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EFFECTIVENESS OF PROBLEM-BASED LEARNING IN URBAN MIDDLE SCHOOLS ON MATHEMATICS ACHIEVEMENT AND SCHOOL CLIMATE

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ABSTRACT

EFFECTIVENESS OF PROBLEM-BASED LEARNING IN URBAN MIDDLE SCHOOLS ON MATHEMATICS ACHIEVEMENT AND SCHOOL CLIMATE

Anika Yasin

The purpose of the investigation was to determine if there was a difference in student performance on the NYS Mathematics State Assessment between schools that implemented PBL versus those that did not. The aim was also to determine if there was a difference in students' and teachers' attitudes about the school community, specifically in rigorous instruction and collaborative teachers between schools that implemented PBL versus schools that did not. The last part of the investigation was to see if rigorous instruction, collaborative teachers, and PBL program predicted student achievement scores on the NYS math state test. The middle schools are randomly selected across two districts in New York City, receiving either math instruction through a traditional approach or the PBL method. The superintendent/deputy superintendent approved all schools using the PBL program. The instruments used for analysis include the 2019 Mathematics State assessment and the NYC DOE survey distributed to both the parents and teachers. The two instruments are archived data and are publicly available. The analysis was run on SPSS using the Mann-Whitney U-test and multiple regression. The results revealed a statistically significant difference in the mathematical scores and students' and teachers' perceptions of schools in the PBL and traditional groups. The schools in the PBL group had more incredible significant growth in scores and attitudes than the schools that implemented the conventional approach. Results also showed that

collaborative teachers and rigorous instruction did not predict student achievement on the mathematics state assessment. However, the PBL practice did predict student achievement. This helps to show that authenticity, student voice & choice, reflection critique & critique & revision, and public presentation of projects can help improve student performance on the mathematics state assessment.

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CHAPTER 1

Introduction

Problem-based learning (PBL) is an instructional approach that utilizes inquiry-based learning to support learners working collaboratively with their peers to learn concepts and principles as they engage in complex issues. PBL was initially designed to prepare medical students for solving problems in clinical settings (Barrows, 2000; Torp and Sage, 2002; Hmelo-Silver, 2004). After its achievement in medical education, PBL isnow being implemented throughout K–12 and higher education. Unlike the teachers' direct presentation of facts and concepts, learners engage in self-directed learning (SDL) to identify research and apply knowledge and skills to solve a problem (Savery, 2006). This instructional method encourages pupils to become responsible for their learning, develop strategies, construct their understanding, and reflect on what they have learned. It also prepares students to build twenty-first-century skills, to develop life-long habits to become college and career-ready.

Purpose of the Study

The purpose of the study is to understand if the Problem-based Learning (PBL) instructional approach effectively improves urban middle school students' performance on the New York State Mathematics Assessment. The research would like to understand if students' and teachers' experience in the PBL classroom environment positively impacts their attitudes towards their school community. The study hopes to determine which subcategories of school climate, rigorous instruction, and collaborativeteachers predict students' achievement in the Mathematics State Test Scores in the PBL classroom.

Theoretics/Conceptual Framework

The Framework for High-Quality Project-Based Learning (HQPBL) (2018) is composed of six criteria. The six criteria are intellectual challenge and accomplishment, authenticity, public product, collaboration, project management, and reflection. The Framework for HQPBL explains the student experience and is designed to equip educators with a foundation for creating good projects. It allows students to approach a challenge innovatively by tackling real-world problems and coming up with innovative solutions. The framework helps students participate in classroom learning to understand challenges, generate ideas, and develop practical solutions as they voice their concerns to make an impact. Students follow a project management process to learn important academic content and develop their creative and critical thinking skills. They learn to lead themselves and their teams' time, tasks, and resources following a multistep project. Students identify a constructive goal, frame ways to pose the problem, and explore data from varied sources to determine what they know and what they need to discover. They use creativity to brainstorm ideas and perspectives that can be novel or refined to solve the problem. They apply strategies to analyze, search for ways to turn ideas into solutions and prepare for successful implementation. Students work collaboratively with other students in the classroom by discussing and contributing their knowledge and skills. They pause regularly to reflect onwhat they know and what they have accomplished to assess the quality of their work. They have ample opportunities to make their work public and share their learning withpeers and people beyond the classroom.

Significance of the Study

Individuals today will enter a workforce that has drastically changed from that of the 20th century. With changes in the industry, economy, and technology, schools need toprepare students to develop 21st-century skills to adapt to the changing world. To supportlearners in the classroom to build on previous knowledge and create a new experience, Cheng et al. (2016) suggest that students should use an active-learning instructional method. Learners in the United States need to strengthen critical thinking, collaboration, problem-solving, and creativity (Stewart, 2012). Schools need to employ the Problem- based learning (PBL) instructional approach to promote 21st-century skills to enhance students' performance and improve their classroom environment perceptions (Romero, Usart, & Ott, 2015). The use of 21st-century skills enriches the school curriculum and engages learners in the classroom beyond this technology-driven world. It also provides pupils with ample opportunities to become more responsive to the world around them.

Although 21st-century skills are essential to support learners to become successfulin college and future careers, many business leaders have stated that learners have "deficits" in these skills, and that can "significantly impact the future economic growth inthe United States and abroad" (Mosier, Bradley-Levine, & Perkins, 2016, p. 13). The Organization for Economic Cooperation and Development (OECD) analyzes student dataon the Programme for International Student Assessment (PISA) examination. This test measures students' reading, math, and science skills across various countries throughout the world. The results revealed that American students' performance on the PISA was much lower than other globally competitive countries such as Singapore, Hong Kong, Ireland, South Korea, Japan, Canada, Germany, and the

United Kingdom. Specifically, out of 71 countries, the United States students ranked 38th in math and 24th in science and reading (Desilver, 2017). Most American students are not yet ready to compete in theglobal market. Implementing these skills is necessary to help learners solve unstructured problems, analyze information, and succeed in a continually changing world.

Implementing PBL is critical in middle school to help create a curriculum that is challenging and exploratory. There has been minimal research conducted in Problem-based learning (PBL) outside the medical field, graduate and postgraduate levels, and gifted education, paying less attention to all students in k-12. There is also little research on PBL instructional methods on middle school students' and teachers' perspectives of their school environment. Students' and teachers' perception is essential to check the instructional program's effectiveness and implement it in schools. Although previous studies suggest that Problem based learning methods have improved student performancein the classroom, understanding how this instructional model will impact learners' perceptions of the classroom environment is an essential part of a research agenda for PBL. The research also aims to determine if students' and teachers' perspectives of the school environment influences student performance on State Assessments. The dissertation focuses specifically on middle schools engaging in problem-based learning intheir math classrooms in urban settings. This study compares schools that implement PBL in their math classrooms versus schools that do not. Schools that implement PBL areprovided with more opportunities to construct meaningfully and are encouraged to work with their peers to ask questions, share ideas, and engage in dialogue. Schools that do not implement PBL are part of a more traditional setting in which the students only obtain knowledge from their teacher.

Research Questions

1. Is there a difference in middle schools' achievement scores in Math State Assessment between PBL schools and non-PBL schools?
2. Is there a difference in students' and teachers' perspectives of the school climate on the NYC School Survey (Rigorous Instruction and Collaborative Teachers) between schools that employed the PBL teaching approach and schools that used the traditional teaching approach?
3. Will practice of PBL, students' perception of rigorous instruction, and students' perception of collaborative teachers predict students' achievement in Math State Test Scores?
4. Will practice of PBL, teachers' perception of rigorous instruction, and teachers' perception of collaborative teachers predict students' achievement in Math State Test Scores?

Definition of Terms

1. Active Learning: Students engage in the learning process instead of passively taking in the teacher's information.
2. Collaborative Groups: Encourages shared knowledge construction as studentswork together with their group members to tackle the problem (Pea, 1993; Salomon, 1993). It will enable learners to have discussions and construct scientific explanations, which will improve their problem-solving and higher-order thinking skills (Blumenfeld et al., 1996; Brown, 1995; Vye et al., 1997).

3. Collaborative Teachers Category: According to The *Framework for Great Schools* by the *NYCDOE,* "Teachers are committed to the success and improvement of their classrooms and schools. They have the opportunity to participate in professional development within a culture of respect and continuousimprovement." The subcategories include cultural awareness and inclusive classroom instruction, innovation and collective responsibility, peer collaboration,professional development quality, and school commitment.
4. Facilitator: Is "an expert learner, able to model good strategies for learning and thinking, rather than an expert in the content itself" (Hmelo-Silver, 2004). The facilitator "scaffolds student learning through modeling and coaching, primarilythrough the use of questioning strategies" (Hmelo-Silver and Barrows, 2003).
5. Ill-Structured Problem: Problem that can be solved with multiple solutions(Hmelo-Silver, 2004)
6. Inquiry-based Learning: a form of teaching methodology in which studentsactively participate in their learning process.
7. Mathematics State Assessment: New York State administers the Mathematics Common Core tests to grades 3 to 8 to measure student proficiency in the knowledge and skills needed to succeed in college and careers. This dissertationfocuses on the middle school student scores in grades 6-8.
8. Math6Total: The 6th grade NYS Mathematics State Assessment's total score wasoperationally defined for each school studied by combining students' percentagesat each level (1-4) on SPSS. The COMPUTE

MATH6TOTAL=MATH6L1 * 1 + MATH6L2 * 2 + MATH6L3 * 3 + MATH6L4 * 4.

9. Math7Total: The 7th grade NYS Mathematics State Assessment's total score wasoperationally defined for each school studied from the 2018-19 school year by combining students' percentage at each level (1-4) on SPSS. The COMPUTE MATH7TOTAL=MATH7L1 * 1 + MATH7L2 * 2 + MATH7L3 * 3 + MATH7L4 * 4.
10. Math 8Total: The total score for the 6th grade NYS Mathematics State Assessment was operationally defined for each school studied from the 2018-19 school year by combining students' percentages at each level (1-4) on SPSS. TheCOMPUTE MATH8TOTAL=MATH8L1 * 1 + MATH8L2 * 2 + MATH8L3 * 3 + MATH8L4 * 4.
11. MathematicsTotal: The total score for NYS Mathematics State Assessment for each school participating in the study was operationally defined by calculating theaverage score for the Math6Total, Math7Total, and Math8Total on SPSS from the2018-19 school year. The COMPUTE MathematicsTotal= (Math6Total + Math7Total + Math8Total) / 3.
12. NYC School Survey: Survey distributed each year to all NYC public school parents, teachers, and students to measure school quality on the six Frameworkelements (rigorous instruction, collaborative teachers, supportive environment,effective school leadership, and strong family-community ties).
13. Problem-based Learning: An inquiry-based instructional model encourages student-centered learning to promote the teaching of concepts and principles

as groups of learners actively solve authentic, ill-structured problems. It is a "focused, experiential learning organized around the investigation, explanation,and resolution of meaningful problems" (Barrows, 2000; Torp and Sage, 2002).

14. Problem-based Learning Schools: Schools that use the PBL approach have been recognized by the Buck Institute for Education PBL School Rubric. The schools that implement PBL will be used for this research.
15. PBL School Rubric: All schools that teach using the PBL approach have been identifiable for their successful implementation of PBL within their core instruction, evidenced by the Buck Institute for Education by the superintendent/deputy superintendent of the district. The rubric is separated into two essential elements of a PBL school, significant content and 21st-century competencies. Level 1 represents Beginning PBL school, Level 2 represents needsfor further development, and Level 3 means promoting and sustaining best practices for a PBL school. For this study, traditional schools and beginning PBL schools code as level 1, and schools that implement PBL are in levels 2 and 3.
16. Rigorous Instruction Category: According to The *Framework for Great Schools* by the *NYCDOE*, rigorous "Instruction is customized, inclusive, motivating, and aligned to the Common Core. High standards are set in every classroom. Studentsare actively engaged in ambitious intellectual activity and developing critical thinking skills" Subcategories include academic press, common core shifts in literacy, common core shifts in math, course clarity, and quality of

student discussion).

17. School Climate: School environment was operationally defined by the NYC School Survey scores in Rigorous Instruction and Collaborative Teachers. Rigorous Instruction is broken down into five subcategories: Academic Press, Common Core Shifts in Literacy, Common Core Shifts in Math, Course Clarity, and Quality of Student Discussion.
18. Self-directed Learning: a type of learning in which students manage their own“learning goals and strategies to solve PBL’s ill-structured problems (those without a single correct solution)” and “acquire the skills needed for lifelong learning” (Hmelo-Silver, 2004).
19. Twenty-first Century Skills: Skills that prepare students to prepare for the 21st-century workforce and global economy. These skills include creativity, problem-solving, reflective thinking, critical thinking, communication, and collaboration (LaForce et al., 2017).

CHAPTER 2

Introduction

The literature review aims to provide factors that have influenced the need to include problem-based learning (PBL) in middle school classrooms and the effectiveness and challenges in implementing this approach to learners' performance and attitudes. The chapter is divided into eight sections: (a) theoretical foundation, including the connectionbetween constructivist philosophy and inquiry-based learning offering epistemological approaches of Piaget, Vygotsky, Dewey, and Bruner (b) definition and history of problem-based learning, (c) role of students and teachers in PBL to promote active learning, (d) history of Mathematics education in the United States, (e) Previous research of PBL on student achievement and attitudes of classroom climate (f) Problem-based learning (PBL) and the development of a supportive learning environment that promotes Rigorous Instruction with Common Core shifts in Mathematics and Academic Press (g) Problem-based learning (PBL) and the development of a supportive learning environmenton Collaborative Teachers with focus on Cultural awareness and inclusive classroom instruction, Innovation and Collective responsibility, Peer collaboration, Quality of professional development, and School commitment.

Theoretical Framework

The foundation of this research is constructivist epistemology. Constructivism is a theory about how knowledge is developed. The article titled "The Practice Implications of Constructivism" by Wesley A. Hoover states that in constructivism, "human learning is constructed, that learners build new knowledge upon the foundation of previous learning" (Hoover, 1996). Constructed knowledge focuses on active learning rather than the passive transmission of information and emphasizes the student rather than the teacher. The two main types of constructivism in the classroom are social and cognitiveconstructivism. Cognitive constructivism, developed by theorist Jean Piaget, focuses onan individual's articulation of knowledge. In contrast, social constructivism, representedby Lev Vygotsky and later by John Dewey and Jerome Bruner, stresses that learners build knowledge through interaction in social situations with the teacher and other classroom members.

Constructivist perspectives have provided frameworks for teaching strategies and practices in the classrooms. Wesley A. Hoover describes important implications for constructivism in the classroom. First, the teacher must act as a facilitator and guide students to learn for themselves through self-exploration and dialogue. Students are not told what to think but how to think for themselves in classes that use the constructivist philosophy. They explore ideas, formulate their thoughts, use prior knowledge to build onnew experiences, and actively participate in classroom discussions and teamwork activities. Second, teachers should understand students' prior knowledge and provide them with "learning environments that exploit inconsistencies between learners' current understandings and the new experiences before them" (Hoover, 1996). Third, educators must engage learners by incorporating problems that are relevant to their lives. Teachers should also allow students to become explicit about their understanding by collaborating and sharing their thinking with their classmates. Fourth, students should have time to reflect and develop a deeper understanding of new knowledge against their current beliefs.

Swiss biologist and psychologist Jean Piaget (1896-1980) focused on individuals and constructing knowledge. He developed a four-stage model that children progress through to make sense of the world around them. His stages of cognitive development include the: "Sensorimotor stage, which a child goes through from ages zero to two; preoperational stage (two to seven years old), concrete operational stage (seven to eleven years old), and the formal operational stage (eleven years old to adulthood)" (Powell et al., 2009, p. 242). This model explains how individuals pass through a series of stages, building one upon the other to reach biological maturation. During the stages of cognitivedevelopment, the physical environment influences how children learn and grow. He proposed that one makes sense of their experiences by creating schemas or mental frameworks to interpret new information. He explained that individuals adapt to new skills through the two processes, assimilation and accommodation. According to Piaget (1953), "assimilation is when children bring in new knowledge to their schemas and accommodation is when children have to change their schemas to "accommodate" the new information or knowledge" (Powell et al., 2009, p. 243). These cognitive learning processes support learners to acquire new knowledge and advance through the cognitive stages of development.

Lev Vygotsky, a Russian developmental psychologist and social constructivist (1896-1934), emphasized how interaction and collaboration with the social environment play a vital role in children's learning. Vygotsky believed that social interaction, culture, and language all influence how the individual gains knowledge. One of his primary importance is the theory of the zone of proximal development (ZPD). In this theory, "ZPD has been described as a zone where learning occurs when a child is helped in learning a concept in the classroom" (Powell et al., 2009, p. 243). It explains the difference between a child's existing abilities and what they can learn under the guidanceof an adult or a more capable peer. Vygotsky believed that social interaction and scaffolding support learners to develop skills and strategies as they move through the various zones. Social interaction with the teacher and students in the classroom gives opportunities for internalization to occur more effectively.

Inquiry-based learning is an "approach in which the teacher presents a puzzling situation, and students solve the problem by gathering data and testing the conclusion" (Powell et al., 2009, p. 245). Supported by social and cognitive constructivism, inquiry learning allows students to take responsibility for their learning and become independent thinkers. Engaging in inquiry-based learning enables students to design and conduct independent scientific investigations, think like scientists, make first-hand decisions, and expand knowledge about the natural world. Learners are encouraged to work with their peers to ask questions, share ideas, and engage in dialogue. American Philosopher John Dewey (1859—1952) was a strong proponent for educational reform and focused on 'learning by doing' (Dewey, 1933). He advocated for child-centered learning with an emphasis on learning about the needs and interests of the child. Dewey believed in a balance between progressive and traditional education as neither of them alone applied to the principles of a carefully developed philosophy of experience. He wanted learners to gain real-world experiences to develop research skills and become lifelong learners.

According to Dewey, the best way to provide knowledge for students is through interaction and continuity. Students must interact with their environment and past experiences to adapt and learn (Dewey, 1938). The problem-based learning approach is part of this tradition of meaningful, experiential learning in which students developstrategies and construct knowledge through self-directed learning.

Similar to Dewey and Vygotsky's ideas, Jerome Bruner (1961) introduced the theory of discovery learning in which students understand new concepts using their experience and existing knowledge. It is "in such a way that one is enabled to go beyondthe evidence so reassembled to additional new insights" (J. S. Bruner, 1961, p. 22). *Discovery learning* is a guided process in which the roles of the teacher and students change. Bruner explained the students' and teachers' roles in the discovery classroom as hypothetical rather than expository. In the *expository* mode, "decisions concerning the mode and pace and style of exposition are principally determined by the teacher as an expositor; the student is a listener" (J. S. Bruner, 1961, p. 23). However, in the *hypothetical* mode, "the teacher and student are in a more cooperative position" in whichthe student, at times, plays the leading role (p. 23). Bruner believed that students must develop their knowledge, as there are "powerful effects that come from permitting the student to put things together for himself, to be his own discoverer" (p. 22). When students self-direct their learning with social interaction with their peers and proper guidance from their teacher, they can effectively gather the information they need to solve a problem. PBL takes on all these theorists' constructivist views as it puts the learning of contents and skills on the students.

Review of Related Literature

Definition and History of Problem-based Learning

Hmelo-Silver (2004) defines Problem-based learning as an instructional method that provides experiential learning around the research, analysis, and resolution of ill-structured problems to support learners in developing flexible and lifelong learning skills (Hmelo-Silver, 2004). In PBL, learners acquire knowledge by working collaboratively to solve real-world problems and reflect on their experiences (Barrows and Tamblyn, 1980).

Problem-based learning began in the mid-1960s in medical education to help students connect the content learned in class to real-world scenarios reflecting their futureprofessions as doctors (Barrows and Tamblyn 1980; Schmidt 1983). The medical school of Donald Woods McMaster University in Hamilton, Canada, was the first to incorporateproblem-based learning relating to medical situations as a valuable alternative to conventional teaching. Students at this University were given a problem scenario at the start of the learning process before receiving any meaningful background information on the topic (Barrows 1996). Since its origin in medical education, PBL has been implemented across many disciplines such as Law, Economics, Business Administration,social sciences, and even secondary education (Barrows 1996).

The problem-based learning approach effectively supports medical students in developing critical thinking and problem-solving skills to diagnose and treat patients effectively. Prior research on the effects of PBL revealed that medical students felt increased satisfaction and confidence about their learning compared to the traditional approach (Albanese and Mitchell, 1993; Hmelo, 1994; Vernon and Blake, 1993). Successin medical schools has led to a growing interest in implementing this methodology in k- 12 education, as described by the widespread publication of Problem-based learning books (Duch et al., 2001; Torp and Sage, 2002). PBL has inspired educators because of its importance in promoting active, flexible learning and its potential to engage students in self-directed learning.

Through practical experience and research in problem-based Learning (PBL), thecomponents needed to create a realistic problem scenario have been developed (Barrowsand Kelson, 1995). The problem should be open-ended, apply to a real-world situation, and relate to students' prior experiences to promote motivation, flexible thinking, and knowledge construction. The problem should encourage students to formulate a hypothesis and put together companion pieces to form multidisciplinary solutions. The problem scenario should foster communication skills as learners work collaboratively with other students in the classroom and their teacher (Hmelo-Silver, 2004).

In the PBL instructional method, students are actively assembling knowledge in collaborative groups. Students do not receive all the information directly from the teacher. They now have to utilize various resources and work collaboratively with their group members to solve a problem scenario. The student's and teachers' roles transform in the PBL approach. The students become responsible for their learning, including reflective, critical thinking about what is being investigated (Bereiter and Scardamalia, 1989). The teachers are no longer considered the primary depository of information but rather the facilitator of collaborative learning. There is a shift from the traditional lecturing of information. Teachers serve as a guide to model strategies for learning and thinking by asking open-ended questions and providing constructive feedback to get learners to use critical thinking and problem-solving skills to progress in the PBL processand develop a solution to their problem learning (Hmelo-Silver, 2004). The facilitator is accountable for leading the students through the PBL process stages by ensuring that all learners are involved in the learning process and supporting them to justify their thinkingand comment on each other's thoughts (Hmelo-Silver, 2002; Koschmann et al., 1994). The facilitator models problem solving and self-directed learning processes to encouragestudents to collaborate and learn together. It provides students with ample opportunities to build knowledge, reasoning, and learning strategies.

Research on the Role of Students and Teachers in Problem-based Learning (PBL) to Promote Active and Collaborative Learning

In Problem-based learning, the students become the central figure of the learning process and take responsibility for their education. They are provided with a problem situation to which they use their prior knowledge to choose and analyze research connected to the problem they are trying to solve. Students' activation of previous experience during the problem discussion with their peers "sets the stage for the to-be- learned information, which facilitates elaboration and increases retention" (Loyens et al.,2008, p. 413). Throughout PBL, students engage in self-directed learning. This is a "process in which individuals take the initiative, with or without the help from others, in diagnosing their learning needs, formulating goals, identifying humans and material resources, choosing and implementing appropriate learning strategies, and evaluating learning outcomes" (Knowles, 1975, p. 18). Self-directed learning allows learners to "apply their new knowledge to the problem and reflect on what they learned and the effectiveness of the strategies employed" (Hmelo-Silver, 2004, p. 235). The goal is not tolearn the content through memorization but rather through learners' engagement in groupwork and individual study activities (Tick, 2007). Self-directed learning gives students the freedom to work collaboratively with their peers and attain knowledge with their teacher's proper guidance.

Effective group interaction is essential to pupils' success in Problem-based learning. According to Knowles (1975, 1990), education does not occur in solitude but with the cooperation of teachers, tutors, or peers. Learners should be provided with opportunities to co-construct knowledge through active discussions with the teacher and their peers to propose possible explanations or solutions to the problem (Loyens et al., 2008, p. 413). Problem-based learning relies heavily on group activities, whether in smallgroups or the entire class may act as one group (Savery, 2015). Working in a group setting allows students to engage in group dialogue, develop a deep understanding of the problem and possible solutions, and resolve potential inconsistencies in the research findings (Hmelo-Silver, 2004). Working in groups also provides the opportunity to develop content knowledge, critical thinking, problem-solving, and interpersonal skills.

Freire's (1970) metaphor for traditional education is banking education. The teacher deposits all the knowledge into learners' minds, and students tend to memorize facts and regurgitate the information without genuinely understanding the deep meaning.He describes this approach as highly problematic because there is a lack of critical thinking, and creativity is not encouraged or lost altogether. Without critical thinking andcreativity, students fail to ask questions and accept the information passed down from theteacher.

Freire proposed an alternative "problem-posing" model with its roots in the constructivist learning theory compared to banking education. Like Dewey, Freire saw education as requiring social co-construction of knowledge. His model emphasizes that the teacher should not control the students' thinking and action but rather allow learners to construct their knowledge through experience and dialogue. The role of the teacher changes from that of the depositor to that of a facilitator. In Problem-based learning (PBL), the teacher's role is to serve as a guide and "facilitate the learning process rather than to provide knowledge" (Hmelo-Silver, 2004, p. 235). The teacher becomes part of the students' journey in providing student-centered learning experiences to promote content and acquire skills. They play a critical role in helping students to think, reflect, and think about their thinking.

Research on the History of Mathematics Education in the United States

Over the past seven decades, the United States has developed a series of educationpolicies that have transformed schooling, teaching, and education. The advancement of atomic weapons in the 1940s and the Soviet launch of Sputnik in 1957 triggered the United States to provide federal funding for research and education to develop scholars that could compete internationally (Barrows, 1996). According to Steelman's (1947) presidential report, *Manpower for Research,* there was a push for schools' programs to increase technical workers for a more scientific society (Steelman, 1947).

The new math curricula of the 1950s and 1960s sought to enhance computational and conceptual skills starting as early as elementary school grades (Barrows, 1996). During this movement, mathematicians like Max Beberman helped enhance discovery learning. Learners would observe and explore mathematics patterns to understand the concepts and generate helpful questions and hypotheses (Lagermann, 2000). Due to the rigorous content demands with the new curricula, educators could not keep up with the expectations and teach effectively (Klein, 2003). By the end of the 1970s, this new mathematics curriculum had ended in so much frustration that the United States emphasized learning primary mathematics. This era became known as the back-to-basics movement of the 1970s, emphasizing reading, writing, and mathematics in schools. During this time, there was a push to make educators the prominent figures in the classroom instruction and standardized tests as a core dependent measure to measure the schools' quality (Woodward, 2004).

By the 1990s, the National Council of Teachers of Mathematics (NCTM) standards had been developed to help push the U.S to create individuals who are "proficient in the uses of technology and communication skills and who possess high levels of mathematical literacy" (p. 22). The goal of these standards was to guide educators with the curriculum and teaching. By the early 2000s, every state had selected its learning standards. The No Child Left Behind Act of 2001 (NCLB) by the second Bush administration "introduced the concept of scientifically based research as a mechanism for guiding instructional practices in classrooms throughout the country" (Woodward, 2004, p. 25). This law aimed to provide equal educational opportunities for all students in poverty, minorities, and those receiving special education and English language services by holding schools responsible for how students learned. Schools wererequired to test statewide math and reading every year in grades 3-8 and once in grades 10-12 and publicly report the performance. Schools had to monitor all students' performance, set targets for improvement, and support all learners to do well on standardized exams. This law was later replaced in 2015 by Every *Student Succeeds Act (ESSA)* by President Obama to push all students to be taught to high academic standards to prepare them to succeed in college and careers.

Research on Problem-based Learning (PBL) on Student Academic Achievement and Attitudes of Classroom Environment

There are prior research studies on problem-based learning on students' performance and attitudes toward their classroom environment. Anne Horak and Gary Galluzzo conducted a study to examine problem-based learning (PBL) and the traditionalclassroom environment on student performance and classroom perceptions. The researchincluded 457 pupils in middle school that were considered high performing. The instrument used to measure student achievement was the pre and post-test data, which consisted of a 25-item multiple-choice test aligned with state and local objectives.

Students' attitudes to their classroom environment were measured using the Student Perceptions of Classroom Quality (SPOCQ) scale, which is a 38-item survey comprisingof five constructs: (a) meaningfulness, (b) challenge, (c) choice, (d) self-efficacy, and (e)appeal. In the PBL group, three educators engaged in Professional Development for 2- days to receive coaching on implementing PBL using the Stepien and Pyke (1997) five- phase PBL model before executing it in their class. In the traditional group, learners received regular classroom instruction consisting of lectures, readings, and worksheets. Students in both the conventional and PBL groups participated in a 3-week unit of study.

Students were given the same test before and after the unit. At the end of the unit,students were asked to complete a perception survey. The results indicated that there wasa statistically significant gain score in both groups. However, there was a higher gain score in the PBL group. The data also revealed statistically significant differences in the total score on the Student Perceptions of Classroom Quality (SPOCQ) in favor of the PBL group. A limitation of the study is that it only looked at the gifted student population. The research only examined one unit of the study in both the traditional and PBL groups. The teachers were all white and not selected randomly but instead volunteered to participate in the study. The pre-and post-tests used to measure student achievement are not standardized measurements as the teachers themselves created them (Horak & Galluzzo, 2017).

Another study aimed to examine the significance of STEM curriculum on learners' attitudes and investigate the connections between the subscales. The sample included 206 sixth-grade pupils attending a suburban middle school enrolled in a 6th-grade Earth science course. The instruments used were a Modified attitudinal survey, modified perceptions of collaboration, pretest, and post-test scores. Participants showed to which degree they agreed or disagreed with the attitudinal and perceptions study according to a 5-point Lickert response scale. The constructs measured were: students' interest in STEM, students' perceptions about STEM, students' intentions to persist in STEM, students' STEM self-efficacy, and students' experiences in group activities. The surveys were distributed before and after students engaged in space science learning activities in groups. In the investigation, learners could take on either the leader worker, or observer.

The study results indicated that student performance from pretest to posttest increased after participation in the STEM program. Students in the STEM program did show the most significant increase in usefulness, which was a good predictor of students' intention to continue STEM. Also, students' group roles predicted self-efficacy, where those who were group leaders had higher self-efficacy scores than students who were workers or observers. Overall, positive experiences in STEM activities enhanced learners' confidence, perceptions, engagement, and intention to stay in STEM. A limitation of the study is that the students took on either the observer, worker, or group leader role throughthe learning activities. Teacher involvement in role switching would have supported passive students who choose the worker or observer role to have a chance to be a group leader and thus boost their confidence and intention to persist in STEM instruction.

Another limitation is that the study focused on one school of 6th-grade students in the science classroom. Another constraint of the study is that the results on the effectiveness of PBL are based solely on one problem-based design on rockets. Also, this research doesnot use any standardized measurements (Brown et al., 2016). A research investigation looked at the impact of engineering design-based curriculum on learners' knowledge and attitudes. After engaging in Ecology's STEM curriculum unit, the study also aimed to determine the relationship between demographics and student achievement and interest. The sample includes three middle school life science teachers and 275 seventh-grade students from the Midwest urban schools. A pre and post-test research design of 45-item multiple-choice questions were used to measure student achievement. A 28 Likert-type attitude survey was given to thestudents before and after the engineering unit and includes three subscales: engineering,mathematics, and science. Teachers participated in professional development for three weeks to learn science through engineering design and practices. They then worked in teams to develop a curriculum unit that combined science and engineering. Educators created a problem-based task that required students to design a loon-nesting platform asthe loon population has been declining due to habitat loss. The results showed no significant relationship between the pretest and post-test in student achievement. The only significant predictor for performance was for Special education students, implying that the teaching and curriculum instruction positively affected their performance in class. The survey results indicated that students' attitudes toward STEM improved by their participation in the PBL program. Also, student demographics had no connection with aninterest in the STEM curriculum. One limitation of the study is that the unit was developed by first-year science teachers in the Professional Development program. The curriculum's effectiveness could have influenced the relationship between pretest and post-test performance in student achievement. Another limitation is that the study only includes one Problem-based learning project, and there are no standardized assessments (Guzey et al., 2016).

Another study was conducted to discover if learners' participation in inquiry-based instruction shaped their attitudes towards math and science. The sample includes eighth-grade students in the United States. The data is gathered from the comparative assessments of the TIMSS (2007). The study outcomes indicate a significant and positiverelationship between inquiry-based instruction and student attitudes in self-efficacy, interest, and utility in math and science subjects. The analysis also showed a difference instudent attitudes favoring male and white students in both subject areas.

Specifically, for science, there were no significant interactions between racial/ethnic groups and inquiry- based instruction. However, there was a weaker association for math inquiry-based instruction self-efficacy than interest and utility. Black students reported higher self- efficacy levels, interest, and utility than white males. Hispanic students also reported higher levels of interest and utility as compared to white students as well. Overall, there were "positive attitudes of students from different gender and racial/ethnic backgrounds are similarly associated with more frequent experiences of inquiry-based instruction in their science and mathematics classrooms" (Catherine et al., 2019, p. 13). A limitation ofthe study is that it does not provide information on the classroom norms or practices thatcould have influenced female and minority student attitudes in math and science. The TIMSS survey also does not include the questions used to measure students' perceptions of classroom practices or all identities' culturally and racially inclusive norms. Future research should include this information to understand better what factors influence female and minority student attitudes.

An investigation was carried out to examine how PBL learning experiences in theschool can improve student interest in the classroom and their motivation to continue STEM fields in the future. The sample includes 3,852 9th–12th-grade students at 17 public STEM high schools, with 34 percent in 9th grade, 28% in 10th grade, 24% in 11thgrade, and 14% in 12th grade. The sample schools were located in different states in America, specifically Ohio (N = 4 schools), Washington (N = 4), Texas (N = 3), California (N = 2), Tennessee (N = 2), New York (N = 1) and North Carolina (N = 1). The overall demographics includes approximately 43% of the sample identified as White,28% as Latino/Hispanic, 10% as Black, 8% as Asian, 8% as Mixed Race, and 3%

as another race (American Indian or Alaskan Native, Hawaiian or Pacific Islander, Middle Eastern, or Prefer Not to Answer). The researchers first identified seven states with organized STEM networks. They then asked the networks' leaders to provide them with potential schools representing the STEM program in their state, to which they contacted the schools' leaders directly to participate in the study. Once the participating schools were chosen for the study, the researchers examined the association between student ratings of PBL and students' math and science intrinsic motivation and ability ideas.Next, the researchers examined the connections between math and science intrinsic motivation and ability ideas and students' interest in continuing a STEM career.

The study results indicate that the PBL science classroom environment improved students' intrinsic motivation and ability beliefs and thus predicted a greater interest in a future STEM career. However, the results did not find a similar relationship between student ratings of PBL and math intrinsic motivation or ability beliefs in the math classroom. Overall, the study showed that race and gender did not influence student attitudes toward the PBL classroom environment. A limitation of the study is that it did not utilize administrative data to account for student contextual variables such as whetherthe student was an English language learner or special education. Another limitation is that this research study looked at an inclusive STEM high school and did not compare theanalysis to non-PBL classrooms in the context of both STEM and non-STEM schools (LaForce et al., 2017).

Research on Problem-based learning (PBL) and the development of Rigorous Instruction that promotes Academic Achievement

In problem-based learning, students engage in a process to pool their knowledge and skills and reflect on their understanding to develop a solution. Implementing Problem-based learning sets high standards in the classroom. Students engage in complex learning activities to build 21st-century communication, collaboration, research, critical thinking, problem-solving, and decision-making skills. According to the *Framework for Great Schools* by the *NYCDOE*, rigorous instruction is “customized, inclusive, motivating, and aligned to the Common Core,” in which students actively engage in challenging intellectual learning. Teaching mathematics using the PBL instructionalapproach and aligning it to the common core standards provides students with opportunities to make connections with the real world, increase academic rigor, andprepare for the future demands in the 21st-century world.

Academic rigor is an essential component of a learner’s educational experience challenging in a way that prepares them for college and career (Boser & Rosenthal, 2012;Wagner, 2008). Incorporating rigor in schools includes implementing rigorous content and instruction inside the classroom (Grubb & Oakes, 2007; Matusevich, O’Conner, & Hargett, 2009). Although there is no clear definition of rigor, it involves students engaging in critical thinking to learn complex content knowledge and skills (Matsumura, Slater, & Crosson, 2008; Mitchell et al., 2005). In Problem-based Learning, students are provided with numerous opportunities to work collaboratively with their peers to exchange knowledge and have discussions. As students solve problems, they also analyze, evaluate, conclude, and formulate strategies that foster critical thinking skills (Dwyer et al., 2014; Susilo et al., 2018).

In a PBL mathematics classroom, rigor can include incorporating problem-solvingand reasoning strategies in which learners interact with their peers, reflect, and revise their thinking (Mitchell et al., 2005; Stein & Lane, 1996). If implemented correctly, the problem-based learning instructional method provides students with the essential content and common core standards of a discipline and numerous necessary opportunities for engaging in 21st-century skills of critical thinking, problem-solving, and collaboration (Larmer & Mergendoller, 2010). Rigorous instruction implemented in a Problem-based learning classroom contributes to increased student retention and deeper understanding of concepts and overall student achievement on assessments. Students are not merely memorizing facts and concepts provided by the teachers but instead using a self-directedactive learning approach to develop higher-order thinking, researching, and problem- solving to succeed in a rapidly changing world. Students begin to take ownership of theirwork and build analytical reasoning skills, which helps raise their understanding of the content and their academic assessment performance.

Common Core Shifts in Mathematics

Because every state had its explanation of knowledge and proficiency, there was alack of standardization among all states. To develop an agreement among all states on what students should know and be able to do led to the development of Common Core State Standards. The Common Core includes a collection of academic standards in Mathematics and English language arts/literacy (ELA) to describe what knowledge and skills students have to obtain at the end of each grade. The standards also align with college and career expectations to support learners in graduating from high school and succeeding in college and future careers (Common Core State Standards Initiative, 2018).

The NYS Board of Regents adopted the NYS P-12 Common Core Learning

Standards (CCLS) in January 2011, including the Common Core State Standards (CCSS) and additional New York State standards. The CCLS were implemented in NYS schools at the start of the 2012-13 school year. The Office of State Assessment (OSA) organizes, develops, and executes the Grade 3-8 tests, Regents Examinations, Alternate Assessments, and English Language Proficiency assessments in NYS. These examinations are given to pupils in Kindergarten through Grade 12 enrolled in public, nonpublic, and charter schools throughout the State. The standardized tests align with the NYS Learning Standards and Core Curriculum.

The Common Core Learning Standards provide mathematics education guidelinesand describe what content, skills, and practices students should understand to solve real- world problems. According to the New York State P-12 Common Learning Standards forMathematics, the purpose of the CCSS is for educators to support students in developing expertise in problem-solving, reasoning and proof, communication, representation, and connections. The CCSS ties to problem-based learning as pupils are provided with a problem to solve. They work to analyze the givens, constraints, and relationships to create meaning and solve the problem. Learners are taught to apply what they already know and apply new knowledge to deepen their understanding of concepts and solve problems in everyday life, society, and the workplace. Students can utilize relevant resources, such as digital content located on a website, to create a solution pathway to solve the problem.

Academic Press

The academic press refers to how educators create environments that emphasize students' educational success through collaborative, engaging activities focused on higher-order thinking skills and a cognitively challenging curriculum that prepares themfor college and career (Brown, 2008; Kelly & Turner, 2009; Staples, 2007). Extensive research suggests that when teachers create a culture of learning that emphasizes high expectations for all students, it positively influences student performance in the classroom and assessments. A study was conducted using the quasi-experimental design to examine problem-based learning (PBL) effectiveness on students' critical thinking skills and retention in mathematics. The control group received the Direct Instruction (DI) model, whereas the experimental group received the PBL model. The sample involved learners from three senior high schools with two class samples in each school. The instruments include testsand questionnaires. The factorial multivariate covariance MANCOVA was used to analyze the data. The research study results show a significant difference in student critical thinking skills and retention between the two groups. Learners of the PBL group learned better than students in the control group (Arifin et al., 2020).

A study was conducted on the effects of Problem-Based Learning and Mathematical Problem Posing in improving students' critical thinking skills. The purposeof the research was to determine if there were differences in enhancing learners' critical thinking skills in Problem-based Learning, Mathematical Problem Posing, and conventional learning. The study also sought to see discrepancies in improving learners' critical thinking skills by gender. A quantitative design was used to evaluate 124 undergraduate students participating in the mathematics education program at the University of Negeri Semarang in Indonesia, with pretest-posttest, documentation, and observation. After the data was analyzed using the normalized gain and the Mann-

Whitney test, the results showed that students participating in Problem-based Learning and Mathematical Problem Posing showed more significant improvements in critical thinking skills than the traditional approach. Also, the analysis showed that improvements in necessary thinking skills were not different by gender (Darhim et al., 2020).

Research on Problem-based learning (PBL) and the development of Collaborative Teachers that Promotes Academic Achievement

The NYCDOE describes *Collaborative Teachers* as dedicated to the school community and students' success by creating an inclusive classroom environment, incorporating peer collaboration, and participating in opportunities to develop, grow by participating in ongoing professional development.

Cultural Awareness and Inclusive Classroom Instruction

Understanding cultural diversity is essential because it allows individuals to see theworld through different lenses and eliminate stereotypes and personal biases. Educators must understand the student population's cultural diversity to develop explicit instructional design approaches to meet learners' needs and prepare them for college and future careers. Revising the curriculum, embedding instructional strategies, and creating culturally relevant learning opportunities give students more significant opportunities to improve their classroom performance and assessments. Teaching strategies that interface with students' real lives and interests and advance comprehension of different societies are related to better academic results.

Cultural awareness and an inclusive classroom curriculum are necessary to meet all the students in the classroom. According to the National Center for Education

Statistics (NCES), the enrollment of white students in public schools over the past ten years has declined by 8%. In contrast, the minority student population increased by 10%(NCES 2013). The US Census Bureau confirms that 48% of pupils under 18 are minorities, and by 2020 more than 50% will be minorities (US Census Bureau 2015b). Ithas also been projected that by 2060 the number of minority students will increase to 64% (US Census Bureau 2015a). Therefore, it is essential for all stakeholders, includingeducators, administrators, and policymakers, to develop a curriculum that meets the nation's 21st-century diverse learners' needs.

A qualitative case study examines students' and teachers' perceptions and experiences at a K-8th grade low-income private school in the southeast United States that receives a multicultural curriculum. The sample includes twenty African American participants, including 15 students, four teachers, and one administrator. The instrumentsinclude classroom observations and participant interviews after collecting data, analyzingit using open and axial coding to identify themes and categorize similarities among the participants' comments. The study results indicated that a culturally inclusive curriculum is beneficial to the students' social, cultural, and academic achievement (Wiggan et al., 2016).

Developing culturally relevant pedagogy in Problem-based Learning is essential to recognize and affirm students' diverse cultural backgrounds and experiences to the classroom. Ladson-Billings (2009) explained culturally relevant pedagogy as one that "empowers students intellectually, socially, emotionally, and politically by using culturalreferents to impart knowledge, skills, and attitudes" (p. 20). Problem-based Learning requires teachers to develop a relevant problem to students' lives and relate to students' prior experiences to promote engagement, flexible thinking, and knowledge construction to improve their academic performance in the classroom and assessments. Problem-basedlearning methodology that is culturally responsive and inclusive allows students to connect new information to their prior knowledge, which is a crucial part of Learning. Schools need to foster equity by relating to students' cultural experiences and creating lessons that include real-world problems to improve student engagement and performance.

Innovation and Collective Responsibility

Teacher collective responsibility is how teachers feel accountable for learners' education and achievement and maintain discipline in the entire school (Lee & Smith, 1996; LoGerfo & Goddard, 2008). It also highlights the commitment and trust among teachers and school administrators to try new ideas, collaboratively design instructional lessons and units, and coordinate their instruction with other grade levels to improve theirteaching and meet all learners' needs (Bryk & Schneider, 2002).

Extensive research concludes that educators generally avoid communicating ideasand feedback that imposes other teachers' work and value working independently more than the chance to influence others (Little, 1990; Lortie, 1975; McLaughlin & Talbert, 2001). The collaboration process among teachers and leaders in a professional learning community requires trust-building, routines, and reforms to encourage training and teamwork to tackle issues and prior misconceptions and critique each other's practice (Young, 2007; McDonald et al., 2003; Meier, 2002).

Thomas H. Levine & Alan S. Marcus's (2007) qualitative case study on multiple trajectories of teachers showed what educators have already achieved, what progress theyare currently making, and what kinds of support could benefit their growth and work independently and collaboratively. The sample includes two groups of teachers from twoseparate high schools over two years. The instruments included are classroom observations and interviews with administrators, educators, and support staff. After data collection, the first analysis included bottom-up coding, which provided themes to develop from the data. It also had top-down coding, which allowed researchers to determine how teachers share their work, critique others, and participate in discussions that can affect their classroom practice. The study results indicated possible solutions to support educators in creating supportive structures to improve school performance.

Outcomes showed that administrators should provide educators with the time and proper training to encourage growth in knowledge and skills. Also, school leaders should provide multiple sources of learning, such as readings, specialists, observations of exemplary programs, and other professional experiences. These possible solutions wouldstrengthen teachers' knowledge and skills to improve student performance in the classroom collaboratively.

Morales-Chicas and Agger (2017) conducted a study to determine if repeating algebra in the eighth grade and teachers' collective responsibility impacted students' mathematics scores by the twelfth grade and if this relationship differed by gender. The sample includes learners who participated in the High School Longitudinal Study (HSLS:09) throughout the United States. High school Longitudinal Study of 2009 (HSLS:09) dataset includes student surveys from the ninth and eleventh-grade year and information on students' postsecondary, students' self-reported occupational plans in the twelfth grade, and teacher surveys on their collective responsibility perspective.

Students'mathematical scores at the end of eleventh grade, Grade 12 GPA in STEM courses, and Grade 12 GPA in mathematics courses were also collected. Independent t-tests and multiple regressions were used to analyze the data. The results of the research indicate that repeating algebra may support students' mathematics success. In schools with teachers with low perceptions of collective responsibility, the final performance scores in algebra were lower than in teachers with high perceptions. The results explain that teacher collective responsibility and support can better influence academic performanceand engagement in the classroom.

Collective responsibility encourages teachers to work together and take responsibility for students' learning (Kruse, Louis, & Bryk, 1995). It could also act as a protective factor to support the school environment during a change (Whalan, 2010), suchas implementing Problem-based Learning (PBL). As PBL is executed in schools, educators' tasks and responsibilities are modified, such as taking a facilitator's role. Instead of directly presenting facts and concepts, this shift includes creating new lessons and implementing new guidelines that will likely influence teachers' innovation and responsibility beliefs. However, little is known about how teachers' collective responsibility in middle school mathematics that includes PBL could affect student achievement.

Peer Collaboration

Social learning or learning as part of a group is a crucial way to have students work collaboratively to solve a problem, complete a task, or design a product, which improves critical thinking, self-reflection, and co-construction knowledge. Collaborativelearning allows students to interact, share their experiences, and reflect upon what they have learned. This learning type helps students gain resources and skills and provide feedback to evaluate each other's' work (Chiu, 2004). There is substantial literature supporting the idea that learners can attain higher achievement, especially in mathematics, through collaborative learning with their peers. Ardodo and Gbore (2012) and Lawrence (2004) explained how collaborative learning strategies could stimulatestudents' interest in mathematics and improve their performance on assessments.

A study analyzed how collaborative learning techniques and Mathematics anxietyaffect secondary school students' mathematics learning performance in Gombe State, Nigeria. The sample size includes 21,360 public secondary school students in 11 Local Government Areas (LGAs) of Gombe State, Nigeria. A quasi-experimental design with a2x2 factorial matrix analyzed pretest and posttest data from a Mathematics Learning Achievement Test (MLAT), which comprises thirty-one multiple-choice items. A multi- stage sampling technique to sample the participants from four local government areas in the state and data were analyzed using an independent samples t-test. The first part of thestudy indicated that students with low mathematics anxiety had higher mathematics assessment scores than students with high mathematics anxiety. The second part of the study showed that students exposed to the collaborative learning technique had better mathematics scores than the control group (Olanrewaju et al., 2019).

Another study conducted in selected secondary schools in Natore, Bangladesh, examined the effects of the *Learning Together* model on students' mathematics achievement and attitudes toward mathematics. The research also sought to determine teachers' attitudes towards the model in the classroom. The *Learning Together* model requires students to work together in small groups to complete a task presented by the teacher. The sample includes 112 9th grade students from two separate schools. A mixed-methods study was used, including mathematics pre/post-test, attitudes toward mathematics questionnaire, and teachers' interview. The quantitative data were analyzed using independent samples t-test, and the qualitative data were examined using content analysis. The study results indicated that students who worked collaboratively with theirpeers performed better on the mathematics assessment and had more positive attitudes towards the subject. Teachers who utilized this model in the classroom did perceive thismodel as being overall positive (Hobri et al., 2018).

Hui-Chuan Li & Tsung-Lung Tsai researched in a Taiwanese mathematics classroom. The purpose of the research is to look at the impact of PBL on students' experiences, concentrating on their actions during small group discussions to explain what inspired their engagement in PBL. The study also examined how students retained learned material by comparing their performances on five researcher-designed written tests. The sample includes 35 5th grade mixed ability students from a public primary school in a suburban central-west Taiwan area. The instruments used are parent Perception surveys, student interviews, and teacher interviews. Teachers chose to participate in the study as they wanted to change their teaching practice to incorporate PBL and help the students have a more in-depth understanding of fractions. Educators participated in a 4-week professional development before implementing the PBL approach in their classrooms.

The results of the study indicated the benefits of PBL on student achievement andsocial skills. Results showed that students' communication and explanation skills influenced their group's climate and affected their overall performance on the PI test. Theresults also indicated that students in the PBL intervention could better explain the fractional concepts on the assessment as they developed a deeper understanding of their content. The findings suggest that student PBL intervention increases students' ability to retain information. Also, students, the developmental process is primarily influenced by their experience of working with their peers. It cannot be assumed that students can operate independently in groups but rather be guided by their teachers to work collaboratively with their peers. A limitation of the study is that it only looked at one elementary class of 35 students. Another limitation was that the study did not include anystandardized assessments.

Quality of Professional Development

Professional development opportunities are essential for the continuous growth of teachers' knowledge, skills, and effectiveness in planning and instructional practices. It isa "key focus of U.S efforts to improve education" (Birman et al., 2000) because "teachersare the most important key players in students' educational outcomes" (Ekmekci et al., 2019). Professional development provides educators with opportunities to "integrate whatthey learn with other aspects of their instructional content, because teachers from the same school, department, or grade are likely to share common curriculum materials, course offerings, and assessment requirements" (Birman et al. 2000). It also helps teachers recognize the students' diverse needs and the communities they serve by setting high expectations, enhancing learning, and breaking down academic barriers.

A multilevel analysis was conducted to measure teachers related professional background, adaptive educational beliefs, and Mathematical Knowledge for Teaching (MKT) on students' mathematics achievement. The sample included 34 elementary and middle school mathematics teachers and 2,078 K-8 students from Houston, Texas. The mathematics teachers who participated in the study attended Rice University School Mathematics Project's summer professional development program. The instruments usedwere teacher surveys and the Stanford 10 to measure student achievement in mathematics. The data were analyzed using hierarchical linear modeling to estimate the effects on student achievement. The study results indicate that developing teachers' mathematical knowledge plays a vital role in improving students' academic success in mathematics. Teachers should also be provided with professional development opportunities to strengthen their mathematical content and pedagogical knowledge. A limitation of the study is that the representative dataset is too small, and therefore elementary and middle school levels had to be combined. With a larger dataset, each school level can be looked at independently to measure teacher factors' effect on student achievement (Ekmekci et al., 2019).

School Commitment

Teachers who are satisfied with their job are more highly committed or dedicatedto an organization (Firestone & Rosenblum, 1988; Crosswell, 2006). Educators with strong school commitment ties can enhance student academic achievement. High levels of commitment can include looking forward to working and recommending the school toparents and other educators.

Qadachm, Schechter, and Da'as (2020) explored the effects of principals' characteristics with teachers' characteristics with students' performances on national mathand science examinations. Principals' factors include principals' information-processing mechanisms (PIPMs) and instructional leadership (IL). Teachers' features involve teachers' affective commitment (TAC), collective teacher efficacy (CTE), and teachers' job satisfaction (TJS). The sample included 130 principals and 1,700 teachers. The data were collected from a multisource survey and aggregated at the school level for structuralequation modeling (SEM) analysis. The investigation outcomes indicated that principal characteristics played an essential role in supporting collective learning within schools,predicting teacher characteristics and overall student achievement.

Ma & McIntyre (2005) looked at the effects of pure and applied mathematics courses on mathematics achievement. The study also looked at students, teachers, and school characteristics on student performance on the standardized mathematics examination. A total of 1,518 tenth-grade students from 34 schools participated in this study. The data was gathered from these students until the end of their high school courses. Assessment scores and questionnaire data were used from the Longitudinal Study of Mathematics. After analyzing data using multilevel modeling, the results indicated that students taking pure and applied mathematics performed better in schools with higher teacher commitment.

CHAPTER 3

Introduction

This research uses a quantitative design to examine problem-based learning (PBL)effects on middle school students' Math achievement. The study also analyzes the impact of the PBL and traditional instruction approaches on students' and teachers' perceptions of the school environment. The result of the NYC School Survey in the categories: Rigorous Instruction and Collaborative Teachers were examined to explore if the categories can predict student performance on the NYS Mathematics Assessment.

The PBL instructional approach's influence is essential for reviewing how engaging students in authentic, real-world tasks and developing their creativity and problem-solving skills can lead to success in college and careers of the 21st century. Twodistricts from NYC public schools were selected for this research study. The independentvariable is whether or not the school implements the Problem-based Learning program.

There are 27 schools analyzed in this study. Eleven schools in the intervention group(Group 1) have implemented the PBL curricula in the 2018-19 school year. Sixteen schools in the control group did not implement the PBL curricula during the 2018-19school year. The dependent variable is students' performance on the Math State assessments and students' attitudes toward their school community.

The achievement gains are analyzed using the NYS Assessment in Mathematics test scores for the 2018-19 school year. The Math tests measure students' knowledge, skills, and practices embodied by the P-12 Common Core Learning Standards. The scoresare calculated on four performance levels; Level 1, Level 2, Level 3, and Level 4. Level 1students perform well below proficient according to the standards for their grades. Level 2 students are considered partially proficient in standards but insufficient for the expectations at this grade. Level 3 students are proficient in standards and sufficient for the expectations for the grade. Level 4 students excel in standards for their grade and areadequate for this grade's expectations.

The second outcome variable captures students' and teachers' perceptions of theirschool community using archived data from The New York City Department of Education (NYCDOE). The survey has collected essential data about a school's capacityto improve student achievement and strengthen students to compete in the 21st century. This study focuses on the two constructs of Rigorous Instruction and Collaborative Teachers.

Methods and Procedures

Four research questions are used to determine if Problem-based learning improved student achievement and attitudes towards class. The level of significance forthe acceptance of the hypothesis will be less than .05.

Research Questions

1. Is there a difference in middle schools' achievement scores in Math State Assessment between PBL schools and non-PBL schools?
2. Is there a difference in students' and teachers’ perspectives of the school climate on the NYC School Survey (Rigorous Instruction and Collaborative Teachers) between schools that employed the PBL teaching approach and schools that usedthe traditional teaching approach?

3. Will practice of PBL, students' perception of rigorous instruction, and students' perception of collaborative teachers predict students' achievement in Math StateTest Scores?
4. Will practice of PBL, teachers' perception of rigorous instruction, and teachers'perception of collaborative teachers predict students' achievement in Math StateTest Scores?

Research Design and Data Analysis

The first research question is to see a statistically significant difference in the Mathematics State Assessment scores between schools implementing the PBL intervention. The independent variables are the PBL groups. Group 1 participates in the Problem-based learning intervention, and Group 2 is the traditional schools not participating in the PBL program. The dependent variables are students' performance scores on the NYS Mathematics Assessments. The hypothesis of the research study are as follows:

- H0: There is no difference in Math State Assessment Scores between the PBLgroups (PBL, Traditional). (H0: $u1 = u2$).
- H1: There is a significant difference in Math State Assessment Scores betweenthe PBL groups (PBL, Traditional). (H1: $u1 \neq u2$).

Mann-Whitney U test will analyze the data for the first research question. The purpose of the test will be to determine if there is a significant difference between the means of two unrelated groups, with one categorical variable with two groups and onecontinuous dependent variable.

The second research question determines whether there is a difference in students' perspectives of the school climate on the NYC School Survey (Rigorous Instruction and Collaborative Teachers) between schools that employed the PBL and schools that used the traditional teaching approach. The independent variables are the groups. Group 1 participates in the Problem-based learning intervention, and Group 2 is the conventionalwas schools are not participating in the PBL program. The dependent variables are the NYC student survey, Rigorous Instruction, and Collaborative Teachers.

The hypothesis for the second research question is below.

- H0: There is no difference in Rigorous Instruction and Collaborative Teachersbased upon the groups (PBL, Traditional). (H0: u1 = u2).
- H1: There is a difference in Rigorous Instruction and Collaborative Teachers based upon the groups (PBL, Traditional). (H1: u1 ≠ u2).

Mann-Whitney U test will analyze the second research question data statistically.The rationale for using this test is to compare two independent groups (Group 1: PBL vs.Group 2: Traditional) to see the PBL program's effect on student attitudes on the NYC student survey.

The third research question will determine which subcategories of school climate from the NYC Student Survey, rigorous instruction, or collaborative teachers predict students' achievement in math state test scores in the PBL classroom. The subcategoriesof the school climate will serve as the mediator variable.

The hypothesis for the third research question is below:

- Ho: There will be no significant interaction between school climate on student achievement on the math test scores.

- H1: There will be a significant interaction between school climate on student achievement on the math state test scores.

The statistical test used to analyze the data for research question three will be a multiple linear regression. This test is used because there is a single dependent variable topredict more than one independent variable.

The fourth research question will determine which subcategories of school climate from the NYC Teacher Survey, rigorous instruction, or collaborative teachers predict students' achievement in Math State Test Scores in the PBL classroom. The subcategories of the school climate will serve as the mediator variable.

The hypothesis for the third research question is below:

- Ho: There will be no significant interaction between school climate on student achievement on the Math test scores.
- H1: There will be a significant interaction between school climate on student achievement on the Math state test scores.

The statistical test used to analyze the data for research question three will be a multiple linear regression. This test is used because there is a single dependent variable to predict more than one independent variable.

Reliability and Validity of the Research Design

This research examined the influence of Problem-based learning on learners' performance on the NYS Math test and their attitudes towards their school environment compared to a traditional education method. All schools in the two districts within the same borough of New York City (11-PBL and 16-Traditional) examine the PBL learningapproach's effectiveness. The following measures were taken to increase the level of reliability and validity of the research design:

- The data is collected from all schools within two districts in the same borough inNew York City that serve students in grades 6 to 8 to avoid selection bias and obtain a sufficient sample size.
- A standardized PBL School Rubric from the Buck Institute for Education is used to determine whether schools actively engage students in real-world and personally meaningful projects. Schools that use traditional instruction methods are coded as 1, and schools that implement PBL in their classroom are coded as 2.
- The study sample represents similar student demographics compared to the entire NYCDOE student population, and therefore the study can be generalized.

The Sample and Population

The New York City Department of Education is the largest school district in the United States. They currently house over a million students of diverse socioeconomic, racial, ethnic, and academic backgrounds.

Sample

27 middle schools in NYC public school system across two districts

- 11 middle schools that employ problem-based learning methods of instruction
- 16 middle schools that use problem-based learning methods of education in thesame district

A former student at St. John's University, Nayeon Naomi Hwang, reached out to superintendents/deputy superintendents from districts 28 and 30 to determine which schools implemented PBL. Schools that were using the PBL approach were recognized by the Buck Institute for Education PBL School Rubric. The schools that implement PBLwill be used for this research.

The schools selected for this study are chosen randomly across two districts in New York City. The superintendent/deputy superintendent has approved all schools using the PBL program to successfully implement PBL within their core instruction, evidenced by the PBL School Rubric. The Buck Institute for Education has established the PBL School Rubric. The schools examined in this research consist of diverse student populations and can be generalized to the overall populations in NYCDOE. The demographics of the general NYC DOE population and the two districts examined in thisresearch study are shown in Table 1.

Population

This quantitative study's target population was middle schools in urban public-school systems receiving math instruction, either through a traditional method or through the problem-based learning approach.

Table 3.1

Description of Participants in Participating Schools and All NYC DOE

Category	Participating Schools	NYC DOE
Race		
Asian	19.3%	16.2%
Black	20.7%	25.5%
Hispanic	34.3%	40.6%
White	15.7%	15.1%

Students with Disabilities	15.4%	20.2%
English Language Learners	11.7%	13.2%
Economically Disadvantaged	71.6%	72.8%

Table 3.2

Description of Participants in PBL Schools and Traditional Schools

Category Schools	PBL Schools	Traditional
Race		
Asian	19.8%	18.8%
Black	20.4%	21.0%
Hispanic	32.0%	36.6%
White	16.0%	15.4%
Students with Disabilities	14.7%	16.0%
English Language Learners	13.0%	10.4%
Economically Disadvantaged	70.0%	73.5%

Instruments

Mathematics State Assessment

The Mathematics Test was created in alignment with the New York State P–12 Learning Standards. The test consists of two sessions, with session one composed of multiple-choice questions and two of multiple-choice, short-response, and extended-response questions. According to the 2019 exam for 6th grade, there were 38 multiple choice questions, seven short responses, and one extended response question. The topics covered on the 6th-grade test included number systems, expressions, and equations, ratiosand proportional relationships, geometry, statistics, and probability. For the 7th grade, there are 40 multiple choice questions, seven short responses, and one extended response question. The topics covered on the 7th-grade test included number systems, expressions,and equations, ratios and proportional relationships, geometry, statistics, and probability. In the 8th grade, there are 40 multiple choice questions, seven short responses, and one extended response question. The topics covered on the 8th-grade exam included numbersystems, expressions and equations, functions, geometry, statistics, and probability.

Reliability and Validity of the Mathematics State Assessment

The NYS Mathematics exam is a highly standardized instrument chosen to ensurea full range of the state's grade-level academic content standards. It gives all students equal access to success in the assessment by guiding English Language Learners and Students with Disabilities to receive appropriate accommodations. There are also standardized scoring procedures and protocols to deliver reliable results. The state has documented reliability and validity in the *New York State Testing Program 2019: English Language Arts and Mathematics Grades 3–8* Technical Report.

To ensure reliable evidence, Questar used Cronbach's alpha and Feldt-Raju coefficients to determine how consistent the results are for the items that measure the same construct on the mathematics assessment. Reliability was calculated for the multiple-choice, constructed-response items and the subgroups. The reliability estimatesfor both methods ranged from 0.92 to 0.95, ensuring excellent test internal reliability.

According to the 2019 Technical Report, to ensure content validity evidence, theNYS Testing Program (NYSTP) explains the state content standards and defines the aligned skills to assess these content standards. During the NYS test construction, the NYSTP process works to provide explicit content representation and balance.

Educators are also involved in developing the assessment during the item review process andestablishing scoring rubrics for constructed-response questions.

Various evidence supports the Grades 3–8 Mathematics tests' construct validity, including internal consistency, unidimensionality, and bias detection. Internal consistencywas determined using high coefficients of the tests for the total population and subgroupsof students. For the mathematics state assessment, Cronbach's alpha's high consistency indicated construct validity as the entire population ranged from 0.92 to 0.94. For the subgroups, it was greater than or equal to 0.83.

Unidimensionality helped determine the degree to which the test items conform tothe statistical models' requirements. The IRT model fit analysis determined that the assessment items were included across the grades and content area. Factor analysis such as the matrices of polychoric correlations helped indicate that the items tested on the mathematics assessments measure one underlying mathematics proficiency construct.

Differential item functioning (DIF) statistical methods were used to reduce itemand operational test construction bias to evaluate validity. Precisely, standardized meandifferences assess constructed responses, and Mantel-Haenszel methods were used to determine the multiple-choice items. During the assessment review process, the items were checked to conform to Questar's editorial policies and guidelines and NYSED's procedures and were reviewed by New York State educators. Reviewers carefully evaluated any items flagged by the DIF as biased to ensure that they did not negatively affect any demographic studied.

NYC Student Survey

Students, parents, and teachers both participate in the NYC DOE survey in schoolannually. Schools in the fall decide if they would like their students to take the survey online or on paper. The NYC School Survey is voluntary and confidential in which students, parents, and teachers can exempt themselves from taking the survey or choose not to answer as many questions as they want. The survey gathered information from school communities on the six elements of the Framework for Great Schools. The six components include rigorous instruction, a supportive environment, collaborative teachers, effective school leadership, strong family-community ties, and trust.

The NYC DOE distributes surveys to parents, teachers, and students. The survey measures the six elements for the framework of great schools. According to the Framework for Great Schools (2021), the construct 'Rigorous Instruction' measures if students are engaged in a high standards classroom and develop critical thinking skills aligned to the Common Core. 'Supportive Environment' construct determines if students feel supported, safe, and challenged by the school community. The 'Collaborative Teachers' construct measures if teachers are devoted to their school community's progressand development. The 'Effective School Leadership' construct determines school administrators address the instructional and social-emotional support that drives student achievement. 'Strong Family-Community Ties' construct measures to see if the school principals encourage and develop partnerships with other stakeholders such as families, businesses, and community-based organizations. The last component measures 'Trust' to see if everyone is working towards growing student performance and equipping them for success in school and beyond.

Rigorous instruction and collaborative teachers are the two categories of the NYCDOE student and teacher survey examined for this particular study. Within rigorous instruction, the subcategories include academic press, common core shifts in math, courseclarity, and quality of student discussion. For the student survey, the subcategories under rigorous instruction include academic press and course clarity. For the teacher survey, thesubcategories under Rigorous Instruction include Academic Press, Common Core shifts in math, and Quality of student discussion.

Within Collaborative Teachers, the subcategories include Cultural awareness andinclusive classroom instruction, Innovation and collective responsibility, Peer Collaboration, and Quality of professional development. For the student survey, the subcategories under Collaborative Teachers include Cultural awareness and inclusive classroom instruction. For the teacher survey, the subcategories under Collaborative Teachers include Cultural awareness and inclusive classroom instruction, Innovation andcollective responsibility, Peer Collaboration, and Quality of professional development.

Reliability and Validity of the NYC Student Survey

Overall, the NYCDOE had a very high percentage of teachers, students, and parents completing the NYC School Survey, increasing the instrument's reliability. The variation of question types in students and teacher surveys also increased the validity of this study.

PBL School Survey

The PBL School rubric designed by the Buck Institute for Education (2013) is used in this research to determine which schools participate in the PBL instructional method. This rubric is divided into two essential elements of a PBL school; Significant Content and 21st Century Competencies. The rubric includes determining if school leadership consistently promotes, models, and recognizes, and teachers have opportunities to implement the 4'Cs: communication, collaboration, critical thinking, andcreativity and innovation. The rubric also includes whether schools include the eight essential elements for teachers to define quality project design. These eight essential elements are key knowledge, understanding, success skills, challenging problems or questions, sustained inquiry, authenticity, student voice & choice, reflection, critique & revision, and public product. The eight essential elements align with the HQPBL framework providing students with effective implementation of PBL (Buck Institute for Education, 2013).

The first level is called 'Beginning PBL School.' The second level is the 'Needs Further Development.' The third level is the 'Promotes and Sustains Best Practices of a PBL School.' For this research study, schools that do not participate or are at the beginning of the PBL program are treated as traditional schools. School leaders in conventional schools could have established PBL, but the challenges remain addressed (Buck Institute for Education, 2013).

Beginning PBL School- Level 1

For this research, schools that do not implement PBL or are in level 1 of the rubric are in group 1 that uses traditional instruction methods. In level 1, school leaders could have begun taking steps to support PBL, but obstacles remain. These barriers include not having established a PBL Implementation Plan to define the vision, craft, goals, and outline steps to support PBL. Teachers are still ambiguous about the "next steps" and how they will execute the plan.

Teachers at this level could have begun developing awareness of the 8 Essential

Elements, but the entire school has not implemented them in quality project design. In addition, the school leadership has not encouraged, understood, and showed the use of the4 Cs to its staff, and there have been limited chances for educators to exhibit them. Thereis limited participation between faculty members during meetings, restricted to little or nocollaboration, limited opportunities to examine complex problems related to PBL implementation and effectiveness of student learning, and lack of clarity on how to implement PBL in the classroom (Buck Institute for Education, 2013).

Needs Further Development- Level 2

For this study, schools with some growth areas or in level 2 of the rubric are in group 2 using PBL instruction methods. At this level, the school administration has developed the PBL Implementation Plan, and it is being administered in most of the content areas. Compared to level 3, even though the school leaders have begun building the culture and methods that support PBL, some staff members might lack understandingof the plan and why it is crucial to learner maturity in content education and 21st-century skills.

Most educators are practicing the 8 Essential Elements to establish quality project design, and the administration is starting to encourage and implement the use of 4 C's. Educators are presented with chances to work collaboratively and interact in meetingswith equal participation to investigate complex problems associated with PBL implementation. Educators have also begun to execute innovative ideas into practice. Compared to level 3, although educators can analyze complex issues, the suggested solution will affect various elements that make up the school system (Buck Institute for Education, 2013).

Promotes and Sustains Best Practices of a PBL School- Level 3

For this study, schools that have adopted the practices that encourage PBL or arein level 3 of the rubric are in group 2 that uses PBL instruction methods. In level 3, school leadership has formed a PBL implementation plan to accomplish the vision, meetperformance goals, and promote PBL. All stakeholders comprehend the program and arethriving in delivering the project that centers on student education.

All teachers successfully use the eight elements to define quality project design and are provided with constant possibilities to demonstrate the 4 Cs. Educators work together to share their ideas and receive feedback as they communicate their opinions. They work collaboratively in teacher teams to share their expertise and abilities to develop the best practices that support PBL. They think critically to examine complex problems and propose solutions to PBL implementation and efficient student education.The school has established the PBL program in which the staff can innovate.

Procedures for Collecting Data

The student and teacher surveys for the 2018-19 school year are archived data thatis publicly available. The NYC DOE schools distribute the student survey during school time to students enrolled in grades 6-12. The guidelines address how the school community should maintain the survey's confidentiality, not influence student responses, and not review survey responses. Each school implements time in its schedule for learners to complete the survey. Depending upon the school's request, students can complete paper surveys or use the survey access codes to take the survey online. The school should collect the paper student surveys and return them using the

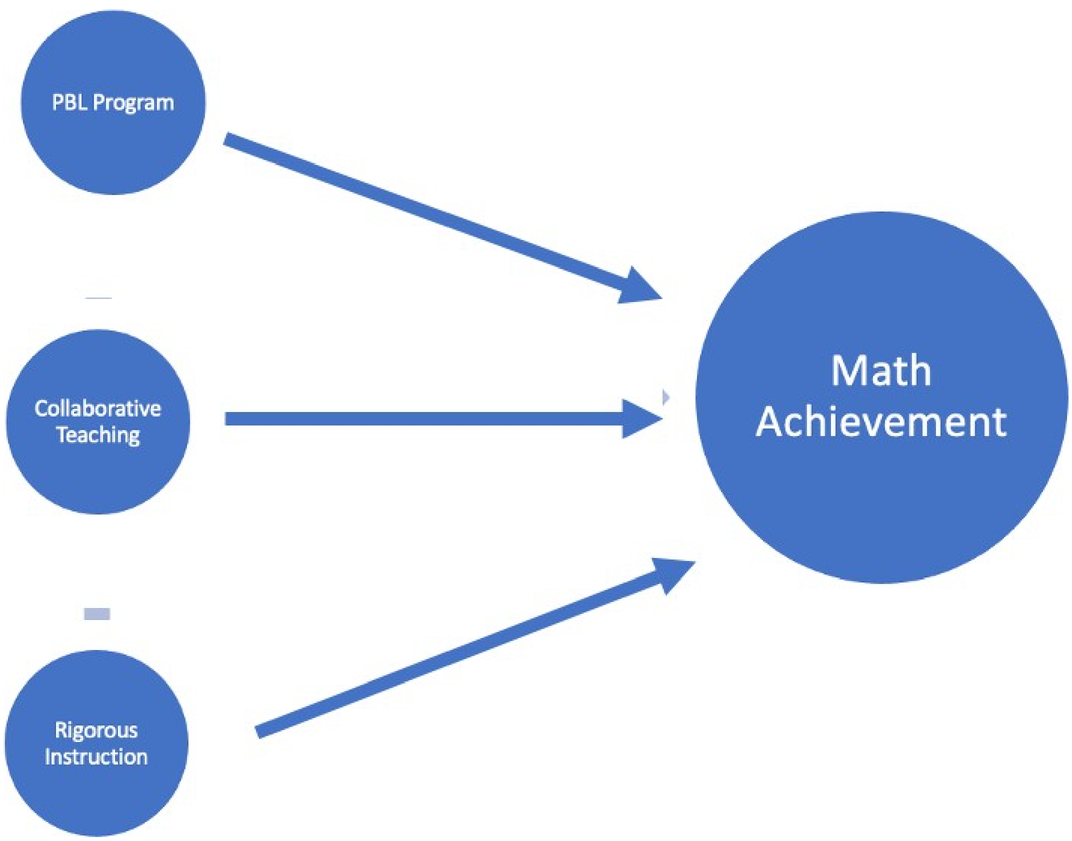
UPS shipping form.

The Mathematics Assessments for the 2018-19 school year are on the New York State Education Department (NYSED) data site. All public-school students in Grades 3 through 8 take the state tests administered for their grade level. The examination is secured before the distribution in all schools to ensure test security.

Conceptual Framework

Figure 1

A Conceptual Framework showing the relationship between the four variables; rigorous instruction, collaborative teachers, PBL program, and math achievement



The conceptual framework looks at the relationship between the four variables; rigorous instruction, collaborative teachers, PBL program, and math achievement.

Rigorous instruction and collaborative teaching are elements of the *Framework for GreatSchools* conceptualized by NYC measures school quality that drives student achievementand school improvement. According to the *Framework & School Survey Scoring Technical Guide* (2018-19), rigorous instruction is to see if "curriculum and instruction are designed to engage students, foster critical thinking skills, and are aligned to the Common Core." Collaborative teachers are if "teachers participate in opportunities to develop, grow, and contribute to the continuous improvement of the school community" (p.1). The PBL program included schools that implemented the practices and culture of a PBL instructional program and utilized the 8 Essential Elements to define quality projectsin their classrooms. These eight essential elements shown in the Project Design Rubric are key knowledge, understanding, success skills, challenging problem or question, sustained inquiry, authenticity, student voice & choice, reflection, critique & revision, and public product.

CHAPTER 4

Introduction

The purpose of this chapter is to explain the results and findings for each research question.

Results/Findings

Research Question/Hypothesis 1

Is there a difference in middle schools' achievement scores in Math State Assessment between PBL schools and non-PBL schools? The hypotheses chosen were:

- H0: There is no significant difference in Math State Assessment Scores between the groups (PBL, Traditional). (H0: u1 = u2).
- H1: There is a significant difference in Math State Assessment Scores between the groups (PBL, Traditional). (H1: u1 ≠ u2).

The Mann-Whitney U test was used to determine a significant difference in middle schools' achievement scores (grades 6-8) in Math State Assessment by the PBL Intervention (Group 1: PBL, Group 2: Traditional). In other words, this research questionwas trying to determine if schools that implemented problem-based learning outperformed schools that did not on the Mathematics State Exam administered to students in grades 6-8. A total of 27 schools were analyzed in this study, with 16 schools that did not receive PBL and 11 schools that did receive PBL.

A Mann-Whitney U test indicated that the total score of 6th-grade mathematics assessment was significantly more significant for the PBL group (Mdn =273.00) than for the traditional group (Mdn=222.00), U= 43.00, z= -2.222, p=.0026. An effect size can becalculated by dividing the absolute (positive) standardized test statistic z by the square root of the number of pairs. Here the effect size is 0.43, which is a moderate effectaccording to Cohen's classification of effect sizes which is 0.1 (small effect), 0.3 (moderate effect), and 0.5 and above (large effect).

$r = Z/\sqrt{N} = 2.222/\sqrt{27} = 2.222/5.196 = .43$

A Mann-Whitney U test indicated that the total score of 7th-grade mathematics assessment was significantly more significant for the PBL group (Mdn =280.00) than forthe traditional group (Mdn =206.50), $U = 23.00$, $z = -2.715$, $p = .007$. An effect size can be calculated by dividing the absolute (positive) standardized test statistic z by the square root of the number of pairs. Here the effect size is 0.52, which is a large effect accordingto Cohen's classification of effect sizes which is 0.1 (small effect), 0.3 (moderate effect),and 0.5 and above (large effect).

$r = Z/\sqrt{N} = 2.715/\sqrt{27} = 2.715/5.196 = .52$

A Mann-Whitney U test indicated that the total score of 8th-grade mathematics assessment was significantly more significant for the PBL group (Mdn =270.50) than forthe traditional group (Mdn=203.00) $U = 17.00$, $z = -2.393$, $p = .017$. Standardized test statistic z by the square root of the number of pairs. Here the effect size is 0.54, which isa large effect according to Cohen's classification of effect sizes which is 0.1 (small effect), 0.3 (moderate effect), and 0.5 and above (large effect).

$r = Z/\sqrt{N} = 2.393/\sqrt{20} = 2.393/4.47 = .54$

Table 4.1

Mann-Whitney U Test: Mean and Sum of Ranks of Math Achievement of Grade 6, Grade7, and Grade 8 between PBL and non-PBL Schools

		N	*Mean Rank*	*Sum of Ranks*	*U*	*Z*	*p*
Math G6	PBL	16	11.19	179	43	-2.222	.026
	Non-PBL	11	18.09	199			
Math G7	PBL	16	10.56	169	33	-2.715	.006
	Non-PBL	11	19.00	209			
Math G8	PBL	16	7.92	95	17	-2.393	.017
	Non-PBL	11	14.38	115			

Research Question/Hypothesis 2

Is there a difference in students' and teachers' perspectives of the school climateon the NYC School Survey (Rigorous Instruction and Collaborative Teachers) between schools that employed the PBL teaching approach and schools that used the traditional teaching approach?

- H0: There is no difference in Rigorous Instruction and Collaborative Teachers basedupon the groups (PBL, Traditional). ($H0: u1 = u2$).
- H1: There is a difference in Rigorous Instruction and Collaborative Teachers based uponthe groups (PBL, Traditional). ($H1: u1 \neq u2$).

The Mann-Whitney U test determined if there was a significant difference in middle schools' survey scores (Total Collaborative Teachers and Total Rigorous Instruction) by the PBL Intervention (Group 1: PBL, Group 2: Traditional). In otherwords, this research question was trying to determine if schools that implemented problem-based learning had greater teacher collaboration and rigorous instruction thanschools that did not.

Before developing the second research question, a Mann-Whitney U test was tested for all six elements under the *Framework for Great Schools.* The six elements include rigorous instruction, collaborative teachers, a supportive environment, effective school leadership, strong family-community ties, and trust. The two elements that were found to be statistically significant were rigorous instruction and collaborative teachers. Rigorous instruction and collaborative teachers' elements were then used to determine ifthere is a difference in students' and teachers' perspectives of the school climate betweenschools that employed the PBL teaching approach and schools that used the traditional teaching approach.

Table 4.2

Mann-Whitney U Test: Hypothesis Test Summary

		Null Hypothesis	Sig.	*Decision*
1	Collaborative Teachers	The distribution of Collaborative Teachers Score is the same across categories of PBLCODE.	.032	Reject the null hypothesis
2	Effective School Leadership	The distribution of Effective School Leadership Score is the same across categories of PBLCODE.	.407	Retain the null hypothesis
3	Rigorous Instruction	The distribution of Rigorous Instruction Score is the same across categories of PBLCODE.	.049	Reject the null hypothesis
4	Strong Family-Community Ties	The distribution of Strong Family-Community Ties Score is the same across categories of PBLCODE.	.913	Retain the null hypothesis

5	Trust Score	The distribution of Trust Score is the same across categories of PBLCODE.	.238	Retain the null hypothesis
6	Supportive Environment	The distribution of Supportive Environment Score is the same across categories of PBLCODE.	.467	Retain the null hypothesis

a. The significance level is .050

Collaborative Teachers Score

According to the NYC School Survey on rigorous instruction scores from 2019, aMann-Whitney U test indicated that the total score of Rigorous Instruction was significantly more significant for the PBL group (Mdn = 4.28) than for the traditional group (Mdn=3.63), U= 32.00, z= -2.117, p=.034. An effect size can be calculated by dividing the absolute (positive) standardized test statistic z by the square root of the number of pairs. Here the effect size is .41which is a moderate effect according to Cohen's classification of effect sizes which is 0.1 (small effect), 0.3 (moderate effect), and 0.5 and above (large effect).

r=$Z/\sqrt{N}$ = 2.117/$\sqrt{27}$ = 2.117/5.20 = .41

These results suggest a significant difference in collaborative teachers' scores between schools implementing PBL versus schools not. Collaborative teacher scores in the schools that implement PBL are significantly higher than in schools that do not.

Rigorous Instruction

According to the NYC School Survey on rigorous instruction scores from 2019, aMann-Whitney U test indicated that the total score of rigorous instruction was significantly more significant for the PBL group (Mdn = 4.04) than for the traditional group (Mdn=3.58), U= 34.00, z= -1.998, p=.046. An effect size can be calculated by dividing the absolute (positive) standardized test statistic z by the square root of the number of pairs. Here the effect size is .38, which is a moderate effect according to Cohen's classification of effect sizes which is 0.1 (small effect), 0.3 (moderate effect), and 0.5 and above (large effect).

$r = Z/\sqrt{N} = 1.998/\sqrt{27} = 1.998/5.20 = .38$

These results suggest a significant difference in rigorous instruction scores between schools implementing PBL versus schools not. Rigorous instruction scores in theschools that implement PBL are significantly higher than schools that do not.

Table 4.3

Mann-Whitney U Test: Median of Collaborative Teachers and Rigorous Instructionbetween PBL and non-PBL Schools

		N	*Median*	*U*	*Z*	*p*
Collaborative Teachers	PBL	16	3.63	32	-2.117	.034
	Non-PBL	11	4.28			
Rigorous Instruction	PBL	16	3.58	34	-1.998	.046
	Non-PBL	11	4.04			

Research Question/Hypothesis 3

Will practice of PBL, students' perception of rigorous instruction, and students'perception of collaborative teachers predict students' achievement in Math State Test Scores?

According to the 2019 NYC student school survey, the subcategories for rigorous instruction include Academic Press and Course Clarity. The subcategory for collaborativeteachers includes Cultural awareness and Inclusive classroom instruction.

The average total score was determined for the subcategories for rigorous instruction and collaborative teachers. The average for 6th grade, 7th grade, and 8th-grade mathematics scores was computed to determine the total Mathematics score. The total mathematics score was chosen because the survey combined all middle school students (grades 6-8).

A multiple linear regression analysis was run to predict students' achievement on the mathematics state test based on the student survey scores for rigorous instruction and collaborative teachers. The rationale for using multiple regression was there was only one continuous outcome dependent variable and three continuous predictor independent variables.

The hypotheses chosen were:

- Ho: Practice of PBL, students' perception of Rigorous Instruction and students' perception of Collaborative Teachers will not have significant predictive relationship with student Math achievement scores.

- H1: Practice of PBL, students' perception of Rigorous Instruction and students' perception of Collaborative Teachers will have significant predictive relationship with student Math achievement scores.

The alpha level of .05 was chosen to test for significance.

Before running the multiple regression analysis, the six assumption tests were conducted. The relationship between the independent and dependent variables was linear,as was demonstrated with scatterplots. There was no multicollinearity in the data except for collaborative teachers with the variable (rigorous instruction), $r = .883$, $p <$

.001. However, when viewing the Collinearity statistics in the SPSS output, the VIF scores were well below 10 (Rigorous Instruction= 4.526 and Collaborative Teachers = 4.526), and the tolerance scores were above 0.2 (Rigorous Instruction= .221 and Collaborative Teachers = .221). Therefore, the multicollinearity assumption was met. The values of the residuals were independent, as were noted by the Durbin-Watson statistic, which was close to 2 (Durbin-Watson = 2.305). The variance of the residuals was constant, which was identified by the plot showing no signs of funneling, which suggests the assumption of homoscedasticity has been met. The values of the residuals were normally distributed, which was evidenced by the P-P plot. Finally, no influential cases of biasing or outliers were evident in the data, verified by calculating Cook's Distance values, all under 1.00.

The stepwise multiple regression analysis was run using SPSS. The three predictors included in the study are PBL, students' perception of Rigorous Instruction, and students' perception of Collaborative Teachers. The dependent variable is the Total Mathematics State Score of Grade 6, 7, and 8. Students' perception of Rigorous instruction and students' perception of collaborative teaching were not significant in the analysis. Only the practice of PBL predicted students' achievement scores. According to these results, the practice of PBL explains 48.8% of math achievement scores. A regression equation was found $F(1,18) = 19.118$, $p < .001$ did significantly predict the total mathematics state score. The null hypothesis is rejected. By changing the non-PBL to PBL schools, the total mathematics score increased by 87.431.

Table 4.4

Model Summary

R	R Square	Adjusted R Square	F Change	df1	df2	Sig. F Change
.718	.515	.488	19.118	1	18	<.001

a. Predictors: (Constant), Practice of PBL
b. Dependent Variable: Mathematics Total

Table 4.5

Coefficients

Model	B	Std. Error	Beta	t	Sig.
1 (Constant)	109.597	29.659		3.695	.002
Practice of PBL	87.431	19.996	.718	4.372	<.001

a. Dependent Variable: Mathematics Total

Research Question 4 /Hypothesis

Will practice of PBL, teachers' perception of rigorous instruction, and teachers'perception of collaborative teachers predict students' achievement in Math State Test Scores?

According to the 2019 NYC teacher school survey, the subcategories under rigorous instruction are the Common Core shift in mathematics and academic press. The subcategory for collaborative teachers includes cultural awareness and inclusive classroom instruction, innovation and collective responsibility, peer collaboration, qualityof professional development, and school commitment. The average total score was determined for the subcategories for rigorous instruction and collaborative teachers. The average for 6th grade, 7th grade, and 8th-grade mathematics scores was computed to determine the total Mathematics score. The total mathematics score was decided because the survey was a combined score of all middle school students (grades 6-8).

A stepwise multiple linear regression analysis was chosen to predict middle school students' mathematics scores based on their total scores on rigorous instruction and collaborative teachers. The rationale for using multiple regression was that there wasonly one continuous outcome dependent variable and three continuous predictor independent variables.

The hypotheses chosen were:

- Ho: Practice of PBL, teachers' perception of Rigorous Instruction and teachers' perception of Collaborative Teachers will not have significant predictive relationship with student Math achievement scores.
- H1: Practice of PBL, teachers' perception of Rigorous Instruction and teachers' perception of Collaborative Teachers will have significant predictive relationship with student Math achievement scores.

The alpha level of .05 was chosen to test for significance.

Before running the multiple regression analysis, the six assumption tests were conducted. The relationship between the independent and dependent variables was linear, as was demonstrated with scatterplots. There was no multicollinearity in the dataexcept for Collaborative Teachers with the variable (Rigorous Instruction), r = .783, p <.001. However, when viewing the Collinearity statistics in the SPSS output, the VIF scores were well below 10 (Collaborative Teachers = 2.583 and Rigorous Instruction = 2.583). The tolerance scores were above 0.2 (Collaborative Teachers = .387 and Rigorous Instruction = .387). Therefore, the multicollinearity assumption was met. The values of the residuals were independent, as were noted by the Durbin-Watson statistic, which was close to 2 (Durbin-Watson = 2.689). The variance of the residuals was constant, which was identified by the plot showing no signs of funneling, which suggests the assumption of homoscedasticity has been met. The values of the residuals were normally distributed,which was evidenced by the P-P plot. Finally, no influential cases of biasing or outliers were evident in the data, verified by calculating Cook's Distance values, all under 1.00.

The stepwise multiple regression analysis was run using SPSS. The three predictors included in the analysis are PBL, Rigorous Instruction, and Collaborative Teachers. The dependent variable is the Total Mathematics State Score. The correlationsof the independent variables (rigorous instruction and collaborative teachers) were not significantly correlated with the dependent variable, Mathematics State Score. Only PBLexplained 41.2% of math scores. A significant regression equation was found F (1, 14) =11.505, $p < .05$, and accounted for approximately 41.2% of the variance of Mathematics Score (R^2 = .451, adjusted R^2 = .412). The model is significantly fit with the data at p<.05. By changing from non-PBL to PBL, the mathematics scores increased by 71.757.

Table 4.6

Model Summary

R	R Square	Adjusted R Square	F Change	df1	df2	Sig. F Change
.672	.451	.412	11.505	1	14	.004

a. Predictors: (Constant), Practice of PBL

Table 4.7

Coefficients

Model	B	Std. Error	Beta	t	Sig.
1 (Constant)	141.725	32.171		4.405	<.001
Practice of PBL	71.757	21.156	.672	3.392	.004

b. Dependent Variable: Mathematics Total

CHAPTER 5

Discussion

The previous chapter showed findings from the quantitative data of the research study. This last chapter presents the implications of findings, relationship to prior research, limitationsof the study, and recommendations for future research. The purpose of the study was to understand if the Problem-based Learning (PBL) instructional approach effectively improved urban middle school students' performance on the New York State Mathematics Assessment.

The research also aimed to understand if there was a difference in students' and teachers' perceptions of their school environment as they participated in the PBL and traditional instructional methods. Lastly, the researchers hoped to determine if the practice of PBL, perception of rigorous instruction, and perception of collaborative teachers predicted students' achievement in Math State Test scores. This research study wanted to uncover whether the PBL instructional approach could support learners to become successful in the mathematics classroomby comparing public middle schools from districts 28 and 30 in New York City. This study also addressed the need for evidence-based practices in PBL in boosting the math proficiency of learners in the United States to those of global competitors.

Implications of Findings

Research question one was trying to determine if there's a difference in students' scores on the 2018-19 mathematics NYS state assessment between schools that implemented PBL versus schools that did not. The scores revealed a statistically significant difference in the mathematical scores for schools in the PBL and traditional groups. The schools in the PBL grouphad greater significant growth than the schools that implemented the conventional approach.

NYC DOE Survey provides information on what teachers, parents, and students within the community think in regards to the learning environment of the school. The second research question wanted to determine if there is a difference in students' and teachers' attitudes in schools that supported PBL versus schools that did not. The scores from the NYC DOE Survey from the 2018-19 school year revealed a statistically significant difference in the perception scores for schools in the PBL and traditional groups. Students' and teachers' perceptions of collaborative teachers and rigorous instruction for the schools implementing the PBL instructional approach showed a greater significant difference than those implementing the conventional strategy. PBL schools' teachers and students responded that they received more rigorous instruction and collaboration than the non-PBL schools. In the rigorous category, students and teachers in the PBL schools responded with a greater academic press, course clarity,and common core shifts in mathematics than in non-PBL schools. In the collaborative teachers' category, PBL schools responded that there was greater cultural awareness & inclusive classroom instruction, collective responsibility, peer collaboration, quality of professional development, and school commitment compared to non-PBL schools.

The results for research questions one and two showed that PBL schools performed betteron the NYS Mathematics state assessment for grades 6-8 and had more positive attitudes in rigorous instruction and collaborative teachers compared to schools that used conventional learning. The results could be due to the PBL program promoting and sustaining the PBL Implementation Plan to establish the knowledge and methods that support PBL across the school.This implementation plan includes the 8 Essential Elements to define quality project design. The school also provides opportunities for staff to demonstrate the 4 C's; communication, collaboration, critical thinking, creativity & innovation. The results can also be because PBL schools gave more rigorous instruction and incorporated more collaboration, making their PBLinstructional program more effective.

PBL School Rubric- Buck Institute for Education (2013)

According to the PBL School Rubric by Buck Institute for Education (2013), the leadership committee in PBL schools had developed a plan to articulate the vision and goals of PBL in all of the targeted content areas and work together with all members of the community insupporting student learning. The schools that implemented the practices and culture of a PBL instructional program had educators utilize the 8 Essential Elements to define quality projects in their classrooms. These eight essential elements shown in the Project Design Rubric are key knowledge, understanding, success skills, challenging problem or question, sustained inquiry, authenticity, student voice & choice, reflection, critique & revision, and public product. The PBL schools also provided consistent opportunities for educators to implement the 4Cs, which are Communication, Collaboration, Critical Thinking, Creativity & Innovation inside and outsidethe classroom to develop professional learning communities for successful implementation of thePBL instructional approach in all of the classrooms (Buck Institute for Education, 2019).

When comparing schools that implement PBL versus those that did not, the rubric servedas a guide to explain the possible reasons for the differences among student performance on the Mathematics State Assessment scores and the teachers' and students' perceptions of the school community.

Essential Elements in PBL Instructional Program

Challenging Problem or Question

This research study confirms with prior research that PBL effectively improves learner content knowledge and a wide range of skills valued in secondary education, therefore, positively impacting their academic performance on assessments. Cunningham (2004) explains that problem-based learning enhances student responsibility as they construct their knowledge. Italso follows a constructivist perspective in learning as the facilitator's purpose is to guide and stimulate the learning process.

Schools that implemented PBL had given students an appropriate challenge to solve meaningful, open-ended problems to engage in classroom learning. Schools that did not participate in PBL or lacked effective PBL implemented several small tasks instead of focusingon a central problem. Those tasks could all have a single or simple answer and not engage with the students nor connect to their previous experience and understanding (Project Design Rubric,2019). A closed problem is straightforward and easier to develop because the facilitator knows the correct answer, making it easier to foretell what content to use and what resources learners will require. Therefore, an open-ended problem is essential as it has multiple correct solutions, allows learners to address the question from various angles, and challenges them to investigate before answering. It also "provides students with greater flexibility in developing solution strategies, and it better mimics the type of problems students will encounter outside the classroom" (Steck et al., 2012).

The PBL instructional method implemented in this research study aligns with the classroom learning goals. It contains specific standards to develop twenty-first-century critical thinking, problem-solving, collaboration, and self-management skills. Previous research indicates that PBL instructional approach can increase student curiosity in the topic, promote flexible thinking, develop students' dispositions and inquiry skills (Silver, 1994). The problem is also understandable and inspiring to the learners. PBL prepares learners to relate mathematicalconcepts to real-life situations and supports learners to understand concepts, skills, modes of thinking, and means of expressing themselves (Joyce, Weil, & Calhoun, 2009).

Sustained Inquiry

The problem-based learning instructional approach encourages self-directed, collaborative, and lifelong learning through inquiry. Inquiry-based instruction is when educationuses active learning strategies within the classroom context to get a "deeper interaction with the important features, concepts, and goals embedded within the ill-structured problem" (Tawfk et al. 2020, p.654). According to the Buck Institute for Education (2019), a sustained inquiry is when learners participate in a "rigorous, extended process of asking questions, finding resources,and applying information."

Based on the constructivist learning theory, knowledge is not passively received but actively built upon prior knowledge and experiences. According to Dewey, the origin of thinking is some "perplexity, confusion, or doubt" triggered by "something specific which occasions and evokes it" (Dewey, 1933, p.12). Learners make sense of this “perplexity, confusion, or doubt” by stimulating their prior knowledge and working collaboratively with theirpeers to find resources and understand the phenomenon. Throughout the inquiry process in PBL,learners can make connections among mathematical ideas and then assemble and reassemble their knowledge based on earlier ones (Moses, Bjork, & Goldenberg, 1990).

Previous literature and this research study provide sufficient evidence that confirms the advantage of PBL over traditional methods of instruction as inquiry is sustained over time and isacademically rigorous. According to the Project Design Rubric provided by the Buck Institute for Education (2019), schools that used features of effective PBL gave students opportunities to build their knowledge and skills by posing questions, collecting and describing data, generating and assessing answers, and asking additional questions. Asking questions is essential for the "knowledge construction process" (Tawfk et al. 2020, p.654). Learners engaged in problem-solving use inquiry processes to generate questions to seal knowledge gaps and gain new knowledge to achieve their goals. Posing questions allow students to connect their current understanding of a subject, compare with other ideas, and become informed of what they do or do not know. The Project Design Rubric (2019) explains that schools that did not participate in PBL or lacked effective PBL could have provided students with a simple "hands-on" task or activity to complete. They did not implement an academically rigorous extended inquiry processto allow learners to ask more profound questions or give opportunities to formulate questions through guided research.

Authenticity

According to Lunce (2006), "like other instructional methodologies, traditional classroominstruction has its strengths and limitations . . . and, for the most part, the content presented in theclassroom is disconnected from its real-world context" (p. 37). Schools in the research study that lacked effective PBL resembled traditional schoolwork, did not include real-world context, nor connect to the learners' personal lives and interests. Previous research explains that learning that does not constitute authentic contexts with real-world tasks, tools, and quality standards, knowledge, and skills becomes more abstract and less meaningful to students' concerns, interests,or identities (Glazer et al., 2005). This type of learning can negate student interest in the classroom and negatively impact their performance.

The purposes of PBL are to provide "guided experiences in learning through complex, real-world problems" (Hmelo-Silver, 2004, p. 239) to engage learning and provide students with the opportunities to apply their knowledge and skills to real-world situations (Hmelo-Silver, 2004). In the study, schools involved in PBL were provided with authentic projects that includedreal-world tasks that spoke personally to students' lives and interests (Project Design Rubric, 2019). This research reinforced the significance of providing real-world context meaningful to the students' personal lives, which is beneficial to the academic growth in becoming self-directedlearners and problem solvers. Solving real world problems can improve pupils’ critical thinking skills and better equip them for the workplace outside the classroom. In PBL, the facilitator's roleis to support students using effective techniques to practice real-world problem-solving to develop a more comprehensive understanding of the curriculum, reflect on their experience, and build on pre-existing conceptions (Khalid & Azeem, 2012). The real-world application allows students to think outside the box and pose alternative or various answers exceeding the textbook response (Barrows & Wee, 2010).

Student Voice & Choice

Student voice and choice are essential in student academic growth in the classroom because it allows students to take personal responsibility for their knowledge and skills and workindependently with appropriate guidance from the teacher and their peers. Schools participating in the PBL instructional program gave learners great chances to express their voice and make choices as they conducted their PBL projects. Specifically, students created questions, topics to investigate, texts and resources to use, and organized their tasks. Student voice and choice allow learners to share their ideas and understandings, ask questions, set goals, and lead discussions with their peers and teachers to monitor their learning and make connections to new knowledge. The "engaged voice must never be fixed and absolute but always changing, always evolving in dialogue with a world beyond itself" so that students can express their opinions, ideas, and perspective to connect their lived experiences to content knowledge (Hooks, 1994, p. 34). Students in schools participating in the traditional approach did not allow students to expresstheir voice and make choices in the classroom, and the lessons were more teacher-directed (Project Design Rubric, 2019).

John Dewey (1897, 1938) emphasized learners' engagement and student input, giving students a voice-over one hundred years ago in developing school learning and promoting active democratic citizens. Giving students a choice in their academic education can help them develop decision-making skills and a deeper connection to their interests in the classroom. Learner-drivenchoices empower students to become self-directed learners and explore content that is meaningful to them. The problem-based learning instructional approach can "provide voice and choice for students in how and what they want to learn and foster inquiry and student ownership of the learning process" (Miller, 2018). This approach can enhance intrinsic motivation in a PBLclassroom as pupils take ownership of the inquiry process to design their projects that show off their learning. Giving learners the right to become active participants in their education is a vital part of a student-centered approach.

Reflection

Reflection is a cognitive manner on how students acknowledge what has happened duringthe learning process (Ngeow & Kong, 2001). Ngeow and Kong state that there are two kinds of reflection activities that include content knowledge. The pupil considers what they need to know about a specific task and the overall learning process, such as whether or not they understand the plan's goals. According to the PBL Project Design Rubric, schools participating in the PBL program provided students and teachers with opportunities to engage in “thoughtful, comprehensive reflection both during the project and after its culmination, about what and how students learn and the project’s design and management” (Buck Institute for Education, 2019). Schools not participating in the program did not have students and teachers “engage in reflectionabout what and how students learn or about the project’s design and management” (Buck Institute for Education, 2019).

Students who participate in reflective thinking can examine and interpret experiences tolearn what they could have done to improve their learning and gain a new understanding. Reflection is the fundamental part of experiential learning as it can encourage students to understand their individual goals, develop higher-level thinking skills, and internalize their knowledge. It also allows teachers to know how students think as derived from their experience in the PBL classroom. Learners enhance their metacognitive awareness as they articulate their thoughts to make connections of new learning to prior knowledge and develop critical thinking skills, such as problem-solving (Davidson and Sternberg, 1998). Reflection enhances student understanding as they make connections of personal meaning to the concept that is to be learned by conversing in dialogue and asking questions and can improve their performance in the classroom and school assessments (Leung & Kember, 2003 and Levin, 2001). When students reflect on their work, they develop a personal connection to their work and gain a deeper understanding that can improve their overall performance in the classroom and on assessment.

Critique and Revision

Students can use critique and revision throughout the PBL process to improve and modify their thinking and make necessary changes to their final project. According to the PBLProject Design Rubric, schools participating in the PBL program provided students with manyopportunities to receive feedback from their peers and teachers to revise and improve their projects. Schools not participating in the PBL program could receive limited input from their teachers but not their peers. Students in the traditional classroom were not required to take theadvice to revise their work (Buck Institute for Education, 2019).

Students should have multiple opportunities to give and receive feedback to support theirgoals and needs to practice, reflect, and analyze their final product throughout the PBL process. In PBL, students learn how to actively participate in the classroom and develop speaking and listening skills. They know how to ask questions, work collaboratively with their team members,critique, and receive feedback to improve their projects.

Public Product

According to the PBL Project Design Rubric, student work is done into a public product as students are provided with opportunities to offer their creations to others outside the classroom. These students present what they have learned and the inquiry process to show what they have found. Schools not participating in PBL "do not make their work public by presentingit to an audience or offering it to people beyond the classroom" (Buck Institute for Education, 2019).

According to McGrath (2004), PBL is a social process in which the learning environmentrelies heavily on the development of collaboration. Presentation of work to outside experts can provide students with additional feedback to improve their project design and take it outside the classroom. Students are given further opportunities to apply critical thinking as they are asked questions and envision what they will say and answer them. Learners in the PBL classroom exhibit higher motivation to focus on authentic performance and collaboration with their peers, teachers, and experts outside the school. Increased motivation can then lead students to gain a deeper understanding of the content and perform better in the classroom. They improve their 21st-century skills in collaboration, creativity, teamwork, problem-solving, and decision-making(Blumenfeld et al., 1991).

4 Cs: Communication, Collaboration, Critical Thinking, Creativity & Innovation

According to the PBL School Rubric (2013) generated by the Buck Institute, schools thatdid not implement the PBL instructional approach or were in the beginning stage; provided little to no opportunities for staff to develop communication, collaboration, critical thinking, creativity& innovation. Schools that implemented PBL offered consistent opportunities for staff to communicate, collaborate, think critically, and be creative & innovative. These four components incorporated in PBL schools are essential in positively influencing teachers' and students' perceptions of the school community in rigorous instruction and collaborative teachers.

Communication

A professional learning community is developed among educators withshared trust and balanced participation during meetings. Professional learning communities in which all members listen actively and communicate will support advances in teaching practice and thus enhance students' learning outcomes. In the PBL schools, teachers agreed-upon norms to build trust to set a positive environment in which they can openly give and receive feedback. Open-communication in which all educators' opinions are valued creates a robust background inwhich educators can learn from one another to share their knowledge and expertise. Communication and balanced participation can positively influence teacher growth and supportstudent learning.

Collaboration

In the PBL school, all teachers regularly work together in collaborative teams to participate in the learning process to develop the knowledge and skills to address students' learning challenges. Teachers will become active participants in the collaborative, intellectually stimulating environment and better understand how to implement these techniques to enhance learning. Collaboration in teacher teams will allow educators to address fundamentalmisconceptions, be engaged in the learning process, and incorporate this PBL instructional method in the classroom by providing opportunities for students to work together, collaborate, and have discussions.

Critical Thinking

Educators work together to analyze complex problems related to the PBL implementation and best support student learning in the classroom. They also utilize reasoning to identify the best solution and systems thinking to see how the entire school community will be impacted.

Creativity & Innovation

School leaders have established the culture and practices that support PBL in the school community allowing staff to innovate and encourage innovation.

Findings Concerning the Practice of PBL on Students' Achievement

The analysis of research question 2 showed that PBL school teachers and students perceived that they do more rigorous instruction and collaborate more in the PBL schools. However, this question did not explain why PBL schools were doing better in Math. Was it because of rigorous instruction, collaborative teachers, or PBL instruction? Multiple regressions were run to determine if PBL, teachers and students' perception of rigorous instruction, and perception of collaborative teachers predicted students' achievement in Math State Test Scores. The results of the multiple regression showed that from the three predictors, only PBL was a significant predictor in student achievement on math state test scores.

PBL has other critical elements and rigorous instruction and collaborative teaching that help it predict student achievement. The practice of PBL consists of authenticity, student voice & choice, reflection, critique & revision, and public product. Schools that implemented PBL practice used an authentic context that included real-world tasks and quality standards. Students were given ample opportunities to express their voice and make choices throughout the investigation, making the learning more personal and encouraging them to take ownership of their education. Students were given many opportunities to reflect on their work to evaluate theirwork and determine what they needed to improve. Through reflection, students were able to critique and revise their projects and make further improvements. Lastly, students were able to present their work to outside experts and make their work public. Interacting with outside expertsallowed students to receive additional feedback and take their projects outside the classroom. Students were also able to share their findings and the inquiry process to solve a real-worldproblem.

Relationship to Prior Research

There is a notable amount of research on problem-based learning (PBL) in medical education and gifted education. However, there is little research on this instructional approach insecondary mathematics education. Prior research confirms that middle school students in the United States have difficulty competing in mathematics on international exams (Ahuja, 2006 & Dawson, 2005). The Principles and Standards for School Mathematics suggest that educators "build new mathematical knowledge through problem solving" (National Council of Teachers of

Mathematics, 2000). This approach provides ample chances for learners to solve quality problems that stimulate their thinking.

Bell (2010) emphasized that the active learning process of PBL includes student choice toboost their confidence and empower them to discover who they are as learners. Students in the PBL classroom use various learning styles; to build upon their prior knowledge, find authentic sources of information during research, develop reflective thinking skills, and find an innovative way to solve real-world problems. To support such learning in the classroom, facilitators need to understand the problem-solving process and present students with guided instruction and variousproblem-solving activities (Kroll & Miller, 1993).

There are common themes identified from prior research. The first common theme is the rationale behind their research: to prepare students for 21st-century skills to prepare them for college and career readiness. The second shared similarity is that the researcher utilizes constructivist perspectives to teach classroom strategies and practices. The third similarity is howthe classroom is set up where students work collaboratively to solve an ill-structured problem.

The fourth common theme is the role of the teachers and students in the school. Specifically, the learners explore ideas, formulate their thoughts, use prior knowledge to build on new experiences, and actively participate in classroom discussions and teamwork activities. The teacher takes the facilitator's role and guides students to learn for themselves through self- exploration and dialogue. The fifth common theme is professional development’s effectiveness in supporting teachers to implement a problem-based learning curriculum.

Previous literature and this research study provide sufficient evidence that confirms the advantage of PBL over traditional methods of instruction. Previous research studies were primarily done in a classroom setting or a specific school and looked at individual students. This research study compares schools across two districts in NYC. Previous research conducted did include the effect of PBL on mathematics achievement and student and teacher attitudes about the school community. However, there is no research on the impact of PBL on students' and teachers' attitudes, specifically in the areas of rigorous instruction and collaborative teaching. In addition, the study was also unique in that it was trying to determine if rigorous instruction and collaborative teaching alone can predict student achievement. However, the study results helpedto show that these two categories cannot independently predict student achievement. Still, other essential components unique to PBL practice can improve student performance on mathematics performance on state assessments.

This research study shows the effectiveness of the PBL program in improving student performance in grades 6-8 on the NYS Mathematics State Assessment. It also shows how students' and teachers' attitudes in the PBL schools were more positive in collaborative teachersand rigorous instruction. Research findings indicate that collaborative teachers and rigorous instruction do not predict higher student scores on math state tests in the PBL schools but ratherthe PBL program itself. The schools that implemented the practices and culture of a PBL instructional program had educators utilize the 8 Essential Elements to define quality projects intheir classrooms. These eight essential elements shown in the Project Design Rubric are key knowledge, understanding, success skills, challenging problem or question, sustained inquiry, authenticity, student voice & choice, reflection, critique & revision, and public product. The PBL schools also provided consistent opportunities for educators to implement the 4Cs, which are communication, collaboration, critical thinking, creativity & innovation, to develop professional learning communities to successfully implement the PBL instructional approach inall classrooms (Buck Institute for Education, 2019).

Limitations of the Study

A possible limitation was the sample size. A total of 27 schools were analyzed in this study, with 16 schools that did not receive PBL and 11 schools that did receive PBL. A Mann-Whitney U test was used instead of an independent sample t-test to analyze the data due to thelow sample size. Another limitation is that there is only a low amount of research studies on this instructional approach in secondary mathematics education. Although PBL began in the late 1960s in medical school education, it is still a comparatively new instructional program insecondary school education.

Another limitation is that the research design relied on interpreting information from teachers' and students' interpretation of their experiences in the school community. Teachers were asked to complete a survey about themselves regarding their strategies and techniques usedin their classrooms and how they experienced success. This can inflate their responses on the survey, and the reactions do not correctly reveal a participants' accurate level of a given survey item.

Lastly, the research was gathered from only districts 28 and 30 from New York City.Both districts are located in Queens and are part of urban districts at one point in time, and findings may not generalize to other populations.

Recommendations for Future Practice

As a result of the findings of this study, the following recommendations are presented:

1. Future research should include other schools from different districts in NYC. The research study included 27 schools across two districts in NYC. Increasing samplesize can create accurate mean values and identify outliers that could skew the datain a smaller sample. Larger sample size can reduce the margin of error and reducethe chances of the results simply by chance.
2. This research study confirms that the PBL program predicts student achievement in middle school mathematics. Future research should look at if the PBL programpredicts student achievement in other disciplines. Looking at different fields can help develop a broader scope of the PBL methods, strategies, and techniques in preparing students with the knowledge and skills to succeed across all contentareas and implementing this pedagogy in the classrooms.
3. PBL effectiveness should also be analyzed in NYC elementary and high school schools to see if this dynamic classroom approach can improve student performance on state exams and help them develop 21st-century skills to be betterequipped for college and career. Looking at other grades will provide a greater deeper understanding and range of the spectrum of using PBL in K-12 education.
4. The recommendation for future research is to develop further studies on the methods, strategies, and techniques implemented by PBL middle school

administrators and teachers to effectively meet the learning needs of middle schoolstudents in mathematics. Research can analyze the collaborative settings of teacherteams to describe the routines followed in planning and implementing rigorous PBLinstruction in their classrooms. Analysis of professional learning communities thatimplement PBL can help develop professional development learning opportunitiesfor other educators and administrators trying to implement the PBL program into their schools effectively.

5. English language learners are a growing part of the school-age population in the United States, representing a remarkable group of linguistically and culturally diverse backgrounds. Teachers should be provided with professional developmentto support English language learners in establishing culturally responsive and inclusive PBL projects and reducing the ELL community's achievement gap. Future research recommends developing further studies on how culturally responsive PBL can improve student performance on state assessments for ELL students.
6. Future research can compare the PBL instructional approach to a different methodology to explore if the PBL program improves student knowledge and skillsin the mathematics classroom.

Recommendations for Future Research

The problem-based learning instructional approach challenges students to explore real-world problems and develop a more profound knowledge and understanding of their learning content. It is also essential to help students develop

21st-century skills to become college and career-ready and compete in the global market.

Although PBL is well developed in medical education, it is still relatively new in k-12 education. Many teachers might struggle with implementing this instructional program into theirclassrooms. Teachers can feel challenged in incorporating projects as it takes time to plan and execute. They are still required to meet state accountability requirements in completing the required curriculum in the course over the year.

Recommendations for future practice include having ongoing collaboration between educators, administrators, and policy-makers to effectively develop a PBL curriculum that alignsto state standards in k-12 education. Also, to provide students with ample opportunities to build twenty-first-century skills and determine how to assess if students have developed these skills. Future practice should look at how to embed this program within the school curriculum,so it does not feel like an additional task for teachers to complete. There should also be proper guidance, professional development, and collaborative teacher meetings within the school community to give educators time within their schedule to work collaboratively with othereducators to design and implement effective PBL in the classroom.

Future practice should also determine how to develop professional learning communities in the school and develop norms and practices for teachers to actively share and receive feedbackfrom their colleagues. Stakeholders in the school community can work alongside policymakers to create professional development courses for educators and administrators to incorporate a culturally responsive PBL relevant to all students' lives to increase engagement and student retention in the classroom. Professional development courses could also be transitioning from a traditional role to a facilitator in the school and learning how to exercise 21st century skills as students participate in the project-based learning experience.

APPENDIX A

Certificate of Completion

ST. JOHN'S UNIVERSITY

fhi360 THE SCIENCE OF IMPROVING LIVES

THIS ACKNOWLEDGES THAT

Anika Yasin

HAS SUCCESSFULLY COMPLETED
THE IRB COURSE IN THE PROTECTION OF HUMAN SUBJECTS

MAY 11, 2021

REFERENCES

Ahuja, Om. P. (2006). World-class high quality mathematics education for all k-12 American students. Department of Mathematical Sciences. Kent State University. *TheMontana Mathematics Enthusiast, 3*(2), 223-248.

Albanese, M. A., and Mitchell, S. (1993). Problem-based learning: A review of literatureon its outcomes and implementation issues. Acad. Med. 68: 52–81.

Ardodo, S.O. and Gbore, L. O. (2012). Prediction of interest of science students of different ability on their academic performance in basic science. *International journal ofpsychology and counseling, 4*(6), 68-78

Arifin, Syamsul, Punadji Setyosari, Cholis Sa'dijah, and Dedi Kuswandi. "The Effect of Problem Based Learning by Cognitive Style on Critical Thinking Skills and Student Retention." *Journal of Technology and Science Education* 10, no. 2 (September 8, 2020): 271. https://doi.org/10.3926/jotse.790.

Barrows, H. S., and Tamblyn, R. (1980). *Problem-Based Learning: An Approach toMedical Education*, Springer, New York.

Barrows, H.S. (2000). Problem-Based learning applied to medical education, SouthernIllinois University Press, Springfield, IL.

Barrows, H., and Kelson, A. C. (1995). *Problem-Based Learning in Secondary Education and the Problem-Based Learning Institute* (Monograph 1), Problem-Based LearningInstitute, Springfield, IL.

Barrows, H. S. (1996). Problem-based learning in medicine and beyond: A brief overview. In W. H. Gijselaers (Ed.), *New directions for teaching and learning* (vol. Vol.68, (pp. 3-11)). San Francisco: Jossey-Bass

Barrows, H. S., & Wee, L. K. (2010). *Principles and practices of a PBL*. Springhill, IL:Southern University School of Medicine.

Bell, S. (2010). Project-based learning for the 21st century: Skills for the future. *TheClearing House, 83,* 39-43. doi:10.1080/00098650903505415

Bereiter, C., and Scardamalia, M. (1989). Intentional learning as a goal of instruction. In Resnick, L. B. (ed.), *Knowing, Learning, and Instruction: Essays in Honor of RobertGlaser*, Erlbaum, Hillsdale, NJ, pp. 361–392.

Birman, B. F., Desimone, L., Porter, A. C., & Garet, M. S. (2000). Designing professionaldevelopment that works. *Educational Leadership*, 28-33.

Blumenfeld, P. C., Soloway, E., Marx, R., W., Krajcik, J. S., Guzdial, M., Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist, 26*(3), 369-398.

Boser, U., & Rosenthal, L. (2012). Do schools challenge our students? *What student* *surveys tell us about the state of education in the United States.* Washington, DC: Centerfor American Progress.

Brass, J. (2015). Standards-based governance of English teaching, past, present, and future? *English Teaching, 14*(3), 241-259. http://dx.doi.org.jerome.stjohns.edu:81/10.1108/ETPC-06 2015-0050

Brown, B. A. (2008). Assessment and academic identity: Using embedded assessment as an instrument for academic socialization in science education. *Teachers College Record,110*(10), 2116–2147.

Brown, Patrick L., James P. Concannon, Donna Marx, Christopher W. Donaldson, and Alicia Black. "An Examination of Middle School Students' STEM Self-Efficacy with Relation to Interest and Perceptions of STEM." *Journal of STEM Education: Innovationsand Research; Auburn* 17, no. 3 (September 2016): 27–38.

Bruner, J. S. (1961). *The act of discovery*. Harvard educational review.

Bryk, A. S., & Schneider, B. (2002). *Trust in schools: A core resource for improvement.* New York, NY: Russell Sage Foundation.

Buck Institute for Education. (2014). *What is project-based learning*? Retrieved fromhttp://bie.org/about/what_pbl

Cheng, B. H., D'Angelo, C., Miller, G., Bhanot, R., Van Brunt, J., & Nourse, H. (2016). Approaches to science education for 21st century learning in the

United States. In Country note: Key findings from PISA 2015 for the United States (pp. 61-73). Retrievedfrom https://www.oecd.org/pisa/PISA-2015-United-States.pdf

Chiu, M. M. (2004). Adapting teacher interventions to student needs during cooperativelearning. *American Education Research Journal, 41*, 365-399.

Common Core State Standards for Mathematics, www.corestandards.org/wpcontent/uploads/Math_Standards1.pdf

Common Core State Standards Initiative. (2018). Development Process. Retrieved fromhttp://www.corestandards.org/about-the-standards/development-process/Content Analysis. (n.d.).

Crosswell, L. (2006). Understanding Teacher Commitment in Times of Change. DoctoralThesis.

Cunningham, R. F. (2004). Problem posing: An opportunity for increasing studentresponsibility. *Mathematics and Computer Education, 38*(1), 83-39.

Darhim; Prabawanto, Sufyani; Susilo, Bambang Eko. "The Effect of Problem-Based Learning and Mathematical Problem Posing in Improving Student's Critical ThinkingSkills." *International Journal of Instruction* 13, no. 4 (October 1, 2020): 103–16. https://doi.org/10.29333/iji.2020.1347a.

Davidson, J. E. & Sternberg, R. J. (1998). Smart problem solving: How metacognitionhelps. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Metacognition ineducational theory and practice* (pp. 47-68). Mahwah, NJ: Lawrence Erlbaum.

Dawson, J. (2005). US students retain middle-of-the-pack status. *Physics Today, 58*(3),pp. 31-32.

Desilver, D. (2017, February 15). U.S. students' academic achievement still lags that of their peers in many other countries. Retrieved from http://www.pewresearch.org/facttank/2017/02/15/u-s-students-internationally-math- science/

Dewey, J. (1933). How We Think: A restatement of the relation of reflective thinking to theeducative process. Boston: D.C. Heath.

Dewey, J. (1938). *Experience and Education*, Macmillan, New York

Duch, B. J., Groh, S. E., and Allen,D. E. (2001). *The Power of Problem-Based Learning*,Stylus, Steerling, VA.

Dwyer, C. P., Hogan, M. J., & Stewart, I. (2014). An integrated critical thinking framework for the 21st century. *Thinking Skills and Creativity, 12*, 43–52.https://doi.org/10.1016/j.tsc.2013.12.004.

Ekmekci, Adem, Danya M. Corkin, and Weihua Fan. “A Multilevel Analysis of the

Impact of Teachers’ Beliefs and Mathematical Knowledge for Teaching on Students’Mathematics Achievement.” *Australian Journal of Teacher Education* 44, no. 12 (December 2019): 57–80.

Firestone, W. A., & Rosenblum, S. (1988). Building commitment in urban high schools. *Educational Evaluation and Policy Analysis, 10*, 285-299.

“Framework for Great Schools.” Accessed April 7, 2021. https://www.schools.nyc.gov/about-us/vision-and-mission/framework-for-great-schools.

Freire, P. (1972). **Pedagogy of the oppressed**. New York: Herder and Herder.

Glazer, E., Hannafin, M. J., & Song, L. (2005). Promoting technology integration through collaborative apprenticeship. *Education Training Research and Development, 53*(4), 57–67. doi:10.1007/BF02504685

Guzey, S. Selcen, Tamara J. Moore, Michael Harwell, and Mario Moreno. “STEM Integration in Middle School Life Science: Student Learning and Attitudes.” *Journal ofScience Education and Technology* 25, no. 4 (2016): 550–60.

Hmelo, C. E. (1994). *Development of Independent Thinking and Learning Skills: A Study of Medical Problem-Solving and Problem-Based Learning*, Unpublished Doctoral Dissertation, Vanderbilt University, Nashville, TN.

Hmelo-silver, C. (2004). Problem-Based Learning: What and How Do Students Learn? *Educational Psychology Review, 16*(3), 235-266. http://dx.doi.org.jerome.stjohns.edu:81/10.1023/B:EDPR.0000034022.16470.f3

Hmelo-Silver, C. E. (2002). Collaborative ways of knowing: Issues in facilitation. In Stahl, G. (ed.), *Proceedings of CSCL 2002*, Erlbaum, Hillsdale, NJ, pp. 199–208.

Hoffmann, V., Rao, V., Datta, U., Sanyal, P., Surendra, V., & Majumdar, S. (2018). Http://www.3ieimpact.org/en/publications/3ie-impact-evaluation-reports/3ie-impa ct-evaluations/impact-evaluation-report-71/. doi:10.23846/ow3.ie71

Hooks, B. (1994). *Teaching to transgress: Education as the practice of freedom.* New York, NY:Routledge.

Hoover, W.A. (1996). The Practice Implications of Constructivism. *Southwest Educational Development Laboratory Newsletter, 10* (3). Retrieved July 20, 2004,from http://www.sedl.org/pubs/sedletter/v09n03/practice.html

Horak, Anne K., and Gary R. Galluzzo. "Gifted Middle School Students' Achievement and Perceptions of Science Classroom Quality During Problem-Based Learning." *Journalof Advanced Academics; Thousand Oaks* 28, no. 1 (February 2017): 28–50. http://dx.doi.org.jerome.stjohns.edu:81/10.1177/1932202X16683424.

Joyce, B., Weil, M., & Calhoun, E. (2009). *Models of teaching.* (8th ed.). Boston, MA:Pearson.

Keiler, Leslie S. "Teachers' Roles and Identities in Student-Centered Classrooms." *International Journal of STEM Education; Heidelberg* 5, no. 1 (September

2018): 1–20.http://dx.doi.org.jerome.stjohns.edu:81/10.1186/s40594-018-0131-6

Kelly, S., Turner, J. (2009). Rethinking the effects of classroom activity structure on the engagement of low-achieving students. *Teachers College Record, 111*(7), 1665–1692.

Khalid, A., & Azeem, M. (2012). Constructivist vs. traditional: Effective instructional approach in teacher education. *International Journal of Humanities and Social Science,2*(5), 170–177.

Knowles, M.S. (1975). *Self-directed learning: A guide for learners and teachers.* NewYork: Association Press. Knowles, M.S. (1990). *The adult learner. A neglected species* (4th ed.). Houston: Gulf Publishing.

Koschmann, T. D., Myers, A. C., Feltovich, P. J., and Barrows, H. S. (1994). Using technology to assist in realizing effective learning and instruction: A principled approachto the use of computers in collaborative learning. *J. Learn. Sci*. 3: 225–262.

Kroll, D. L., & Miller, T. (1993). Insights from research on mathematical problem solving in the middle grades. *Research ideas for the classroom: Middle gradesmathematics,* 58-77.

Kruse, S., Louis, S. L., & Bryk, A. S. (1995). An emerging framework for analysing school-based professional community. In K. S. Louis, D.

Kruse, & Associates. *Professionalism and community: Perspectives on reforming urban schools* (pp. 23–42).Thousand Oakes, CA: Corwin.

Ladson-Billings, G. (2009). *The dream keepers: Successful teachers of African American children* (2nd ed.). San Francisco, CA: Jossey-Bass

LaForce, Melanie, Elizabeth Noble, and Courtney Blackwell. "Problem-Based Learning (PBL) and Student Interest in STEM Careers: The Roles of Motivation and AbilityBeliefs." *Education Sciences* 7, no. 4 (December 20, 2017): 92. https://doi.org/10.3390/educsci7040092.

Lagemann, E. (2000). *An elusive science: The troubling history of education research.* Chicago: University of Chicago Press.

Larmer, J., & Mergendoller, J. R. (2010). The main course, not dessert: How are Students reaching 21st century goals? With 21st century learning. Buck Institute of Education.

Lawrence, R. (2004). Teaching data structures using competitive games education. *Journal for competitive learning 47*(4), 459-466.

Lee, V. E., & Smith, J. B. (1996). Collective responsibility for student learning and its effects on gains in achievement for early high school students. *American Journalof Education, 104*(2), 103–147.

Leung, D. & Kember, D. (2003). The relationship between approaches to learning andreflection. *Educational Psychology, 23*(1), 61-71

Leviomas H., and Alan S. Marcus. “Closing the Achievement Gap through Teacher Collaboration: Facilitating Multiple Trajectories of Teacher Learning.” *Journalof Advanced Academics* 19, no. 1 (January 1, 2007): 116–38.

Levin, B. B. (Ed.). (2001). *Energizing teacher education and professional development with problem-based learning.* Alexandria, VA: Association for Supervision andCurriculum Development

Li, Hui-Chuan, and Tsung-Lung Tsai. “The Implementation of Problem-Based Learning in a Taiwanese Primary Mathematics Classroom: Lessons Learned from the Students’Side of the Story.” *Educational Studies* 43, no. 3 (May 27, 2017): 354–69. https://doi.org/10.1080/03055698.2016.1277138.

Little, J. W. (2002). Locating learning in teachers’ communities of practice opening up problems of analysis in records of everyday work. *Teaching and TeacherEducation, 18,* 917–946.

LoGerfo, L., & Goddard, R. (2008). Defining, measuring, and validating teacher andcollective responsibility. In W. K. Hoy & M. F. DiPaola (Eds.), Improving schools: Studies in leadership and culture (pp. 73–97). Charlotte, NC: Information Age.

Loyens, S. M., M., Magda, J., Rikers, R. M., J., & P. (2008). Self-Directed Learning inProblem-Based Learning and its Relationships with Self-Regulated Learning. *Educational Psychology Review, 20*(4), 411-427. http://dx.doi.org.jerome.stjohns.edu:81/10.1007/s10648-008-9082-7

Lortie, D. C. (1975). *Schoolteacher: A sociological study.* Chicago: University of Chicago Press.

Lunce, L. M. (2006). Simulations: Bringing the benefits of situated learning to the traditional classroom. *Journal of Applied Educational Technology, 3*(1), 37–45.

Ma, X., & McIntyre, L. J. (2005). Exploring Differential Effects of Mathematics Courseson Mathematics Achievement. *Canadian Journal of Education*, *28*(4), 827–852.

Matthews, L. J., & Crow, G. M. (2009). The principalship: New roles in a professionallearning community. New York: Pearson

Matsumura, L. C., Slater, S. C., & Crosson, A. (2008). Classroom climate, rigorous instruction and curriculum, and students' interactions in urban middle schools. *The Elementary School Journal, 108*(4), 293–312.

McDonald, J., Mohr, N., Dichter, A., & McDonald, E. (2003). *The power of protocols:An educator's guide to better practice.* New York: Teachers College Press.

McGrath, D. (2004). Strengthening collaborative work. *Learning and Leading withTechnology, 31*(5), 30-33.

McLaughlin, M. W., & Talbert, J. E. (2001). *Professional communities and the work ofhigh school teaching.* Chicago: University of Chicago Press.

Meier, D. (2002). In schools we trust: *Creating communities of learning in an era oftesting and standardization.* Boston: Beacon Press.

Miller, A. (2018). Using Project-Based Learning to Drive Inquiry and StudentQuestioning. *Social Education*, *82*(2), 114–118.

Mitchell, K., Shkolnik, J., Song, M., Uekawa, K., Murphy, R., Garet, M., et al. (2005). *Rigor, relevance, and results: The quality of teacher assignments and student work innew and conventional high schools.* Washington, DC and Menlo Park, CA: AmericanInstitutes of Research and SRI, International

Mosier, G. G., Bradley-Levine, J., & Perkins, T. (2016, Winter). Students' perceptions ofproject-based learning within the new tech school model. *International Journal ofEducational Reform, 25*(1), 2-15.

Morales-Chicas, Jessica, and Charlotte Agger. "The Effects of Teacher Collective Responsibility on the Mathematics Achievement of Students Who Repeat Algebra." *Journal of Urban Mathematics Education* 10, no. 1 (July 2017): 52–73.

Moses, B., Bjork, E., & Goldenberg, E. P. (1990). Beyond problem solving: Problem posing. In T. J. Cooney (Ed.), *Teaching and learning mathematics in the 1990s* (pp. 82-91). Reston, VA: National Council of Teachers of Mathematics.

National Center for Education Statistics (NCES). (2013). ‘‘Percentage distribution of students enrolled in public elementary and secondary schools, by race/ethnicity: Fall2002, fall 2012, and fall 2024,’’ Retrieved from http://nces.ed.gov/programs/coe/indicator_cge.asp

National Council of Teachers of Mathematics. (2000). *Principles and standards forschool mathematics*. Reston, VA: Author.

New York State Education Department. (2017). *New York state next generation English language arts learning standards.* http://www.nysed.gov/common/nysed/files/programs/curriculum-instruction/nys-next- generation-ela-standards.pdf

New York State Education Department. (2017). *New York state p-12 learning standardsfor mathematics* (revised 2017). http://www.nysed.gov/new-york-state-revised- mathematics-learning-standards

Ngeow, K. & Kong, Y. S. (2001). Learning to learn: Preparing teachers and students for problem-based learning (Report No. EDO-CS-01-04). Bloomington, IN: ERICClearinghouse on Reading, English, and

Communication. (ERIC Document Reproduction Service No. ED457524).

PBLWorks. “Gold Standard PBL: Essential Project Design Elements.” Accessed August26, 2021. https://www.pblworks.org/what-is-pbl/gold-standard-project-design.

Powell, Katherine C., and Cody J. Kalina. “COGNITIVE AND SOCIAL CONSTRUCTIVISM: DEVELOPING TOOLS FOR AN EFFECTIVE CLASSROOM.” *Education* 130, no. 2 \(Winter 2009): 241–50.

Qadach, M., Schechter, C., & Da’as, R. (2020). From Principals to Teachers to Students: Exploring an Integrative Model for Predicting Students’ Achievements. *EducationalAdministration Quarterly*, *56*(5), 736–778.

Riegle-Crumb, Catherine, Karisma Morton, Ursula Nguyen, and Nilanjana Dasgupta. “Inquiry-Based Instruction in Science and Mathematics in Middle School Classrooms:Examining Its Association With Students’ Attitudes by Gender and Race/Ethnicity.” *AERA Open* 5, no. 3 (July 2019): 233285841986765. https://doi.org/10.1177/2332858419867653.

Romero, M., Usart, M., & Ott, M. (2015). Can serious games contribute to developingand sustaining 21st century skills? *Games and Culture. 10*(2). 148-177. doi:10.1177/1555412014548919

Savery, J. R. (2006). Overview of Problem-based Learning: Definitions and Distinctions. *Interdisciplinary Journal of Problem-Based Learning, 1*(1), 13.

Savery, J. (2015). Overview of problem-based learning: Definitions and distinctions. In A. Walker, H. Leary, C. Hmelo-Silver, & P. Ertmer (Eds.), Essential readings in problem based learning: Exploring and extending the legacy of Howard S. Barrows (pp. 9–22). West Lafayette, IN: Purdue University Press.

Schmidt, H. G. (1983). Problem-based learning: Rationale and description. *MedicalEducation, 17*, 1116.

Silver, E. A. (1994). On mathematical problem posing. For the Learning of Mathematics,14(1), 19-28

Steck TR, Dibiase W, Wang C, Boukhtiarov A. The use of open-ended problem-based learning scenarios in an interdisciplinary biotechnology class: evaluation of a problem-based learning course across three years. *J Microbiol Biol Educ.* 2012;13(1):2–10.

Staples, M. (2007). Supporting whole-class collaborative inquiry in a secondarymathematics classroom. *Cognition and Instruction, 25*(2–3), 161–217.

Stein, M. K., & Lane, S. (1996). Instructional tasks and the development of student capacity to think and reason: An analysis of the relationship between teaching and learning in a reform mathematics project. *Educational Research and Evaluation, 2*(1),50–80.

Stewart, V. (2012). *A world class education: Learning from international models of excellence and innovation.* Alexandria, VA: ASCD

Steelman, J. (1947). *Manpower for research.* Washington, DC: Government PrintingOffice.

Susilo, B. E., Darhim, D., & Prabawanto, S. (2018). Supporting activities for critical thinking skills development based on students' perspective. Paper presented of the *1st International Conference on Science and Technology for an Internet of Things.* EuropeanAlliance for Innovation (EAI).

Tawfik, A. A., Graesser, A., Gatewood, J., & Jaclyn, G. (2020). Role of questions in inquiry-based instruction: towards a design taxonomy for question-asking and implications for design. *Educational Technology, Research and Development, 68*(2),653-678. http://dx.doi.org.jerome.stjohns.edu/10.1007/s11423-020-09738-9

Tick, A. (2007). Application of Problem-Based Learning in classrooms activities and multimedia. 5th Slovakian Hungarian Joint Symposium on Applied Machine Intelligenceand Informatics. Retrieved from http://bmf.hu/conferences/sami2007/36_Andrea.pdf

Torp, L., and Sage, S. (2002). *Problems as Possibilities: Problem-Based Learning forK–12 Education*, 2nd edn., ASCD, Alexandria, VA.

US Census Bureau. (2015a). Projections of the size and composition of the USpopulation: 2014 to 2060: Estimates and projections. Washington, DC.

US Census Bureau. (2015b). New census bureau report analyzes US population predictions. Retrieved from https://www.census.gov/newsroom/press-releases/2015/cb15-tps16.html

Vernon, D. T., and Blake, R. L. (1993). Does problem-based learning work?: Ameta-analysis of evaluative research. *Acad. Med.* 68: 550–563.

Wagner, T. (2008). Rigor redefined. *Educational Leadership, 66*(2), 20–25

Whalan, F. (2010). *An investigation of teachers' collective responsibility for student learning* (Unpublished doctoral dissertation). University of Newcastle, Australia.Retrieved from http://hdl.handle.net/1959.13/805553

Wiggan, Greg, and Marcia J. Watson. "Teaching the Whole Child: The Importance of Culturally Responsiveness, Community Engagement, and Character Development in High Achieving African American Students." *The Urban Review* 48, no. 5 (December2016): 766–98. http://dx.doi.org.jerome.stjohns.edu:81/10.1007/s11256-016-0377-6.

Woodward, J. (2004). Mathematics education in the United States: past to present. *Journal of Learning Disabilities, 37*(1), 16-31.

Yeo, J., & Tan, S. C. (2014). Redesigning problem-based learning in the knowledge creation paradigm for school science learning. *Instructional Science, 42*(5), 747-775. doi:10.1007/s11251-014-9317-6

Young, V. (2007, April). *Hilltop Elementary: The co-evolution of collaboration and "data-drivenness."* Paper presented at the 2007 annual conference of the AmericanEducational Research Association, Chicago

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