media; curiosity arising from personal encounters, family members' concerns, or observations of others; and issues arising from previous lessons in the school curriculum. On the other hand, questions asked individually pertained to validation of common beliefs and misconceptions, basic information, explanations, and imagined scenarios. The results of the study led the researchers to make two assertions, first that students' questions drove their course of learning and inquiry. These questions supported students to engage in different types of thinking which led to knowledge construction. Second, the ability to ask a relevant and authentic question was important to sustaining students' interest in the project.

Chin and Chia (2004) found when PBL is structured around students' questions, the questions facilitate learning. This is accomplished by the question directing students' inquiry and scaffolding students' thinking. In their discussion, the authors suggest that based on these results PBL can be used to bridge the gap between theory and practice to promote inquiry and question-driven instruction.

In a study that extended their previous work, Chin and Chia (2006) used a within-case analysis where groups of students were considered as sub-units to be studied within the case to explore how ill-structured problems in a PBL context influenced the way students worked through their problems in project work and the issues and challenges related to the use of such problems. Findings indicated that several students initially experienced difficulties in identifying a problem themselves but with support were able to overcome this barrier and subsequently form a problem for investigation. Furthermore, students ultimately carried out independent inquiry after posing questions which led to

the development of action plans for their research. Additionally, the independent inquiries the students conducted were multidisciplinary and extended beyond the boundaries of typical school science. Finally, the researchers asserted that the nature of instruction in a problem based learning unit required students to think about how they could find out what they wanted to know which ultimately led them to pursue diverse types of inquiry and alternative information-gathering and data-collection procedures.

Several issues and challenges were identified from the data. These included identifying a problem for investigation; asking questions to negotiate the learning pathway; deciding what areas to pursue, given a multitude of possibilities; and figuring out how to extract relevant information from the available mass and synthesize answers to the questions posed; using PBL in school settings in the face of time constraints; and the teacher having to perform different roles as a meta-cognitive guide. Even in light of the issues and challenges Chin and Chia (2006) concluded that the use of ill-structured problems in PBL can engage students in ways that elicit desirable cognitive processes and beneficial habits of mind. Specifically, the desirable cognitive processes include formulating a research problem, posing questions, designing and conducting investigations, making comparisons, proposing explanations, applying prior knowledge to new situations, generating alternatives, constructing arguments with justifications, making decisions, and monitoring the progress of one's work. Specifically the beneficial habits of mind include brainstorming to identify problems for investigation, generating questions to direct their own learning, considering multiple and varied stances to a problem, figuring out how to solve a problem via different types of inquiry, and thinking

independently. Finally, Chin and Chia (2006) elaborate to conclude that PBL is an effective instructional practice because the flexibility of the self-directed study as well as the ill-structured problem can accommodate a variety of learning styles, reflects authentic real-world challenges, and embodies active engagement, personal relevance and collaborative learning.

In a rare example of a study on PBL in the Kindergarten classroom, Zhang, Parker, Eberhardt and Passalacqua (2011) found that pre-post tests revealed students improved their content understanding and that the teacher's facilitation strategies associated with PBL provided opportunities for students to develop their questioning skills. This study took place as a result of a teacher participating in a multi-year professional development program that adopted PBL as an overarching approach to improving K-12 science teachers' content knowledge and pedagogical content knowledge professional. The professional development included a 2-week summer workshop and a school year action research project. Of the teachers attending the professional development, one teacher, who taught kindergarten, conducted an action research study involving PBL.

The study involved 24 students in a full-day kindergarten in a suburban school district. The students were about equally divided between girls and boys. Data sources included the teachers' research plan, classroom video of the PBL lesson, student assessment data, the teachers' study group meeting notes and the teacher's final report summarizing her action research project. The teacher developed a problem for her kindergartners to explore around the topic of earth materials. Specifically, the objectives

included the understanding that earth materials such as rocks, minerals, soils, water and the gasses of the atmosphere occur in nature, a topic emphasized in the new state curriculum standards and that some earth materials have properties that can sustain life. As a result, students were to be able to identify earth materials, such as water, air, soil, that are used to grow plants.

An assessment was developed to evaluate student learning. The assessment included an open-ended question targeted at the big ideas of the lesson. The teacher then identified an age-appropriate response that represented a thorough understanding of the big ideas and the key components of an ideal response. Students' responses were then evaluated for the key components and misconceptions. The pre-post tests revealed that more students were able to include key components in their responses after the PBL lesson. More specifically, there was a substantial increase in the number of students who included soil in their responses.

For comparison, data from the previous year's class which was taught using traditional methods were examined. The PBL students out-performed the comparison class students from the previous school year who were taught by traditional instructional methods. In the previous year 19 out of 22 students who were taught by traditional instructional methods were able to give at least one correct response in comparison to all of the 24 PBL students who were able to give at least one correct response. Furthermore, there was a substantial decrease in the number of responses showing misconceptions in their responses. These results of this cross-sectional study suggest that PBL is an effective method of instruction for kindergartners in terms of constructing and retaining

conceptual understandings of science concepts. In summary, the research on the cognitive outcomes of PBL suggests that students engaged in PBL have no deficits in content acquisition and in fact learn more and are more positive about their learning than students engaged in traditional instruction. The results also suggest students taught through PBL consider more perspectives, develop greater depth of understanding and an increased conceptual understanding of the content. Additionally, evidence suggests that during PBL students develop problem-solving strategies including problem-finding. Finally, another significant outcome of PBL is reflected in students' questioning skills. PBL students have been found to pose more inquiry questions and generate hypothesis-driven approaches to their questions.

Non-cognitive Outcomes of PBL. Of great interest to researchers is the question of the benefit and value PBL has to P-12 education beyond cognitive outcomes. In particular, researchers are concerned with addressing non-cognitive outcomes such as interpersonal skills and service to the community. The literature examines these outcomes as significant value-added aspects of the PBL experience.

Social Skills. In an evaluative case study design of 21 students in one United States history class, Brush and Saye (2000) explored the issues involved in implementing a technology-enhanced student-centered unit focused on a central problem. The teacher was a 17-year teaching veteran who described her teaching style as teacher-oriented and structured. The students were 11th grade students not enrolled in honors history. The class was part of a required program of courses.

The authors of the study developed a problem-based learning unit titled *Decision*

Point!, in which students assumed the roles of civil rights leaders in 1968 immediately following the assassination of Martin Luther King, Jr.. Their problem was to develop strategies that could be pursued in 1968 to continue the struggle for a more just, equal United States. Data included student interviews, teacher debriefings, teacher interviews, classroom observations, and analysis of student products. The results suggested that a variety of factors influenced the success or failure of this type of learning activity.

The students struggled with the lack of structure and the overwhelming amount of information they were managing. Their lack of meta-cognitive skills also played a role. The teacher struggled with understanding how to facilitate instruction in her role as facilitator. Classroom management was also a factor as the teacher had difficulty managing groups. Accountability and feedback also proved to be difficult. In addition, the teacher did not require depth on the part of the students' responses when developing solutions to the unit problem, did not engage in any evaluative dialogue with the students and did not provide any critical comments regarding the depth of their proposed solutions. Overall, the class exhibited high levels of enthusiasm, dialogue and persistence. In conclusion, the most important consideration for the success of student centered problem-based learning is providing the additional aids required by teachers to implement this type of learning activity.

As an instructional method for P-12, PBL has been studied largely in the context of gifted classes. However, as students with special needs are increasingly placed in general education classrooms, some consideration has been given to the application of PBL to the mainstreamed classroom in order to meet the needs of learners with diverse

needs. Using a case study approach, Belland, Glazewski, and Ertmer (2009) studied how members of mainstreamed groups interact to determine the potential for PBL to be used to support students with special needs in mainstreamed classes. Results suggest that mainstreamed students have the potential to effectively engage in PBL and that PBL may increase the motivation and social confidence of students with special needs.

This study took place at a middle school in a small, low-SES rural community in the Midwest. Twenty seventh-grade science students participated in a unit called “Genes, Dreams, and Reality: The Human Genome Project” for two weeks. Survey data, classroom video and interview transcripts were analyzed for themes and coded. Using a constant comparative method, the researchers checked for the accuracy of their assertions. Belland, et al. (2009) found that each group member filled a unique role and helped each other overcome individual difficulties in order to solve the problem. These results suggested that PBL has the potential to effectively engage mainstream students.

Tarhan, Ayar-Kayali, Urek, and Acar (2008) sought to examine the effectiveness of a problem-based learning (PBL) on 9th grade students’ understanding of intermolecular forces in a high school in Izmir, the third largest city in Turkey. In an experimental study of 78 students randomly assigned to experimental PBL ($n=40$) or control lecture-style teaching groups ($n=38$), researchers measured the student’s alternate conceptions about intermolecular bonding and their beliefs about PBL. A pre-test of 4 open-ended questions and 8 multiple choice questions revealed that there was no significant difference between the two groups of students and that the students had no major alternate conceptions about the subject matter.

Immediately following instruction, a posttest of 6 open-ended questions and 6 multiple-choice questions and a questionnaire related to the quality of the problem and the teacher's role and group functioning was administered. Evaluation of the post-test was conducted by the researchers, two expert science tutors and the teacher. Post-test mean scores were found to be 81.8 (SD=22.10) in the experimental PBL and 62.4 (SD=15.97) in the control lecture-style teaching groups ($p<.05$). Results from the post-test as well as interviews conducted immediately after instruction showed students in the control lecture-style group had some alternate conceptions about intermolecular forces.

In an open-ended questionnaire given to the students in the experimental PBL group Tarhan, et al. (2008) examined students' beliefs about their PBL experience regarding the quality of the problem and found responses could be categorized into three broad areas: (a) the quality of the problem; (b) the teacher's role; and (c) group functioning. In the area of quality of the problem, the students reported that problems should be related to their previous knowledge and there should be some leading questions. In the area of teachers' role, the students indicated awareness that the role of teacher in PBL was different than in traditional instruction. In the area of group functioning, students thought that while participation of group discussion was difficult in the traditional class, democratic small group discussions in PBL provided all students with the opportunity to be an active participant.

Finally, responses on the open-ended questionnaire showed a majority of students in the experimental PBL group agreed that working in a PBL group increased achievement. Of these students, 77.5% believed that in comparison to traditional

instruction, during the PBL process, their responsibilities increased and they learned by doing their own research. Some results showed benefits to developing social skills as well, 65% of the students indicated that PBL increased their friendships and 55% indicated PBL helped them to share knowledge, ideas, and feeling. No *p*-value was reported for this finding. Tarhan, Ayar-Kayali, Urek, and Acar (2008) provided evidence that PBL influenced students' achievement, formation of alternate conceptions and also social skills.

In a similar study, Tarhan and Acar (2007) sought to examine the effectiveness of problem-based learning (PBL) on eleventh grade students' understanding of the effects of temperature, concentration and pressure on cell potential' and also their social skills. In an experimental pretest-posttest study of 40 students in a PBL class (n=20) and a teacher-centered control class (n=20) the researchers found PBL had beneficial effects on students' attainment of content and affective behaviors. The subjects of this study were on average 17-years-olds, attending a high school located in Izmir, Turkey, and of similar socio-economic status and scientific backgrounds. Interviews consisting of five open-ended questions were conducted with ten volunteer students from each of the classes to determine students' misunderstandings and misconceptions about closely related, previously covered subjects, such as oxidation reduction reactions and electrochemical cells. A preparatory lesson was implemented to address misconceptions as determined by the interviews. Following the preparatory lesson, a pre-test of six multiple-choice and four open-ended questions was given to all 40 students to determine their understanding of oxidation-reduction reactions and electrochemical cells. No significant difference was

found between the two groups of students.

The same teacher taught the lesson on factors that affect cell potential to both the teacher-centered traditional control class, and the experimental PBL class. Subsequently, a post-test consisting of eight multiple-choice and five open-ended questions was conducted. The open-ended responses on the post-test were evaluated by the researchers, two expert tutors and the teacher. The scores were rated, compared and discussed until there was agreement. A *t*-test was used from the data on the pre-test and posttest to compare students' achievement in both groups. Interviews with the teachers and the students were recorded and analyzed by the researchers.

Tarhan and Acar (2007) found that PBL was effective in influencing students' achievement, problem-solving abilities and conceptual understanding ($p < .001$). The results on the open-ended questions supported the conclusion that the students in the experimental PBL class were also better in critical thinking. This is because the responses to the open-ended questions of students in the control group showed that the students in the teacher-centered control class had more misconceptions related to the equilibrium constant, effect of concentration and temperature on electrochemical equilibrium than the PBL class. No *p* value was reported for this finding.

Additionally, in order to collect data on the PBL process, the teacher and eight students from the experimental PBL class were interviewed individually. The results of the interviews revealed that students in the PBL class were more motivated, self-confident, willing to problem-solve and share knowledge, and were more active in cooperative group activities than the traditionally-taught students. Therefore, in their

discussion, Tarhan and Acar (2007) state PBL is effective as an active learning approach for knowledge-formation, content acquisition and improvement of social skills.

Gordon, Rogers, Comfort, Gavula, and McGee (2001) found, that supplementing the existing curriculum with PBL 2% of the time improves behavior and increases achievement among urban minority students. In a 6th-8th grade neighborhood public school in North Philadelphia where the student population is 90% African American and 10% Hispanic, and more than 96% of the students live below the federal poverty guidelines, students in two classrooms at each of three grade levels participated ($n=66$) in a PBL unit about health science issues over the course of three years. At each grade level, two comparison classes did not participate in PBL. Data included a student and staff survey, focus group discussions, concept maps assessed by the teacher coordinating the unit, and self-assessments completed by the students in the PBL classes. The self-assessments were composed of questions that asked students to list what they learned, areas in which they considered the group to be successful, areas in which the group needed improvement and student report cards.

Results of the survey data showed that students indicated positive perceptions of PBL. The overall mean was 3.7 on a five-point Likert-type scale with 5 defined as the most positive option. The mean scores on the three most positive items were: “I like being responsible for what I learn” (4.3); “I would like to use PBL next year” (4.2); and “I like PBL” (4.2). Focus group data showed that in particular students valued the active learning, the inquiry, rigor, collaboration and personal relevance of the problem.

Analysis of behavior ratings on student report cards from the 6th grade cohort and

the 7th grade cohort over two consecutive years revealed the students in the PBL group received significantly better ratings. Analysis of grades showed that for the cohort starting in 6th grade the overall grade point average was significantly higher by the final report card for the PBL students. For the cohort starting in 7th grade no significant difference was found in grade point average in either 7th or 8th grade. Also, for both the 6th grade and 7th grade cohort there was no consistent difference between the PBL group and the comparison group specifically in Language Arts, Social Studies and reading. The cohort starting in the 6th grade received higher mathematics scores in both 6th (38%) and 7th grades (60%). The cohort starting in 6th grade also showed a trend for an increase in science grades in 6th grade (9%) and a significant difference in 7th grade (26%) ($p < .05$). For the cohort starting in 7th grade, a significant difference was found in science in both the 7th grade (80%) ($p < .01$) and 8th grade (31%) ($p < .05$). In their discussion of the results, Gordon, et al. (2001) explained that given PBL was implemented in the area of science the lack of observed change in reading, language arts and social studies was not surprising. The data support previous studies which have found students enjoy and value PBL and further reveal that PBL can have a statistically significant positive effect on behavior and achievement of urban minority students.

In a paper discussing the preliminary findings of a qualitative study of three classrooms in two schools, Sage (1996) examined whether ill-structured problems are appropriate for young students in terms of the effect on learning content and thinking skills. Two school sites in the Chicago area where PBL was not in the very earliest stages of implementation were chosen for the study. The first site was a suburban

elementary school. From this school, two classes, one 1st/2nd grade combination and the other a 3rd/4th grade combination class, participated. The other school was a suburban middle school in the Chicago area where one science and one language arts teacher were team teaching an integrated curriculum to combine their two 8th grade classes into a double period. Data included classroom observations, semi-structured interviews with the students and the teachers, student work, other artifacts, teacher reflections, a pre/post test to measure content acquisition and focus group interviews with the teachers, students and parents. The pretest-posttest for basic knowledge was administered in each of the three PBL classes as well as a corresponding comparison class for each of the three PBL classes.

Sage (1996) explained that a preliminary analysis classified the data into three general conclusions and implications, first the design of the problem, second the implementation of the problem in real diverse classrooms and third the nature of PBL itself as a curriculum and instructional strategy. In terms of the design of the ill-structured problem, Sage (1996) identified two concerns, finding or developing a credible ill-structured problem scenario and alignment with the curriculum. In terms of implementation of PBL, Sage (1996) indicated that issues pertinent to implementation in K-12 classrooms is very different than issues pertinent to implementation in medical schools. In particular, the researcher identified time spent in tutorial groups, the capacity of students to engage in independent research at young ages, inconsistency in availability and access to resources and the inflexibility of the school day schedule to provide for long blocks of time. Another factor addressed was the teachers' knowledge of the subject

matter and their ability to encourage PBL. Sage (1996) explained this is a key factor in the success of PBL.

Finally, in terms of PBL as a curriculum and instructional strategy Sage (1996) addressed whether PBL is an effective way for students to learn and retain content. In particular, issues that emerged were to consider specifically what constitutes the most critical outcomes for the PBL experience either covering content or thinking skills, problem solving, interpersonal skills and service to the community.

In summary, Sage (1996) suggests the design of the ill-structured problem was important, the implementation of the problem in real diverse classrooms has implications for instruction in terms of time management and resource allocation and finally the non-cognitive outcomes of PBL may be more critical than content acquisition.

Students' Perceptions. Of increasing interest is the influence of student perceptions of the learning experience on performance. Azer (2009) examined the effects of students' characteristics such as gender, age, and first-language spoken at home on their perceptions about problem-based learning (PBL) in six public schools, one high and five primary schools, in the State of Victoria in Australia. Support for the successful implementation of PBL in the six schools was provided by the schools' principals, the class's teacher and the cluster educator.

A questionnaire was administered anonymously to 187 students. Seventy-one from grade five, 60 from grade six, and 56 from grade seven, completed it. The questionnaire included: (a) background and demographic data; (b) resources used in self-directed learning; (c) perceptions regarding the case, the discussion, use of the case in learning,

and contribution to the group discussion; and (d) students' perceptions regarding group function. Students were asked to complete a 5-point Likert-type questionnaire, where 1 indicated "strongly agree" and 5 indicated "strongly disagree". Data showed that students from the fifth, sixth and seventh grades perceived PBL in a positive way. Students felt that the information learned from the PBL cases was appropriate to their needs ($p < .001$). For this finding, there were significant differences between the grades. The 7th graders in this study did not appear to be as engaged in the PBL process as the 5th and 6th graders. A higher percentage of grade five students "strongly agreed" and "agreed" that the questions raised during the case discussion kept them thinking and looking for answers ($p < .004$). A higher percentage of grade six students "strongly agreed" and "agreed" with the statement that the cases kept them engaged during the discussion ($p = .001$).

Another difference was the variability in the use of resources. As the student grade increased, there was more variability in the resources identified by students as the most useful to their self-directed learning in the PBL unit. For students in grade five, 76% highly valued practical classes as the most useful resources in their self-directed learning. Other resources identified by grade five students were textbooks (51%), educational websites (56%) and dictionaries (31%). The grade six students were more evenly divided in their valuing of resources, 59% for atlases, 52% for educational websites and 57% for textbooks. The grade seven students most valued websites (34%), then textbooks (14%) and finally dictionaries (13%). The grade seven students ranked practical classes and atlases lower than other categories.

Additionally, the students' perceptions survey showed the effects of other parameters, such as gender on their perceptions of learning. In response to the statement "the case has not added to my understanding and my learning" the mean for the female grade five students was 4.24 SD .81 in comparison to the mean for the male grade five students which was 3.86 SD 1.18($p=0.02$). The mean for the response to the same statement for the female grade six students was 3.86 SD.71 and the mean for the males was 3.38 SD 1.18 ($p=0.01$). However, no significant difference was observed by gender for grade seven students. The mean for the response for female grade 7 students was 4.06 SD.426 and the mean for male grade 7 students was 3.69 SD.83 ($p=0.426$). No differences were observed for all other questions on the basis of gender.

Results also showed that there were no significant differences between students' responses on the basis of first language spoken at home, grade five students ($p=.056$), grade six students ($p=0.467$) grade seven students ($p=.265$). Results showed students across the grades enjoyed their problem-based learning process and case discussion. Specifically, the data revealed that students across the board felt the case added to their understanding and learning about the topic discussed, they worked effectively together as a group, and used a wide range of resources in their self-directed learning (Azer, 2009).

Another important question to consider when examining a teaching method is how will individual groups, including special populations, such as students at risk, respond. Cerezo (2004) addressed this concern in her case study of the perceptions PBL of at-risk females at the middle school level. Cerezo focused on the changes in the students' learning processes and the changes in self-efficacy among nine young women

in grades 6-8 considered to be at-risk of failure in a metropolitan school system.

Qualitative data such as student interviews were collected.

The findings indicated that the students believed PBL improved the quality of the learning environment. The participants expressed overwhelmingly positive feelings about PBL. They cited interesting problems, working in groups, and the challenge of the problem as reasons for liking PBL. Additional evidence revealed that they believed PBL helped them with organization, engagement, staying on task, learning from others, processing information and applying information to real-world contexts. They also expressed the benefits related to the collaborative nature of PBL as well. Responses indicated the students benefited by developing a respect for others and listening to what others have to say. Overall, Cerezo (2004) concluded the results suggested that PBL increased the students' self-efficacy.

In a one-year, qualitative action based collaborative inquiry study, Goodnough and Cashion (2006) explored on a small scale the complexities of PBL as a feasible curriculum and instructional approach for high school science classes. Data were collected from one teachers' classroom implementation of PBL. Twenty-six 12th grade students ages 17 and 18 in a high school biology course that took place in the fall semester, September-January, participated in the study. The students were average in terms of academic ability and evenly divided between girls and boys. The data included student-generated work, classroom observation, student interviews, and audio-taped planning meetings.

Three data sources were used, participant observation, documents, and semi-

structured interviews. Observations were made over a 6-month period implementation and post implementation debriefing occurred. During observations, field notes were recorded. Throughout this 6-month period, observers would meet once a week to reflect and analyze data. All meetings were audiotaped and transcribed. Documents that were examined included concept maps, assignments and projects. Each student was interviewed for 30 minutes. Grounded theory was used to analyze the data. Coding was used to identify concepts. Labels were assigned to text from transcripts, field notes and interviews. Constant comparison analysis was used to identify similar incidents and events for grouping into conceptual categories. Next, axial coding was used to generate main categories and subcategories.

The results showed that overall, 18 out of 26 students reported they liked learning through PBL and they ranked their group as functioning at 7 or higher on a scale from 1 to 10 with a score of 10 indicating a rating of highly effective. Nineteen students identified finding possible solutions to open-ended problems as a prominent component of PBL and the three prevailing skills identified by students included negotiating and sharing within a group, research skills and presentation skills. The outcomes of this study suggest that students have positive perceptions of PBL and enjoy learning this way because it promoted active learning, made science relevant, provided variety in learning and supported group work. Statistical significance was not reported for the qualitative results of the study. In their discussion of the results, Goodnough and Cashion (2006) caution that in the application of PBL to K-12 settings, the success of PBL is dependent on considering the developmental readiness of the students, the availability of resources

to support PBL, and the comfort level of the teachers and students in using PBL.

In summary, the non-cognitive outcomes of PBL suggest that it had a positive effect on students' social skills. Students reported overcoming individual differences to work together and had high levels of dialogue with each other. This extended to individual behavior as well. Through the interviews, students reported increased motivation, self-confidence and group cooperation. Additionally, students had positive perceptions of PBL. Results show increased enjoyment and quality of the learning experience.

Summary. The existent literature on PBL in P-12 frames the curriculum and instructional model as effective in producing both cognitive and non-cognitive outcomes. The literature examining cognitive outcomes showed particular emphasis on not only content acquisition, retention and transfer but depth of understanding as well. Additional areas of interest were questioning, problem-solving/problem-finding and the development of critical thinking, analysis and research skills. With regard to this, studies showed PBL to be effective. Next, the literature examined non-cognitive outcomes of PBL. In particular, social skills and student perceptions were explored. In this area, the literature showed PBL conducive to a classroom environment where students experienced success, felt enjoyment and developed self-directed study skills.

The evidence presented here on the literature on PBL in P-12, supports the constructivist theory of learning posited by Bruner (1962), in which children learn by discovery and become intrinsically motivated by the reward of discovery and mastery. In light of the evidence regarding the efficacy of a constructivist model such as PBL, it is

reasonable to question the role of students' attitudes especially considering that according to Bruner, there are several attitudes related to pursuing inquiry, as in PBL, as a way of life.

Student Perceptions of Classroom Quality

Students' success and achievement have been tied to students' perceptions about school. However, measurement of their perceptions has been not been consistently assessed in part due to the unavailability of suitable instrumentation (Gable & Wolf, 1993; Haladyna & Thomas, 1979, Popham, 2001). Gentry and Owen (2004) developed an instrument, the Student Perceptions of Classroom Quality (SPOCQ) scale, designed for use with secondary students to measure students' perceptions of various aspects of classroom activities. The SPOCQ assesses their perceptions using five constructs: (a) meaningfulness; (b) challenge; (c) choice; (d) self-efficacy; and (e) appeal. These constructs constitute the substance of many curricular and instructional differentiation efforts including initiatives targeted specifically towards the development of learning experiences for gifted students (Renzulli, Leppein, & Hays, 2000; Tomlinson, 1995, 1999), and fit well with the attributes associated with PBL and PBLi in the literature.

A national sample of middle schools ($n=12$) and high schools ($n=14$) from urban, suburban and rural settings participated in the validation study. The sample included 7,411 students from a total of 26 schools in 7 different states (Connecticut, Florida, Michigan, Minnesota, New York, Texas, and Wisconsin) and one foreign country. The sample was equally balanced male and female and included participants from varied ethnic backgrounds that approximated the representation of the diversity in the U.S.

population according to 2002 census data. The survey administration was conducted one-time in group settings by contact persons who followed a set of standardized instructions. Students' responses were anonymous.

The survey consisted of a short biographic section and 38 items using a 5-point Likert-type scale with responses ranging from strongly disagree to strongly agree. Content validity was ensured through a review of the literature and by using 22 content experts to rate items for each construct. The instrument was then pilot tested with 500 high school students. Construct validity was examined using exploratory factor analysis. Revisions were then made to the instrument. A confirmatory factor analysis was conducted to explore validity evidence for construct interpretation. Results of the confirmatory factor analysis were very strong. Alpha estimates for the constructs were: appeal (.85), challenge (.81), choice (.81), meaningfulness (.81), and academic self-efficacy (.82).

In the discussion of the results, Gentry and Owen (2004) noted that the consideration of academic success, learning, and perceptions of accomplishment extended beyond what is measured by standards-based achievement tests. Data from a large sample of secondary students indicated strong evidence for the internal consistency and validity of score interpretations of the SPOCQ. Gentry and Owen suggest the SPOCQ should be valuable to school research and improvement.

Data from a pilot study revealed that students associated learning through PBL with the constructs assessed on this measure. Responses to an open-ended question asking students, "Compared to other forms of learning did you like PBL more, less, the

same or it depends. Please explain why providing detail,” indicated that the students found meaning and were empowered by the authenticity of the task, engaged by the self-directed learning aspect of instruction, and motivated and challenged by the nature of the ill-structured problem. Thus, this seemed an appropriate measure for the study.

Chapter Summary

The review of literature in this chapter focused on the literature relevant to the current study. The literature review began with the conceptual framework of PBL. The review continued by examining an overview of implementation of PBL in the medical research literature. Next, the review examined the literature related to PBL in P-12 settings. Finally, a review of an instrument designed to measure student perceptions of classroom quality was presented.

The review of literature provided not only the conceptual framework of PBL, but also a framework for studying PBL as a curricular and instructional model for learning experiences and its possible effect on students’ attitudes, engagement and achievement. The literature points to a gap between the research of PBL in clinical years of medical school and whether, when implemented, PBL fulfills the intended mission of delivering content and advancing middle school gifted students’ preparation for scholarly work. According to Hmelo-Silver (2004), the literature also points to a gap in the effects of PBL on motivation and collaboration of students.

As with many outcomes of instruction in general and with PBL specifically, there are cognitive and non-cognitive outcomes. This study sought to examine a representation of both sets of outcomes in middle school PBL and non-PBL science classes. The content

of the lesson is about *Understanding Our Environment*, a unit in the 7th grade Investigations in Environmental Science course and is discussed in Chapter 3. As such, the purpose of this study is to explore the impact of the Problem Based Learning (PBL) units developed by a large suburban school district in the mid-Atlantic of the Advanced Academic Program middle school curriculum on: (a) students' performance on standardized tests in middle school Science; and (b) students' perceptions of classroom quality according to the constructs of: meaningfulness, challenge, choice, self-efficacy, and appeal as measured by the Student Perceptions of Classroom Quality (Gentry & Owens, 2004).

Chapter Three describes the procedures, subjects, setting, and instrumentation used in this study, along with the statistical analysis techniques to address the following research questions:

- a) What is the effect of PBL on advanced academic students' achievement on common assessments in comparison to a matched group of students taught in a traditional lecture/discussion format?
- b) What is the effect of PBL on advanced academic students' perceptions of classroom quality in comparison to a match group of students taught in a traditional lecture/discussion format?

Chapter 3: Methods

The purpose of this study was to explore the impact of the Problem Based Learning (PBL) on student performance and students' perceptions of classroom quality. This chapter includes a description of the setting of the PBL experience by looking at the PBL curriculum and instruction and the students' performances on pre- and post-standardized tests and the students' responses to a survey about classroom quality.

Setting

This study was conducted in Rockland County Schools, a pseudonym for a large suburban school district in a major metropolitan area in the mid-Atlantic region of the U.S. The school system serves approximately 180,000 students, roughly 13,000 at each grade level and the demographics reflect about a 50% non-Hispanic White population and 50% of the students from underrepresented minority populations. The population of limited English proficiency students is 13%. Overall, the per capita income of the area within the school system boundaries exceeds the national average with most residents deriving their income from professional, scientific and technical services; however, 25% of the population is eligible to receive free or reduced lunch.

One of the many special programs and services the school district offers is a center program for highly able students in grades 3-8. The center program is housed in selected schools and is based on the talent development approach (Renzulli, 1977; Treffinger, 1975). The center program offers students in grades 3-8, who are identified

as eligible, a highly challenging instructional program aligned with district and state standards and extended in depth and complexity with an emphasis on higher level thinking skills. Instruction is differentiated in depth, breadth, and pace of instruction to provide an appropriate level of challenge for gifted learners. A strong emphasis is placed on critical and creative thinking, problem-solving, self-assessment and reflection, the development of conceptual understandings, independent inquiry and decision-making. The center program provides highly able students the opportunity to explore and express their ideas in a classroom with highly able peers. Curriculum and professional development for the center program is managed by the school district's central office.

Students are identified for the center program by a screening process utilizing a holistic multiple-criteria approach. In order to be found eligible, students must show evidence of a general intellectual ability requiring full-time educational services in an advanced setting. Sufficient academic documentation to support placement includes a review of: exceptionally high ability test results, achievement test results, report cards, a rating scale of gifted behaviors, and student work samples. Optional documentation that may be considered in the screening file includes: a parent questionnaire, awards and honors, and/or letters of recommendation.

PBL Group. The PBL group was selected from one of the twenty-seven middle schools in the district specifically because the three seventh grade science teachers in that school decided as a collaborative learning team to implement one of the problem-based learning units written for the center program curriculum. The PBL middle school in this study includes 7th and 8th grades and is attended by a total of 1,000 students. The school

houses a center program for highly able students. Table 1 shows the demographics of the PBL school are Asian 34%, Black (not of Hispanic origin) 5%, Hispanic 11%, White (not of Hispanic origin) 45%, Other 6%. At the school 7% of the students are identified as limited English proficient and 14% are identified for free and reduced lunch.

Comparison Group. The comparison group was chosen specifically because the school is alike in housing a center program for highly able students and has similar demographics in addition to the fact that the 7th grade Science teachers did not plan to implement the problem-based learning units written for the center program. The students in this school are characterized as the traditionally instructed group because when asked, “What does instruction typically look like in your classroom?” all of the teachers at the comparison school included in this study agreed they stick closely to the district’s pacing guide and implement the district’s traditional science curriculum, which includes hands on lab activities.

Table 1

Membership and Staffing of the Schools for the PBL and Comparison Groups

	PBL	Comparison
Staffing(Specialists and Teachers)	91	94
# students	1000	1345
Asian	34%	36%
Black (not of Hispanic origin)	5%	7%

Hispanic	11%	8%
White (not of Hispanic origin)	45%	45%
Other	6%	5%
limited English proficient	7%	8%
free and reduced lunch	14%	9%

Table 2 shows the demographics of the comparison school are Asian 36%, Black (not of Hispanic origin) 7%, Hispanic 8%, White (not of Hispanic origin) 45%, Other 5%. At the comparison school 8% of the students are identified as limited English proficient and 9% are identified free and reduced lunch.

Table 2

2011 Grade 8 Science Standardized State Test Scores for Center Program Students

	PBL School		Comparison School	
	#	%	#	%
Total tested	209	100	240	100
Pass Advanced	206	98.6	230	95.8
Pass Proficient	2	1	10	4.2
Fail	1	.5	0	0

Participants. This study focused on two groups of students, a PBL group and a comparison group taught in a traditional lecture/discussion format. The participants in the PBL group were 3 teachers and their 7th grade students who attend a school that houses a center for highly able students. Three teachers from this school participated in the study. These teachers were selected because they are experienced PBL teachers. The intention of using experienced PBL teachers was to minimize the effects associated with first-time acclimation to PBL instruction and increase the fidelity to implementation.

The PBL group included students from 3 teachers' classes. Teacher One had 3 classes of Center students with a total of 65 students participating. Teacher Two had 3 classes of Center students with a total of 76 students participating. Teacher Three had 4 classes of Center students with a total of 82 students participating. The total number of students participating in the study was 223. Of these 223 students, there were 206 complete pre/post-test data sets and 192 complete SPOCQ surveys.

The comparison group of traditionally instructed students consisted of 3 teachers and their 7th grade students in the center program at the comparison school. Teacher One had four classes of Center students with a total of 110 students participating. Teacher Two had three classes of Center students with a total of 84 students participating. Teacher Three had three classes of Center students with a total of 58 students participating. The total number of students participating in the study was 252. Of these 252 students, there were 243 complete pre/post-test data sets and 251 SPOCQ complete surveys.

Participants from both the PBL group and the traditionally instructed group were 7th grades students enrolled in the required Investigations in Environmental Science course at each of the respective schools. This course was chosen because it is the course aligned to the objectives in the problem based learning unit taught by the teachers in the school with the PBL group.

Teacher Professional Development

Professional development is offered annually by the central office for teachers interested in implementing PBL. The PBL professional development session is two days long and is offered during the summer. The training is facilitated by Shelagh Gallagher, Ph.D., a nationally recognized expert in PBL for P-12. Dr. Gallagher is the only professional who has been involved in all three initiatives for developing Problem Based Learning curriculum for gifted students: The William and Mary Science Project, Project Insights and Project P-Bliss. In the PBL professional development session, teachers learn how to teach the PBL units developed specifically for the grades 7 and 8 center program classes. During the professional development, teachers experienced a simulation of PBL using one of the units and briefly reviewed the fundamentals of Problem-Based Learning. They learned how to follow the progression of a problem from beginning to end, ensured a successful blend of student engagement, higher order thinking and required learning objectives. A PBL summer camp ran concurrently with the training. This provided teachers participating in the PBL training the opportunity to observe PBL in action from both the student and teacher perspective. As a result of the PBL training session, the teachers developed a plan that involved recording the class activities,

featured skills, concepts and questions, materials and resources, and assessment possibilities for each phase of PBL.

All three of the PBL teachers attended the summer professional development session on PBL and one of the teachers attended it two summers in a row. All of the teachers previously implemented the *Ferret It Out* PBL unit once prior to the study.

Statement of the Research Questions

Two research questions will be investigated in this study:

- a) What is the effect of PBL on advanced academic students' achievement on common assessments in comparison to a matched group of students taught in a traditional lecture/discussion format?
- b) What is the effect of PBL on advanced academic students' perceptions of classroom quality in comparison to a match group of students taught in a traditional lecture/discussion format?

Hypotheses

Two null hypotheses are derived from these research questions:

H₁: There will be no significant differences in the gain scores of the students taught in the PBL classrooms in comparison to the students taught in the traditional classroom.

H₂: There will be no significant differences in the perceptions of classroom quality of students taught in the PBL classrooms in comparison to students taught in the traditional classroom.

Procedures

This section reviews the procedures. It begins with a description of the treatment, then explains the data collection and finally accounts for the fidelity of implementation.

Treatment. An overview of the required Investigations in Environmental Science course is given below. The course description is taken from the course catalog that is published by Rockland County's Instructional Services Central Office and provided to the district's local schools for use with course selection and enrollment. Although the course catalog is designed to help students determine the courses in which to register, the course sequence and grade requirements mandate students take the Investigations in Environmental Science course in 7th grade.

The course description from the Rockland County Schools district's course catalog for the Investigations in Environmental Science course is as follows:

“Investigations in Environmental Science builds upon the experiences in the life sciences introduced to students in upper-elementary grades. Cellular structure and function, heredity, diversity, populations and ecosystems are content strands developed through a sequence of hands-on investigations. To augment the inquiry-based investigations, computer technologies including graphing calculators, Vernier probeware, CD-ROMs, and streaming videos are used to build background knowledge and enhance student understanding. Process skills related to scientific investigation, reasoning, and logic are integrated throughout the course as students carry out investigations, collect and analyze data, and formulate conclusions.” (Rockland County Public Schools Middle School Course Catalog, 2012-2013).

In the traditionally instructed group, teachers implemented the district's science curriculum for the *Understanding Our Environment* unit. The *Understanding Our Environment* unit takes about 10 weeks to complete and aligns to the following the state's standards, benchmarks, and indicators:

- G6.7 The student will investigate and understand the natural processes and human interactions that affect watershed systems. Key concepts include:
- a) the health of ecosystems and the abiotic factors of a watershed;
 - b) the location and structure of Virginia's regional watershed systems;
 - c) divides, tributaries, river systems, and river and stream processes;
 - d) wetlands;
 - e) estuaries;
 - f) major conservation, health, and safety issues associated with watersheds; and
 - g) water monitoring and analysis using field equipment including hand-held technology.
- LS.5 The student will investigate and understand the basic physical and chemical processes of photosynthesis and its importance to plant and animal life. Key concepts include:
- a) energy transfer between sunlight and chlorophyll;
 - b) transformation of water and carbon dioxide into sugar and oxygen; and c) photosynthesis as the foundation of virtually all food webs.
- LS.6 The student will investigate and understand that organisms within an ecosystem are dependent on one another and on nonliving components of the environment. Key concepts include:
- a) the carbon, water, and nitrogen cycles;
 - b) interactions resulting in a flow of energy and matter throughout the system;
 - c) complex relationships within terrestrial, freshwater, and marine ecosystems; and
 - d) energy flow in food webs and energy pyramids.
- LS. 7 The student will investigate and understand that interactions exist among members of a population. Key concepts include:
- a) competition, cooperation, social hierarchy, territorial imperative; and b) influence of behavior on a population.
- LS. 8 The student will investigate and understand interactions among populations in a biological community. Key concepts include:
- a) the relationships among producers, consumers, and decomposers in food webs;
 - b) the relationship between predators and prey;
 - c) competition and cooperation;

- d) symbiotic relationships; and
- e) niches.

- LS. 9 The student will investigate and understand how organisms adapt to biotic and abiotic factors in an ecosystem. Key concepts include:
- a) differences between ecosystems and biomes;
 - b) characteristics of land, marine, and freshwater ecosystems; and
 - c) adaptations that enable organisms to survive within a specific ecosystem.
- LS.10 The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic, change over time, and respond to daily, seasonal, and long -term changes in their environment. Key concepts include:
- a) phototropism, hibernation, and dormancy;
 - b) factors that increase or decrease population size; and
 - c) eutrophication, climate changes, and catastrophic disturbances.
- LS. 11 The student will investigate and understand the relationships between ecosystem dynamics and human activity. Key concepts include:
- a) food production and harvest;
 - b) change in habitat size, quality, or structure;
 - c) change in species competition;
 - d) population disturbances and factors that threaten or enhance species survival; and
 - e) environmental issues.

In the traditionally instructed group, teachers implemented the district’s traditional science curriculum for the *Understanding Our Environment* unit. The traditional science curriculum for the *Understanding Our Environment* Unit is a series of lab activities the students complete. During the *Understanding Our Environment* Unit, students make connections between Earth and Space Science to understand factors which determine the type of climate found in a particular geographic area, learn the characteristics of terrestrial and aquatic biomes, the plants and animals that live in them, and the adaptations of these plants and animals that allow them to survive in their environment. Students learn about watersheds including the importance and vulnerability of the ecosystem of the Chesapeake Bay. Students set up a model aquatic ecosystem and

observe the interactions of the living and nonliving components over time. Students learn how the products of photosynthesis are used by producers and consumers and explore the process of cellular respiration. Students gain an appreciation of the role of submerged aquatic vegetation and the effect of excess nutrients and sediments on them. Students explore the principles of sustainable development and apply what they have learned about environmentally friendly development to design a new community on an undeveloped parcel of land. Students visit a local waterway and model the procedures and processes used by water quality monitors to collect data related to land use, water quality, habitat, and biological indicators in order to determine the relative health of the waterway.

In the PBL group, the teachers implemented a problem-based learning unit titled *Ferret It Out* aligned to a sub-set of the objectives for the *Understanding Our Environment* Unit. Of the above mentioned state's standards, benchmarks and indicators for the *Understanding Our Environment* Unit, the activities associated with *Ferret It Out* incorporated the following benchmarks and indicators:

LS.6 The student will investigate and understand that organisms within an ecosystem are dependent on one another and on nonliving components of the environment. Key concepts include:

- b) interactions resulting in a flow of energy and matter throughout the system;
- c) complex relationships within terrestrial, freshwater, and marine ecosystems;
- and
- d) energy flow in food webs and energy pyramids.

LS. 7 The student will investigate and understand that interactions exist among members of a population. Key concepts include:

- a) competition, cooperation, social hierarchy, territorial imperative; and
- b) influence of behavior on a population.

- LS. 8 The student will investigate and understand interactions among populations in a biological community. Key concepts include:
- a) the relationships among producers, consumers, and decomposers in food webs;
 - b) the relationship between predators and prey;
 - c) competition and cooperation;
 - d) symbiotic relationships; and
 - e) niches.
- LS.10 The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic, change over time, and respond to daily, seasonal, and long -term changes in their environment. Key concepts include:
- a) phototropism, hibernation, and dormancy;
 - b) factors that increase or decrease population size; and
 - c) climate changes
- LS. 11 The student will investigate and understand the relationships between ecosystem dynamics and human activity. Key concepts include:
- a) food production and harvest;
 - b) change in habitat size, quality, or structure;
 - c) change in species competition;
 - d) population disturbances and factors that threaten or enhance species survival; and
 - e) environmental issues.

The lesson activities associated with the *Ferret It Out* Unit took approximately two weeks to complete. *Ferret it Out* was implemented during weeks 6-8 of the 10-week *Understanding Our Environment* unit. Specifically, it was taught after the students learned the basic components and functioning of ecosystems and the effects of human's impact on ecosystems. In the PBL group, during weeks 1-5 and 9-10 of the *Understanding Our Environment* Unit, teachers used the district's traditional science curriculum.

In the unit *Ferret It Out*, students acted in the stakeholder role as a member of the Black Footed Ferret Recovery Implementation Team (BFFRIT). *Ferret It Out* was developed using the Stepien and Pyke (1997) PBL model. During the Problem

Engagement of the *Ferret It Out* PBL unit, students discovered they were tasked with identifying the different aspects of successful ferret reintroduction to prepare the newest test site in Ft. Collins, Colorado. During the Inquiry and Investigation of the *Ferret It Out* PBL unit, the students conducted research on self-selected topics based on the class generated learning issues board developed following the students initial immersion in the problem during the problem engagement. During the Problem Definition of the *Ferret It Out* PBL unit, the students prioritized critical elements to ferret reintroduction which potentially caused constraints and therefore needed to be considered in the problem resolution. The students then created a definition of the problem by responding to the problem using a structured format. For example, in the *Ferret It Out* unit a problem definition statement was, *How can we improve chances of ferret survival while taking into account human safety and the rights of ranchers?* During the Problem Resolution of the *Ferret It Out* PBL unit, the students worked in teams to develop their models for ferret reintroduction and created their presentation for sharing with the class. During the problem resolution, the students reflected on their learning and the PBL experience.

Instrumentation and Data Collection. At the beginning of the unit at each of the schools, all of the students took a pre-instruction assessment aligned to the objectives of the *Understanding Our Environment* unit. This assessment was developed using the district's electronic repository of test items aligned to the state's standards. Each teacher administered the assessment to her/his own students. The pre-assessment served as a baseline for prior-knowledge. The teachers of the traditionally instructed group then implemented the traditional lab book curriculum while the teachers of the PBL group

implemented the *Ferret It Out* unit. At the end of the unit the same assessment was administered again, as the posttest, and the Students Perceptions of Classroom Quality (SPOCQ) Inventory was administered as well. This provided post-assessment data from both groups to determine whether any differences in perceptions of classroom quality and achievement can be attributed to the different educational experiences.

Fidelity of Implementation. Observations were conducted to check fidelity of implementation to the PBL model. The Meta-cognitive coach checklist (see Appendix B), a tool developed by Shelagh Gallagher, was used to rate the teachers actions and responses in the classroom on a 5- point Likert-type scale for 22 items, where “1” is strongly agree and “5” is strongly disagree and N/A means not observed. In addition to the 22 items, there was an overall rating for the teacher. The choices for the overall rating include: excellent, fair, satisfactory, and poor. The meta-cognitive checklist was designed to provide school administrators with an informal tool to check for fidelity of implementation. Its psychometric properties are unknown. To ensure reliability of observation, two observers visited each teacher at the midpoint of the units and made summative judgments using the meta-cognitive coach checklist to assess the degree to which the teachers practiced PBL with fidelity. For teacher 1, the inter-rater reliability was 91% agreement and both observers rated the teacher as fair. The overall rating of fair indicated the observers’ assessment of fidelity to the PBL model. For teacher 2, the inter-rater reliability was 86% agreement and both observers rated the teacher as fair. The overall rating of fair indicated the observers’ assessment of fidelity to the PBL model. For teacher 3, the inter-rater reliability was 86% and both observers rated the

teacher as excellent. The overall rating of excellent indicated the observers' assessment of fidelity to the PBL model.

Dependent Variables

There are two dependent variables: (a) the students' achievement a formative assessment aligned to the objectives of the *Understanding Our Environment* unit developed using the Rockland Formative Assessment System (RFAS), which is described below; and (b) students' perceptions of the educational experience as measured by the SPOCQ. A description of the data analysis for the two dependent variables follows.

Measures. Two measures were used in this study. One measure, a standardized assessment was used to examine student achievement. Another measure, the SPOCQ, was used to examine student perceptions of classroom quality. The next session will describe these measures.

Student Achievement. In order to address the effect PBL has on advanced academic students' achievement, the district's assessment tool was used. The Rockland Formative Assessment System (RFAS) is a web-based application that provides access to teacher and school administrators to the most current curriculum and resources that support teaching and learning in grades K-12. Implementation of RFAS is primarily in the area of assessment for learning. Twice a year, students in select grades and subjects take district-wide assessments that provide data to teachers and curriculum specialists to identify student learning needs. RFAS offers teachers the opportunity to create and deliver both district and teacher-created assessments from a test-question bank as well as

share results with students and parents (see Appendix C). Consistent with the previous literature, a comparison of means using a t-test on the gain scores was conducted.

Students' Perceptions. In order to address the effect PBL has on advanced academic students' perceptions of classroom quality, the *Student Perceptions of Classroom Quality* (SPOCQ) (Gentry & Owens, 2004) inventory was used (see Appendix D). The instrument is designed to assess student perceptions of the instructional environment on the following constructs: meaningfulness, challenge, choice, self-efficacy, and appeal. These constructs are important educational outcomes related to student achievement and relate directly to the engagement students feel in their learning. A review of the instrument was discussed in Chapter 2. The goals of this instrument reflected the outcomes captured in the pilot study.

Data Analysis. Strategies for data analysis included descriptive statistics for each of the dependent variables, comparison of pre- and post-assessment measures. Descriptive statistics were used because the participants of the study do not represent a population from which results can be generalizable. T-tests were used to test for the differences in the gain scores of the students in the PBL and comparison groups on student academic achievement and on the students' post-unit perceptions of classroom quality.

Pilot Study

In fall 2011, a pilot study was conducted at the school with the PBL group. The pilot study consisted of the 3 teachers in the current study and their center students. Two of the teachers attended the Problem-Based Learning professional development session at

the summer institute in June prior to that fall. After attending the session, the teachers decided to implement the PBL unit at their school. A third teacher, who was also a first year teacher, was included in the collaborative planning and implemented the unit as well.

The teachers developed a teacher-made test aligned to the objectives in the PBL unit, *Ferret it Out* which draws objectives from the district's *Understanding Our Environment* unit. They began the unit by implementing this as a pre-test. The teachers then implemented the unit. Instruction took approximately two weeks. At the conclusion of instruction, the teachers re-administered the test as a post test. Overall, on the pre-test administered before instruction began, students scored 70%. Afterwards, on the post-test, students scored an average of 97% in Teacher 1's class, 95% in Teacher 2's class and 93% in Teacher 3's class. Qualitative data collected included responses to the open-ended question, "Compared to other forms of learning, did you like PBL more, less, the same or it depends. Please explain why providing detail. Students' responses were coded according to the themes of engagement, authentic learning, problem-solving, self-directed learning, and content acquisition and retention.

In the area of engagement, the students' responses reflected higher levels of engagement. One student said, "I found this ferret unit really made me interested in science and the world! It made me eager to come to class every day." Students' responses also spoke to the compelling nature of the authentic learning and how it influenced their motivation. One student said, "This was something real people are working on and some of us got pretty passionate about it." Additionally, a benefit of the

authentic problem was the empowerment and efficacy. One student responded, “[PBL] gave us a modern, real-life topic, allowed us to find realistic solutions that could make a difference.” In terms of the influence over problem-solving, student responses captured how PBL challenged them and helped them to comprehend the complexity of the world. One student responded, “[PBL] helped me realize how we solve problems today in the adult world. I learned that not everything can be fixed with duct tape.” Another student responded, “It actually challenged us to think and solve problems.” In regard to the self-directed nature of the learning, student responses reflected how it allowed them to tap into their inherent curiosity and focus. One student said, “You don’t really feel like you are learning, but you are. You also remember the important parts better than by just studying. We didn’t have to purposely memorize everything we learned but soaked up the information so we could solve the problem.” Students also reflected on the cognitive awareness they had for their own content acquisition and retention. One student responded, “It was deeper than just learning from the textbook. It helped me understand interactions in ecosystems better. I also liked how the problem led to learning about other things, like niches.”

Teacher feedback reflected the value of the professional development in the successful implementation of the unit. Additional teacher feedback acknowledged the efficiency of the unit in terms of content and skills covered versus pacing and time allotted for implementation. The results of the pilot study suggested there might be value in gaining a more systemic understanding of the differences in perceptions of classroom

quality and achievement, if any, between students taught via PBL and traditional instruction.

The pilot study influenced changes to the current study in two ways. The results of the responses to the open-ended question revealed that students associated learning through PBL with feeling empowered by the authenticity of the task, engaged by the self-directed learning aspect of instruction, and motivated and challenged by the nature of the ill-structured problem. Thus, the SPOCQ was identified as an appropriate measure for the study. Additionally, while the teacher-made test was informative to the pilot study, the need for a more standardized test accessible to the teachers and students at the schools in both locations was necessary, therefore, the district's assessment tool was used to develop the pre/post assessment using questions from the test-question bank.

Chapter Summary

This chapter included a statement of the research questions for this study, a description of the subjects, an overview of the course and implementation of curriculum in the traditionally instructed and PBL groups, setting, measures and the procedures. This chapter included a summary of the results of the pilot study. The chapter ends with an outline of the data analysis.

Chapter 4: Results

The purpose of this study was to explore the impact of PBL on students' academic performance and changes in students' perceptions about classroom quality and was guided by the following research questions:

1. What is the effect of PBL on advanced academic students' achievement on common assessments in comparison to a matched group of students taught in a traditional lecture/discussion format?
2. What is the effect of PBL on advanced academic students' perceptions of classroom quality in comparison to a match group of students taught in a traditional lecture/discussion format?

In order to answer these questions, data were collected and analyzed using the Statistical Package for the Social Sciences (SPSS) and included the following: a *t*-test for paired samples to compare the pre/post-test data for each of the groups, a *t*-test for independent samples to compare the pre/post-test gain score, and SPOCQ data between each of the schools.

Cognitive Factors Results

In order to address the effect PBL has on advanced academic students' achievement, the district's assessment tool, RFAS, was used to develop a 25 question

multiple choice test aligned to a subset of objectives from the *Understanding Our Environment* unit that correlated to *Ferret It Out*. A *t*-test for paired samples to compare the pre/post-test data for each of the groups and a *t*-test for independent samples to compare the pre/post-test gain score were completed. A description of the results for related to this data follows.

PBL Group Pre/Post-Test. In the PBL group, the pre-test was administered on paper and students recorded their responses on a scan-tron form. As a result, student responses were manually entered into the RFAS system by the researcher and a research assistant with expertise using the RFAS. Every score calculated by the RFAS system was double checked against the score on the paper scan-tron answer sheet. If there was an inconsistency, the individual scan-tron paper answer sheet was examined. There were about two dozen inconsistencies. Of these, less than ten were input errors, the rest were all scan-tron machine reading errors, meaning the paper test had been scored incorrectly by the machine. All input errors were corrected and checked again. The data were then exported by the RFAS system to an Excel spreadsheet. After the data were exported by the RFAS system to an excel spreadsheet, sensitive student information was replaced with research code identification numbers. Data from students who had not submitted consent/assent forms were eliminated. Scores were subtotaled and the percent correct was calculated for each student.

The post-test was administered on the computer. As a result, students directly entered their responses into the computer program so it was not necessary for the researcher and research assistant to input any responses or to check manually scores for

machine reading errors. Data were exported by the RFAS system directly to an Excel spreadsheet. Sensitive student information was then replaced with research code identification numbers. Data from students who had not submitted consent/assent forms were eliminated. Scores were subtotaled and a gain score was calculated for each group. Scores on the post-test were then matched with each student's scores on the pre-test. Incomplete data sets were eliminated. Data were uploaded to SPSS for statistical analysis.

A *t*-test for paired samples was completed on the pre/post-test data from the PBL group. As displayed in Table 3, the *t*-test revealed there was a statistically significant difference pre to post.

Comparison Group Pre/Post-Test. In the comparison school, both the pre- and post-test were administered on the computer. Following the instruction of the unit, the data were exported directly from the RFAS computer program to an Excel spreadsheet. After the data were exported, sensitive student information was replaced with research code identification numbers. Scores were subtotaled. Scores on the post-test were then matched with scores on the pre-test. Incomplete data sets were eliminated. Data from students that had not submitted consent/assent forms were eliminated. Data were then uploaded to SPSS for statistical analyses. A *t*-test for paired samples was completed on the pre/post-test data from the comparison school. As presented in Table 3, the *t*-test revealed there was a statistically significant difference pre to post.

Table 3

Paired Samples t-test for PBL Group and Comparison Group Pre/Post-test

Group	<i>n</i>	Pre-Test		Post-Test		<i>t</i>	<i>p</i>
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
PBL	206	17.57	2.30	23.50	1.40	30.54	.01
Comparison	243	17.89	2.82	22.54	2.06	27.15	.01

PBL and Comparison Group Pre/Post Test Results. An independent *t*-test comparing the two groups pre-test was conducted. Levene's Test for Equality of Variances indicated the variability in the conditions of each of the groups did not differ significantly from each other and that the equal variances were likely to have occurred by chance. As shown in Table 4, the difference in the comparison of means for the two groups on the pre-test was not statistically significant. An independent *t*-test comparing the two groups on the post-test was conducted. Levene's Test for Equality of Variances indicated the variability in the conditions of each of the groups did differ significantly from each other and the variances were not likely to have occurred by chance. As shown in Table 4, the difference in the comparison of means for the two groups on the post-test was statistically significant.

Table 4

PBL and Comparison Group Pre/Post-test Comparison of Means

Group	<i>n</i>	Pre-Test			Post-test			
		<i>M</i>	<i>SD</i>	<i>t</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>p</i>
PBL	206	17.57	2.98	1.17	23.50	1.40	5.88	.01
Comparison	243	17.89	2.82		22.54	2.06		

PBL and Comparison Group Gain Score. An independent *t*-test comparing the two groups gain score was conducted. Levene's Test for Equality of Variances indicated the variability in the conditions of each of the groups did not differ significantly from each other and that the equal variances were likely to have occurred by chance. As displayed in Table 5, the differences in the comparison of means were statistically significant and favored the PBL group.

Table 5

PBL and Comparison Group Gain Score

Group	<i>n</i>	Gain Score			
		<i>M</i>	<i>SD</i>	<i>t</i>	<i>p</i>
PBL	206	5.94*	2.79	4.98	.01
Comparison	243	4.65	2.67		

Non-cognitive Factors Results

The SPOCQ (Gentry & Owens, 2004) was administered using an online survey instrument approved by the county for use with students. Because the students completed the questionnaire using the online survey instrument, their data were automatically inputted into an online spreadsheet format compatible with Excel. As a result, no responses were entered by the researcher. Since its inception, there have been no reported errors in scoring, score calculation or any statistical analysis run by the program, therefore it is reasonable to assume this data did not need to be further checked for accuracy and that the data accurately represented the students' choices. There were 192 usable responses from the PBL group and 251 usable responses from the Comparison group. Responses were converted from the online format to an Excel spreadsheet and data from students that had not submitted consent/assent forms were eliminated. The total score and the totals of the constructs were then calculated. Data were then uploaded to SPSS for statistical analyses. An independent *t*-test comparing the two groups' results on the SPOCQ was conducted on the total score and each of the constructs. Levene's Test for Equality of Variances indicated the variability in the conditions for the total score, the challenge construct, the choice construct, the meaning construct, and the self-efficacy construct did not differ significantly from each other and that the equal variances were likely to have occurred by chance. Levene's Test for Equality of Variances indicated the variability in the conditions for the appeal construct was statistically significant.

As presented in Table 6, the difference in the comparison of means of the total score was statistically significant and favored the PBL group. The difference in the comparison of means of the choice construct was statistically significant and favored the PBL group. Table 5 also reveals that the results for the challenge and meaning constructs were not found statistically significant. The difference in the comparison of means on the appeal construct was statistically significant and favored the Comparison group. The difference in the comparison of means on the self-efficacy construct was statistically significant and favored the Comparison group.

Table 6

Students' Perceptions of Classroom Quality Means

Group (<i>n</i>)	Constructs					
	Total <i>M (SD)</i>	Appeal <i>M (SD)</i>	Challenge <i>M (SD)</i>	Choice <i>M (SD)</i>	Meaning <i>M (SD)</i>	Self-efficacy <i>M (SD)</i>
PBL (192)	143.77* (25.57)	24.25 (5.84)	28.82 (5.36)	26.93* (5.25)	18.22 (4.07)	30.67 (5.51)
Comparison (251)	129.02 (21.49)	26.31* (4.73)	26.53 (5.19)	25.07 (4.95)	18.91 (3.74)	32.15† (5.09)
<i>T</i>	6.591	3.998	.580	3.811	1.847	2.927

* $p < .01$

† $p < .05$

Correlations of the SPOCQ and Gain Score. Given the differences in the two groups' gain scores and on the SPOCQ, the researcher explored the relationship between the students' academic achievement and their perceptions of classroom quality. As displayed in Table 7, the results for the PBL Group indicated there was no statistically significant relationship between gain score and the SPOCQ total score. A correlation between each of the constructs of the SPOCQ and the gain score was also calculated and showed no statistical significance.

As displayed in Table 8, the results for the Comparison Group indicated there was no statistically significant relationship between gain score and the SPOCQ total score. A correlation between each of the constructs of the SPOCQ and the gain score was also calculated and showed no statistical significance. When taken together, the combined results between the PBL Group and the Comparison Group for the correlations suggest there is no relationship between the students' perceptions of classroom quality and academic achievement indicate that these students have the potential to learn regardless of the environment of the classroom.

Table 7
Summary of Correlations between Gain Score and SPOCQ total and Constructs for PBL Group

Measure	1	2	3	4	5	6	7
1. Gain Score	—	-.014	-.016	-.019	-.010	-.004	-.034
2. Total	-.014	—	.840*	.901*	.916*	.827*	.879*
3. Appeal	-.016	.840*	—	.713*	.721*	.682*	.614*
4. Challenge	-.019	.901*	.713*	—	.822*	.701*	.709*

5. Choice	-.010	.916*	.721*	.822*	—	.679*	.778*
6. Meaning	-.004	.827*	.682*	.701*	.679*	—	.693*
7. Self-Efficacy	-.034	.879*	.614*	.709*	.778*	.693*	—

* $p < .01$

Table 8

Summary of Correlations between Gain Score and SPOCQ total and Constructs for Comparison Group

Measure	1	2	3	4	5	6	7
1. Gain Score	—	-.068	-.053	-.060	-.060	-.078	-.055
2. Total	-.068	—	.889*	.917*	.911*	.915*	.940*
3. Appeal	-.053	.889*	—	.738*	.773*	.761*	.772*
4. Challenge	-.060	.917*	.738*	—	.805*	.759*	.842*
5. Choice	-.060	.911*	.773*	.805*	—	.774*	.772*
6. Meaning	-.078	.915*	.761*	.759*	.774*	—	.819*
7. Self-Efficacy	-.055	.940*	.772*	.842*	.772*	.819*	—

* $p < .01$

Correlations of the Constructs. A correlation coefficient between the appeal construct and the self-efficacy construct was calculated for the PBL group and for the Comparison Group. Though this extended beyond the scope of this study this was

calculated to examine the relationship between appeal and self-efficacy in order to understand the relationship of these variables to one another in light of the differences on the SPOCQ. Since the differences in the comparison of the means for the appeal construct and self-efficacy construct favored the Comparison Group, this was intended to further explain the students' perceptions of the classroom experience. As displayed in Tables 9 and 10 for the PBL and the traditional group, respectively, these results suggest that when self-efficacy is low or high, appeal tends to be low or high, respectively.

Table 9

Summary of Correlations on Appeal and Self-Efficacy Constructs for PBL Group

Measure	Self-Efficacy	Appeal	N
1. Self-Efficacy	—	.614*	192
2. Appeal	.614*	—	

* $p < .01$

Table 10

Summary of Correlations on Appeal and Self-Efficacy Constructs for Comparison Group

Measure	Self-Efficacy	Appeal	N
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1. Self-Efficacy	—	.772*	251
2. Appeal	.772*	—	

* $p < .01$

In sum, several conclusions can be drawn based on the results of this study. The first is that students in a PBL classroom will acquire the required content as reflected on an achievement test. Second, the gain score for PBL students is greater than in the traditional classroom. Third, the students' perceptions of the overall classroom quality in a PBL classroom are greater than in the traditional instruction classroom. As a result of these analyses, therefore, the two null hypotheses derived from the research questions can be rejected. There was a significant difference in the gain scores of the PBL group over the Comparison group on the academic achievement measure. In addition, there was a significant difference in the scores on the SPOCQ in favor of the PBL group. Each of these conclusions is discussed more fully in Chapter 5.

Chapter 5: Conclusions, Discussion and Implications

The purpose of this study was to explore the impact of Problem Based Learning (PBL) on students' performance and students' perceptions of classroom quality. Specifically, this study explored the impact of the Problem Based Learning (PBL) units developed by a large suburban school district in the mid-Atlantic for the Advanced Academic Program middle school curriculum on: (a) students' performance on standardized tests in middle school Science, as measured by a sample of relevant test questions from a district-managed test bank; and (b) students' perceptions of classroom quality according to the constructs of: meaningfulness, challenge, choice, self-efficacy, and appeal as measured by the Student Perceptions of Classroom Quality (Gentry & Owens, 2004).

This study describes the educational experiences in a PBL classroom setting as well as a traditional classroom setting and examines student achievement along with students' perceptions of the classroom environment in each of these settings. Two schools from the same school district participated in the study. The PBL group was specifically selected to participate in this study because the three seventh grade science teachers had decided as a collaborative learning team to implement the PBL curriculum. The comparison school was chosen specifically because it has similar demographic features to the school with the PBL group, and because the PBL curriculum was not implemented there.

This study focused on 7th grade students enrolled in the required Investigations in Environmental Science course. Between the two schools, a total of 457 students participated in the study, although the number for each variable measured varied slightly due to incomplete data sets for the pre/post-test and students failing to complete the SPOCQ. Pre and post student achievement data were collected using a 25 item multiple choice test that is aligned with the objectives of the *Ferret It Out* PBL unit, which is a subset of the objectives of the *Understanding Our Environment* unit of instruction ($n=449$). Data analysis, as presented in Chapter 4, indicated statistically significant gain scores in both of the groups with a higher gain score in the PBL group. The results also revealed a significant difference in gain scores that advantaged the PBL group over the Comparison group. The survey of classroom perceptions, the SPOCQ, was also administered to both groups. Data analysis revealed statistically significant differences; the PBL group ($n=192$) scores for overall classroom quality were higher than the Comparison group of traditionally instructed students ($n=251$). The research questions guiding this study and the implications for future research are discussed more fully in subsequent sections of this chapter.

Discussion of Findings

This study was guided by two research questions. The first being: what is the effect of PBL on advanced academic students' achievement on common assessments in comparison to a matched group of students taught in a traditional lecture/discussion format? The second research question guiding this study was: what is the effect of PBL on advanced academic students' perceptions of classroom quality in comparison to a

matched group of students taught in a traditional lecture/discussion format? First, the findings related to students' academic achievement will be discussed. Next, the finding related to students' perceptions of classroom quality will be discussed. Finally, a summary will be provided.

Academic Achievement. The data revealed that PBL, an indirect teaching model, compares more than favorably with the more direct, and traditional, teaching models that many in education believe is the best way to teach content for passing state standardized tests. Many educators continue to struggle with the more intense focus on the assessment of academic content standards as a result of national, state, and local accountability regimes. This culture of accountability has created pressure on teachers to focus on students' academic knowledge at the expense of their academic skills, such as conceptual understanding, creativity, critical thinking, problem-solving, communication and collaboration (Abrams, Pedulla, & Madaus, 2003; Brown et al., 2006; Moon, et al. 2003). A recent report from the Association for Career and Technical Education, National Association of State Directors of Career Technical Education Consortium and Partnership for 21st Century Skills (2010) highlights the need for these skills in a creative, innovative society concerned with preparing students for college and career readiness.

Common concerns articulated by teachers when considering an indirect teaching model such as PBL is that a self-directed, student-centered learning environment: (a) takes too much time to plan and implement, (b) does not provide scaffold for students who do not have the requisite prior knowledge or skills to be successful; and (c) is not conducive to students acquiring the required content because it is not explicitly taught

(Ertmer & Simons, 2006). These attitudes were evident in teacher feedback during the pilot study as well as in prior professional development conducted on PBL in the Rockland school division. Thus, the challenge for implementation then becomes to clarify the misunderstanding that the PBL model primarily functions to teach skills in lieu of content and demonstrate that an indirect teaching technique is an instructional pedagogy that effectively influences student acquisition of content.

To this end, it was necessary to find matched groups of students, one in a PBL classroom environment and one in a traditional classroom environment, in order to make a direct comparison between these two pedagogical approaches. Both groups were comparable on a pre-test of the academic achievement measure. The results showed on both the academic achievement measure and the SPOCQ, the scores favored the PBL group, thereby indicating that an indirect approach to teaching can outperform a more direct approach to teaching. This finding challenges teachers' generally held belief that direct instruction is the most productive way to prepare gifted students for state standardized tests.

This finding is consistent with a general trend in the previous literature that found PBL enhanced learning, resulted in positive achievement effects, improved content understanding and resulted in equally or better scores on achievement tests (Dods, 1997; Feng, et al. 2005; Kang, et al. 2012; Tarhan, et al. 2008; VanTassel-Baska, et al., 1988; Zhang, et al. 2011) Previous literature also showed that students increased in their knowledge from pre- to post test (Hmelo, Holton, Allen & Kolodner , 1997). This differs

from Nowak (2011) who found students in a teacher-directed class learned at a higher rate.

Perceptions of Classroom Quality. The data revealed that PBL, an indirect teaching model, compares more than favorably on students' overall perceptions of classroom quality than the more direct, and traditional, teaching models that many in education believe is the best way to teach content for passing state standardized tests.

As presented in Chapter 2, scholars have become concerned with non-cognitive outcomes of classroom instruction, not only in terms of skills but also the quality and meaningfulness of the classroom experience (Gentry & Owens, 2004). The genesis of this focus has been driven in part by the persistent push for statewide and national educational standards accompanied by a steadily increasing emphasis on accountability and improving test scores. Some researchers suggest that this increasing emphasis narrows the aims of education by marginalizing the importance of other purposes for education such as developing student potential as lifelong learners and becoming productive members of a diverse society (Gentry & Owens). Consequently, some believe this narrow emphasis has jeopardized the quality of education and are critical of this approach (e.g., Eisner, 2001; Popham, 2001). Accordingly, quantifying the affective and non-cognitive effects of educational practices is needed, if teaching practice is going to be more than direct instruction without concern for students' perceptions of the classroom environment.

Literature has shown that appeal, challenge, choice, meaningfulness, and academic self-efficacy reflect affective non-cognitive constructs central to learning

(Gentry & Owen, 2004). These constructs form the basis for many curricular and instructional differentiation efforts (Renzulli, et al. 2000; Tomlinson, 1995, 1999). Therefore, in order to determine more comprehensively the value PBL offers to educational practice, it was necessary to measure the effect on the concurrent emphases of achievement and perceptions in classroom quality in both the PBL and traditional classroom environments. To this end, the SPOCQ was administered at the conclusion of instruction in both the PBL and traditional classroom settings as a measure of student perceptions of classroom quality.

An independent *t*-test comparing the two group's results on the SPOCQ was conducted on the total score and each of the constructs. Consistent with the previous literature, the differences in the comparison of means of the total score favored the PBL group (Azer, 2009; Cerezo, 2004; Goodnough & Cashion, 2006; Vernon & Blake, 1993). This finding may reflect the match between the design of the curriculum and the way learning naturally takes place in the real world as proposed by Alfred North Whitehead (1929) in his theory of education. This match between the way learning takes place in the real world and the PBL classroom may explain why students perceived the total classroom quality to be superior in the PBL classroom. The difference in the comparison of means of the choice construct was statistically significant and favored the PBL group. This finding is not unexpected, as choice, often characterized as flexibility in the literature is commonly found to support students' positive perceptions of PBL (Chin & Chia, 2006; Lancaster, et al. 1997; Nowak, 2011). This finding may also reflect the

intentional design of the PBL curriculum to allow students to be self-directed thus giving them choice over the direction of their learning.

Furthermore, PBL was designed to create change simultaneously in curriculum and in instruction (Barrows, 1988; Barrows & Tamblyn, 1980). Specifically, the change in instruction as it relates to choice is the role of the teacher as the meta-cognitive coach. As the meta-cognitive coach, the teacher's role is to prompt students' own thinking by answering questions with questions and giving students the opportunity to assume control over the direction of instruction while maintaining responsibility for the content and objectives being covered. During PBL, teachers concentrate on the degree to which they facilitate learning by balancing questioning, feedback and guidance (Wetzel, 1996). This is a departure from traditional practices and beliefs and allows for students to have choice in their learning experiences.

The finding indicating that the challenge construct was not statistically significant may reflect the rigorous curriculum of the gifted program and suggests students in this school district are challenged no matter what environment they are in. Likewise, the result indicating the meaning construct was not statistically significant may reflect on nature of gifted children to find meaning in their learning regardless of the context.

The difference in the comparison of means on the appeal construct was statistically significant and favored the Comparison group. Considering that the relationship between self-efficacy and appeal is higher with the PBL group, this may be explained by the notion of an implementation dip, the inevitable difficulties people encounter when they are first learning new behaviors and beliefs (Fullan, 2001). The PBL

students may not have the same sense of efficacy in the PBL environment that they have in traditional instructional settings because of the active role that PBL demands of them as learners. Regardless, their gain scores on the pre- and post-test appear unaffected by their personal sense of efficacy. It appears they persevered, which is another important attribute of successful learners.

The difference in the means of the self-efficacy construct was statistically significant and favored the Comparison group. This may be the case as the data reveal a relationship between appeal and self-efficacy. In other words, students find an activity appealing when they feel they have the belief in their ability to be successful in that activity. In order to test this relationship, a correlation between the appeal construct and the self-efficacy construct was conducted for the PBL group and for the Comparison Group. These results appear to suggest that when their self-efficacy was low or high, their appeal score tended to be low or high, respectively, supporting the notion that there is a relationship between appeal and self-efficacy. While this result extended beyond the scope of the research questions in this study, previous literature provides support for this finding. For example, Diggs (1997) provided strong evidence that student attitudes might be attributed to the design and delivery of instruction. Additionally, Cerezo (2004) found PBL to improve the quality of the learning environment and increase students' sense of self-efficacy. Gordon, et al. (2001) found using PBL for as little as 2% of the curriculum improved behavior in minority students and resulted in their more positive perceptions of the classroom environment. Chin and Chia (2004) showed PBL facilitates student engagement by focusing on students' interests.

To explore the association of academic achievement and students' perceptions of classroom quality, a correlation between the total score on the SPOCQ and gain score was completed for the PBL group. The results indicated no statistically significant relationship. A correlation between each of the constructs of the SPOCQ and the gain score was completed and also showed no significant relationships. This suggests that students have the potential to learn regardless of the environment of the classroom. This finding also extended beyond the scope of this study; however, there is some support for this in the previous literature. Conversely, several studies found the enhanced perceptions of the learning environment yielded better learning outcomes. Diggs (1997) found that PBL positively affected students' attitudes and they attained higher GPA's in science. Kang, et al. (2012) found students using an inquiry curriculum performed better. Belland, et al. (2009) found PBL was a better experience for special needs students because it engaged them in a more positive way. Additionally, Tarhan, et al. (2008) found PBL increased achievement suggesting that while students have the potential to learn regardless of the environment, a quality classroom experience may potentially result in better outcomes.

Summary. This study found interesting differences between PBL and traditional instruction and therefore several conclusions can be drawn. Consistent with a general trend in the previous literature, the findings indicate that students in a PBL classroom setting will acquire the required content on a standards-based achievement test, and as such, PBL is an effective method for teaching required content and should be used for instruction even in a standardized test culture. Second, the gain score for PBL students

was greater than in the traditional classroom, further suggesting that PBL has the potential to be a more effective method of instruction than traditional instruction in this era of test-based accountability. Third, the data analysis tells us that students' perception of the total overall classroom quality in a PBL setting is greater than the traditional instruction classroom. This finding suggests that in addition to acquiring required content, PBL affords students a value-added learning experience in non-cognitive ways that support students' motivation and engagement. Lastly, while the students' perceptions of the overall classroom quality are greater in the PBL setting, there appears to be an implementation dip from the disorienting nature of PBL instruction. Consequently, vertically articulating a curriculum with successive PBL units as well as planning a pacing guide with successive PBL units in a year might be an effective way to address student familiarity with the method and orient them to the learning experience.

Implications

This study has provided new knowledge about the effects of PBL on student achievement and perceptions of classroom quality in gifted middle school science classes, and consequently provides several implications for future research, for students, and for teachers.

Implications for Future Research. This study found positive effects of well-implemented PBL instruction. However, much more remains to be known. This study could be expanded to determine the longitudinal effects of successive PBL units over time with a group of students. It would be interesting to more systematically study the effect of successive units on the initially disorienting nature of PBL to examine whether

or not over time students become more comfortable with PBL and over time find it more motivating and engaging than traditional instruction. This study could be expanded by conducting it in different subjects, grades and populations to examine the effects on social skills, such as collaboration among students, the development of conceptual understanding and problem solving skills could also be investigated. These social skills have been addressed in the previous literature but not in this study.

Future research should also include teachers' perceptions and attitudes of PBL, the effect of teacher professional development on the expertise of teachers implementing PBL and the reliability and validity of the meta-cognitive coach checklist as a tool for evaluating the effectiveness of PBL instruction. The findings indicated several implications regarding the meta-cognitive coach checklist, a tool developed by Shelagh Gallagher. First the checklist was written from the perspective of the unit having been completed rather than from the perspective of an observation of any single instance or lesson of PBL. The tool would be more flexible if it was designed for an observer to be able to come in at any point during the PBL and evaluate the instruction for fidelity to the PBL model.

Another aspect revealed from the findings was that the Likert-type rating scale on the meta-cognitive coach checklist was not completely appropriate for a study such as this one. For example, it was hard to rate an indicator of "the teacher encouraged students to think logically" on a scale of strongly disagree to strongly agree, but rather it made more sense to note it as observed or not observed. Another realization was that all items on the checklist might not necessarily be observed. For example, one indicator was

“addressed group problems when they arose” but it was not clear that group problems arose. In one class, a lively debate ensued, but (a) it did not seem to be a problem, and (b) the students resolved it themselves. It appeared that group problems might be handled outside of the classroom venue and therefore not observable.

The findings also revealed that PBL instruction is not just about observing what the teacher is doing, but also about observing what the teacher is not doing and what the students are doing. The meta-cognitive checklist might be expanded to include some student behaviors and some statements phrased in the negative as in, “the teacher did not”. Extending this thought, another realization was that the strongest PBL teacher observed was actually in the middle of the continuum because she showed an appropriate balance between teacher-directed and student-directed learning. It wasn’t that she always answered a question with a question, but rather she knew when to answer a question with a question and when to provide more information. This relates to the observations in one of the PBL classes in which the students were almost entirely self-directed. The teacher was implementing the lessons of the PBL curriculum, but very little teacher behavior was observed so it was difficult to assess whether the teacher possessed the dispositions of the meta-cognitive coach.

Implications for Teachers. Teachers’ concerns regarding content acquisition and adequate preparation for standardized tests cannot be summarily dismissed. However, this study demonstrated that PBL can and does challenge that prevailing assumption that the best way to teach in a standardized test environment is to use traditional teacher-directed instruction. The PBL units were intentionally designed to align with content

standards. This is done through the use of the ill-structured problem, which leads students to the content required in the core curriculum. Consequently, students' questions become the basis of instruction, empowering the students' with a sense of inquiry. Since the core content emerges naturally through the problem, instruction can focus on bringing greater complexity to their understanding not only of content, but also by adding depth and breadth through developing the emerging skills of self-directed learners.

Equally valid is the concern regarding whether students have the capacity to function appropriately in an inquiry-based, student-centered, self-directed classroom environment. One element of this concern is the varying degree of prior knowledge with which students come to the classroom. The instructional response to this influence is to provide modifications to instruction, which create a scaffold for learning, or in other words, differentiation. PBL allows the teacher to respond to the individual needs of students by creating groups and activities in response to students' questions, which typically vary in depth and complexity. The use of self-directed learning allows for adjustments in pacing, depth, breadth, level of abstraction, level of complexity, degree of generalizability, and talent development.

The other element of teachers' concern about the capacity of students to function appropriately in an inquiry-based, student-centered, self-directed classroom environment, such as PBL, are the skills students need to be able to self-regulate. Students who are new to PBL may require significant instructional scaffolding to support the emergence of self-directed learning skills, problem-solving skills, and collaboration skills. As the results of the present study suggest, some students will find the indirect instruction of

PBL to be initially disorienting. This means teachers may need to be prepared to develop these emerging skills to a level of proficiency at which the students will be successful independently.

Research, including the results of this study, shows students will learn as much or more content and perform equally well or better in a PBL environment. Accepting the notion that an inquiry-based, student-centered, self-directed classroom is as or more effective as a traditional classroom reflects a belief in a constructivist framework of teaching and learning. For many teachers, embracing this constructivist framework may require changes in pedagogical practice. Therefore, teachers may experience a learning curve when beginning to implement PBL. Considering PBL requires a shift in the role of the teacher for planning, instruction, and behavior management it may take some time to adjust to this new role as the meta-cognitive coach. Therefore, participating in professional development specific to the PBL model may help support teachers in the transition. Therefore, when considering this role shift, teachers should seek support through professional development and/or collaboration with experienced PBL teachers. Likewise, it is important for school leaders who seek to add PBL to their teachers' instructional repertoire to offer sustained professional development and support to reap the kind of benefits found in the present study. Only providing after school workshops will not suffice.

Additionally, while there is a learning curve around implementing PBL instruction for the first time, the combination of cognitive and affective outcomes makes the investment in time worth the effort. Literature further elucidates that in addition to

content acquisition, students in a PBL environment have longer-term retention and more positive attitudes in the long run about the subject matter (Azer, 2009; Cerezo, 2004; Dods, 1997; Eisenstaedt, et al., 1990; Gallagher & Stepien, 1996; Goodnough & Cashion, 2006; Hmelo, Holton, Allen & Kolodner, 1997; Nowak, 2011; and Vernon & Blake, 1993). It is also important to understand that writing PBL curriculum is a complex process and to minimize the learning curve, it is advisable to begin by using curriculum that has previously been developed and pilot tested. In this way, teachers can rehearse and practice the skill of adopting the role of meta-cognitive coach, one that is critical to the success of PBL. The results of this study suggest that there is more than one way to teach middle school science to academically advanced students. Further, the results challenge teachers' beliefs about the advantage of direct instruction over other forms of instruction. Certainly, the case is not closed on the contributions that PBL can bring to a teacher's repertoire, and more studies are needed in more disciplines and even in other science content areas. Regardless, the evidence from this study is clear that with proper professional development, teachers can incorporate PBL into their repertoire and that it will accomplish the same goals as traditional instruction, and increase students' views of teaching and classroom quality.

Likewise, it is important for teachers to know that PBL can be disorienting for students as well. As such, students have a learning curve when participating in PBL. This may in part be due to the nature of the ill-structured problem and the expectation for students to be self-regulating. It is important to remember that the nature of the problem is ill -structured, not unstructured. Moreover, the problem requires additional information

before it can be resolved, changes with new information, can be resolved in more than one way and all activities revolve around it. Thus, students develop the impression the problem is unfolding as they process through it and that they are in control of the direction of their learning when in reality, the problem and all activities have been carefully crafted and unfold in a predictable, repetitive pattern. The effect for students is that they feel their moments of discovery are unique and individual while to the teacher these are a routine part of the process. This means that teachers should not give up if it appears to generate some initial discomfort with students. Over time, students become familiar with the model and become more comfortable with it so much so that they find it a better quality classroom experience.

Implications for Students. PBL should be used as a part of a comprehensive educational curriculum. PBL is an inquiry-based model of curriculum and instruction that initiates learning with an ill-structured problem that has been carefully constructed around content in the core curriculum. During PBL students are asked to consider the problem from the perspective of a central stakeholder, a role that is likely unfamiliar to them. The stakeholder role increases ownership and helps students experience authority, accountability and responsibility for the problem. In order to develop a relevant resolution to the problem, students are compelled to consider the different perspectives of many stakeholders. Considering these multiple points of view provides students with practice at developing the habits of mind of people in different professions or living in different circumstances. Evidence suggests that this immersion into the learning process,

or mindful learning, the awareness of context and the changing nature of information, can enhance academic performance (Langer, 1990).

It may be helpful for teachers to remember that some students will experience an initial disorientation when a PBL unit begins. This means that PBL may initially generate some discomfort for some students, especially those who have become accustomed to and profited from didactic instruction and have little experience with inquiry-based instruction. The perception of students that the classroom experience is better may fuel their desire to function in an inquiry-based, student-centered, self-directed classroom environment and help them to persist in overcoming the initial disorientation. With increased exposure to the model, students may become more comfortable and develop tolerance for the ambiguity associated with the PBL instruction.

Summary. Problem-based learning has a solid philosophical and epistemological foundation (Duffy & Cunningham, 1996, Savery & Duffy, 1995; Torp & Sage, 2002). Given the potential PBL has to influence the development of characteristics identified as important for success in the 21st century, such as high-level skills in communication, effectively defining problems and developing solutions, motivation and persistence, and the ability to work with others in team settings, it is critical students experience PBL.

The adoption of any instructional innovation, including PBL, in public education is a complex process. Most state-funded P-12 schools are constrained by a state mandated curriculum and accountability standards. High-stakes standardized testing tends to support instructional approaches that teach to the test such as memorization through drill and practice and rehearsal using practice tests. Furthermore, typical

instructional time is divided into specific blocks of time and organized around subjects, a structure that limits the opportunity to engage students in a cross-curricular interdisciplinary problem.

However, students can now access considerable amounts of information in ways that were not possible even as recently as a decade ago and the increasing complexity of a global society leads to an abundance of suitable ill-structured real-world problems. Therefore, more than ever, as the 21st century progresses, higher-order thinking skills, self-regulated learning habits, and problem-solving skills are necessary for all students. Providing students with opportunities to develop and refine these skills through PBL is more essential than ever and has the potential to be an instructional approach with lasting impact.

Limitations

So often in studies of teaching, fidelity of implementation is a barrier to good data. That was not the case in this study. In all ways, the professional development, the implementation of the PBL model, and the data gathering were not compromised. As such, none of the usual limitations of classroom-based research is present. However, the results of the study are specific to the population studied, namely middle school gifted students. Additionally, these results are specific to the district examined in the study and to the content of the *Ferret it Out* unit. Since the study examined a specific instructional model, it was necessary to collect data from classrooms where the instructional model was being used, therefore, the study was further limited by the fact that the teachers were not selected randomly, but rather volunteered to be a part of the study. It remains to be

seen whether teachers who try implementing *Ferret it Out* without adequate professional development would achieve the same results.

In addition, the meta-cognitive checklist, as the tool most readily available and designed for measuring the implementation of PBL, did not capture everything that happens *in situ* during PBL instruction. While the results of this study do not appear compromised in any way, one must keep in mind that these data could have been more closely aligned with capturing implementation rather than making only overall judgments.

Chapter Summary

This chapter began with a review of the purpose of this study and the research questions. The chapter continued with a discussion of the results for both for academic achievement and perceptions of classroom quality. In both cases, the data revealed PBL compared more favorably than traditional instruction. Implications for future research, teachers and students were shared. The chapter ended with the limitations of the study.

Appendix A

Learning and Innovation Skills

Learning and Innovation Skills	Definition
Creativity and Innovation	<ul style="list-style-type: none">• Demonstrating originality and inventiveness in work• Developing, implementing and communicating new ideas to others• Being open and responsive to new and diverse perspectives• Acting on creative ideas to make a tangible and useful contribution to the domain in which the innovation occurs
Critical Thinking and Problem Solving	<ul style="list-style-type: none">• Exercising sound reasoning in understanding• Making complex choices and decisions• Understanding the interconnections among systems• Identifying and asking significant questions that clarify various points of view and lead to better solutions• Framing, analyzing and synthesizing information in order to solve problems and answer questions

- Communication • Articulating thoughts and ideas clearly and effectively through speaking and writing
- Collaboration • Demonstrating the ability to work effectively with diverse teams
- Exercising flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal
- Assuming shared responsibility for collaborative work

Information Media and Technology Skills

Information Media and Technology Skills	Definition
Information Literacy	<ul style="list-style-type: none"> • Accessing information efficiently and effectively, evaluating information critically and competently and using information accurately and creatively for the issue or problem at hand • Possessing a fundamental understanding of the ethical/legal issues surrounding the access and use of information
Media Literacy	<ul style="list-style-type: none"> • Understanding how media messages are constructed, for what purposes and using which

tools, characteristics and conventions

- Examining how individuals interpret messages differently, how values and points of view are included or excluded and how media can influence beliefs and behaviors
- Possessing a fundamental understanding of the ethical/legal issues surrounding the access and use of information

ICT (Information, Communications and Technology)	• Using digital technology, communication tools and/or networks appropriately to access, manage, integrate, evaluate, and create information in order to function in a knowledge economy
Literacy	• Using technology as a tool to research, organize, evaluate and communicate information, and the possession of a fundamental understanding of the ethical/legal issues surrounding the access and use of information

Life and Career Skills

Life and Career Skills	Definition
Flexibility and	•Adapting to varied roles and responsibilities

Adaptability	<ul style="list-style-type: none"> • Working effectively in a climate of ambiguity and changing priorities
Initiative and Self-Direction	<ul style="list-style-type: none"> • Monitoring one's own understanding and learning needs • Going beyond basic mastery of skills and/or curriculum to explore and expand one's own learning and opportunities to gain expertise • Demonstrating initiative to advance skill levels towards a professional level • Defining, prioritizing and completing tasks without direct oversight • Utilizing time efficiently and managing workload • Demonstrating commitment to learning as a lifelong process
Social and Cross-Cultural Skills	<ul style="list-style-type: none"> • Working appropriately and productively with others • Leveraging the collective intelligence of groups when appropriate • Bridging cultural differences and using differing perspectives to increase innovation and the quality of work

Productivity and
Accountability

- Setting and meeting high standards and goals for delivering quality work on time
- Demonstrating diligence and a positive work ethic (e.g., being punctual and reliable)

Leadership and
Responsibility

- Using interpersonal and problem-solving skills to influence and guide others toward a goal
 - Leveraging strengths of others to accomplish a common goal
 - Demonstrating integrity and ethical behavior
 - Acting responsibly with the interests of the larger community in mind
-

Appendix B

Meta-cognitive Coach Checklist

Rate each item on a scale of 1-5, 1 being strongly agree, 5 being strongly disagree.

Behaviors

<i>The teacher...</i>	1-5 or N/A	Comment
Was enthusiastic about teaching		
Did not dominate group discussion		
Created a supportive learning climate		
Showed concern with the progress of individuals		
Encouraged involvement of group members		
Kept the class focused on the discussion		
Encouraged students to reflect and evaluate how they worked as a team		
Addressed group problems when they arose		
Gave students feedback on their performance as a group		
Gave individual students feedback on performance when asked		

Reasoning Process

<i>The teacher encouraged students to...</i>	1-5 or N/A	Comment
Identify the relevant clues in when the problem was first introduced		
Think logically		
Think broadly		
Ask for information to check ideas	??	

Say how new information helped clarify what was going on		
Summarize progress /what they learned		
Restate the problem as they moved through the problem		
Make a decision based on the information they found		
Think logically and broadly as they developed a solution		

Independent Study

<i>The teacher encouraged students to...</i>	1-5 or N/A	Comment
Identify what they needed to find out more about in relation to the problem		
Seek out the information they needed		
Communicate effectively with classmates about what they learned		

Overall Process

All things considered how would you rate this teacher?	excellent	fair	satisfactory	poor
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General comments

What did the teacher do that was most useful for learning?

What suggestions for improvement would you make?

What components of PBL did the teacher do well?

Appendix C

Test: Interactions in Ecosystems Pretest

Question 1: ID: 136292 SOURCE: A016919

In an ecosystem, a niche describes-

A: the physical area in which a species is usually found

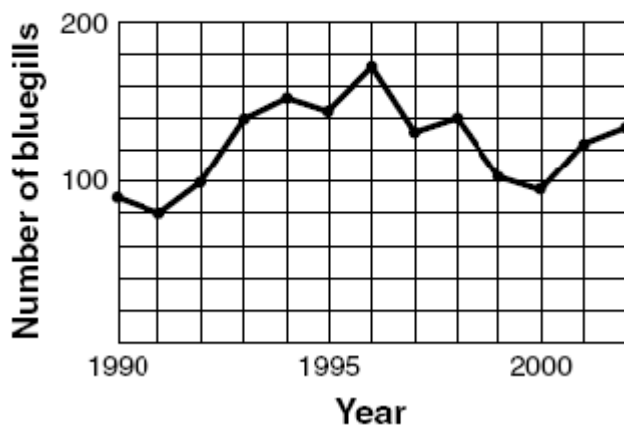
B: how a species recycles material in the ecosystem

C: the area one species has taken from another species

D: how and where a species survives

Question 2 : ID: 177511 SOURCE: A01608F

**Bluegill Population in Farm Pond
1990–2002**



Which of the factors below most likely affected the blue gill population from 1996 to 1997?

F: An algae bloom reduced the level of dissolved oxygen.

G: More food was available to the bluegill in the pond.

H: Fewer predators made their home in the pond.

J: The climate was mild during the spring and summer of 1996.

Question 3 : ID: 178138 SOURCE: A015166

Communities of different organisms interacting with the abiotic factors which affect them are known as a(n) –

A: community

B: territory

C: population

D: ecosystem

Question 4 : ID: 80938 SOURCE: A0150BB

A good example of a community living in a forest ecosystem is ---

F: ten deer

G: ten deer, four rabbits, six squirrels, and the plants they share as food

H: one deer and the plants it ate last winter

J: the Sun, the soil, and the air in the forest

Question 5 : ID: 80929 SOURCE: A0150BA

A good example of a population living in a forest ecosystem might be ---

A: ten deer

B: ten deer and the plants they eat

C: ten deer and fifteen squirrels

D: five rabbits, the grass, and a colony of ants

Question 6 : ID: 177731 SOURCE: A002D82

The Harris' hawk is a bird of prey with an unusual behavior. These birds hunt in family groups. After sighting their prey from the air, they land and take turns scaring the prey animal. When the prey darts out from its hiding place, it is captured by a family member.



The hunting behavior of the Harris' hawk is *best* described as –

F: territorial imperative

G: social hierarchy

H: courtship

J: cooperation

Question 7 : ID: 136313 SOURCE: A01691E

Coyotes live in packs and actively defend their hunting range. If an outside pack wanders into another pack's area, a battle may occur. Which of the following terms *best* describes the relationship between coyote packs?

A: Territorial imperative

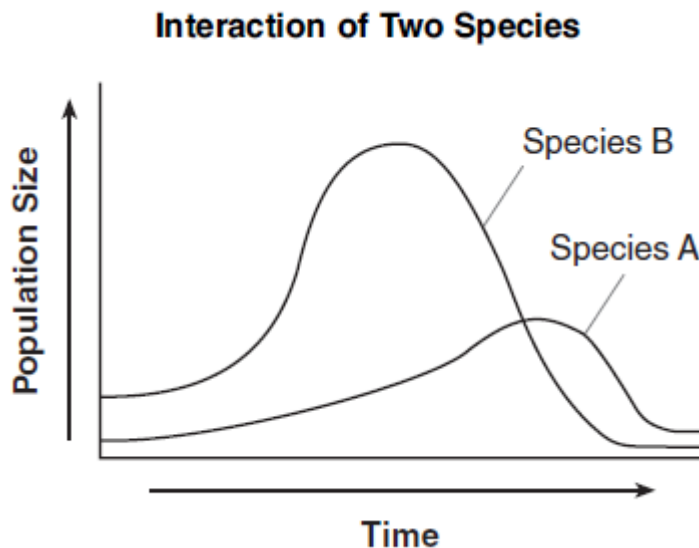
B: Social hierarchy

C: Courtship

D: Cooperation

Question 8 : ID: 177998 SOURCE: A0178F8

The graph below shows changes in the populations of two species that interact only with each other over a period of time.



Which statement *best* describes these two species?

F: Species A is a producer and species B is its consumer.

G: Species A is a host and species B is its parasite.

H: Species A is a predator and species B is its prey.

J: Species A is a scavenger and species B is its decomposer.

Question 9 : ID: 136288 SOURCE: A016923

Green sea turtles must keep their shells clean so they can swim smoothly through the water. The turtles interact with small reef fish that eat the algae and other parasites off the turtle's shell. The relationship between the turtle and the reef fish is an example of –

A: commensalism

B: mutualism

C: parasitism

D: predator-prey

Question 10 : ID: 136488 SOURCE: A018226

Orchids grow in the branches of trees in the rain forest and get their water from the moist air. They do not harm or help the trees in which they grow. This relationship demonstrates –

F: mutualism

G: commensalism

H: behaviorism

J: parasitism

Question 11 : ID: 51110 SOURCE: A002D90

A tapeworm lives in human intestines absorbing the nutrients that would normally be absorbed by the person. This eventually causes the person health problems. The relationship between the tapeworm and the human is ---

A: parasite/host

B: predator/prey

C: herbivore/omnivore

D: consumer/producer

Question 12 : ID: 176308 SOURCE: A014C60

Lichen, a common organism found in the tundra, is made up of a fungi and algae living together. The algae provide the fungi with sugars as they perform

photosynthesis. The fungi provide the algae with a greater amount of habitat in which to live.

F: parasitism

G: mutualism

H: commensalism

J: competition

Question 13 : ID: 54309 SOURCE: A002CB9

Organisms that absorb nutrients from dead plants and animals are called ---

A: carnivores

B: decomposers

C: herbivores

D: producers

Question 14 : ID: 102789 SOURCE: A015186

An example of an herbivore is a ---

F: wolf

G: moss

H: rabbit

J: tree

Question 15 : ID: 78940 SOURCE: A002C99

Living things that get their energy from breaking down the remains of plants and animals or their wastes are called ---

A: decomposers

B: producers

C: consumers

D: predators

Question 16 : ID: 52001 SOURCE: A0017F2

Of the following, which is the correct progression in the food chain?

F: producers → herbivores → carnivores

G: herbivores → producers → carnivores

H: producers → carnivores → herbivores

J: carnivores → herbivores → producers

Question 17 : ID: 178006 SOURCE: A01518E

The level of a food chain with the most energy contains –

A: omnivores

B: herbivores

C: carnivores

D: producers

Question 18 : ID: 83437 SOURCE: A002C8E

Which of these organisms would *most* likely be found at the top of an energy pyramid?

F: Clams

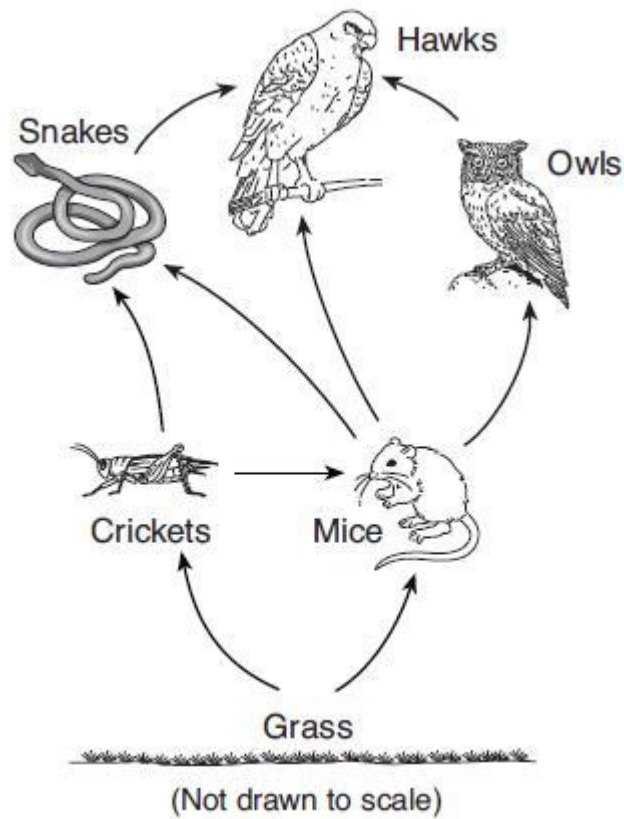
G: Sardines

H: Sharks

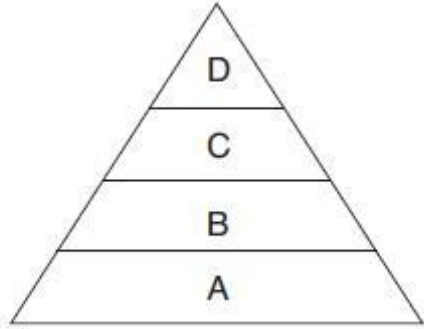
J: Kelp

Question 19 : ID: 175923 SOURCE: A018702

The diagram below shows a food web.



Letters A, B, C, and D represent different energy levels in the energy pyramid below.

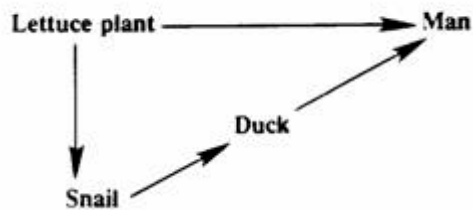


Which of the following organisms from the food web could be placed on the energy pyramid at level B?

- A: Grass
- B: Hawk
- C: Cricket
- D: Snake

Question 20 : ID: 80145 SOURCE: A002CA8

Look at the diagram.



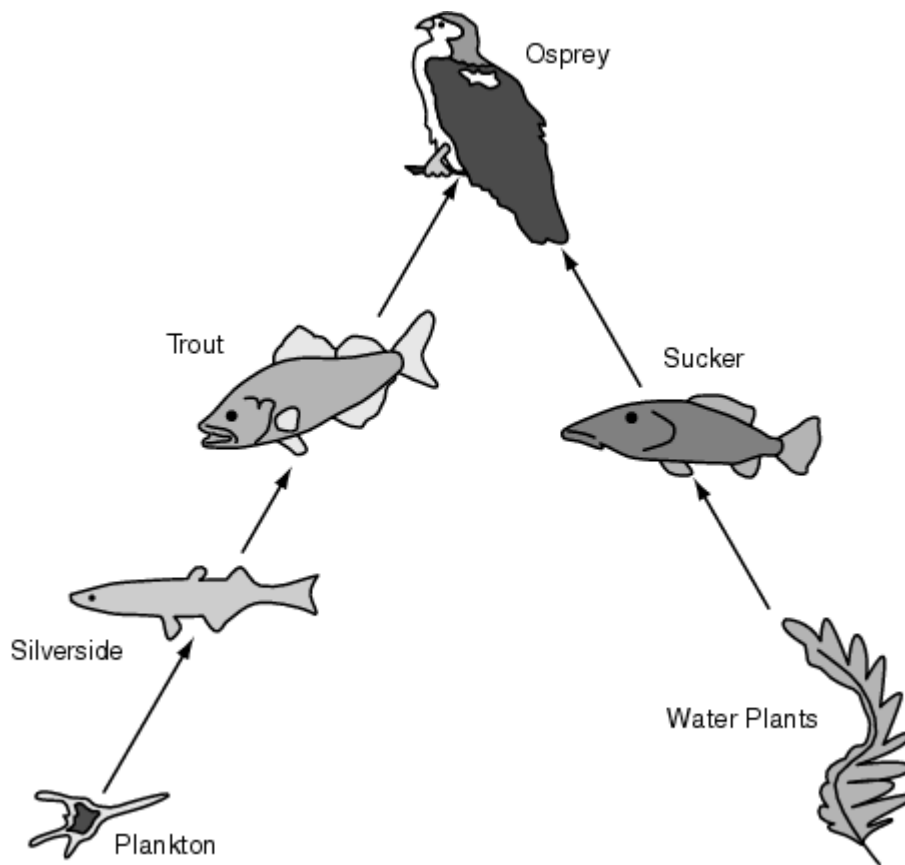
The first level consumer in this food web is the ---

- F: lettuce plant
- G: duck
- H: snail and/or the man

J: snail and/or the duck

Question 21 : ID: 60591 SOURCE: A0146FF

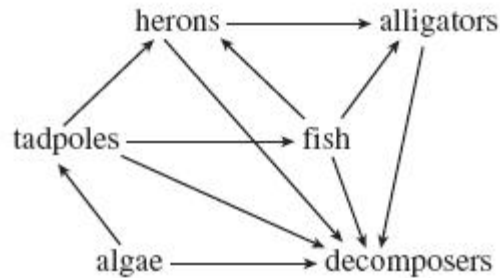
While studying the ecosystem shown below, an ecology student observed a large increase in the number of water plants. The next year, she observed an increase in the osprey population. Which hypothesis could be based on these observations?



- A:** The water plant population increased because ospreys ate all the suckers.
- B:** The osprey population increased because the number of animals that prey on them decreased.
- C:** The water plant population increased because suckers began eating plankton.
- D:** The osprey population increased because the increase in plants allowed their prey, the suckers, to increase.

Question 22 : ID: 80917 SOURCE: A014E8B

The diagram below shows a food web.



Which population would *probably* increase if the tadpole population decreased?

F: Herons

G: Alligators

H: Fish

J: Algae

Question 23 : ID: 100098 SOURCE: A01629D

Black bears roam over large territories. What effect would building shopping centers in these territories have on the bears?

A: Promote an increase in black bear reproduction

B: Stabilize the black bear population

C: Reduce the black bears' habitat

D: Introduce a new bear population to the area

Question 24 : ID: 79755 SOURCE: A002D2D

Coyotes live in packs of 10-20 members. A mated pair rules the pack, and only they produce pups. Other members of the pack help to raise the pups and protect the territory. Which term *best* describes this relationship within the coyote pack?

F: Territorial imperative

G: Social hierarchy

H: Courtship

J: Competition

Question 25 : ID: 102735 SOURCE: A015142

The diet of white-tailed deer consists mostly of shrubs. Sika are another species of deer that eat both grasses and shrubs. After an extended drought period, why might the sika population be more numerous than the white-tailed deer population?

A: Sika require less food than do the white-tailed deer.

B: Sika require more water than do the white-tailed deer.

C: Sika have more food sources than do the white-tailed deer.

D: Sika have fewer food sources than do the white-tailed deer.

Appendix D

Gentry and Owen

Appendix B Student Perceptions of Classroom Quality (SPOCQ)

Student Survey About...

Student Perceptions of Classroom Quality

Marcia Gentry, Steven V. Owen, and Penny Sprigler

Secondary Version

We would like to know how you feel about your class activities. Read each statement and show how much you agree with it by filling in the circle. There are no right or wrong answers. Your answers will be kept confidential. Remember to mark an answer for each statement. In the example below, the person agreed that the class was enjoyable. Thank you for your help in this project!

Student ID	A	B	C	D
1	1	1	1	1
2	1	1	1	1
3	1	1	1	1
4	1	1	1	1
5	1	1	1	1
6	1	1	1	1
7	1	1	1	1
8	1	1	1	1
9	1	1	1	1
10	1	1	1	1
11	1	1	1	1
12	1	1	1	1
13	1	1	1	1
14	1	1	1	1
15	1	1	1	1
16	1	1	1	1
17	1	1	1	1
18	1	1	1	1
19	1	1	1	1
20	1	1	1	1

Your Current Grade in this Course
 A B C D F

Name/ID (Optional) _____
 Teacher _____ School _____

SUBJECT AREA
 (please choose the answer that most closely describes the type of class in which you are completing this survey)

Math Foreign Language
 Science Art
 Social Studies Music
 Language Arts Physical Education
 Other: _____

COMMUNITY
 Which type of community best describes your school community?

Rural
 Urban
 Suburban

GENDER
 Male Female

ETHNIC GROUP
 African-American
 Asian-American
 Caucasian-American
 Hispanic-American
 Native American
 Other: _____

Do you receive any special services from your school district?
 Yes No

If yes, what services do you receive:
 Gifted/talented
 English as a second language
 Speech
 Hearing
 Special education-learning disability
 Special education-behavioral services
 Compensatory services
 Other: _____

Is this class an advanced level, Advanced Placement, or honors course?
 Yes No

GRADE
 7 8 11
 9 10 12

Strongly Disagree Disagree Undecided Agree Strongly Agree

Example: My class is enjoyable.

- I am given choices regarding how to show the teacher what I have learned.
- I'm good at helping other kids understand concepts.
- I find the contents of my class interesting.
- I find my class time instruction appropriately challenges my intellectual abilities.
- My teacher lets me choose the resources I use for projects.
- When there are different ways to show what I have learned, I can usually pick a good way.
- The teacher applies the lessons to practical experiences.
- I find my class assignments a good challenge.
- The assigned reading material for my class is interesting.
- My teacher makes connections between the course material and society.

Please continue on the back

SPOCQ Honors/Nonhonors Students

Side 2

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
11. I learn best when I am challenged.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
12. I am given lots of choices in my class.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
13. In my class my teacher relates current issues to the material we are learning.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
14. I am good at connecting material from this class with the real world.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
15. This class content is an appropriate challenge for me.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
16. I feel responsible for my learning because I am allowed to make choices in my class.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
17. The teacher uses a variety of instructional techniques that make this class enjoyable.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
18. I like the challenge of the projects in this class.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
19. The material covered in my textbook is interesting.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
20. The textbook provides examples of how the material relates to society and daily living.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
21. I am good at answering questions in this class	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
22. I am encouraged to pursue subjects that interest me in my class.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
23. It is pretty easy for me to earn good grades.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
24. In my class I explore real issues that affect the world around me.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
25. I look forward to learning new things in this class.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
26. I find the reading material for my class a pleasure to read.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
27. I use my critical thinking skills in my class.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
28. I'm good at taking tests in this class.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
29. I can relate the material discussed in my class to my daily life.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
30. I can easily understand reading assignments for this class	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
31. I like going to my class each day.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
32. I can usually discover interesting things to learn about in this class.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
33. I like the way my teacher challenges me in this class.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
34. I can express my opinions clearly in this class.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
35. Good grades are mainly the result of my hard work.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
36. Good grades are mainly the result of my ability.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
37. I can improve my intelligence by working hard.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
38. I plan to go to college.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

01021

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Curriculum Vitae

Anne Horak grew up in Albany, New York. She attended State University of New York College at Oswego where she received her Bachelor of Arts in Secondary Education. She went on to receive her Masters of Education in Curriculum and Instruction from George Mason University. She has served as an adjunct professor in the Advanced Studies in Teaching and Learning and Gifted programs at George Mason University. She received her Doctorate degree in Teaching and Teacher Education from George Mason University in 2013. Previously, she taught middle school English and Social Studies in North Carolina. She subsequently moved to Northern Virginia where she was an English teacher at Twain Middle School in Alexandria, Virginia. Currently, she is the Fairfax County Public Schools Advanced Academic Program Specialist for Middle School. The greatest joys in her life are her husband, David, and their daughter, Emily. As a family, they enjoy taking their dog, Zeldie, an Irish Terrier with reckless, heedless pluck, for walks, watching Notre Dame football during the fall season and traveling to Rincon, Puerto Rico.