Fostering Engagement for Students from Low-Socioeconomic Status Backgrounds using Project-Based Mathematics

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Abstract

In overcrowded urban high schools, students are dealing with many issues in and out of school. Issues at home paired with math curriculum that does not seem relevant to their lives, leads to a lack of engagement in the classroom.

This research poses the question: How can project-based algebra engage low-socioeconomic status high school students? Will teaching through projects promote engagement for this population of students?

The curriculum in many high schools throughout the US is designed to promote success on standardized tests. Many students who score basic or below basic on these tests, may find in part the skills and concepts they are learning in algebra irrelevant to their lives.

Project-based learning is a curriculum approach that is derived from constructivist theory. Constructivism can be traced to the theories of Dewey and later Piaget. This theory states that instruction must be based on experiences, where students build upon their previous knowledge to construct new knowledge with guidance from the teacher.

The literature shows that students from lower socioeconomic backgrounds and minorities have increased engagement when using a curriculum that includes project-based mathematics. Examining comparative studies on instruction comparable to project-based learning versus traditional instruction, the literature suggests that students are more motivated, engaged and have an increased understanding of mathematics.

Introduction

For the past two years I have taught in San Francisco at a small high school. It is known in the larger community as a “poor” high school. This is because more than half of the families that are a part of this community come from a background of low-socioeconomic status. Based on my experience, working with students from this area, I have come to believe that my students come to school with much more on their mind than just normal teenage issues, because of the stresses of growing up poor. With issues at home and math curriculum that does not seem relevant to their life, there is a lack of engagement in the classroom.

To promote engagement, the math department curriculum at our school is based on the Coalition of Essential Schools principle (CES National, 2006), “student as worker and teacher as coach.” We use this principle to guide how we teach mathematics in our classrooms.

The type of teaching instruction we use is a problem-based approach to mathematics by teaching curriculum using the Interactive Mathematics Program (IMP). The IMP program strives to have students solve math problems based around a main unit problem. Students use problem-solving skills to come up with concepts and formulas either on their own or in a cooperative learning group. Although we use this less traditional approach of problem based learning, I have noticed a lack of understanding for some students using our current math curriculum. I believe using a project-based approach to instruction and learning will help students see the correlation between the math they are learning in school and their “real life”. I define project-based learning as

Robert Moses (1989) describes his five-step teaching and learning process. These five steps are: a physical event (mathematical project), a picture or model of the event, intuitive language description of this event and symbolic representation of the event (Moses, Kamii, Swap, & Howard, 1989). My research has examined if teaching through standards based projects promotes engagement for this population of students and indicates the need to create a project-based algebra curriculum.

Statement of the Problem

Although the curriculum in many high schools throughout the US is designed to promote success on standardized tests, there are still many students who score at a basic or below basic level on these tests. This occurs, in part, because many find the skills and concepts they are learning in algebra irrelevant to their lives; therefore, retention of concepts and engagement in classroom activities is decreasing.

In most schools students are expected to learn concepts through direct instruction and then practice these new skills by solving problems on a worksheet or in a textbook. Teachers then assess the student's mastery of skills and concepts by giving traditional assessments, such as tests and quizzes. These assessments are usually made up of a set of problems with no context to anything outside of the math classroom.

Researchers define traditional mathematics instruction as students being taught methods and techniques by the teacher at the front of the room proceeded by students practicing these techniques using textbooks to answer a series of short, closed questions (Boaler, 2001). While many students have been able to successfully master math skills using this traditional way of instruction, there is a large group of students who have not and another group who do not retain the information and are not motivated to learn more.

This problem has been observed at even greater rates in communities that serve students of lower socioeconomic status and minorities (Moses et al, 1989). Lower socioeconomic status students are defined throughout this paper as students whose families qualify for free or reduced lunch, which is calculated based on family income by the state in which they reside.

Research Question

How does project-based algebra engage low-socioeconomic high school students? I reviewed the research that relates to the use of project-based learning in secondary mathematics classrooms. I examined empirical studies that compare traditional versus project-based instruction. By reviewing the literature behind this topic, I hope to establish the need for a curriculum that encourages the students to become active and engaged learners in the classroom.

Theoretical Rationale

Project-based learning is a curriculum approach that is based on constructivist theory. Constructivism grew from the writings on democratic education by Dewey and later Piaget. This theory is based on the idea that learning is an active process; in which learners construct new ideas based on their current knowledge. It states that instruction must be based on experiences, where students build upon their previous knowledge to construct new knowledge with guidance from the teacher. Project-based learning and the construction of objects or pieces of work enables students to show their interests, abilities, diversity and their learning styles (Grant, 2002).

Until recently, mathematics education has been taught as a drill and practice subject. A teacher taught students a skill or formula and then students did many practice problems to understand or memorize that skill. E. L. Thorndike said, "Meaning gets in the way of efficient computation and those students cannot deduce mathematical rules from example and other rules" (Gadanidis, 1994, p.93). This method is still used in many mathematics classrooms across the country. As mathematics education is starting to shift, more educators and researches are looking at Piaget's constructivist approach. This approach applies knowledge of children's cognitive development to classroom pedagogy (Gardner, 2001). Piaget's constructivism is based on his view of psychological development, in which "the growth of thinking structures proceeds in hierarchical fashion from simple to complex and from concrete to abstract through four structurally distinct stages" (Havis & Yawkey, 1998, p.136).

Gardner (2001) describes Piaget's stage theory as follows: children progress through four stages of development in the same order, but at varying rates. Piaget's stages are sensory motor (age 0-2), preoperational (age 2-7), concrete operational (age 7-12), and formal operational (age 12+). The age ranges are "relative - not absolute - and depend upon the factors of the child's background experiences with the environment, broad, yet undefined, maturational aspects, as well as cultural and societal patterns transmitted to the child by family and school." (Havis & Yawkey, 1998, p.136).

Teachers mostly deal with students during the concrete operational and formal operational stages. All children develop differently; hence, not all students at the high school level work at the formal operational stage, some are able to grasp abstract mathematical concepts through a direct instruction approach while others need a more hands-on learning approach to grasp these concepts. According to Gadanidis (1994), 50 percent of students sixteen or older function at Piaget's concrete operational level. This informs educational professionals that at the middle and high school level, teachers need to use concrete objects for students to fully understand and internalize mathematical concepts (Gardner, 2001).

Piaget describes a hierarchy of knowledge; the base is physical knowledge, then spatial-temporal knowledge, followed by logical-mathematical thinking (Gardner, 2001). Piaget uses this hierarchy and constructivism with his stages of development to discuss how mathematics should be taught in the classroom. Physical knowledge in a developmental and mathematical sense translates into the idea that "a teacher will need to provide much opportunity for the children to manipulate objects through investigation and exploration" (Havis & Yawkey, 1998, p.137). This investigation allows the student to identify the "mathematical-physical properties of them as well as other objects" (Havis & Yawkey, 1998, p.137). Spatial-temporal thinking looks at space and time relationships, similar to looking at closed and open curves (Gardner, 2001). Logical-mathematical thinking is the last step Piaget describes in the evolution of children's mathematical thinking. After children have manipulated and looked at the relationships between objects they can now come up with hypotheses like equivalence, correspondence, multiplication, and similar functions (Havis & Yawkey, 1998).

Piaget's hierarchy of knowledge and stages of development are the underpinnings for his constructivist approach to mathematics education. Gardner (2001) states, "The task of learning mathematics is too immense to use a rote method, where the teacher explains the process using the left-hand pages in the text and the students practice problems on the right hand side" (p. 75). Mathematics is about understanding patterns and making conjectures from one relationship to another. Without these connections to real applications, students are just reciting mathematical facts. In the constructivist approach, teachers are seen as more of a coach, someone to guide the student in the development of his or her thinking. The key is for the teacher to draw students together at the end of a math exploration and ask them to show how they went about finding their answer and explain why they think it is correct (Gardner, 2001). As mathematics teachers we need to remember, "Important mathematics principles are not taught for the sake of facts, but for organizing, reorganizing, and systematizing mathematical thinking structures." (Havis & Yawkey, 2001, p.135).

Piaget's theory of mathematical concept development still requires much research before it can be used to support the development of a new type of mathematics classroom. Gardner (2001) states, "Those of us who are engaged in shaping the future through the students in our classrooms need to reflect upon or revisit the foundations of how we teach." (p. 69). Elizabeth Wood's (2003) study on pupil perspectives found that a majority of students' idea of a good lesson was when the lesson is active, enjoyable and students are working with a group or a partner. A good constructivism based lesson will involve all of these characteristics.

Recently, many researchers have begun studying the effects of a more constructivist approach to learning in mostly inner-city classrooms around the country. The results of some of these studies have shown an increase in minority and low-socioeconomic status students moving on to upper level (college level) math classes. Jo Boaler (2006) and a few other graduate students from Stanford conducted a study at an urban high school in California. The math department used a teaching approach that focused on group work with complex conceptual problems and student centered learning. The students took responsibility for their own learning and the teacher was more of a coach, whose job it was to help students see mathematics as a part of their future, by providing them with the quantitative reasoning capabilities needed to function in an increasingly technological and global economy (Boaler, 2006). In this study they found that "students learned more, enjoyed mathematics more, and progressed to higher levels of mathematics" (p.365) than urban schools in the area that were not using this approach and were using a more teacher directed approach.

When looking at urban schools throughout the United States we are, for the most part, looking at school communities with a culturally and economically diverse student body. Usually this diversity is not reflected in the teacher population. The teachers that students see in most classrooms are white middle class females. In response to this, mathematics is taught in the same way in which the teacher learned mathematics in school, which is usually a more traditional approach to math. Translated into the mathematics classroom, this shows an emphasis on repetition, predictability and right-answer thinking (Pennington, 2000). This is traditionally how mathematics has been taught. Where students begin learning the most elementary mathematical concepts and gradually move to gaining a more sophisticated level of mathematical knowledge. Although it is important for students to learn math by building off previous knowledge, it is often taught in a way that if students did not learn the previous mathematical content then there is no way to learn the new mathematical concepts. "Standardized tests that are anchored in this philosophy favor students who learn most efficiently via this style of teaching." (Pennington, 2000, p.37).

Assumptions

My first assumption is that students in the past and present have had a hard time with algebra because of the use of only traditional mathematics instruction to teach algebra. I expect to find that teaching through projects will promote engagement for students who come from low-socioeconomic status backgrounds. Most students can learn algebra if lessons are taught in a way that is engaging, fun, hands-on and relevant to their life. If mathematics educators can establish project-based algebra curriculums, then students will be engaged, interacting, spending time on algebra, and getting excited about math. I believe these results will encourage more students to continue on to more advanced math courses. I also assume that with looking at low-socioeconomic districts versus high socioeconomic districts and the presence or absence of technology within those schools could pose a problem with some project-based curriculums.

Background and Need

Cervone (2002) highlighted six project-based educational programs that promoted engagement and achievement for urban youth in the subject areas. These classes detailed multidimensional examinations, real world projects, and internships, that promoted students self-esteem, increased their engagement in the respected subjects and altered work habits. One of the projects was focused on math called, “Each One Teach One: Math Literacy and Civil Rights”. This Missouri based project uses civil rights to encourage urban youth to engage and achieve in algebra and move on to college preparatory level math classes. Although one of the programs talked about describes a mathematics project for disadvantaged youth, there is a need for more research in the area of project-based learning in mathematics and its effect on engagement for students of low-socioeconomic status backgrounds.

Cervone (2002) states, “In the country’s most under funded and overcrowded urban schools, however, ‘senior slump’ often begins much earlier, boosting dropout rates while devastating students’ options for the future.” (p. 1). The students looked at in this study were able to find learning environments that motivated and supported them to achieve academic success. These six projects were based upon the developmental needs of adolescents: to feel respected and connected to the world around them, to create their own voice through learning, and the need to make a positive impact on the world.

Many educators call algebra the “gatekeeper” for students of color and lower-socioeconomic status, as they are often tracked into basic math classes. Cervone (2002) describes the project in which forty middle and high school students of Pine Bluff, Arkansas, were sent on a two-week summer session of Algebra Project camp to learn aspects of algebra. These students were taught strategies of persistence used in the civil rights movement to promote engagement in the algebra curriculum. They went on field trips to learn African drumming and dance, quilting and folk dance and its applications to algebra, all of which provided students with cultural enrichment with multi-disciplinary and cultural learning. They also learned directly about the civil rights movement by visiting Central High School in Little Rock, where students their age made history in the 1950's. Using this approach, students were more likely to take advanced mathematics courses at younger ages than their peers who were not educated through this project (Cervone, 2002). Most importantly, students reported high levels of enjoyment and engagement in studying math with this approach.

Review of the Literature

The following review of the literature is divided into several sections: 1) describing the role of mathematics in the classroom, 2) traditional mathematics instruction versus project-based learning, 3) economic background and the students' engagement and retention of mathematics, and 4) project-based learning and mathematics. The literature describing the role of math in the classroom looks at the traditional math instruction and reasons its long term effectiveness is questioned. Under the subheading students' engagement and economic background, the literature speaks to the inequities of math instruction and school in general for students who come from a low-socioeconomic background. The research also suggests that project-based learning or experiential learning increases engagement for students who come from disadvantaged backgrounds. Lastly, I describe a few mathematical projects from the literature and their strengths and weaknesses using the instructional strategy of project-based learning.

Role of Mathematics in the classroom

There is mounting evidence that the teaching strategies used by many high school mathematics instructors are not diverse and varied enough for all students to successfully master course content (Bouris, Kreel & Storz, 1998; Horn, 2006; Kress, 2005). Schools are filled with disengaged students who exhibit behavior problems and report being bored in math classes (Bouris, Kreel, & Storz, 1998). In most schools across the country, math is learned as a series of unrelated skills and tasks that have little connection to the students' outside world (Stables, Morgan, & Jones, 1999). Students have difficulty making connections between what they learn in the mathematics classroom to other disciplines and the real world (Southern Regional Education Board, 2000). Many students lack engagement in mathematics because they are asked to learn something that they are not interested in, they feel they have no choice in their learning, they lack skills that are necessary to be successful, and family and or monetary support may not be present (Bouris, Creel, & Stortz, 1998). They are asked to learn through repetitious worksheets that have a dozen mathematical equations for students to practice the math skills they learned early that day or week (Horn, 2006; Stables, Morgan, & Jones, 1999). Using traditional teaching methods like this establishes a classroom community of independent work and has proven to not be effective for students and their engagement in mathematics (Pinzker, 2001).

In a study of 120 interviews from mathematics students in the US and England, students noted that the style of learning is absolute with only one right answer, where they are not asked to critically think as they are asked in other subject classrooms (Boaler, William, & Zevenbergen, 2000). Teachers and educational professionals report that with this traditional type of instruction students are left wondering: "Why do I need to know this?" or "When am I ever going to use this?" (Horn, 2006; Moses & Cobb, 2001; Pinzker, 2001). As a result, it has been widely observed that the number of young people living in the United States who are choosing to pursue academic or career choices that involve the use of math and science is decreasing, especially among underrepresented groups (Cervone, 2002; Kress, 2005).

Traditional Instruction versus Project-based Learning for Mathematics

There have been a number of empirical studies that compare traditional instruction with either project-based instruction or problem-based instruction in mathematics and science classes, where researchers compare two different classrooms or schools. These studies usually consist of data collection through assessments, observations and surveys by teachers, students and parents.

In a longitudinal study of 300 students in England, Boaler (2001) compared two schools with similar demographics. At one school, named Amber Hill, the students were taught math using a more traditional approach, where students used textbooks, lessons began with direct instruction of a mathematical method from the teacher, and then students practiced this method individually with a series of problems from the textbook. At the other school Boaler studied, named Phoenix Park, students utilized and applied mathematics by looking at real life situations and if students needed to learn about a mathematical topic to do so, then the teacher would teach them the topic in order to solve the problem or complete the project. In a related study on the learning of fractions, Boaler found that only when students have developed an understanding of fractions through real world situations should they be introduced to the mathematical algorithims (Boaler, 1993).

Students at Amber Hill were able to distinguish and repeat techniques in a standard format, usually by using a mathematical formula, where as students at Phoenix Park learned how to apply mathematical methods to situations or problems and have mathematical discussions. Both schools were tested at the beginning of the study on a national examination that was made up of about two-thirds procedural questions and about one-third conceptual questions. The results revealed that both schools performed at similar mathematical levels.

At the end of the three-year study, Boaler tested students at both schools again using a national examination and found that Phoenix Park scored higher than the students at Amber Hill. She found this surprising since overall the exam was mostly in standard format, which is unlike anything that the students from Phoenix Park had been accustomed to and the questions were similar to what students at Amber Hill had experienced. The procedural questions were more similar to the type of learning students at Amber Hill received and the conceptual questions were more similar to the type of learning Phoenix Park students experienced. Students at Amber Hill scored more marks on procedural questions than on conceptual questions. Phoenix Park students showed no major distinction on their performance on the procedural and conceptual questions, although they did answer more conceptual questions than students at Amber Hill. When students were interviewed at both schools, students at Phoenix Park said that the mathematics they learned in school was useful in the real world, while the students at Amber Hill said that the methods they learned in school were completely different to the math they use in the real world.

In a different study Wenglinsky (2004) looked at The National Assessment of Educational Progress (NAEP) assessments for math and science of a representative sample of students in 4^{th}, 8^{th} and 12^{th} graders throughout the US. He analyzed the data from the NAEP to evaluate teaching approaches of traditional mathematics and a more hands-on or project-based approach to learning.

Wenglinksy found the data supports teaching that stresses project-based learning; open-ended questions with multiple solutions, hands-on techniques, and critical thinking skills have a correlation with higher scores on the NAEP. The data also revealed that students scored higher on the 4^{th} and 8^{th} grade science tests when the instruction was centered on projects and more traditional approaches, such as reading and answering questions from a textbook, gave no positive effect. Wenglinsky's analysis of NAEP suggests that although the teaching of basic skills is needed, critical thinking skills are crucial to higher achievement and basic skills are not. In other words, if students understand the meaning behind the content, then they can understand the content more successfully.

Bouris, Creel, and Stortz (1998) evaluated mathematics instruction in a district which consisted of three elementary schools, one junior high school, and one high school. The district demographics were students who were mostly white and who came from a middle class socioeconomic background. Low-income students made up about 1.1% of the school population. The district mathematics program was given in a traditional instructional format; the study calls it a lecture format, where the teacher gives direct instruction on a mathematical method while students take notes; students then solve a series of similar problems individually either in a textbook or on a worksheet.

The researchers began by asking teachers to reflect on their teaching by looking at the hours each week they spend on lecturing, percentage of students who have incomplete assignments, not working to their potential, who seldom participate in class. Students and their parents/guardians were asked to fill out a survey, which consisted of questions that targeted homework, learning settings, grading, motivation, and how students' best learn.

The surveys found that the majority of students and parents preferred to work individually and learn through a lecture format. The majority of families stated that the main motivating factor to learn mathematics is grades and parental concerns. Three teacher researchers designed two cooperative learning projects to be implemented into their different level math courses for an eighteen-week research period. They then administered post intervention surveys to both students and parents in their classrooms.

An analysis of the post intervention surveys suggested that both students and parents believe that they are spending more time on math overall and that they preferred to learn by cooperative group settings rather than the lecture driven format. The surveys also suggested that although grades were the main motivating factor to learn the math content, self-esteem as a motivating factor rose, showing that students had a better feeling about their math experience.

The most notable change in pre and post intervention data was that the targeted students went from a 58% assignment completion rate to 83% of completed assignments. The teacher researchers concluded the data suggests that students tended to be more motivated in mathematics than they were prior to the cooperative learning projects.

There has been much research on motivation using project-based learning (PBL) in the subject area of high school economics. Maxwell, Mergendoller, and Bellisimo (2005) used data from 252 high school economics classes at 11 different schools and found that project-based learning can improve student learning as long as teachers are well trained in both the subject and PBL techniques. The schools were located in Northern California, two of them were located in suburban districts and two were in urban districts.

The study focused on five teachers at four different high schools. Each of the teachers selected two classes, before class lists were assigned, one macroeconomics class was taught in lecture format and the other was taught using PBL. Each of the classes had to take a variety of assessments for the study, including pre and posttests on knowledge of macroeconomics. The results were that for two of the teachers project-based significantly increased learning over the traditional instruction, for the third teacher PBL significantly decreased learning over traditional instruction, and for the remaining two teachers there was no difference in learning for the PBL class compared to the lecture format class. This suggests that project-based learning may enhance learning of macroeconomics over traditional methods of instruction for some teachers.

Economic Background and Student Engagement with Project-based Learning

Equity issues around socioeconomic class are particularly important for math teachers and educators because basic mathematics serve as a critical step for moving on to more advanced math classes. More advance math classes help students get into college, and qualify them for a higher paying career (Kress, 2005; Lubienski, 2000; Moses, Kamii, Swap, & Howard, 1998; Pennington, 2000). When most schools try to address achievement gaps between cultures, gender, language and social class they tend to use the same old teaching strategies but teach more mathematics (Kress, 2005). Jo Boaler’s (2006) Railside High School study found that Railside succeeded in creating a more equitable classroom environment because of the experiential and cooperative learning approach to mathematics.

Many studies have noted increased engagement and critical thinking when using project-based learning in the mathematics classroom (Horn, 2006; Schoenfeld, 2002; Upitis, 1995). Specifically, Horn (2006) documented those students who belonged to disadvantaged groups who were in classes with a more experiential approach to mathematics instruction, demonstrated higher levels of achievement and enrolled in advanced math courses at greater rates than students in more traditional math classrooms.

Low-socioeconomic background students in project-based math classrooms have shown engagement and motivation to learn math and attend class, and observe the relevance of mathematical thinking to life and other disciplines (Cervone, 2002; Kress, 2005; Upitis, 1995). Bouris, Creel, and Stortz (1998) in a study done on a school district which included three elementary schools, one junior high school, and one high school found that by adapting lessons to real life situations, students were motivated and engaged in their own learning. Interdisciplinary units will increase engagement because students learn more about their world and how it relates to mathematics (Pinzker, 2001).

The increased engagement and achievement in these project-based classrooms has also been attributed to the teacher's guidance, openness and honesty with the students (Caniglia, 2003; Horn, 2006). One of the participating teachers in the Algebra Project used her inexperience with the project to take the position of a mutual learner of the content, which helped her students build their confidence and engagement (Moses, Kamii, Swap, & Howard, 1989). Teachers are more prepared to help students become active and engaged learners if they themselves get involved in the process of making connections between the real world and the math they are teaching in school (Caniglia, 2003).

Project-based Learning and Math

Project-based tasks, as described by the Principles and Standards for School Mathematics (2000), begin with a student's own exploration into a topic or concept, and help students develop research and problem solving skills, the ability to reflect and work through issues, as well as the ability to collaborate with others and produce a single artifact. Projects should come from a real world situation in order to create motivation for students' right from the start (NCTM, 2000).

One of the most successful projects used to teach middle and high school algebra is the Algebra Project, created by Moses and Cobb (Kress, 2005). The Algebra Project was created to address the low level of school mathematical achievement, confidence and motivation among students of various racial minorities so that with this access to algebra, students will have the chance to advance in high school mathematics in order to open more opportunities for them. (Moses, Kamii, Swap, & Howard, 1998).

This project teaches students mathematical concepts in a variety of culturally relevant and useful contexts, and introduces algebraic content to students during elementary and middle school so as to create a cognitive foundation early in development (Moses & Cobb, 2001). One example of the project, asks students participating in the Algebra Project to learn the slope of lines, the distance formula and various other mathematical concepts by mapping out subway and bus routes that they take everyday throughout Boston (Kress, 2005). The effectiveness of the Algebra Project has been demonstrated widely in literature, which documents studies in many cities and rural communities across the United States (Cervone, 2002; Kress, 2005). In 1986, 39 percent of the Algebra Project's first graduating class enrolled in honors geometry or honors algebra in high school (Moses & Cobb, 2001).

Boaler (2006) completed a four-year study in which they looked at three high schools in California that had different economic and cultural demographics of students. One school (Railside High School) was an urban school that served students who came from diverse socioeconomic status, cultural and linguistic backgrounds. Railside High school students experienced a less traditional approach to math curriculum, with a more project conceptual approach; whereas the other two schools were taught using more traditional math instruction. The math classes at Railside were multidimensional classrooms, which were taught in groups with complex instruction that focused on real life social issues and circumstances (Boaler, 2006). This study looked at 700 students in two traditional math classrooms and one using the "Railside Approach." The research used both qualitative and quantitative research methods consisting of 600 hours of classroom observations, assessments, questionnaires and interviews given to all students over a three year study, following students in their math classes. The study found that the students at Railside were more engaged in math and progressed to higher levels of math than the other two schools (Boaler, 2006). After two years, students at Railside were outperforming students from the other high schools, by senior year about 41 percent were taking advanced classes like precalculus or calculus compared to approximately 27 percent of the students from the other two high schools, which had been taught with more traditional math instruction (Boaler, 2006). Using a project-based approach to instruction, students were observed to have more respect for one another regardless of their socioeconomic status, race, ethnicity, gender or intellectual level (Boaler, 2006; Caniglia, 2003; Cervone, 2002; Kress, 2005). The study also stated that some students were challenged with not knowing where to start on open-ended projects and discovering variables to represent their equations (Boaler, 2006).

The last project-based curriculum study I researched was *Math in the City* (2003) whose purpose was to help teachers and students make connections between standards based mathematics and real life (Caniglia, 2003). This program's focus was for students to experience math through a tour of historic Detroit landmarks where students conducted mathematical investigations related to concepts of statistics, measurement of three dimensional geometric figures, mapping, fractions, box and whisper plots, and cost comparisons (Caniglia, 2003). After students performed the investigations, they were asked to develop their ideas through group discussions, reading assignments and journal writing, which helped them connect their learning of math concepts, the standards and their culture (Caniglia, 2003). Most importantly, this curriculum helped students build upon their prior knowledge and move from ideas to formal understanding, a key component of project-based learning (Boaler, 2006; Bouris, Kreel, & Storz, 1998; Cagnilia, 2003; Horn, 2006; Kress, 2005; Moses & Cobb, 2001).

Summary of Major Findings

Math curriculum in US schools is frequently presented separate from real world context and primarily through lecture-style teaching. There are many high school students who disengage during math class and do not retain an understanding and mastery of concepts in algebra by the time they graduate high school. The research above points to the reality that algebra is the benchmark for mathematics mainly because it is a requirement for high school graduation in California and many other states, due to the adoption of High School Exit Exams. Algebra is a prerequisite for students to enroll in higher-level math classes. Research looks at traditional instruction as holding many students back from succeeding in algebra because it is not related to the student's real life and they are left wondering why they need to know it (Cervone, 2002; Horn, 2006; Kress, 2005; Moses & Cobb 2001; Stables, Morgan, & Jones, 1999).

Students from disadvantaged backgrounds are the ones feeling the consequences of this argument. Recent research shows that students are more engaged and motivated when teachers are using instructional approaches that promote experimentation and real life context (Boaler, 2006; Horn, 2006; Schoenfeld, 2002; Upitis, 1995). By guiding students through the practice of identifying problems, evaluating and exploring a variety of processes to solve the problems, and drawing their own conclusions, teachers can encourage students to integrate complex mathematical reasoning skills. Along with expanding on student's critical thinking skills, this approach is providing a real world context through which students can solve new problems and enrich concepts that they have already learned.

Studies that compared project-based learning and traditional instruction suggest that PBL increases motivation, excitement about mathematics, and in some cases increased test scores. Through a variety of tests and observations in these studies, researchers found that when projects are planned with high-quality teaching pedagogy, learning in this way can add meaning and deeper understanding for students, which then increases engagement in school (Boaler, 2001; Bouris, Creel, & Stortz, 1998; Maxwell, Mergendoller, & Bellisimo, 2005; Wenglinski, 2004). Boaler's (2001) study suggests that students see a major correlation between project-based learning and the connection math in school has to the real world. This connection increased student's interest and engagement in mathematics classes, which was proven by completion of math assignments (Bouris, Creel, & Stortz, 1998). When comparing project-based mathematics curriculum to traditional math instruction, students seem to be more engaged in the subject, which creates more understanding for students.

Some of the most notable projects that come from the research on project-based learning allow students to visualize the concept by going on a field trip such as, visiting civil rights landmarks and local cultural landmark; others have speakers or real life circumstances and data to support the project. This approach to learning has given students a concrete real life concept or example to begin their own math project. This connection between math and real-life is believed to enhance their mathematical understanding of the concept. The Algebra Project, Railside High Project, and Math in the City have all shown that using a project-based approach to learning will enhance achievement and engagement for students (Boaler, 2005; Cagnilia, 2003; Cervone, 2002; Kress, 2005; Moses & Cobb, 2001). Most of these projects focused on urban middle or high schools where educators were dealing with inequity in mathematics classrooms for minority and socioeconomic status students.

Limitations/Gaps in the Literature

In reviewing the literature I noticed that some issues are not present in the qualitative and quantitative research projects. I was not able to find any research that gave a negative view for project-based learning. This research has shown to both support and refute my hypothesis. I also noticed that there are many articles that look at only socioeconomic status and math or project-based learning and math or engagement and project-based learning, but barely any research on all of them combined. This could be because my topic is too broad or it could be because most of the research on these topics has been largely completed in the past ten years. Therefore, there is a need for research on the correlation between a student's socioeconomic status and math curriculum being taught. I also found that the literature on project-based learning was not only focused on students from low-socioeconomic backgrounds but more on urban school districts. Therefore, there is not a direct correlation between the engagement of students from low-socioeconomic backgrounds and project-based learning.

Another limitation in the research I found was that most of the studies were action research. The studies were done on a very small scale, like comparing two math classrooms in two different schools. There was no research done on a larger scale, such as throughout a state looking at different types of communities. Lastly, most of the studies were done by teachers, not researchers who had nothing to gain. Having teachers do the research creates a limitation because the teachers are looking for their hypothesis to be answered. Also, a teacher's personal charisma or personality could be a factor in increasing student success, as much as the project's. Although, this could be true of any research.

In looking at using constructivism in daily classroom practices, I see one main challenge for students and teachers. This problem is standardized testing. The constructivist approach is contradictory to traditional ways of learning mathematics in the U.S. educational system. This approach to learning focuses on building student thinking and problem solving skills which can be applied to real world situations. This is not easy to measure with multiple-choice questions or aligned with the discrete skills being tested on standardized tests. One would hope that once students learn the concepts that no matter how the test is constructed, students would know the concepts well enough to do well on any standardized test. I could only find two studies that have shown an increase in standardized test score results when using theoretical frameworks, like constructivism, in the classroom (Boaler, 2006 & Wenglinksy, 2004). After using the constructivist approach, students are not familiar with solving the problems as they are set up on standardized tests (Pennington, 2000). This problem has very real demands for research in the mathematics classroom, since much of the funding for public schools comes from state standardized test scores.

Implications for Future Research

There are not many studies on the function of project-based learning in the mathematics classroom and whether or not it promotes engagement and achievement. However, there are many studies that look at project-based learning in the science or technology classroom. The studies on mathematics and project-based learning seem to omit how these programs are funded. Future research should focus on longitudinal experimental studies of students who come from lower socioeconomic backgrounds and if project-based learning in the math classroom promotes engagement and achievement so that students can move on to higher level math classes. There is also a need for more research on comparing standardized test scores of schools that use traditional mathematics instruction versus project-based instruction. Lastly, there is a need for more longitudinal research analyzing the retention of high school mathematics concepts of students who come from both traditional and project-based mathematics instruction.

Overall Significance of the Literature

Evidence from multiple studies suggests that students who learn mathematics by answering and exploring complex problems that fit into real world contexts not only learn to think about quantitative concepts in multifaceted, multicultural and multidisciplinary ways, they are also able to develop strong content knowledge of the topics taught in high school mathematics classes such as algebra, geometry and trigonometry (Bouris, Kreel & Storz, 1998; Cervone, 2002; Horn, 2004; Kress, 2005). The research shows that students have been shown to develop a motivation to learn math and attend class, and they can observe the relevance of mathematical thinking to life and to other disciplines (Cervone, 2002; Kress, 2005). On standardized tests, students who learned mathematics through project-based learning surpassed those who learned through traditional instruction on both conceptual and procedural questions, this creates a strong reason to study how project-based learning in algebra can create engagement for low-socioeconomic status students.

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