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Effectiveness of Hands-on Pedagogy in STEM Education

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COLLEGE OF EDUCATION

This is to certify that the doctoral study by

John Kyere

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2016

Abstract

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John Kyere

M.A., University of Cape Coast, 2008

B.S., University of Ghana, 1999

Doctoral Study Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

With the low enrollment in the science, technology, engineering, and mathematics (STEM) fields at the high school and college levels, administrators at the local school district have been struggling to improve elementary school students' performance in math and science. Therefore, the purpose of this study was to evaluate the effectiveness of the STEM program using hands-on instruction facilitated by professional development (PD) activities. Guided by Dewey, Piaget, and Vygotsky' constructivism theory, the qualitative program evaluation using the research questions examined the success of the STEM program using a hands-on instructional approach and the PD support that teachers need to be effective in the classroom. Through a purposeful homogenous sampling, 10 science and math teachers having the experience in using the hands-on instructional approach participated in the data collection. Data collected from the 6 interview respondents, a 4-member focus group respondents through semi-structured interviews, and Grade 5 students' science and math test scores were analyzed for assessing outcomes. Thematic coding, peer debriefing, and member checks were employed as methods to ensure the trustworthiness of interpretations. Two themes emerged indicating that hands-on pedagogy allowed students to become active learners and PD activities provided teachers with quality teaching skills. The program evaluation report recommends efforts to make PD necessary for kinesthetic learning as an integral component implementing a STEM program. Social change is promoted by helping teachers to use proper kinesthetic learning skills to translate STEM concepts into reality to increase student's performance.

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Dedication

I dedicate this study to my parents, Christiana Yaa Sekyere and John Adu Kofi.

Acknowledgments

To God be the glory, all the members of my family, especially my mother Christiana Yaa Sekyere and my father Opanin John Adu Kofi whose support has brought me this far. I am also grateful to Bishop Joseph Osei Bonsu for his encouragement and support. To my committee chair, Dr. Joe Ann Hinrichs and member, Dr. Michael Brophy and University Research Reviewer, Dr. Maureen Ellis thank you. I could not have completed this study without your support.

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Introduction

The success, worth, and welfare of the United States in the 21st century, largely depends on the technological knowledge and skills of the population. Unfortunately, current research indexes indicate that American students are underperforming in science, math, technology, and engineering subjects (U.S Department of Education, 2015). National Science Board ([NSB], 2010) reported that the United States possesses the most innovative, technologically capable economy in the world, and yet students in the educational system are failing. The United States' Program for International Students' Assessment (PISA) test scores from 2003 to 2012 in math and science are low relative to the scores in the other nations (Organization for Economic Co-operation and Development [OECD], 2012). The continuous fall of the United States in math and science indicates a decline of science and engineering workforce, moreover, U.S. reliance on foreign-born scientists and engineers (NSB, 2010).

The National Assessment of Educational Progress ([NAEP], 2015) test scores indicate that many students in the United States complete the middle grades under prepared in STEM subjects. For example, on the NAEP science test in 2011, 32% of eighth graders scored above the proficiency and in 2015 only 33% of eighth graders scored above proficiency on the NAEP mathematics test (NAEP, 2011; NAEP, 2015).

STEM education has the potential to determine whether America will continue to be a leader among nations in offering numerous job opportunities to improve the economic and social lives of many people. STEM career fields have gone a long way to solve problems in the areas of energy, health, environmental protection, and national security (U.S. Council of Advisors on Science and Technology, 2010). The majority of the innovations and advancements in the world is basically dependent upon scientists. Scientific innovations and inventions in the areas of aviation, audio and visual technologies have changed the world (Helpman, 2004). In the 20th century, the world benefited greatly from STEM skills to the fast growing economy (OECD), 2000). For America to continue to be a leader among nations, American educational institutions, educators, and stakeholders of schools need to put in much more effort into better implementation of STEM standards. The findings of 2010 U. S Council of Advisors on Science and Technology reported:

> In the 21st century, the country's need for a world-leading STEM workforce and a scientifically, mathematically, and technologically literate populace has become even greater, and it will continue to grow – particularly as other nations continue to make rapid advances in science and technology... STEM education is essential

> to our economic competitiveness and our national, health, and environmental security. It is also our obligation to empower future generations with the tools and knowledge they will need to seize the opportunities and solve the global problems that they will inherit. STEM education is critical to the Nation's roles and responsibilities in the world, including our ability to play a role in international development (U.S Advisors on Science and Technology, 2010, p. 2).

The quality of STEM education in the United States will serve as the major resource for future growth and advancement. Living in this technological age, the best career options and decision making for our students should be in the STEM fields. Through STEM education, students critically explore, understand, and engage with their environment scientifically and can have the capacity to change the world (U.S. Council of Advisors on Science and Technology, 2010).

Definition of the Problem

The school district site chosen for the setting of the study teaches students who are scoring below the state's average in math and science at the elementary level. The school district's teachers stated that they lack detailed information and adequate preparation about the content knowledge in the implementation of STEM and are using the inappropriate instructional strategy at the elementary level, thus resulting in students' poor performance. Students' achievement scores are lower than is acceptable on state assessment tests in science and in math (Sullivan, 2008). Consequently, low students' test scores in math and science in the elementary grades does not promote high participation in the STEM education to the high school and college levels (Luthra, 2013). The low performance of students in math and science in the school district is indicated in the figure 1:

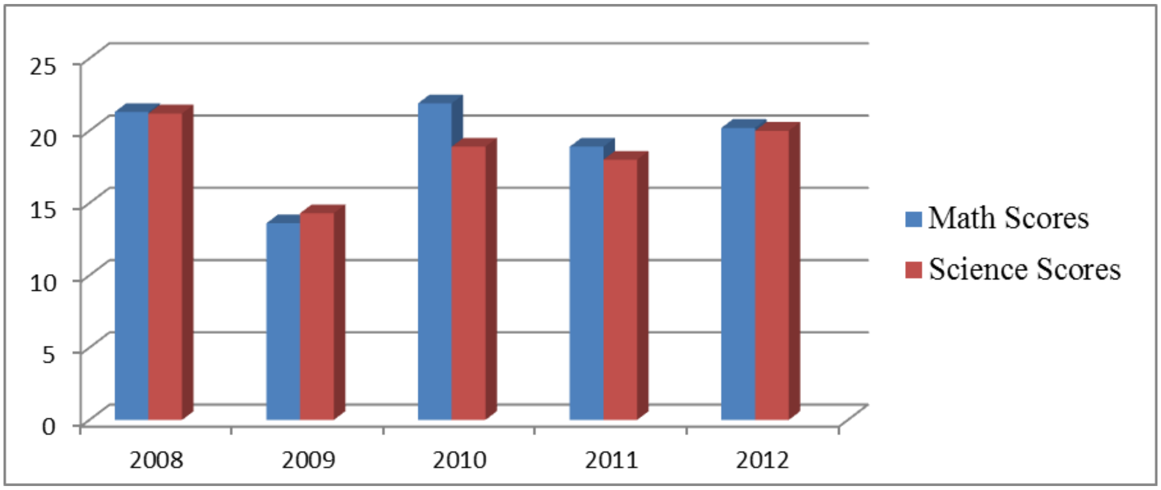

Figure 1. CAPT Math and Science scores from 2008-2012 academic years. Adapted from the Data Interaction for Connecticut 3rd Generation Academic Performance Test. Retrieved from http://solutions1.emetric.net/captpublic/Default.aspx.

Due to the poor performance of students in math and science in the school district, more parents are looking at magnet schools outside the district for better STEM education for their students. The district has 11 elementary schools, 2 public middle schools, 4 high schools and 4 colleges/universities (National Center for Education

Statistics, 2011). Although, the various schools in the school district have realized the importance of STEM, teachers are not adequately and sufficiently prepared. Many more teachers at the elementary levels struggle with how to balance the lecturing method with the innovative hands-on instruction in the teaching of STEM subjects. To provide an intervention, the school board in the district designated one of the elementary schools to be a STEM academy where professional development and hands-on instruction components are strategically put in place to promote the STEM program. In addition, the district hopes that students' performance in math and science will increase to get more students to remain in the STEM fields.

The purpose of the study is to evaluate the implementation of the STEM program using hands-on instruction facilitated by professional development programs. The problem that is to be addressed in the study is to identify the teachers' points of view and perceptions about how progressive and effective is the STEM program using the innovative hands-on inquiry based pedagogy enhanced by professional development. Recommendations may be made to the district's school administrators to maximize efforts to make hands-on instructional strategy an integral part in the implementation of the STEM program.

Rationale

Evidence of the Problem at the Local Level

According to the U.S. Council of Advisors on Science and Technology (2010), STEM education has been proven to make a considerable positive impact worldwide; however the implementation in the education system has not been efficient. Currently, most of the teachers in the school district over rely on the instructional method in the classroom consisting of lectures and textbook reading, which lead to poor understanding of students in the science and math subjects. Consequently, most of the students fail to meet the standard of performance in the STEM subjects. Research has shown that over reliance on lecture instructional strategy has negative effects on students' performance (Rogers & Petkovic, 2011; Trainor, 2011). However, engaging students with real-world problem solving can help to improve students' performance (Rogers & Petkovic, 2011). Importantly, the successful implementation of the STEM program using the innovative hands-on inquiry based pedagogy facilitated by professional development activities has become the district's priority. The efforts put in place to ensure using an appropriate hands-on instructional approach in the teaching of science and math are becoming more critical in the district as an intervention to increase students' performance in the STEM subjects to meet the state's standards.

Although, some schools in the district practice hands-on instruction, there are inadequate teacher preparation, insufficient hands-on instruction materials, and superficial understanding of hands-on instruction practices. To improve students' performance in STEM, professional development activities are recommended by the school district to retrain teachers in hands-on instructional approach. The school administrators together with the stakeholders of the school district selected one out of the 11 elementary schools to be used as a STEM academy school by providing all the needed preparation and support to focus on the STEM courses. The principal of the school emphasized:

> The STEM Academy (K-6) includes a STEM program, which is open to all students in grades 4-6 who are curious about their world and interested in learning through hands-on activities in science, engineering and mathematics. In our STEM program, technology is used in all subjects to increase student engagement and learning. Students are engaged in high level thinking and problem solving as they explore and ask questions about their world and gather and reflect on information using an inquiry-based process. Enhanced learning opportunities are provided in and beyond the classroom and in after school programs which support the STEM theme. Connections are made to opportunities in the middle and high school, and STEM career options are introduced and explored (Morgan-Thompson, 2013, para. 2).

At the selected school and the school district, where hands-on strategy has been the focus of instruction, facilitated by professional development training, students' performance in the STEM subjects has been proposed to improve. According to the figures 2 and 3, students continued to fall in math at the school and district levels.

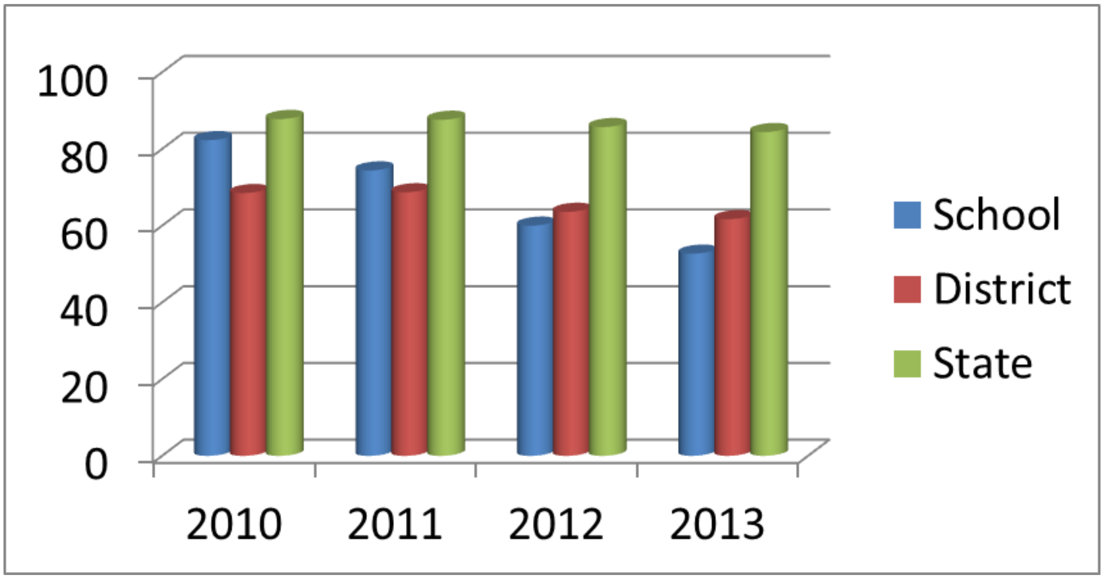

Figure 2. Connecticut Mastery Test Percentage Scores for 5th Grade Math from 2010-2013 academic years. Adapted from the Data Interaction for Connecticut 3rd Generation Academic Performance Test. Retrieved from http://solutions1.emetric.ne

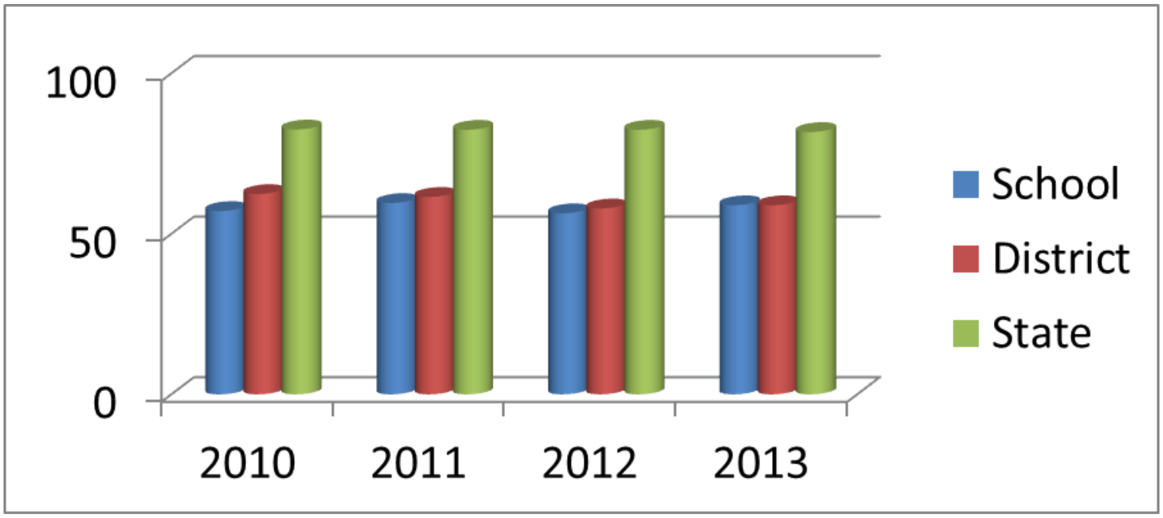

Figure 3. Connecticut Mastery Test Percentage Scores for 5th Grade Science. Adapted from the Data Interaction for Connecticut 3rd Generation Academic Performance Test. Retrieved from http://solutions1.emetric.net/captpublic/Default.aspx

The school selected for the research study site is one of the 11 elementary schools in the district. The school board, school administrators, and stakeholders of the district selected the school for the STEM academy with the intention of helping to improve students' performance in math and science through hands-on approach to serve the STEM needs of the students in the district (Trainor, 2011). The school has the largest elementary school body size in the district with diversity. The student body is ethnically composed of Hispanics, 41%, African-Americans, 38.4% and Whites 13.6%. The research site a public school that serves 388 students in Grades K through-6. The STEM project focuses on Grades 4 through 6 and the curriculum focuses on science as a theme.

The teacher student ratio is 13. 70% out of 388.The district spends 68% of its budget on instruction including STEM. The school is a former middle school with about 60,000 square feet with several large outdoor fields that surround the buildings. Currently, there are 11 classrooms that are devoted to STEM program. There are large grounds, fields and courtyard space that will enable the students to use it for environmental and outdoor study sites: including gardens so that students can learn about plants and their various nutrients (Traynor, 2011). Additionally, the proposal for creating a STEM school attracted as a $ 750,000 collaborative grant, from the National Aeronautics and Space Administration (NASA) which would provide summer STEM programs to train teachers and students to have real and hands-on experience on topics about geology, life sciences and astronomy.

The STEM academy for the study site used constructivism as the basis of the use of hands-on approach to improve students' performance in STEM subjects. Constructivism describes the acquisition of knowledge as a process of consistent self-construction tied to action by engaging students with physical action and hands-on experiential knowledge (Dewey, 1963; Kolb, 1962; Kuhns, 1962; Matthew, 1998; Piaget, 1968; Vygotsky, 1973). The purpose of constructivism in the study is to help teachers of the school to know that the application of hands-on instruction may have the potential to increase students' performance in STEM subjects. The administrators and the stakeholders of the school and school district saw the need to put in place professional development programs to make the implementation of the STEM program work.

The project study has focused on conducting a program evaluation to examine the teachers’ perceptions about the improvement involved in the implementation of the STEM program using hands-on instructional strategy facilitated by professional development. This study used the qualitative method to interview and record the experiences of teachers in the hands-on instruction and examines students’ test scores to provide answers to how successful is the STEM program. The findings of the study may offer suggestions and recommendations to the STEM curriculum planners to maximize efforts to improve hands-on instructional strategies through professional development in the running of the STEM program in the school.

Evidence of the Problem from the Professional Literature

The main focus of the study is to examine the effectiveness of the STEM program in the local school using hands-on instructional approach. The findings of the study may help to make recommendations to the school administrators and the curriculum and instructional planners in the school district and to assist the numerous students who struggle with STEM content at the elementary and secondary levels. Empirical evidence indicates that the American students are falling behind in STEM education as compared to other nations (NSB, 2010, OECD, 2012). Additional comments revealed:

> Innovations of the United States have often led the world to new discoveries and solutions to complex problems. However, there are alarming indications that the United States is falling behind other countries in the ability to apply science, technology, engineering, and math to complex problems facing our world. In order for our country to maintain its position in global business and as a major innovator, there is a need for educators to rededicate their efforts in the areas of science, technology, engineering and math (Bill 2010, p. 32).

The issues of America's global competitiveness and innovation have raised a concern about STEM education ranging from the National Academy of Sciences (NAS), the Business Higher Education Forum (BHEF) to the National Center for Education and Economy (NCEE), and the U.S. Department of Education. According to NAS and BHEF (2007), whereas there is the sharp decline in the production of STEM graduates in the U.S., other nations such as China and Singapore are training more STEM professionals to compete with the U.S. Statistics prove that the U.S. has fallen behind innovations, research and production (BHEF & NAS, 2007; NCEE, 2006; U.S. Department of Education, 2006). The BHEF and NAS reported that the U.S. needs to make concerted efforts to train, maintain, and recruit highly professional teachers to handle STEM subjects. The U.S. reform efforts through the 1998 reauthorization of the *Higher Education Act* (HEA) and the reauthorization of the *Elementary Secondary Education Act*

(2002) intend to transform teacher preparation and professional development which require a high level of accountability (Maloney, 2007).

The U.S. Council of Advisors on Science and Technology (2010) reported that the U. S. has now scored below the Organization for Economic Cooperation and Development (OECD) average and lags behind other nations in math and science. The table 1 indicates U.S. performance in the Program of International Student Assessment (PISA).

Table 1

Table 1- United States Performance on PISA from 2003 to 2012

United States Performance on PISA from 2003 to2012

	Math		Science	
Year	Av. Scored	OECD Av.	Av. Scored	OECD Av.
2003	483	500	491	500
2006	474	498	486	498
2009	487	496	502	500
2012	481	494	497	501

1-United States Performance on PISA from 2003 to 2012

Note: Adapted from OECD (2010). PISA 2010 *Results: Overcoming Social Background-Equity in Learning Opportunities and Outcomes (vol. 2).* Retrieved from http://www.oecd.org/pisa/pisaproducts/48852584pdf.

In 2012, the U. S. ranked 27th in math and 20th in science on PISA out of 64 member nations (OECD, 2012). About 60% of students who enter college with the intention of having come from STEM programs turn out to compete with the non-STEM fields (the U.S. Council of Advisors on Science and Technology, 2010). Consequently, not too many students choose to pursue studies in STEM fields (ALT, Laird, & Wu, 2009; Chen & Weko, 2009; Farmer, 2009; Lips & McNeill, 2009). Moreover, there is an evidence that the U.S. students are receiving insufficient academic preparation in STEM education (ALT, Laird, & Wu, 2009; Farmer, 2009; Lips & McNeill, 2009; Moore, 2007; National Science Board [NSB], 2007). Furthermore, other researchers share a similar view:

> The national picture of science education at the Precollege level is a dismal one indeed, documented by countless commissions, panels, and national and state assessments. International tests such as the Trends in International Mathematics and Science Study (TIMSS) suggests that our students are inherently as bright as other students around the globe, but that our schools are progressively, grade by grade, failing to educate them well in math and science. (Alan & Leon, 1998, para. 3)

To reverse the trend of the poor performance of the U.S. students in math and science, most of the school districts across the country are embarking upon improving STEM education by training more teachers to apply the right instructional strategies to teach these classes and trying to get more students to be interested in these fields. According to Alan and Bryan (2013), school districts across the nation have selected STEM academy courses as the framework for their STEM-based programs. Students enrolled in STEM Academy schools are being taught to evolve and grow with enough knowledge to be viable employees and informed citizens.

A research study conducted in Chicago school districts by Allen and Leon (1993) shows that students at academy schools show consistently greater gains over time in terms of achievement on standardized tests than do those in the non-academy schools. Third-graders at academy schools who have been through the math and science programs posted greater gains in math scores than their state and city peers when tested again as sixth-graders, even as the number of schools involved with the academy rose from 14 (for the 1990-93 cohort) to 55 (for the 1994-97 cohort). Sixth-graders at academy schools during the period from 1993 to 1997, for example, showed an average gain of 21% in IGAP math scores over those posted when they had been tested in third grade. The statewide average gain was 3.8% from third to sixth grade during a 4 year period.

According to a further report from the U.S. Council of Advisors on Science and Technology (2010), some of the factors that lead to the attrition rate of students and their poor performance in STEM fields may be attributed to lack of adequate preparation with regard to instruction and content knowledge, lack of coherency and isolated instruction of science and math, uninspiring introductory courses, and academic culture that does not address the learning needs of students. The U. S. Council of Advisors on Science and Technology recommended the federal government to encourage widespread adoption of empirically validated teaching practices, including active and hands-on learning approaches and out of classroom experience among others. Teachers through professional development training are to improve upon content knowledge and to understand and apply the right and effective instructional strategies that are realistic to improve students' performance in STEM fields (U.S. Council of Advisors on Science and Technology, 2010).

Further research by Ellan and Leon (1993) indicated that the main focus of science and math academy is high-quality teaching to help to improve and promote STEM education. Teachers, who are the agents of change, are to be well equipped with the hands-on inquiry-based instructional strategy as a powerful tool for learning math and science.

The move to maximize efforts in using hands-on approach of teaching is seen as an intervention that intends to make changes in the methods of teaching science and math. The belief requiring changes in the school culture demands that the stakeholders of the school understand the whole concept of change (Allen & Leon, 1993). The teachers in the school, the administrators, the parents, and other community members must be involved in the intervention and the change process. Throughout the instruction phase, the academy staff, teachers both content and processes of mathematics and science, and the school community furnishes instructional materials, and model practices that reflect the national standards. The hands-on practices are to include cooperative learning, the use of the manipulatives, the organization of subject matter around major conceptual themes, and peer coaching (Allen & Leon, 1993).

Due to the fact that the institution of STEM academy is an intervention to improve math and science performance in schools through hands-on manipulatives and professional development practices, a program evaluation is necessary to evaluate the impact the STEM academy is having towards students' achievement in the school district. A program evaluation provided a systematic assessment of the process and the outcome of the application of the program with the intention of furthering its development and improvement (Spaulding, 2008). A program evaluation may go through several stages during a program's lifetime. Each of the stages requires detailed assessments:

a. the need for the program.
b. program design and logic model theory.
c. how the program is being implemented (i.e., is it being implemented according to plan? Are the program's processes, maximizing possible outcomes).
d. program outcome or impact (i.e., what it has actually achieved).
e. assessment of the program's cost and efficiency (Rossi, Lipsey & Freeman, 2004, pp. 218-219).

The nature of the program evaluation requires a collaborative process which demands power-sharing and the participation of the program staff or the stakeholders to ensure the success of the intervention (DuFour, DuFour & Eaker, 2008). According to Freeman and Rossi (1993), collaboration is the key to a successful program evaluation. In evaluation terminology, stakeholders are defined as entities or individuals that are affected by the program and its evaluation (DuFour, DuFour & Eaker, 2008).

Program evaluation as a tool has become a very significant component in the field of educational research with the reason of having the potentiality to assess the quality of school programs that are being implemented due to the high cost of instructional materials and accountability issues (Astramovich, et al, 2006; Overbay et al, 2006; Rudd & Johnson, 2008; Slavin, 2008). The No Child Left Behind Act of 2002 [NCLB] policy has helped educational researchers to improve school administration through the use of data-based assessment evaluations to make decisions on instructions and curriculum (Guillén-Woods, et al, 2008; Martinez, 2005; U.S. Department of Education, 2002). School administrators, school boards, and teachers in the states and the districts having had the opportunity to demonstrate proficiency through the educational policy to meet the state minimum standards declare that data driven program evaluations are compulsory (Coburn & Talbert, 2006; Ikemoto & Marsh, 2007).

In spite of the effectiveness of program evaluation in school interventions and programs, other researchers believe as having the potential to undermine the worth of the programs if the instruments for the data collection are unreliable (Bernhardt, 2000; Chatterji, 2008; Coburn & Talbert, 2006; Goldie, 2006; Ingram et al, 2004; Lachat & Smith, 2005; Slavin, 2008; Young, 2004). Moreover, program evaluation is perceived to create time, budget and data constraints and the high demand of technical skills (Bamberger, et al., 2004). Furthermore, program evaluation inherently requires the contributions of the various community groups such as the advocacy groups, the academia and the service providers, but mutual misunderstanding and misperception about the goals and the process of evaluation can result in adverse attitudes (Short et al, 1996; Chalk & King, 1998).

Schools that ignore the implementation and development of program evaluation of school programs are bound to face future problems. Teachers may lack understanding of the goal of the program and its effectiveness to address the needs of the diverse students, resulting in poor performance (Strahan & Ponder, 2005). Furthermore, schools that do not use program evaluation are not challenged to improve students' performance (Fullan, 2005) and that students' failure becomes normal (Mintrop & Sunderman, 2009). By the use of management model, the outcome of the program evaluation provided information to the superintendent of schools, the principals, and the school administrators in charge of curriculum and instruction to bring information about innovations and improvement in the teaching and learning of STEM subjects (Patton, 1997).

Definitions

The following definitions and terms will be used throughout the study;

Comprehensive school development: a school system designed to offer equal opportunities to all students, regardless of their social status, their physical disabilities and cultural backgrounds. The Comprehensive school development intends to provide all children with knowledge and skills to help them develop their potentials and to prepare them for life.

Formative evaluation: is a method for judging the worth of a program while the program activities are in progress. This part of the evaluation focuses on the processor testing a program on a small scale before broad dissemination (Coyle, Boruch, & Turner, 1991). Formative evaluation focuses on the internal performance data.

Hands-on: learning by doing. It involves active personal participation and the total learning experience which enhances critical thinking (Haury & Rillero, 1994). Hands-on involves engaging students in material-centered activities, manipulative activities and practical activities (Doran, 1990). Elementary school math and science teachers are to be trained to be interested in manipulatives to provide concrete teaching experiences (Ross & Kurtz, 1993).

Hands-on, inquiry based pedagogy: describes the science of engaging the total learning experience of children and the young people through instructional programs and curriculum that are characterized with manipulative and practical activities. Haury & Rillero, 1994 & Loughran, 1999).

No Child Left Behind: In 2001, the U.S. Federal Government under George W Bush. The Bush administration passed legislation on standard based education reform that holds primary and secondary schools accountable for students' poor performance. NCLB requires all students, including those under special education (students with disabilities and disadvantaged backgrounds) to reach the same state standards in math and in reading by the year 2014 (Boykin & Noguera, 2011).

Organization for Economic Cooperation and Development (OECD) is a unique forum where governments work together to address economic, social, education and environment challenges of globalization. The organization helps governments to compare policies, seek answers to common problems, identify best practice and coordinate domestic and international policies (OECD, 2010).

Professional development: a formal process such as a conference, seminar, or workshop; collaborative learning among members of a work team; or a course at a college or University. Professional development can also occur in informal contexts such as discussions among work colleagues, independent reading and research, observations of a colleague's work, or other learning from a peer (Mizelle, 2010). Professional development is the strategy schools and school districts use to ensure that educators continue to strengthen their practice throughout their career. The most effective professional development engages teams of teachers to focus on the needs of their students. They learn to solve problems together in order to ensure that all students achieve success. School systems use a variety of schedules to provide this collaborative learning and work time for teachers (Mizelle, 2010).

Program: a set of specific activities and procedures designed for an intended purpose with quantifiable goals and objectives (Spaulding, 2008). Educators use school programs to accomplish clear educational objectives with detailed descriptions on what work is to be done, by whom, when, and what means or resources will be used.

Program evaluation: is a carefully collecting of information about programs or some aspect of a program to determine their worth and to make recommendations for improvement and success. Program evaluation includes formative and summative assessments. Data can be collected either through quantitative or qualitative methods (Spaulding, 2008).

Program for International Student Assessment (PISA): is the most widely international assessments of educational outcomes of students. The program was initiated by OECD as part of the INES program which provides the OECD member countries the opportunity to do a comparative analysis on students' outcomes so that members will be challenged to improve performance. PISA assesses the competencies of 15-year-olds, three year interval in reading, mathematics and science with a focus on mathematics in 65 countries and economies. The program started in 2003 and the 5th one is in 2012. Around 510 000 students participated in the assessment, representing about 28 million 15-year-olds globally (Baumert, et al, 2002).

STEM: stands for science, technology, engineering, and mathematics. STEM education aims at encouraging students to take an interest in STEM subjects at an early age, probably at the elementary and secondary levels. Focusing on STEM at the elementary level is of great benefit to students and future careers, and in turn will benefit the greater economy (STEM School, 2012). Technologies are described as solutions designed by humans to fulfill a need, for example a pen, water filtration, wheelchairs and tunnels, computers and many more. The process that creates what is needed to solve human problems is the engineering. Engineering designs curriculum uses in math and science subjects to teach about technology and engineering (Brenner, 2009).

STEM Academy: school for science, technology, engineering, and mathematics. STEM academy features an integrated core curriculum of math, science, and engineering class, that intends to prepare students for educational and workforce opportunities in STEM careers (Careless, 2011).

Summative evaluation: is a method of judging the worth of a program at the end of the program activities. The focus is on the outcome. Summative evaluation mostly focuses on the external performance data.

Trends in International Mathematics and Science Study (TIMSS): TIMSS aims at collecting data at four year intervals on science and math performance of 4th and 8thgrade students to enable member nations to compare performances to see the need to make improvements (National Center for Education Statistics, 2013).

Significance

The teacher-centered, textbook, lecture-based, and rote learning methods invite less interaction of students with what they study, lacking the ability to motivate and engage students' interests, skills, and talents to study STEM subjects in this modern world (Prensky, 2004; Rogers & Petkov, 2011). Conversely, Rogers and Petkov (2011) view that students in the current generation are eager and curious to experience and interact with what they are interested in, in understanding themselves mostly through the internet and the computer which was different from those who lived in the past decades. The instructional methods that were effective some years ago are not as effective today (Prensky, 2004). However, the problem is that most of the math and science teachers in this current age are not equipped with sufficient modern training and therefore lack the basic understanding of content and the right instructional strategy in the teaching of STEM subjects. Consequently, teachers may not be able to meet the needs of students' performance levels in STEM subject areas.

The continuous fall of students in science and math can create future crises in the scientific innovations, advancement in technology and engineering, and global economic competition. The findings of the study provided documentation of the strengths and weaknesses of program practices that focus on the school (the research site), the Board of Education, school administrators, superintendents, principals, teachers, parents, the community, and the stakeholders of the school district to support and promote professional development programs for teachers in manipulative instructions to improve students’ performance in STEM subjects.

Guiding/Research Question

The guiding questions revealed the teachers’ perceptions and experiences of hands-on pedagogy requiring professional development programs in the implementation of the STEM program. The questions are designed to elicit responses from the teachers to be able to critically evaluate the STEM program. The research questions focused on how hands-on instructions and professional development programs promote the effectiveness of the STEM program. The research questions to guide this study are as follows:

RQ1: What are the teachers’ perceptions of the effectiveness and the value of the innovative hands-on inquiry based pedagogy on the achievement of students in the STEM subjects?

RQ2: What knowledge, experiences and support do teachers need to effectively teach STEM subjects?

The idea of promoting hands-on instructional approach as a means of improving students’ performance, especially in science and math is not something new or innovative in literature. The effective application of kinesthetic approach to learning has been offered as one of the right approaches to improve students' achievement in the STEM subjects. Recent literature supports the use of hands-on as having the intrinsic ability to improve students' performance in STEM subjects (Cruse, 2012; Grulke, 2013; Johnson, 2011; Zeluff, 2011).

Based on the national education policies in support of hands-on as an instructional approach, the time is due to use empirical evidence from the study to support or reconsider its use in the school district. The perception of science and math teachers in response to the research questions through interviews can help to make a decision as to whether to support the trend about the promotion of hands-on instruction through professional development to improve students' performance in STEM subjects or to suggest a further reconsideration.

Review of the Literature

The conceptual framework for the research project included a collection of interrelated concepts that have not been tested, but guided the research study on how hands-on pedagogy impacts STEM subjects. The framework guiding this study is constructivism, Stages of Development Theory, and Cognitive Theory Information Processing Model.

The Conceptual Framework

Constructivism Theory

The concept that describes the experiential nature of learning and how individuals construct what they learn and understand supports constructivism theory. The theory of constructivism varies according to one's perspective and position. Within educational perspectives, there are philosophical meanings of constructivism, personal constructivism as described by Piaget (1967), social constructivism postulated by Vygotsky (1978), radical constructivism advocated by von Glasersfeld (1995), constructivist epistemologies, and educational constructivism (Matthews, 1998). Jones and Brader-Araje (2002) found social constructivism and educational constructivism that have had the greatest impact on instruction and curriculum design because they seem to be most effective in the current educational approaches.

Schunk (2004) also considered constructivism as epistemology by focusing on the nature of knowledge individuals acquire through understanding, self-construction, and experience with the real world. Consequently, other theorists regard constructivism as a learning theory whereby knowledge is constructed in a context based (Knowles, Holton & Swanson, 1998; Vygotsky, 1973). Brown (1998) further explained that contextual teaching and learning theory are rooted in constructivist practice.

Jean Piaget (1968) viewed the task of the teacher to be to facilitate learning which differs from behaviorist theory where the teacher is the main focus (Jones & Brader-

Araje, 2002). Within constructivist theory, knowledge is not something that exists outside of the learner. According to Tobin and Tippins (1993), constructivism is a form of realism where reality can only be known in a personal and subjective way. Piaget (1967) focused on the active role of the individual in learning and in so doing stated that “all knowledge is tied to action, and knowing an object or an event is to use it by assimilating it to an action scheme" (pp. 14-15).

Dewey (1963) in describing what we call reflective activity acknowledged that though the construction of knowledge is a cognitive activity, engaging students with physical action, hands-on experience may be important for learning but not sufficient. The purpose of educators is to provide students with activities that engage the minds and the hands to provide trustworthy knowledge. Again, Dewey discovered that there is a strong connection between the process of experience and education. Based upon the work of Dewey, an American education theorist, Kolb believes “learning is the process whereby knowledge is created through the transformation of experience” (1984, p. 38). The ability of educators to discover the students’ experience and interest areas can stimulate effective learning. Real applications of knowledge may be beneficial to students in the learning of math and science (Sanders, 2008). Students learning of math and science be improved by engaging them in inquiries with problem solving, and learning opportunity that is realistic and hands-on (Dewey, 1963).

Kuhn (1962) postulated that constructivism represents a paradigm change in science education. Kuhn argued that scientists need to construct and not to discover what is really there. Research has shown that constructivism impacts modern education, society, science and technology education in the aftermath of science wars (Gross et al, 1996; Gross & Levitt, 1994). However, Matthews (1998) is of the view that in spite of the potentials that exist in constructivism to promote mathematics and science education through hands-on experience instructional strategy, the overall constructivism has had a slight impact on the theory and practice of science and mathematics education.

Furthermore, the scientific knowledge development theory has been suggested to explain how hands-on science is beneficial to student learning of science. The scientific knowledge development theory involves the content knowledge and process skills (Glynn & Duit 1995; Lawson, 1995). Content knowledge describes the theories, conceptual models, facts, and principles which students are to keep at the cognitive level to be retrieved later in the form of physical activities. Process skills are six means of learning that are significant to the conduct of science: a) observing, b) classifying, c) measuring, d) communicating, e) influencing and predicting (forming new hypotheses). For students to better understand content knowledge and process skills, hands-on science is required (Champagne et al, 1982; Eylon & Linn 1988; Glynn & Duit 1995). Through hands-on activities, abstracts, complex principles and theories that characterize the content knowledge are concretized and illustrated in real terms (Friedlander & Tamir, 1990; (Shulman &Tamir, 1973).

Stages of Development Theory

Hands-on operations have a link to the stages of developmental theory. The highest stage of development theory includes the ability to work with abstractions. The second highest stage may be reached when the mind begins to work well with concrete things through interactions with the physical environment (Gage & Berliner 1994; Lawson, 1995; Piaget, 1973). In other words, hands-on science can help students to pass through the second highest stage to the highest stage as it is able to provide concrete illustrations of abstract ideas when the mind needs concrete and physical activities for understanding. Once at the highest stage, however, hands-on science is of much less importance in helping the student gain understanding as the student tries to understand abstract ideas.

Cognitive Theory Information Processing Model

The issue of hands-on science is also associated with cognitive theory information processing model of the mind which includes a long-term memory and stores information for a long period of time (Gage & Berliner, 1984). The short-term memory holds information on the conscious level and can be worked with. The ability to retrieve relevant knowledge from the short-term memory for use is strengthened by the long-term memory. The reason being that the longer information stays in the short-memory, the stronger the association in the long term-memory. Hands-on activities create further associations by providing an extension between both memories so that information can be referenced both by abstract meaning and by a physical illustration. In this way, information retrieval is improved (Gage & Berliner, 1984).

Based on theory and research, information related to the effectiveness of hands-on inquiry based instructional strategy is to help to bring about improvement in students' performance in STEM subjects. Although the previous instructional strategies for the teaching of STEM subjects came about as a result of many past studies, research continues to provide insight into best practices for teaching STEM subjects in the classroom. Research into best practice in the teaching of STEM subjects is shifting from classroom-textbook level of instruction, rote procedures toward investigation, teacher centeredness and questioning to a more of outside classroom, experiential studies, and student centeredness (Harland, 201; Brew, 2012). The activities within a STEM education curriculum should scaffold from confirmatory, structured, guided, and to open an inquiry to explore the real world (Harland, 2011). STEM well promoted to higher learning has the potential to impact and transform lives.

Our educational system needs significant improvement in STEM education for students who will be the workforce of tomorrow and who will have a competitive edge in a globalized and high-tech marketplace (U.S. Department of Education, 2010; STEM School, 2013). President Barack Obama, in his 2010 State of Nation address stated that "... Leadership tomorrow depends on how we educate our students today—especially in science, technology, engineering and math" (U.S. Department of Education, 2010, p 1). STEM pervades every aspect of social life, such as economics, accounting, health care, education, religion, computer engineering, mechanical engineering, electrical engineering, audio-visual engineering and is to be given a serious attention for a better future.

The United States is falling behind internationally, ranking 25th in mathematics and 17th in science among industrialized nations due to lack of proper application of instructional strategies (the U.S. Department of Education, 2010). Consequently, only 16 percent of American high school seniors are proficient in mathematics and interested in a STEM career. Even among those who go on to pursue a college major in the STEM fields, only about half choose to work in a related career (the U.S. Department of Education, 2010). The problem may be attributed to the fact that schools have previously offered STEM, but without the use of instruction with hands-on exercises. The purpose of qualitative study is to determine and evaluate the implementation of STEM education using hands-on instruction assisted by professional development. The literature reviewed for the study of STEM using innovative, hands-on instruction will provide a conceptual framework for the study. The study is designed to allow the implementation of STEM disciplines by the use of hands-on activities as an intervention or worthwhile to improve students' performance.

The recent literature review is organized into four headings: a) the perception of teachers of the worth of hands-on instruction and STEM education, b) teacher preparation and critical role, c) benefits and negatives of hands-on Manipulatives on STEM, and d) events leading to STEM education.

The worth of hands-on instruction and STEM education, literature will focus on revealing the factors, the potentials and the values in hands-on instruction to enhance STEM education. Literature on the benefits of hands-on in STEM education will reveal how hands-on makes the study of STEM interactive to sustain students' interest. In view of the negatives, literature will focus on the huge investments of time, money, material and the possible dangers involved in the use of hands-on. The literature on the teacher preparation and critical role will also demonstrate how professional development programs can ensure the effective implementation of STEM using hands-on. With the case of the events leading to STEM education, the literature will focus on the significant events that might have led to educational reforms to favor STEM education. For the project study, key ideas and search terms are used for the provision of research. These key ideas and search terms included the following: *journal of information technology,* *educational researcher, educational psychology, the technology teacher, transportation research part A, new directions for evaluation New educational leadership, educational psychology, journal of chemical education, journal of staff development, educational communication, journal of teacher education, teacher academy of math and science, science for all Americans, technology and engineering teacher, journal of staff development, qualitative research for education, American journal of education, field methods, qualitative research for education.* Additionally, theoretical and research based sources were used for the collection of research. Such sources included peer-review journal articles and thesis, dissertations and books from the Walden University Library database. ProQuest, Questia, and Google scholar.

The Worth of Hands-on Instruction and STEM education

Brenner (2009) viewed technology and engineering disciplines in STEM education as that which directly relate to hands-on learning activities. According to Brenner, National Center for Technological Literacy defines technologies as solutions designed by humans to fulfill a need. Pen, water filtration, wheelchairs and tunnels are all technologies. The process that creates is engineering. Engineering designs curriculum uses in math and science subjects to teach about technology and engineering (Brenner, 2009). Eventually, hands-on pedagogy becomes an effective teaching and learning tool for the study of STEM subjects. Merrill (2009) found that STEM teaching and learning focus on authentic content and problems, using hands-on, technological tools, equipment, and procedures in innovative ways to help solve human wants and needs.

According to Satterthwaite (2010), there are three factors that characterize hands-on pedagogy as making a significant contribution to STEM instruction: a) peer interaction through cooperative learning, b) object-mediated learning, and c) embodied experience (Hattie, 2009; Willingham, 2009). By taking these factors into account, teachers of science can design lessons that really use this knowledge. Satterthwait (2010), further explained that funding organizations in STEM education, science education researchers, science curriculum project leaders, and STEM teachers have fully understood that hands-on activities have the potentials to improve students' performance. The teachers who have acknowledged the value and the full potential of hands-on pedagogy incorporate a "hands-on into the minds-on" approach (cognitive approach) in the study of science (Satterthwaite, 2010, p. 7).

Engaging in-depth investigations with objects, materials, phenomena, ideas and drawing meaning and understanding of those experiences, students learn the *what, how*, *when*, and *why*, of things with which they interact. These experiences are necessary to promote STEM education (Willingham, 2009). Zeluff (2011) stated "nowhere is hands-on learning more critical than in science" (p. 8). STEM content knowledge is often abstract and complex. Engaging students in manipulating objects may make the abstract knowledge more concrete and clearer. Hands-on science helps the students to be able to see real-life illustrations of the knowledge (Zeluff, 2011). Carnegie-IAS Commission (2009) reported, “Learning math and science from a textbook is not enough: students must also learn by struggling with real-world problems, theorizing possible answers and testing solutions” (p. 13). Hands-on learning provides the opportunity for students to learn through theory and practice.

According to Tsupros, et al. (2009), the application of real-world lessons through hands-on practices is able to make the study of STEM subjects real and experiential. STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between the school, the community, work, and the global enterprise, enabling the development of STEM literacy and with it the ability to compete in the new economy (Tsupros, et al. 2009).

Johnson (2011) advocated that educational outreach program and students’ learning through STEM by applying real-world, hands-on experiences touches on the curiosity and interest of students to learn. Educators use hands-on instruction to provide children with what they want to do with STEM disciplines. Johnson (2011) further stated that “hands-on approaches to STEM education should be about giving children the opportunity to engage through an interdisciplinary manner where you go beyond the boundaries of science and math to figure out how things work together to make life better" (p. 11). Applying hands-on teaching skills will be beneficial not only to science and math education, but also other fields of accounting, political science, theology, sociology and any more.

Teaching the common core STEM standards with hands-on activities is designed to provide teachers with the information, strategies, and activities needed to instruct students in all its standards for grades 6-8 (Muscahla, et al. 2012). Hands-on learning generally has the potential to enhance students' learning experiences. First of all, STEM students through hands-on instructions learn to be visual, sensing, inductive and active learners. Hands-on naturally prepares the grounds for STEM students to learn. Engaging students in hands-on activities increase confidence and ability to apply the theory and concepts in learning the real world problems (Tse, 2009). Hands-on learning is essential for the study of STEM subjects to highlight the interdisciplinary and integrated approach to teaching and learning, where discipline-specific content is not divided, but addressed and treated as one dynamic and fluid study (Merrill, 2009). Merrill (2009) stated that the authentic content and problems, using hands-on, technological tools, equipment, and procedures offer an effective opportunity for the teaching of STEM in innovative ways to help solve human wants and needs. On the contrary, Gina and Jacqueline (2009) viewed hands-on pedagogy cannot be the main focus in the study of STEM subjects, however books and other textual materials must relate to experiential hands-on learning. Books are to help explain a phenomenon explicitly before hands-on study can be effective. Gina and Jacqueline identified three methods which books can serve hands-on pedagogy in the study of science: a) supporting firsthand inquiry experiences, b) providing concepts and contexts, and c) understanding the nature of science. A proper integration of textbook and hands-on approaches provides an effective learning approach to the study of science and math.

Cruse (2012), in quantitative quasi-experimental study, investigated the effect of hands-on learning activities on students in high school mathematics. In applying hands-on activities such as mathematics games, students made gains in performance. Students made best efforts to complete the math problem accurately and a faster pace than their peers, because of the ability to relate the study of math to practical experience and integrate manipulative. The statistical information after the posttest (hands-on intervention) indicated that the hands-on teaching method created a difference in students' learning outcomes. Cruse (2012), concluded that hands-on teaching methods were appropriate to tap students' interest in the learning process. Zeluff (2011), added that "hands-on learning is one way to keep them interested in science. Keeping students who are interested in science increases the likelihood they will learn toward science based careers or at the very minimum become scientifically literate" (p. 9). Grulke

(2013), commented that whether a teacher is responsible for STEM curriculum at the middle school or high school, or teach at the college level, finding ways to incorporate hands-on learning opportunities is a way to engage students and ignite interest in STEM careers.

The use of more hands-on activities in the study of science and the other related subjects could help increase the number of students entering and maintaining scientific careers, relieving the growing concern that North America is losing its leadership status in the international scientific community (Roberts & Wasserburg, 2009). Pytel (2013), further explained that the American science educational system is falling behind China and India because the school system overlooks the modern and the most effective learning styles of students. Pytel (2013), concluded that the most preferred learning styles of students are no longer auditory but kinesthetic and visual which naturally foster STEM learning through hands-on. Creating the opportunity for students to see, touch and interact with what they learn ignite the interest of students to learn better.

Zeluff (2011), through experimental research conducted posttest and pretest data to analyze hands-on learning and problem-based learning critical methods in aiding students' understanding of alternative energy concepts. The results of the study suggest that curriculum centered on problem based learning and hands-on activities can lead to an increase in students' understanding of science and particularly alternative energy (Zeluff, 2011). The data collection indicated a 24 % increase in student scores from the pretest to posttest through hands-on activities (Zeluff, 2011). The desire of students to become more actively involved in science related issues that are shaping the world of today has increased based on the results of the survey. Data are significant as indicated by the t-test. The surveys show that students preferred the hands-on activities and problem-based learning to more traditional methods. Generating students' interest in the learning of math and science through concrete learning experience should be the focus of educators to increase students' performance in STEM.

Critelli (2012) conducted a study on how a hands-on action research study and how pre-service teachers' questioning techniques affect student discovery of mathematical relationships. Data showed that through hands-on instructions, students in the STEM study environment achieved and acquired new vocabulary and mathematical concepts and understandings. Students' good performance was shown through pre-and post-assessment scores, in addition to teacher notes and journals. The hands-on activity contributed to the success of the STEM students. Critelli (2012) stated "in cases where students were working hands on, minds-on, the success was greater and the knowledge acquired will potentially last longer as the meaning was deeper" (p. 42). To keep the retention rates of students in the study of STEM, making the teaching and learning very interactive plays a major role.

Ruddick (2012), utilized qualitative and quantitative methods to explain the high dropout rate among science, technology, engineering and mathematics (STEM) students and the need for an intervention. Some of the conclusions were that the focus of students of STEM education is to be directed towards being part of the problem of the society and problem solving instead of students alone. STEM education should not only focus on the well prepared and the gifted students but also on the risk population (Ruddick, 2012). Out of the study, Ruddick (2012), recommended a hands-on instructional strategy as an intervention to improve classroom activities. The study implemented an original hands-on activity using LEGO® blocks to model ionic chemical formulas and computational chemistry lab module on molecular orbital theory used in an Honors General Chemistry course. The results of the study were particular about the value of hands-on instruction capable of effecting positive gains in students' performance in STEM.

Several authors described hands-on STEM programs that have the potential to increase students' interest in STEM and STEM careers, including mentoring, internships, after school programs that focus on STEM subjects and participation in math and science competitions (Johnson, 2011; Merril, 2009; Satterwait, 2010. Other experiences, such as STEM summer camps (Ivey & Quam, 2009), online games such as CSI: The Experience of Web Adventures (Miller, et al. 2010), interactive videos and software (Demski, 2009), and STEM library resources (Barack, 2009) also have the potential to stimulate students' interest in STEM and STEM careers. By promoting STEM skills with hands-on learning experience and designed-based learning tasks, will teach students how to use technology to solve rigorous real-life science, engineering and math challenges (Alka & Lundell, 2010).

Benefits of Hands-on Instruction on STEM Education

Otis (2010) discovered five major benefits from the use of hands-on instruction on STEM education:

a. Developing in students critical and problem solving skills.

b. Personal guidance from a facilitator or instructor.

c. Greater retention of program material.

d. Stimulating learning in a friendly environment.

e. Access to materials and programs used in a job in real time (p. 1).

Rockland, et al. (2009) explored the best practices for bringing engineering into the science and mathematics curriculum of secondary school classrooms described the use of robotic activities. Rockland, et al (2009) stated "the use of practical, hands-on applications of mathematical and scientific concepts across various engineering topics will help students to link scientific concepts with technology, problem solving, and design, and to apply classroom lessons to real-life problems" (p. 53). Additionally, Keith, et al. (2012) also stated that through hands-on, laboratories, demonstrations and lectures, science educators are able to explain difficult scientific concepts and make them interactive and experiential. Satterthwaite (2010) viewed hands-on pedagogy as that which offers students the opportunity to interact with peers and manipulate with objects, make inquiries based on the observation of a phenomenon, collect data and, make conclusions which form the basis of scientific inquiries.

According to Brenner (2009), to increase the enthusiasm and the eagerness of elementary level students about STEM related knowledge, various engineering design and curriculum models have been put in place. Some of the models of Project Lead the Way (PLTW) and Engineering are Elementary (EiE). The models are enhanced by the use of hands-on learning activities, project-based learning activities, and cooperative based learning activities. Specifically, the use of hands-on learning activities promote higher order thinking skills and help to increase the academic achievement of students in STEM subjects (Brenner, 2009).

According to Robinson and Stewardson (2012), STEM curriculum developers have been engaged in continuous search for new ways to sustain the interest of students in STEM subjects through hands-on projects and real-world applications in the last few decades. STEM educators have discovered robotic activities as powerful tools to engage students in the classroom (Kressly, et al, 2009). Researchers claim that robotic competitions have managed to improve the enthusiasm of students in STEM content areas (Nugent, et al, 2010). Nugent, et al, (2010) after a study about the effectiveness of robotic activities, concluded through hands-on experimentation, such technologies can help the youth translate abstract mathematics and science concepts in concrete real-world applications" (p. 392). Robotic competitions which are hands-on activities can improve STEM content knowledge, and at the same time learning can extend beyond the content of technical challenges and into broader scientific, and social (Robinson & Stewardson 2012).

Negatives in the Use of Hands-on Instruction on STEM Education

According to Love (2013) injuries associated with hands-on design-based learning that form the basis of integrated (STEM) education is a negative reality. Wells & Ernest (2012) defined integrative (STEM) education as,

> The application of technological and engineering design based pedagogical approaches to intentionally teaching the content and practices of science and mathematics education concurrently with the content and practices of technology/engineering education. Integrative STEM education is equally applicable at the natural intersections of learning within the continuum of content areas, educational environments, and academic levels" (Wells & Ernest, 2012, para. 2).

Love (2013) saw a handsome designed-based learning as the most appropriate pedagogy and basis for STEM education concludes that safety and liability will continue to be an issue. The designed based learning strategy that defines STEM education becomes the central problem of its pedagogical practices, however, most of the STEM educators overlook the possible dangers that hands-on practices come with. Some of the dangers are accidents leading to eye injuries, lacerations, amputations and other permanent injuries resulting from STEM education classroom, laboratory and outdoor activities (Pennsylvania Department of Education [PDE], 2013; Love, 2013). Zirkel and Barnes (2010) argued that despite the potential injuries, STEM educators are to develop strategies to avoid liability and to let the advantages of hands-on learning such as laboratory experiences to foster inquiry-based science that are essential to STEM students. Roy (2011) emphasized that to be able to maintain a hands-on learning pedagogy, teacher preparation through pre-service and in-service training is very crucial to equip STEM teachers with knowledge of safety and liability involving how to develop a case law and how to save time, money, and injuries that result from accidents.

Teacher Preparation and Critical Role

According to Avery and Reeve (2013), for the United States to remain globally and economically competitive with regards to innovation and invention, the teaching of STEM has become a matter of concern in P-12 education today. To focus on the need to improve students' performance in STEM, so does the need to improve teacher performance with well-qualified STEM teachers to promote high-quality STEM programs (Merrill & Daugherty, 2010; O'Brien, 2010). Avery and Reeve (2013) suggested professional development (PD) to have the potential to offer opportunities for STEM teachers to learn how to effectively integrate various instructional approaches, including engineering design into their teaching and learning environments. Scott (2009) discussed how crucial are teachers to make sure that hands-on experiences promote thinking. Teachers' special experience in the hands-on instruction in promoting STEM education helps the students who are prepared to face the demand of the new world (Cohan & Honigsfeld, 2011). If students are directed by quality teachers to be thinking while performing, they could effectively learn new information. The process of involving quality teachers in the teaching of math and science will help to stimulate and sustain the interest of students to decide to major in STEM disciplines (Khatri & Hughes, 2012)

Satterthwaite (2010) in describing how teachers of science incorporate hands-on activities into our classroom practice to enhance STEM learning experiences, suggested: a) find out what students know before the lesson sequence begins, b) foster conversations among the students that involve asking and responding to good and thought provoking questions, c) require students to manipulate objects in usual and unusual ways and to collect this information as part of their investigation, and d) attempt to include lessons in which exploration is promoted. When the handling of hands-on teaching and learning is safe and appropriate, students are encouraged to play with the materials to help identify properties (or limitations) of the objects (Satterthwaite, 2010).

The Carnegie Corporation of New York's Institute for Advanced Study Commission on Mathematics and Science Education (Carnegie-IAS Commission, 2009) recommended professional development for teachers to help to make technology and hands-on pedagogy in the classroom effectively. Further comment revealed that:

> to lead a revolution in math and science education, teachers need opportunities to experience powerful math & science learning. Motivating relevant, inquiry-based science and math learning... should be built into teachers' initial preparation and on-going professional development. Educators also need continuing contact with fresh contact, especially in science and technology (Carnegie-IAS Commission, 2009, p. 6).

Darling-Hammond, et al. (2009) conducted a study to examine how effective professional development learning is on teacher performance and students' successes in STEM subjects. The conclusions were that teachers can learn very well in professional development activities when: a) their content knowledge is addressed as well as how best to convey that knowledge to their students, b) they understand how their students acquire specific content, c) they have the opportunities for active hands-on learning, d) they are empowered to acquire new knowledge and apply it to their own practice and reflect on the results, e) their learning is an essential part of the reform effort that commands curriculum, assessment and standards, e) learning of collaborative and collegial and f) professional development is intensive. Studies show that students who perform better in math and science are those who interact with teachers who have good hands-on laboratory skills and promote higher order learning, critical thinking and hands-on learning (Cohan & Honigsfeld, 2011).

Chalufour (2010) designed six key elements or modules for teacher Pedagogical Science Knowledge and experience to assess their ability to teach STEM subjects: a) an approach to inquiry-based science teaching that is well defined and well structured, b) carefully selected science content, c) a hands-on, inquiry-based approach to teachers' own learning, d) opportunities to apply new learning through analysis, e) performance-based assignments, and f) ongoing mentoring (p. 1).

Hang (2012) through a qualitative approach conducted a study about the perception of STEM teachers on STEM integration and classroom practices. The theoretical STEM integration framework suggested STEM integration as a model which allows teachers to focus on the real world engineering problem, application of science, problem solving through hands-on instructional strategies and independent thinking. Hang (2012) emphasized the need to have a good quality STEM integration, which requires the critical role of the teacher. Good quality STEM integration does not only have to focus on the subject that teachers teach, but also should relate to other STEM subjects standards to help teachers to be more effective to implement STEM integration in their classrooms. Similarly, Sousa and Pilecki (2013) emphasized that “the STEM initiative is not just about adding more STEM courses, but about getting teachers to recognize how each of the areas of STEM interact ... to improve students’ critical thinking skills and creativity” (pp. 18-19). Moreover, Hang (2012), stressed on professional development programs and support from school administration for teachers as very critical to promote STEM education. Through professional development programs “teachers develop a more sophisticated understanding and comprehensive strategies for classroom practices of STEM integration” (Hang, 2012, p. 241-242). STEM professionals should develop programs that provide current information to teachers on how to incorporate science and mathematics content into STEM integration lessons (Felix & Harris, 2010; Loucks-Horsley, et al. 2010). Hang (2012), further discovered few difficulties in the STEM integration study, which include students’ abilities in the STEM subjects, compatibility of STEM subjects with time and material resources.

The educational reform movement that is currently under discussion has been advocating for the integration of STEM education with a framework for K-12 science education which spells out the core concepts and best practices of science (American

Association for the Advancement of Science, (2011) & the National Research Council [NRC], 2012).

Hynes (2009) conducted a study to investigate subject matter knowledge, middle school mathematics and science teachers use in the teaching of engineering, what pedagogical content knowledge do middle school mathematics and science teachers know and use to teach engineering, and how mathematics and science teachers relate to content knowledge in the teaching of engineering. The goal of the project study was to ensure that teacher educators, curriculum developers, educational researchers, school administrators and science and math teachers were provided with information with regard to the teaching of STEM subjects. Hynes (2009), discovered that educators should focus much on the preparation of pre-service or in-service or professional development programs for teachers to master specific subject matter and pedagogical content knowledge. Hynes (2009), based on the findings of the study recommended concepts pre- and post-assessments of teachers prior knowledge of STEM curriculum, hands-on skill-building opportunities that allow teachers to interact with engineering films and software materials that relate to the subject matter, modeling instructional strategies, and generating appropriate and real-world examples.

Drew (2011) stated, “to be able to improve STEM education in America is to improve teaching. Teachers are to learn to devote much of their time to academic work, teachers are to communicate high expectations, exhibit explicit teaching skills and support" (p. 1). Teachers are to be exposed to professional development programs to revitalize content knowledge and the effective instructional strategies necessary to implement STEM. Drew (2011) further explained that one major reason why the U.S. students perform poorly in STEM subjects is lack of attention teachers have for hands-on teaching as opposed to lectures. Many STEM teachers teach subjects different from what was majored for the degrees (Drew, 2011).

Bracy, Brooks, Marlette & Locks (2013) conducted a pilot study which focused on building formal STEM teaching efficacy through hands-on teaching practices involving visits to museums, science centers and engaging students in afterschool programs, and summer programs. Quality education plays a very important role in teacher preparation for the success of STEM education, however many elementary school teachers in the areas of STEM do not have science content knowledge and the appropriate pedagogical skills (Ledbetter, 2012). Because some teachers lack the hands-on teaching efficiency, the teaching of the STEM subjects is perceived to be difficult (Bracy, et al. 2013). In the study conducted by Bracy, Brooks, Marlette and Locks (2013), the teacher candidates were made to interact with STEM professionals to learn how best elementary school teachers in areas related to STEM can improve the teaching skills through hands-on teaching experiences.

Events Leading to STEM education

This section discusses the significant events that called for educational reform strategies in the America history. The Soviet Union's launch of Sputnik 1 caused those reform strategies that had a significant impact, especially in science education in America. In 1957, the Soviet Union's launch of Sputnik 1 prompted the United States to improve the quality of science curriculum and initiatives to produce high powered scientists to challenge the nuclear attack efforts of Russia on the country as a global leader. The Soviet Union's launch of Sputnik 1 began an era of space exploration of nuclear-arms race between the U.S. and Russia. Consequently, the U.S. embarked upon intensive school-reform efforts in math and science which began during the Dwight Eisenhower administration. President Lyndon B. Johnson signed into legislation the ESEA in 1965. Before the legislation, ESEA was in the hands of the State and the local government. With the help of the federal government, several revisions, recommendations and authorization have been made about the ESEA in the course of time to make the STEM education work (Glenn, 2000).

Fifty years after the Soviet Union's launch of Sputnik 1, the U.S. is still making greater efforts to improve STEM education to train more engineers, scientists and technicians. In 1985, as part of the U.S. economic recovery effort, the National Commission of Excellence in Education (NCEE) identified an Imperative Educational

Reform strategy to improve upon American education. According to the NCES (2009), after a report on "*A Nation at Risk*" was published in 1985, there has been a growing resolve among educators and policymakers to make educational reforms as the need arises. Over 25 years, there was a dramatic improvement in the American school system.

In 2000, John Glenn, wrote to Richard W. Riley, the Secretary of Education, requesting an investigation into the quality of mathematics and science teaching in the United States. Glenn was then appointed to be the chairman of the National Commission on Mathematics and Science Teaching (NCMST). Glenn and the appointed commission were assigned a responsibility to look into improving recruitment, teacher preparation, retention and professional development for math and science teachers at all grade levels (Glenn, 2000). The Commission emphasized the importance of science and math on which the growth of the economy, social security of our nation, and the wellbeing of the people depend (Glenn, 2000).

Based on the U.S. poor performance in the TIMSS program, the Commission established evidence about the need to do a drastic reform in the teaching and learning of science and mathematics (Glenn, 2000). The Commission stressed the need for America education educators to commit all efforts to improving three specific goals to improve mathematics and science education through the "issues of quality, quantity, and an enabling work environment for teachers of mathematics and science" (Glenn, 2000, p. 5).

The commission recommended: a) establishing an ongoing system to improve the quality of mathematics and science teaching in grades K–12, b) increasing significantly the number of mathematics and science teachers and improve the quality of their preparation, and c) improving the working environment to make the teaching profession more attractive for K–12 mathematics and science teachers (Glenn, 2000).

In 2005, a bipartisan group of Senators and members of Congress in the U. S. charged a committee headed by Augustine Norman to research to provide answers to: a) the top 10 actions, in priority order, that federal policymakers could take to enhance the science and technology enterprise so that the U. S. can successfully compete, prosper, and be secure in the global community of the 21st century and b) the strategy with several concrete steps to be used to implement each of those 10 actions. The committee published "*Rising Above the Gathering Storm*" (RAGS) to focus upon the ability of America to compete in the global employment job market in the midst of fast advancing science and technology, rapidly changing global economy, changing investment patterns, changing education systems, redistribution of skilled workforces, and innovation-driven industries (RAGS, 2005).

A legislation known as *America Compete Act* (2007) was also formulated to implement some of the recommendations RAGS could not fulfil due to the fact that they were specified to expire in 3 years after the 2010 fiscal year combined with budgetary constraints. In 2007, several governments and states in the world had started giving the study of math, science, and reading a global touch due to the recommendation from a 30-member intergovernmental organization known as the Organization for Economic Cooperation and Development [OECD], 2010). The OECD, as part of its International Network of Engineers and Scientists (INES) for global responsibility, initiated the PISA in 2000 to coordinate and implement the OECD recommendations. PISA focused on the comprehensive international assessment of educational outcomes of the 15 year olds which provides member countries with internationally comparable data about the education system (Baumert, Artelt, Klieme, Neubrand, Prenzel, Schiefele, Schneider, Tillmann, & Weiss, 2002).

Additionally, PISA provided information to the member countries about how best to teach students with international standards to meet the global needs and to help schools to make the right and effective school policies. PISA is a long term project with 3 year span for assessment cycles. Each of the three assessment cycles focuses on each of the three domains of study rotating between reading literacy, math literacy and science literacy. The assessment of the first cycle took place in 2000 with the main focus on reading literacy. The second cycle assessment was in 2003 focusing on math literacy and the third cycle, 2006 assessment focused on science literacy (Baumert, et al. 2002).

The average scores and changes in average scores of 15-year-old students in PISA assessment cycle years of 2003, 2006, 2009, and 2012 revealed the trends, the fallen nature, the weakness and strengths of the U.S. in math and science education (OECD, 2012). At the other end of the performance scale, the U. S. also has a below-average share of top performers in mathematics. These top performing students can develop and work with models for complex situations, and work strategically using broad, well-developed thinking and reasoning skills. Only 2% of students in the U. S. reached the highest level (Level 6) of performance in mathematics, compared with an OECD average of 3% and 31% of students in Shanghai-China. The proportions of top performers in reading and science in the United States are both around the OECD average (OECD, 2012).

In 2000, when the PISA test was first conducted, the U.S. ranked 15th in reading and 19th in math. The U.S. Department of Education described the underperformance of U.S. students as “sobering” and took the opportunity to come out with more reforms (OECD, 2012). PISA results since 2000 has revealed that the U.S. students have not improved in the core subjects-reading, math and science, and on the more serious note, felt to have been left out by students in the member countries that people regarded as inferior socially, educationally and economically. The idea of the NCLB Act of 2001 might have advanced and initiated to improve students' performance not only in math and science, but also other areas of study (Harrington, 2011 &Macaluso, 2013).

In 2001, president Bush authorized the ESEA under the NC LB Act. The legislation of the NCLB (2001) came as a result of the need to strengthen the ESEA. The main focus of the legislation was accountability for educators on federal spending, the use of scientifically-based research and data driven and the use of standardized tests to ensure improvement in students' performance in all fields of education (NCES, 2009). According to Kepler (2011), the part of STEM featured in the NCLB Act focused on how to reauthorize and strengthen math and science partnership Program at the Department of Education through the provision of grants to states and districts to improve students' performance in STEM fields. The states and the districts that benefit from grants for STEM were expected to report comprehensive data, such as STEM teacher evaluations, student achievement in the subjects, rates of access to STEM classes, achievement gaps, and the percentage of students participating in advanced placement or International Baccalaureate STEM courses (Bybee, 2010; Oklahoma Science Education Association, 2011). The NCLB Act (2012) enjoins on the states, the districts, and the stakeholders to collaborate to:

a. Encourage and inspire more students—especially those from underrepresented or disadvantaged groups—to study in STEM fields.

b. Strengthen quality STEM instruction and professional development programs.
c. Recruit, train, and support highly effective teachers in STEM subjects and provide robust tools and supports for students and teachers.
d. A close student achievement gaps, and prepares more students to be on track to college and career readiness and success in these subjects.
e. Develop a statewide STEM education plan (Oklahoma Science Education Association, 2011).

With the nation's strong determination to strengthen and improve STEM education, the NSB (2007) came out with different recommendations to deal with the various issues that emerged from the U.S. STEM education system. Some of the recommendations include putting in place: a) Standing Committee on STEM education, b) An Assistant Secretary of Education position of the Department of Education to coordinate its efforts in STEM education with stakeholders outside the Department, and c) National Science Foundation to lead national efforts to improve pre-kindergarten to college and beyond STEM education. In 2009, the *STEM Education Coordination Act* of 2009 was passed. The Act fulfilled the National Science Board's recommendation to establish a committee under the National Science and Technology Council to coordinate STEM education activities and programs of all federal agencies.

Conclusion

Since science and math build the foundation for STEM education, the underperformance of elementary school students becomes a matter of concern to our school administrators. The continuous fall of students in science and math indicates a decline in the STEM workforce. The purpose of this qualitative program evaluation examined the success of the STEM program using the components of hands-on instruction and professional development.

Implications

The results of the program evaluation had implications on the approach to analyzing professional development programs. This project established a three-year evolution in professional development training curriculum matrix to reinforce the proper use of hands-on instructional strategy that could improve students' performance in the STEM subjects. The findings provided information about program strengths and weaknesses in relation to the improving students' performance in the STEM subjects. The school administrators of the local school and the school district have plans to use the recommendations from the evaluation as a guide for decision making.

Summary

Program goals intended to improve students' performance and enrollment in the STEM education were difficult to be established and sustained, without an assessment strategy. Because program evaluation aims at examining program effectiveness, the evaluation strategy became the best method to keep track of the success of the program. The overall purpose of the evaluation used in this study was to assess the effectiveness of the STEM program using hands-on instruction facilitated by professional development, which included program practices, weaknesses and strengths, and making recommendations for improvement. Section 2 included the detailed account of the (a) program evaluation using qualitative methodology, (b) a description of participants, (c) data collection procedures, (d) data analysis, (d) data analysis and results, (e) limitations and, (f) conclusion in section 2.

Section 2: The Methodology

Introduction

The purpose of this program evaluation was to evaluate the success of the STEM program using hands-on instructions supported by professional development programs. Section 2 described the program evaluation approach using a qualitative research design based on data gathered from the perceptions of teachers. Data from the program participants, individual interview and focus group interview, and analysis of Grade 5 students' CMT math and science documents were considered and explained. The research design described, and the instrumentation, the research data, and the data analysis was discussed.

The methodology also considered the detailed description of program evaluation as the type of evaluation design and approach, a justification for using program evaluation, the explanation showing how the program evaluation derives logically from the problem, the description of program evaluation to be conducted (goal based, outcome based, formative or summative), the overall goals, the outcome or performance measures and the overall evaluation goals.

Program Evaluation

The program evaluation research design in this study aims at systematically collecting and using information about the perceptions of teachers and the need for professional development in the effective implementation of STEM with the use of interactive learning practices. The following research questions served as a guide for the evaluation: (1) what are the teachers' perceptions of the effectiveness of the value of the innovative hands-on inquiry based pedagogy on the achievement of students in the STEM subjects? (2) what knowledge, experiences, and support do teachers need to effectively teach the STEM subjects? The findings may help to make necessary decisions and recommendations to the school administrators and the stakeholders to improve STEM education in the school district (Kellogg, 2004; Spaulding, 2009).

The program evaluation is a research design using the qualitative methodology, which aims at helping to collect data through observation, interviews, and document analysis of the participants (Lodico, Spaulding & Voegtle, 2010). The interview data were collected from the 10 STEM teachers and the documentary data were taken from 673 students in math and science over a period of 8 years from which themes were drawn and conclusions made for the program. The findings from the program evaluation may be used to help school administrators and teachers to improve instruction and students' performance in the STEM education.

Justification for Using Program Evaluation

Program evaluation mainly determines performance improvement, outcome assessment, justification, accountability, clarification and cost-effectiveness of a program to assist in making decisions and recommendations about the program (Liston, et al. 2001). Additionally, program evaluation focuses on the efficiency and the effectiveness of a program to make a change in order to improve operations (Lane, 1999). The main purpose of the study is to determine the effectiveness of professional development needed for the implementation of STEM using kinesthetic learning. Qualitative program evaluation has been selected as the appropriate methodology and research design to assist in carefully collecting and analyzing data to determine the efficiency and the effectiveness of hands-on instruction on students' achievement in STEM education.

A qualitative research design was used for the study to provide detailed and in-depth information about the effectiveness of implementing STEM education through manipulative learning. The qualitative research design provided the opportunity to gather quality information about the proper implementation of STEM through one-on-one interviews and focus group interviews to help to make evaluative decisions. Qualitative methods in evaluation program helped to explore specific facts of the implementation of STEM through hands-on practices enhanced by professional development and how to make some improvements. The ability of the qualitative research design provided in-depth and quality information about interactive and real learning to improve STEM education (Spaulding, 2009).

Although, program evaluators apply the quantitative and mixed methods used by other researchers in other fields, findings are typically slow to focus the study on determining the value of a particular program and improving the particular program (Lodico, Spaulding & Voegtle, 2010). The other research methods focus on making generalizations and proving the existence of a reality without going further steps to determine the benefits of the programs to change or improve the programs themselves. The qualitative program evaluation methodology was very relevant to the project study to determine the quality of concrete learning strategy on students' achievement in STEM education when carried out properly through professional development (Coffman, 2003; Stufflebeam, 2007).

Because program evaluation generally focuses on improving programs, the possibility of using the basic logic model approach to guide in the gathering and managing information for use throughout the program lifetime was very high (Kellogg, 2004). Logic model works well as an evaluation tool to ensure effective program planning, better documentation of resources/inputs, activities, outputs, outcomes, and impacts based on findings and shared knowledge about what works and why (Kellogg, 2004). In figure 4, the basic logic model approach demonstrates the connection between the plan works which includes resources/inputs and activities and the intended results or changes that are expected to occur also includes outputs, outcome and impact.

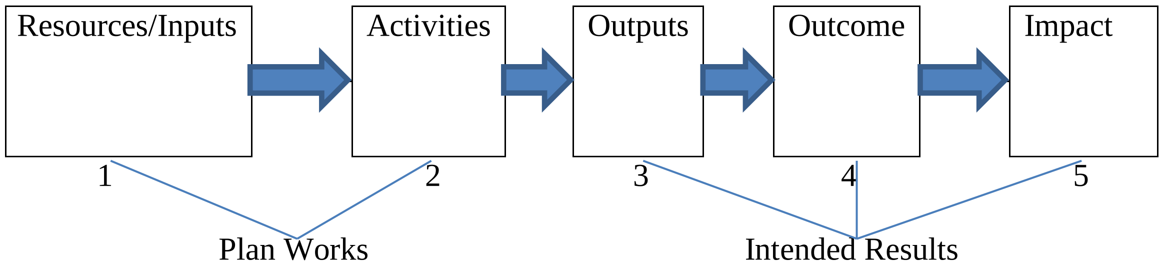

Figure 4. The Basic Logic Model. Adapted from Kellogg (2004), Logic Model Development Guide. Michigan, U.S.A. W.K. Foundation

According to Kellogg (2004), the *resources/inputs* are needed to conduct a program which includes time, money, materials, volunteers, equipment and the community. *Inputs* are the costs of conducting a program. *Program activities* are what the program does with the resources to provide improvement or learning experience to achieve a result which also includes events, camps, professional development, technology, field trips and many more. *Outputs* are the specific services and products derived from the resources/inputs to address a particular type of problem or to reach a level of performance. *Outcomes* describe the changes in the attitudes of participants after a program is concluded. Kellogg (2004) further states that program outcomes include the initial outcomes, intermediate outcomes and long-term outcomes. The initial outcomes involve knowledge, attitudes, skills and aspiration participants acquire within 1 to 3 years. Intermediate outcomes describe the changes in behavior or practice among program participants within 4 to 6 years. The intermediate outcomes fall between the initial outcome and the long-term outcomes. Long- term outcome is connected to the impact the program has had on the participants for 7 to 10 years. The *impact* is the intended change that an organization anticipates for investing in a program.

According to Lodico, Spaulding, & Voegtle, 2010), program evaluation typically involves formative and summative evaluations. Formative evaluations create periodic reports about the implementation of programs and how they work to achieve their objectives. Formative evaluation focuses on activities and outputs, and short term outcomes, monitor the progress of programs. Evaluation results may be used to provide feedback to participants about program implementation and the need to make improvement to keep programs on track (Bond, et al, 1997). Summative evaluation rather focuses on intermediate outcomes and long term outcomes (impacts).

Summative evaluation depends on the information from formative evaluation throughout the program; however, the main purpose is to determine the value and the worth of the program (Lodico, Spaulding & Voegtle, 2010). The summative evaluation used for the project study helped to describe the quality and the effectiveness of the STEM program assessing its impacts on the students (Bond, et al, 1997).

Outcome and Performance Measure

While evaluation focuses on whether a program or an intervention works to achieve its identifiable goal, performance measurement addresses the results, the outcome and the impact of the program on the participants. In other words, performance measurement focuses on continuous monitoring of results of a program by looking for signals and indicators of change to serve as benchmarks which is the focus of logic models. According to Zigon (1999), performance measurement includes activities; value added results, measures, descriptive measures and the descriptive performance measures. Through *activities*, specific actions are undertaken to produce value added results. Organizing professional development programs for teachers, engaging students in the field trips, talking to the stakeholders, providing hands-on materials such as computers and many more are activities. *Value added results* are the worthwhile outcome or impact that is left behind at the end of a program resulting from activities. *Measures* are the standards used to determine how well a result has been achieved to meet expectations. *Descriptive measures* use narratives to evaluate an accomplishment. *The descriptive performance measure* is the true description of a point that indicates that a performance has met the expected goal (Zigon (1999).

The Overall Program Evaluation Goal

The overall goal of the project study focused on professional development required for the proper implementation of STEM through hands-on instruction. The school district perceives concrete learning as an intervention for STEM with the goal of : (a) reducing the dominance of the traditional textbook and lecture instructional methods in the teaching of STEM subjects in order for teachers to help students to develop high level thinking and problem solving in this world of innovations, (b) providing the most effective and appropriate instructional strategy to the teaching of STEM subjects, (c) focusing on students-centered learning to make things easier to understand, and (d) making learning cut across all the domains of learning: psychomotor, affective and cognitive to get students have a better understanding of the tasks related to STEM careers.

The research questions served as guidelines to get a better understanding of the effectiveness of hands-on instructional methods to improve students' achievement in STEM subjects. The perceptions, beliefs and the experiences of teachers provided a good source of information about the need for professional development to implement STEM properly through kinesthetic learning to increase students' performance. A better understanding about the strengths and negatives of hands-on instructional methods can help to make an improvement to promote high level achievement in STEM subjects. The findings from the research questions will be worthwhile to formulate themes for measurement and evaluation.

Participants

Criteria for Selecting Participants

The science and math teachers. The participants for this study included 10 teachers who had between 6 to 22 years of experience in the teaching of math and science subjects with hands-on methods in the school. Data collection strategies included individual semi-structured interviews with 6 teachers and focus group semi-structured interviews with 4 teachers. The rich experience of the teachers was very important to determine the quality of the study. Creswell (2012) states the significance in having many stakeholders in the research study, however qualitative study typically requires few, but well informed participants of the study to provide in-depth, key and detailed information relevant to the study (Lodico, Spaulding & Voegtle, 2010).

Purposeful, homogeneous sampling techniques were used to select the participants to assist in understanding and describing a particular group of teachers in depth who teach in the same school and share similar characteristics in the teaching of STEM subjects (Lodico, Spaulding & Voegtle, 2010). The teachers shared common objectives and interest of using hands-on inquiry based pedagogy to promote STEM education. Through anonymity, the information and the identity of the participants were protected and not disclosed (Grinyer, 2002).

Students. With the help of the principal of the school, students' academic records were accessed through the school's website. Math and science State/District average At/Above goal and At/Above proficiency test scores of 673 students from 2006 to 2015 academic years were accessed. The students' records were necessary to track the STEM program goals and to give affirmation to the teachers' perceptions about the program.

Procedure for Gaining Access to Participants

Protocol procedure was followed seeking permission from the principal of the school and the superintendent of the school district (see Appendix B). With the permission of the superintendent of schools in the school district, the principal of the school was first consulted for permission to hand out the objectives of the study for discussion through email (see Appendices C and D). As permission was granted, the selected teachers for the individual interview and the focus group interview were informed and asked to give consent for participation through letters (see Appendices E and F). In the consent for participation, the participants were provided with sufficient information about the procedures, the risks and the benefits of the research study to avoid coercion or imposition. To maintain confidentiality and privacy, names and identities of participants were not recorded (Badger, 2007).

Methods for Establishing Researcher-Participant

A professional relationship never existed with the school before the study took place. My affiliation to the school started with the recommendation from the superintendent of schools in connection with this qualitative project study. The study school was a STEM academy, which became relevant to the study with the focus on

STEM education. Through professional courtesy, getting permission from the principal of the school through email and in person, consent for participation from the teachers through letters and the act of interviews, a trusting researcher-participant relationship was established. All data from audio tapes and electronic files will be kept much secured in the computer with a password. Data will be kept and discarded 5 years after the completion of this study.

Measures for Ethical Protection of Participants

Following approval of Walden University Internal Review Board (IRB) with IRB number: 06-10-15-0284042, the study was intended to protect participants from harm and to ensure confidentiality. All the rules of the IRB process were followed. A letter of Cooperation from the principal on behalf of the participants of the study was received spelling out voluntary participation, confidentiality, and protection from harm (see Appendix G). The participants were made aware to withdraw from participating at any point in time. Through the Consent form, the selected teachers were informed and asked to give consent for participation. Before the consent for participation, the participants were provided with sufficient information about the procedures, the risks and the benefits of the research study to avoid coercion or imposition through letters. To maintain confidentiality and privacy, their names and identities were not recorded and unique identifiers were assigned to each participant (Badger, 2007).

Data Collection Procedures

The goal of the qualitative program evaluation was to provide a means of answering the research questions and evaluating the outcome of the study. Qualitative program evaluation was used to assist in evaluating professional development necessary for the implementation of STEM through kinesthetic instruction in the study. The findings of the study helped to provide information about the effectiveness of the program as the basis for improvement. Based on the current program investment, a program evaluation was required to assess the effectiveness and worth of STEM program. The purpose of the program evaluation was to report on the perceptions and the experiences of STEM teachers about: (a) the effectiveness and the value of the innovative hands-on inquiry based pedagogy in the implementation of STEM, (b) support the teachers need to effectively teach STEM subjects, and (c) benefits and negatives in the implementation of STEM through hands-on instruction.

Data were collected through semi-structured one-on-one interviews and semi-structured focus group discussions. The semi-structured data collection method was employed to lead the participants to provide in-depth information about the value of hands-on inquiry based pedagogy in the implementation of STEM with flexibility (Lodico, Spaulding & Voegtle, 2010). Data was also collected from the student's academic records through objective-based evaluation for feedback to substantiate the teachers' points of view. The objective-based evaluation approach centered on the specification of the purpose and objectives of this study and the measurement of outcomes to bring about information for decision making (Lodico, Spaulding & Voegtle, 2010).

Justification of Data Collection Choices

The semi-structured interviews using open-ended questions allowed for further probing beyond protocol in a relaxed atmosphere to gain insight into the perceptions of the participants about the study (Lodico, Spaulding & Voegtle, 2010; Creswell, 2012). Gomm (2004) in defending the strengths in the semi-structured interview method, argued that only by developing intimate, trusting, and empathetic relationship will respondents feel able to disclose the truth. The semi-structured interviews helped to engage the teachers in the individual interview and focus group discussions to gather in-depth information based on their experience about the effectiveness and the wealth of kinesthetic methods in the implementation of STEM program. The individual interview and focus group discussions engaged the participants in a report and interactive manner to provide rich information with originality, to give the method invaluably quality (Ritchie & Lewis, 2003). The use of focus group methods provided the opportunity to bring together 4 teachers and 6 teachers for the individual interviews for the interactive instruction in the implementation of the STEM program to share their beliefs, experiences, and perceptions. The questions centered on teachers' perception of the effectiveness of concrete instruction, the potentials in hands-on instruction, how professional development training can improve STEM teachers' instruction through hands-on practices and the possible advantages and the weaknesses of hands-on instruction in the teaching of STEM subjects. Concepts and ideas were derived from open-ended questions through the semi-structured interviews to develop into themes for a decision making (Lodico, Spaulding & Voegtle, 2010). To ensure accuracy, credibility, validity, and trustworthiness of results, peer debriefing was included.

Peer debriefing. Peer debriefing also called analytic triangulation is the process whereby a researcher calls upon a disinterested peer—a peer who is not involved in the research project—to aid in probing the researchers' thinking around all parts of the research process (Guba & Lincoln, 1982; Given, 2008). A trusted colleague outside the research participant pool with special interest and a prior experience with hands-on instruction and STEM education was contacted in person on two occasions to help access the transcript, the general methodology, the findings and the final report of the research study. The qualitative data collection strategies employed, attempted to gather data from three sources to ensure triangulation and validity of the results. The following sections explain the multiple sources used to gather and triangulate the qualitative data.

One-on-one Interviews

With the permission from the teachers and out of their free will, individual interviews were conducted. The one-on-one interview involved the Grades 4 to 6 science and math teachers with the total of 6 in the school. With the open-ended program evaluation questions, participants were interviewed to elicit beliefs and perceptions about professional development needed by teachers to implement STEM through kinesthetic activities without constraints from the interviewer. The individual interview was appropriate and primarily focused on gaining insight and understanding of the program (Crewell, 2012). With the help of an audio tape recorder and interview notes, data were recorded to keep information for retrieval. In the course of the interview, the majority of the questions were created to allow flexibility to probe more questions to get an in-depth understanding of the program. Each participant spent about 45 minutes for the interview based on the number of questions that were created. The interviews ended with finding out from each of the participants if there was any other information they thought could help the study significantly.

Focus Group Interviews

The 4 participants involving the grades 1 to 6 STEM teachers formed the focus group interviews to collect shared information about the effectiveness of the program (Creswell, 2012). The same set of guiding open-ended questions used for the individual interviews was used for the focus group to elicit responses from each person in the group.

Based on the answers the participants provided, discussions were encouraged. The focus group interview lasted for 96 minutes in the conference room of the school. The interview process was very flexible to allow for further probing and clarification. The focus group interview was designed to generate data to be analyzed in different ways to strengthen its triangulation process. Data were recorded in the field notes and all responses were stored electronically on my computer and password protected. A backup was maintained on a flash drive and kept in a locked file cabinet in my home office. All electronic documents will be destroyed 5 years after the conclusion of this project study.

Students' Documents

Through the objective-based evaluation, the final reports on the state/district students' math and science test scores were analyzed to find out if the intended objectives or goals of the program were achieved to support the teachers' perception of the effectiveness of hands-on instruction program on STEM education. The analysis of students' test scores provided a very rich source of information and allowed for the verification of the impact of the STEM program. By analyzing the students' documents, there was a question as to whether a professional development program about inquiry-based instruction helped to achieve its goal or not. The use of logic model helped to check if the outcome of the program was achieved. The model helped to provide a picturesque and sequential presentation of how the program worked and the intended outcome and impact on students' performance in the STEM education (Kellogg, 2004).

The Role of the Researcher

As a concerned community member with vested interest in the STEM education program in the school district, care was taken to remain objective in the study process (Cohen, 2000; Spaulding, 2008). The degree of participation in the data collection was participant observer which helped to acquire a profound understanding and experience of the study setting and the manner in which the participants also perceived and experienced the STEM situation in the school district (Bernard, 1994). As a participant observer in the research study, the other roles such as complete observer, complete participant and observer participant were also considered based on the situation (Creswell, 2012; Lodico, Spaulding, & Voegtle, 2010).

Data Analysis

Merriam (2009) stated "the much preferred way to analyze data in a qualitative study is to do it simultaneously with data collection" (p. 171). The codes and the themes emerged from the data were used for the analysis. The application of inductive process to code text for the broad themes facilitated the data analysis. According to Creswell (2012), coding is the process of segmenting and labelling text to form descriptions and broad themes in the data. The use of coding was intended to make sense of the text data and to form answers to the research questions. Several and similar codes were reduced and aggregated into categories to form broad themes. Through coding, relevant information was selected and data that did not provide evidence for the theme were ignored (Creswell, 2012).

The data analysis went through qualitative processes. After a careful examination of the transcribed data to have a general sense of the material, coding of data began to locate text segments and assign code labels to them. Codes were further developed into themes for the report (see Appendices H and I).

The research questions were designed to elicit from the teachers' perceptions about the need for in-service training to ensure proper implementation of STEM through kinesthetic learning. Data gathered from the one-on-one interviews and the focus group interviews, and saved on the field notes, the flash drive and the computer were transcribed, scrutinized, coded and analyzed to obtain categories and common themes of the report.

Transcriptions. To facilitate the analysis and organization of data, all the transcriptions were saved in a Microsoft Word document with a password. Microsoft Word document helped to edit and create tables in the course of data analysis and to report results in narratives.

Triangulation. To ensure accuracy and credibility of the project, triangulation and member checking played a very important role. Triangulation helped to compare and examine the consistency and to determine accuracy among data from individual and focus group interviews and the literature review (Creswell, 2008). The evidence of these various sources was examined to find out the support to be provided to the themes (Creswell, 2012).

Member checking. Member checking helped to find from the participants of the study whether the information they provided was accurate. Member checking is also known as participant observation (Barbour, 2001; Doyle, 2007; Rager, 2005). The findings were taken back to participants through writing and interview to check on the accuracy of the report (Crewell, 2012).

Credibility

Credibility in qualitative research means the confidence of the data. Credibility is present when the research results mirror the views of the people under study. The findings of the evaluation program went through a critical validation process to ensure accuracy and credibility through triangulation and member checking. To determine accuracy and credibility of the qualitative evaluation program is very important because of the intention to ensure trustworthiness of the findings (Lincoln, 1985). The trustworthiness of the findings was very relevant to the evaluation program to enable confirmation of the purpose of the study**.**

Results

The purpose of the study evaluated the implementation of the STEM program through professional development using hands-on instructional approach. Data from the individual semi-structured interviews, the focus group semi-structured interviews and students' records were gathered and analyzed to provide information to evaluate the STEM program. The participants out of their own free will and time provided answers to the interview questions. The participants included 6 science and math teachers from grades 4 through to grade 6 for the individual semi-structured interviews and 4 science and math teachers from grades 2 to 6 for focus group semi-structured interviews to gather data for the analysis. The total number of participants for the study was 10 science and math teachers. To ensure confidentiality, the names and the personal details of participants were de-identified during the analysis of data. The research questions guiding the one-on-one interviews and discussions are:

RQ1: what are the teachers' perceptions of the effectiveness and the value of the innovative hands-on inquiry based pedagogy on the achievement of students in STEM subjects?

RQ2: what knowledge, experiences and support do teachers need to effectively teach STEM subjects?

In the course of the interview process, the participants shared the great efforts put in place to implement the STEM program through concrete instruction. Sometimes they had to design their own hands-on resources to teach students. Teachers' attitudes towards students were very positive. Students' interest and curiosity increased as manipulatives were used to study science and math. Teachers were inspired to learn more through their active participation in their monthly professional development programs and conferences. Teachers were interested to learn from each other about the new trends in the teaching of STEM with a hands-on approach and collaborate to make the program work. Teachers really demonstrated a positive attitude and a deep interest in the program despite the cumbersome nature in teaching STEM subjects through an authentic approach. The large compound of the research site made it very convenient for outdoor programs such as gardening, light, and shadow demonstrations and many more. The school may benefit in a great deal from the support of the community and the stakeholders.

Data Analysis and Results

The Process by which Data was Generated Gathered and Recorded

The purpose of the study was to evaluate the implementation of the STEM program using hands-on instruction facilitated by professional development programs.

The administrators of the school district have realized that much focus on lecturing instructional method does not maximize students’ performance in science and math education. Following the Walden IRB approval, a letter of cooperation was signed and received by the principal of the school. After permission was granted to conduct the study, a list of teacher participants was requested. Letters were written to request for participation at which point confidentiality and the willingness to participate were clearly spelt out. Following the acceptance of participation and reaching consent, time and date were agreed upon to the interview. One-on one interview was scheduled which took about 45 minutes each. The focus group interview took place on the same day as of the one-on-one interview, which took about 96 minutes. The interviews were audio recorded and were electronically saved on the computer which was later on transcribed into written text using Microsoft Word Document for the analysis. Member checks were made for accuracy. The major themes that emerged were:

- **Theme 1.** Effectiveness of Instructional Strategy
- **Theme 2.** Enhancing teacher quality through in-service training

Comments from the teachers revealed an acceptance of kinesthetic learning as the effective instructional approach to the learning of science and math to promote STEM education. Additional comments stressed that though, the lecturing method in the study of math and science provides the background of the study, manipulating the objects in relation to the study through hands-on instruction makes learning realistic to create a better and deeper understanding. Further remarks emphasized the need for professional development training as a means of giving the teachers the needed preparation and the competency to teach STEM with current standards. The science and math teachers' experiences and abilities to engage students in hands-on teaching and learning approach can increase students' performance in STEM education. The following steps describe how to get the consent of the science and math teachers and access to the student's test scores:

Step 1. Through email and in person, the principal of the school was consulted for permission to use the school as the research site, because of the special connection to STEM education programs. When agreement was reached, the superintendent of schools, the director of data analysis, research and technology were contacted through email and in person for permission.

Step 2. Upon the permission granted by the superintendent of schools and the principal with the signing of the letter of Cooperation, the date and time were scheduled through the principal to meet the teacher participants to sign the consent forms in person. The participant emails were given for further contacts.

Step 3. With the help of the principal of the school, date and time were scheduled for the interview. Participants were notified that the interview would be audio recorded, field notes were taken, information be kept confidential, and participation is purely voluntary. One-on-one interviews were conducted for about 45 minutes each with the 6 participants in person. The focus group followed on the same day after the one-on-one interview for about 96 minutes also in person. At the conclusion of each interview, the audio recordings and written field notes were saved electronically on the computer with a password and transcribed for analysis. Data were scrutinized, coded, and analyzed to obtain categories and common themes for the report. Member checking and analytic triangulation were involved to ensure credibility.

Step 4. After interviews were concluded, the principal emailed the website of the school district to locate the students' records where students' test scores from 2006 to 2015 could be retrieved for the analysis.

Findings, Patterns, Relationships, and Themes

By employing data triangulation strategy, data collection from the 6 science and math teachers for the one-on-one semi-structured interview and 4 science and math teachers for the focus group semi-structured interview and the students' science and math records was complete for the analysis. A total of 10 participants freely and willingly provided answers to all the interview questions. Though each individual participant provided the answers from different perspectives, they eventually turned out to provide similar answers to the interview questions. The participants were encouraged to provide very precise, but deep and quality answers to the interview questions. Based on the experience of the participants, they believed that professional development has the potentials to equip teachers with new and modern skills to effectively implement STEM by the interactive learning approach irrespective of the challenges. The themes emerged from the data analysis include: Theme 1: Effectiveness of Instructional strategy and Theme 2: Enhancing teacher quality through in-service training. The following are the research questions, the relational data findings, and the discussions of the themes.

RQ1: One-on-one science and math teacher interview and Theme 1. Theme 1, Effectiveness of Instructional Strategy was developed from the research question: what are the teachers' perceptions of the effectiveness and the value of the innovative hands-on inquiry based pedagogy on the achievement of students in STEM subjects?

Participants believed that the quality of the authentic instructional approach is a powerful tool to increase students' achievement in STEM education. Science and math students who have the opportunity to be taught through manipulatives stand the chance to have a greater achievement in STEM education. The reason is that students who engage in real hands-on practices develop a profound understanding in the STEM subjects. The participants felt that having applied the effective teaching approach to the teaching of STEM subjects will result in better achievement of students in STEM subjects.

Concerning the perceptions of the teachers about the effectiveness and the value of the hands-on inquiry based pedagogy on the achievement of students in STEM subjects, the participants indicated learning to make connections to the real world which goes beyond the classroom experience. Experiencing learning by touch increases children's curiosity and are prompted to ask questions and begin to thrive and learn more than just the isolated facts in the book. Again, kinesthetic learning is perceived by the participants as physically doing and seeing contributing to the concrete learning experience. One of the participants said hands-on is something like, "Show me and I will understand" (Teacher 3, personal communication, October 6 2015).

Additionally, the participants perceived hands-on learning as highly engaged learning approach which creates an opportunity for active and conscious involvement of students' minds and hands in the process of learning. Moreover, the kinesthetic learning approach was understood to be an authentic learning which provides an opportunity for students to explore critique, discuss in groups and partners and meaningfully construct concepts that relate to the real world problems and projects that are relevant to the learner. Hands-on learning was also perceived as a higher-ordered learning which engages students in the critical thinking skills such as making of inquiries into real problems, analyzing, synthesizing, designing, manipulating and evaluating information with a conclusion. Finally, the participants saw hands-on approach as a flexible learning approach which gives students the opportunity to analyze issues from different perspectives instead of restricting it with a particular answer. Students' responses are based on how they physically and directly interact with objects.

In addressing how hands-on instruction fits into textbook and lecturing approaches in STEM curriculum, the participants believed that the teacher first of all has to have a goal and the application of the right methodology must depend on the content, the learning styles of students, the unique approach of students to learning based on their strengths, weaknesses and preferences. The teacher therefore does not have the perfect formula. There were two views:

First, most of the participants were of the view that students learn better when made to conceptualize and intellectualize the content through lecturing before making connections through manipulatives. Furthermore, participants believed that giving the students the background knowledge and prerequisites of the area of study gives the students the foundation. As students' understanding gets stronger and stronger, they are allowed to manipulate objects with the proper guidance of the teacher.

Another participant gave an example of how the proper application of lecturing and hands-on experience promoted a better understanding of students in the teaching of "Light and Shadows". The purpose of the lesson was to provide students with a fundamental understanding of light and how light can travel through objects. The children were to discover how the change in distance of an object from a light source can change the size of a shadow. On a sunny day, after about 10 to 15 minute lecture was delivered in the background to light and shadow in relation to the rotation of the earth around the sun, ordered the students to go outside to measure, track and record their shadows with their names on them. The students saw changes in the direction, distances, and the sizes of their shadows. Students were given a better understanding that the sun remains stationary, but the planets such as the earth moves to change objects. The students also understood that light travels through straight lines and is able to pass through transparent objects, but when hit opaque objects; the light beam cannot pass through which then cast shadows to produce darkness. The side which is far away from the sun causes the night and the side which faces the sun is day. According to the teacher, the interactive method of learning, intends to reinforce what was learned in the classroom lecturing. The main intention of this lesson was to prepare the students to take up careers in the fields of science such as astronomy, biology, and engineering.

Another participant also added that before teaching fractions in math, 10 minute lectures was provided to give the students the background of the lesson. Later on, fraction bars were introduced to students to alleviate difficulties with abstract. The students were made to touch the fraction bars as manipulative. One whole bar was given to every student and were asked to break up into four. The students were told to subtract 1 out of the 4 to make ¼ remaining ¾. Accordingly, the use of fraction bars provided a hands-on instruction to reinforce concrete and make representations of the abstract. As the children were allowed to manipulate with the fraction bars on their own, they became interested in what they were doing and asked so many questions to find a solution to the fraction problem. This created some level of inquiry based learning. The conclusion was that when abstract principles are used in conjunction with concrete skills, students get a better understanding of what they study (Harrison & Harrison, 1986; Suydam & Higgins, 1977).

With the second school of thought, participants indicated learning from the concrete through hands-on to abstract through lecturing. There are some students who need to see and hold on to something before they can intellectualize. Such students need a concrete representational, abstract sequence of instruction. In the process, teachers give students the opportunities to manipulate and master what they are learning by hand before engaging in lecturing to build concepts. Learning through concrete experience is very common with the majority of students who have science and math learning problems. Students who are allowed to develop a concrete understanding of issues are much more likely to perform in science and math with excellence.

In view of why there has been a much more concern of hands-on over lecturing methods, the participants believed that lecturing does not need to be against the methodology of instruction. Though lecturing allows teachers to share their expertise, explain the contents clearly and provide the background information about the area of study, making the teaching and learning more interactive helps the students to get a better understanding of math and science concepts. Based on their experience with the use of more actively engaged learning, students' performance has improved about 20% better than they were using more lecturing. One of the participants added that “since active learning increases students’ performance in STEM, teachers need to step back from too much lecturing and move forward with active and direct approach” (Teacher 4, personal communication, October 6 2015).

The interviewees also pointed out that concrete and manipulative learning has existed for over 30 years. But because many people are retiring from scientific fields, there should be much more emphasis on inquiry based method in the teaching of STEM to inspire and equip students to fill those positions. The participants believed that based on their own experience, students’ attitude towards math and science has been very negative over the years, and that attitude tends to be more negative as pupils move from the elementary to secondary level. The general attitude of students towards math and science relates to the approach of teaching and to the psycho-social climate of the teaching environment. The authentic learning approach was subscribed as the better approach with the potential to build students' interest in math and science fields.

On the other hand, the participants expressed concern that though the reasons in support of the emphasis of manipulative based instruction over lecturing are true, students' assessment driven by Computerized High State Testing (CHST) gives the schools less opportunity for hands-on learning activities. The majority of the education policymakers do not understand the process of learning. Assessment of students navigating through evidence and coming out with conclusion has not been easy. Teachers therefore go through the easy way, the multiple test questions to test students. The CHST testing attitude of educators moves the teachers to teach according to the standardized test requirements instead of teaching the realities of life through hands-on.

In describing the specific resources available for hands-on, the participants believed that teachers do not need complex material resources doing science at the elementary level. Students need to be frequently given opportunities to go outside the classroom, experience playing with science tools such as fraction bars, images of what they study, seeing real life, real plants, growing things, going to field trips and excursions, observing real changes in weather and seasons and many more. Teachers can invent things using simple materials. One participant shared that students were put in an air conditioned room for 10 minutes and later on, put them in a non-air conditioned room for the same minutes. Students' feelings indicated a real experience of the changes in the weather temperature in the room helping to get a better understanding of the changes in the weather conditions which resulted from the changes in the seasons. In the teaching of math, participants believed that students at the elementary schools do not need to do many calculations. Students are to be exposed to how to use measurement tools, estimate sizes, weight, and distances and so on. Again, students are to be made to know motions: how slowly and how fast things move so that by seeing the formulas, speed problems can be identified.

In response to the question of how to integrate manipulatives into the curriculum in making the teaching of STEM subjects effective, the participants perceived that most of the students in elementary schools have a hard time with the abstracts. And the best way to integrate kinesthetic practices into the curriculum is to have a program design that supports active engagement of students in hands-on activities. One participant said, “if you are teaching Fractions, use fractions bars. If you want to teach Light and Shadows, go outside the classroom during the daylight. If you are teaching plants, let students go out to observe plant growth” (Teacher 4, personal communication, October 6 2015).

The participants concluded that hands-on has been characterized with active engagement of students’ minds and hands, inquiry and investigation of objects or ideas, object-centered learning, student centered learning, experiential learning and cooperative learning. In response to how the characteristic features and the potentials in hands-on instruction can enhance the teaching of STEM subjects, the participants agreed that active engagement of students' minds and hands helps students to translate what is learned into reality: inquiry and investigation of objects or ideas to promote discoveries and inventions. Object-centered learning allows the manipulation of objects to be led to an in depth understanding of the subject matter. Student-centered learning allows students to construct knowledge through interactions. Experiential learning may lead to critical thinking. Cooperative learning will help students to learn in an experiment or laboratory activities together as a team.

To elicit from participants based on their experiences and perception about the benefits of hand-on instruction in STEM education, they indicated, (a) students learn authentically to bring about improvement in their retention and retrieval levels, (b) the learning process of students empowers and stimulates them to learn more, (c) students learn and have fun learning, (d) students learn to have a sense of accomplishment when an activity is completed (e) studying by doing instills in students the understanding as they touch and see what they study, (f) students learn based on evidence rather than on authority, (g) students learn better interpretation of events instead of memorization and greater achievement in STEM content, (h) students experience increased skill proficiency, increased perception and creativity, and (i) students have much flexibility and freedom to study.

The participants indicated the following negatives in the making of the study of STEM interactive. The use of hands-on is messy, because of its involvement in taking things apart, cutting things into pieces, touching things, learning from real life, getting students dirty at times, making noise and taking them from their comfort zones. One of the participants shared her experience when she took her grade 4 students to the farm to study plant growth. The principal responded, "Keep your students from getting dirty. Don't let them make a mess (Teacher 4, personal communication, October 6 2015)". Secondly, the unstructuredness of hands-on instruction does not promote predictability. Students are required to get out of order that sometimes slows down the process of following the rubrics and to arrive at a solution. The climate of the class dictates the lecture and skill development.

Again, hands-on strategy does not fit into the school schedule at all seasons since they are sometimes weather dependent. A lot of planning and time go into hands-on instruction in getting things ready for the class. Additionally, because hands-on teaching strategy involves a certain amount of flexibility, students easily lose focus. Sometimes students misuse the materials given them to cause distractions as they use them as toys and play with them. The participants did not deduce anything physically harmful from learning kinesthetically at the elementary level except the possibility of fewer chemicals and electrical accidents that may occur if student are not closely monitored. The teachers admitted that if proper care is taken to monitor students in the learning process, making the study of STEM interactive will make teaching and learning very be effective.

RQ2: One-on-one science and math teachers' interview and Theme 2. Theme 2, Enhancing teacher quality through in-service training was derived from the research question: what knowledge, experiences and support do teachers need to effectively teach STEM subjects? The participants supported the idea of teacher competency and agreed that teachers are to have confidence and a basic knowledge about the area of study, the professional ability, and the ability to allow students to manipulate objects to make discoveries and help have answers to the questions. The participants felt that with the changes in education and the accountable testing, teachers are to be abreast with the dynamics of hands-on instruction in relation to STEM education in order to be able to help students to achieve good results. Consequently, teachers need to be provided opportunities to attend professional development programs at the school, district and state levels. Additionally, creating an environment for peer coaching, cooperative workshops and engaging teachers in the activities that relate to manipulative learning can improve their teaching skills.

The participants admitted that the professional development programs about hands-on activities are available in the school and the school district and in the state; however, finding time to learn about the use of them is the problem. The teachers then expressed the need for principals and administrators of schools to make professional development activities not only on STEM their primary focus to support the teachers and their continuous development. Finally, all the participants based on their experiences believed that the quality of the teacher on hands-on instruction correlate with the quality of teaching in STEM subjects leading to students' high achievement.

The participants concluded that the teaching experience, content knowledge, credential and academic ability levels of the teacher in kinesthetic learning approach can impact the teaching of STEM. Participants believed that professional development opportunities for teachers are to be made available on a regular basis to promote teacher confidence and effective teaching of STEM which will in turn ensure high achievement of students' test scores.

RQ1: Focus Group science and math teacher interview and Theme 1. Theme 1, Effectiveness of Instructional Strategy was developed from the research question: what are the teachers' perceptions of the effectiveness and the value of the innovative hands-on inquiry based pedagogy on the achievement of students in STEM subjects?

The responses from the focus group revealed that hands-on professional development is very beneficial and necessary in the implementation of STEM subjects. The responses were almost similar to the themes of the one-on-one interview. Students' achievement in STEM subjects is more likely to maximize if the teaching strategy is more of the interactive type. All the 4 members of the focus group supported and appreciated the benefits and the effectiveness of hands-on pedagogy in the teaching of STEM subjects most especially at the elementary level. The participants felt that since a lot of learning or disposition towards learning occurs at the elementary school years, students are to be exposed to authentic learning which will help them to develop skills in problem solving at the early stages of their school life.

The participants perceived hands-on approach as: (a) skilled learning approach leading to a higher level of participation with a career orientation, (b) active learning approach leading to a higher level participation, (c) inquiry-based learning with the ability to increase students' curiosity and critical thinking skills, (d) creative learning helping students to take initiatives to construct their own products, and (e) higher-ordered learning leading to the construction of knowledge. Most of the perceptions of teachers on hands-on in STEM were positive.

In response to the question of how actively engaged instruction fits into the lecturing approaches in the STEM curriculum. The participants based on the learning styles of the students to respond to the question. The responses indicated that teachers are to incorporate hands-on approach in the curriculum with students who easily learn kinesthetically to help them reach the highest level of understanding. On the other hand, teachers are to do lecturing on verbal and visual learners and be assisted to translate learning into reality through manipulatives. Participants believed that in all the different learning styles of students, teachers are to incorporate real life learning experience into the curriculum to improve performance.

On the question of why there has been a shift from lecturing approach to hands-on approach in STEM curriculum, the participants shared that although, lectures are the easiest and the most economical way to educate students, they provide low retention rate in students. The participants shared that the elementary school students' attention and retention rates are between 10 to 15 minutes of lecturing. Class time on math and science beyond 15 minutes are highly engaged to make teaching more effective. One of the participants said, "by reducing lecturing from class time and promoting more hands-on makes the teaching of science and math more engaging and active" (Teacher 4, personal communication, October 6 2015). Again, the emphasis was that the only way students can be trained to occupy engineering and manufacturing industries in this modern technological world is by hands-on instruction.

However, the participants revealed that though in principle, there is the shift, in reality hands-on instruction is not fully practiced. Teachers who fully put hands-on instructional strategy into practice are those who have the motivation of the school. The participants believed that the NCLB Art associated with its standardized test scores and assessment favored the lecturing methods. Teachers are tempted to push aside hand-on instruction because of its cumbersome and time consuming nature of assessment. However, since the research site is a STEM school, teachers get enough opportunities and the motivation through in-service training at the school, district and state levels to improve students' performance.

Participants cited some of the examples of hands-on resources as opportunities to enhance the teaching of STEM. Some of which are field trips, lab activities, videos, teaching and learning objects, games/digital labs, gardening, outreach programs, visit to the STEM related professional associations, after school enrichment programs, partnering with a University or museum and many more. One of the participants stated categorically that "you cannot do science and math without hands-on, students' natural curiosity should drive the STEM curriculum and be turned into learning opportunities" (Teacher 3, personal communication, October 6, 2016). If students should ask for instance, "how does an airplane fly"?, "How do cars move"?, These questions should lead the teacher to incorporate the appropriate hands-on resources or STEM related professional associations into the curriculum to provide answers.

According to the participants, hands-on has been characterized as multimodal/sensory learning which gives the students the multiple opportunities to learn STEM subjects by touch, sight, hearing and taste. A participant said "when teachers turn science and math lessons into that which students can see, touch, feel, hear, and experience provides them with great opportunities for differentiated learning" (Teacher 4, personal communication, October 6, 2016). Again, the participants saw concrete learning as that which supports direct teaching in making abstract concepts concrete.

Moreover, the participants believed hands-on to be an explanatory approach which gives the students the chance to manipulate materials under the flexible guidance of the teacher to stimulate interest and courage to raise questions. Again, hands-on is a discovery approach which gives the students the opportunity to handle materials to work with to discover things on their own under the guidance of the teacher to give them a better understanding of how science works. Finally, hands-on is characterized with inquiry approach which stimulates thinking and questioning in students in the course of interacting with hands-on materials in finding solutions to problems. The teacher's main role is to provide guidance in providing answers to questions.

The participants felt that hands-on resources have the potential for authentic problem solving and students' interest for teaching STEM subjects. The respondents further indicated the implications of teacher preparation, curriculum development and coordinated public and private partnerships with the schools.

Participants also revealed 6 benefits of interactive approach to learning STEM: (a) making students active learners, promote a higher level of participation and motivation, increase students' interests and understanding, (b) leading to the construction of knowledge by the students themselves, (c) repeated actions on hands-on allowing students to remember how things are done better than those simply memorized theories, (d) the easiest way of teaching that is more conducive to information retention, (e) making STEM education more relevant for today's industries, prepare students to be most effective when they enter the workforce fully ready to compete in the technological world, and (f) having the ability to promote the teaching of critical thinking and real life problem solving skills to maximize students' performance in STEM subjects.

The participants shared the same perception with one-on-one respondents. Apart from the cumbersome nature in setting up the manipulatives for learning, the use of hands-on activities is messy and time consuming, which can cause students to lose essential concepts in the area of study. The over engagement of students in the manipulatives limits the minds-on factor leading to lack of professional guidance which disconnects them from theory informing practice. Occasionally, students manipulate hands-on materials to make fun and in so doing, does not always result in learning.

RQ2: Focus Group science and math teacher interview and Theme 2. Theme 2, Enhancing teacher quality through in-service training was derived from the research question: what knowledge, experiences and support do teachers need to effectively teach STEM subjects? The respondents revealed that hands-on professional development has been very beneficial and necessary in the implementation of STEM subjects. The responses were almost similar to the themes of the one-on-one interview. STEM Professional development training, conferences, and workshops organized at the school and state levels and learning from the experienced colleague teachers were strongly recommended.

The participants emphasized a special professional design for STEM teachers to ensure the effectiveness of the implementation of the STEM program using hands-on instructions. The respondents realized that though the school is making efforts to increase the subject-matter knowledge of teachers in hands-on strategy in the teaching of STEM, professional development programs should be continuous and constant to ensure its effectiveness. Teachers are expected to show professionalism in the teaching of STEM with the current and emerging hands-on technology tools, new curriculum resources and teaching strategy. Teachers are to exhibit mastery of teaching STEM with manipulatives and provide opportunities for students to have a real experience of what they study.

Participants' responses were almost similar to the one-on-one interview outcome in the area of credential, professional ability, theoretical and practical knowledge and experience levels of teachers in the authentic way of learning STEM subjects. The respondents revealed that the quality of teachers increases students' learning and achievement in STEM, especially when professional training focuses on teacher skilled training which intends to address the major challenges in teaching. Professional development becomes effective on students' performance when the teaching performance of teachers improves and teachers becoming better educators. Students need to be coached and facilitated by seasoned and well experienced teachers to be able to handle hands-on materials beneficially.

Students' Documents. The state by district/school Connecticut Mastery Test (CMT) math and science scores of students in Grade 5 were used as program documents from 2006 to 2015 academic years for the analysis. CMT math and science scores were examined and compared with the actual practice. By examining the provision of best practices, coaching and monitoring processes of program directives, students' documents were reviewed to determine program goals and the progression of these goals. Students' records were reported in report tables as indicated in table 2 and table 3.

Table 2

State by District/School Report, Grade 5 Math Scores

2- State by District/School Report, Grade 5 Math Scores

Year	Number Tested	Average Score	% At/Above Goal	% At/Above Proficiency
2006	42	259.4	66.7	81
2007	41	265.6	73.2	90.2

2008	43	288.5	86	95.3
2009	42	278.4	73.8	90.5
2010	41	293.5	78	95.1
2011	42	276.2	73.8	92.9
2012	40	179.9	77.5	90
2013	44	269.1	68.2	81.8
2014	NV	NV	NV	NV
2015	NV	NV	NV	NV

Note. Adapted from student performance results on the Data Interaction for Connecticut Mastery Test (CMT), 2006-2015 academic years 4th Generation at the school, district, and state levels. Retrieved from http://solutions1.emetric.net/captpublic/Default.aspx

Table 3

State by District/School Report, Grade 5 Science Scores

3-State by District/School Report, Grade 5 Science Scores

Year	Number tested	Average Scale Score	% At/Above Goal	% At/above Proficiency
2006	NA	NA	NA	NA
2007	NA	NA	NA	NA

2008	43	288.5	86.0	100.0
2009	42	292.4	92.9	100.0
2010	43	276.7	69.8	88.4
2011	42	276.2	73.8	88.1
2012	40	282.3	75.0	92.5
2013	45	274.4	73.3	84.4
2014	41	263.6	63.4	92.7
2015	42	276.2	76.2	97.6

Note. Adapted from student performance results on the Data Interaction for Connecticut Mastery Test (CMT), 2006-2015 academic years 4th Generation at the school, district, and state levels. Retrieved from http://solutions1.emetric.net/captpublic/Default.aspx

Table 2 and table 3 indicate the program document of students' results in science and math from 2006 academic year to 2015 academic year. The CMT provided a source of information for a better evaluation. The percentage of the at/above goal for both science and math is over 70% and that of the at/above proficient is over 90%. The student test scores in science and math provide a great deal of evidence of the effectiveness in the implementation of STEM using hands-on instruction influenced by professional development. The fluctuations in the results might be influenced among other things by teacher-complacency leading to low commitment to professional development on hands-on instruction. The rise in the at/above goal and that of the at/above proficient in recent years, especially in science suggests a recommitment to appropriate hands-on activities influenced by professional development.

The good performance of students' test scores from 2006 academic year to 2015 academic years in math and science confirms the teachers' perception that hands-on pedagogy needed by professional development has the potential to make the STEM program a success. In spite of the fluctuations in the results, the student document could reveal a positive pattern to make a suitable evaluation.

Limitations

In spite of the appropriateness of the qualitative research method to gather data to evaluate the implementation of the STEM program with an active engagement, teaching strategy, there were possible limitations in the study that might affect the validity, reliability and, generalization of findings. Though the data were actually collected from the right participants, by subjecting them to reflection, the validity of the study results may be weakened. For the lack of time, data collected through the individual and the focus group interviews occurred once without multiple follow ups. The lack of multiple data collections did not create enough room to confirm and clarify the specific concepts which might reduce precision and validity of the results. On the other hand, though there were no follow up interviews, there is a strong belief that the one-time interview could provide detailed and basic information needed to evaluate the STEM program. The sample used for the study included only students in Grade 5 and teachers in a specific research site which is possible to affect generalization. In spite of the possible limitations that were discovered, a great effort in the areas of triangulation, member checking and objectivity were made to ensure the validity, accuracy and reliability of results.

Conclusion

The study aimed at collecting data to evaluate the implementation of the STEM program involving highly engaged learning practices. Data provided the right answers to the research questions which were also coherent with the conceptual framework and the literature review. The use of qualitative program evaluation design allowed data to be collected through semi-structured interviews and students' documents. Participants' included one-on-one and focus group interviews intended to collect data from the perceptions and beliefs of the teachers about the worth and the value of hands-on inquiry based pedagogy and the impact on the implementation STEM program.

The analysis of data revealed that hands-on pedagogy has the potential to make students active learners, promote a higher level of participation and motivation, to increase students' interest and understanding, to lead, to the construction of knowledge by the students themselves, and to bring greater retention of program material to increase performance. Furthermore, students' performed better when kinesthetic learning approach is used to illustrate the principles of science and math. Although, lecturing and textbook method in the study of math and science provide the background and conceptual framework of the study, manipulating the objects in relation to the study through hands-on makes learning realistic to create a better and deeper understanding. Additionally, students' curiosity increased as they participated in the highly engaged learning which resulted in great achievement. Moreover, teacher quality through professional development is also crucial in the implementation of STEM education. Students needed to be coached by well experienced teachers who will be abreast with handling hands-on materials to effectively teach STEM subjects. Students' documents were presented through the logic model analysis to complete the program evaluation. Data were provided from the research site and the school district useful information about professional development needed in the implementation of STEM using hands-on instruction.

Section 3: The Project

Introduction

Section 3 describes the program evaluation and how evaluation reports could address the problem of how hands-on inquiry-based pedagogy impacts STEM education. Discussions included a description and goals, rationale, literature review, implementation, project evaluation and implementation of social change: local community and far reaching. The findings and the reports from the program evaluation provided a credible source of information and suggestions to STEM teachers, principals, superintendents of schools and the school district as a whole in making the teaching of STEM subjects at the elementary level highly engaged and interactive.

The study revealed that a hands-on approach has proven to be very beneficial when well applied to the study of STEM subjects. Students' performance in STEM subjects is more likely to improve when kinesthetic teaching and learning approach is used in a more appropriate way. After a thorough data analysis of the participants' perception, agreement was reached that concrete learning approach to the teaching of STEM subjects was very positive. The analysis of students' reports and documents supported and confirmed the perceptions of the participants. The findings of the study recommended that getting students active and practically involved in the teaching of the STEM subjects be promoted intensely.

Program Description and Goals

The purpose of this project was to examine how the direct and realistic instructional approach to STEM subjects can effectively and valuably offer motivation for professional development opportunities. The practice of focusing on hands-on pedagogy to improve STEM education as the study site has existed for 9 years. The study was conducted in 2014/15 academic year. Data were collected through the one-on-one semi-structured interviews and focus group semi-structured interviews and students' science and math test scores. The interview questions intended to provide answers to the research questions. The research questions for the study are:

QR 1: what are the teachers' perceptions of the effectiveness and the value of the innovative hands-on inquiry based pedagogy on the achievement of students in STEM subjects?

QR 2: what knowledge, experiences and support do teachers need to effectively teach STEM subjects?

Project Goal

The overall goal of the project was to conduct a program evaluation. The findings of the study identified that kinesthetic and inquiry based practices are very appropriate for instructing students at the elementary level in STEM subjects. The findings were presented to the Superintendent of schools in the school district, the principal and the

STEM elementary teachers in the research site. Recommendations were made to the school administrators to promote and emphasize the use of hands-on instruction in the teaching of STEM subjects appropriately. Reports included teachers' perceptions of authentic learning practices and the benefit to STEM education. Reports presented the summary of the methodology and how data were evaluated.

Rationale

The program evaluation intended to gather and analyze data from teachers' perceptions about the effectiveness of direct and interactive instructional approach on STEM education at the Grade 5 level. The findings may help to make recommendations and suggestions to the school district administrators and the stakeholders of the school about maximizing the making of the teaching of STEM subjects as practicable as possible to improve students' performance. The main objective of the study focused on gathering and analyzing data to evaluate hands-on inquiry based pedagogy on STEM education enhanced by professional development. The use of program evaluation methodology was very appropriate for the study because of the potential to determine the effectiveness of an existing program to help make recommendations to the stakeholders and the administrators of schools with positive change (Lodico, Spaulding, & Voegtle, 2010 & Creswell, 2008). The school district administrators decided to increase kinesthetic and inquiry based instructional activities in the research site as a model of STEM education in the district to improve students' performance. The literature review revealed that students nationwide perform poorly in STEM subjects. Program evaluation helped to validate hands-on inquiry based pedagogy as the credible option to improve students' performance in STEM subjects. Program evaluation used a qualitative approach to gather and analyze data through individual, focus group interviews and students' documents to address the research problem.

The project provided a solution to the research problem by focusing on evaluating kinesthetic instructional approach and its ability to improve students' performance in STEM subjects. Through interviews and students' documents, data were collected and analyzed to reveal the outcome of the benefits of experiential and active learning approach of STEM education. The findings of the study helped to suggest and to make recommendations to the school administrators in the district about the need to intensify and apply the appropriate instructional strategy to improve students' performance in STEM subjects.

Through the one-on one interview and the focus group interview, professional development using the hands-on instructional strategy has been proven to improve students' performance in STEM education. Summative evaluation on students' CMT math and science test scores was used to determine the effectiveness of the STEM program. The summative evaluation used for the project study helped to describe the quality and the effectiveness of the STEM program assessing its impacts on the students.

Literature Review

The literature review focused on the program evaluation, the theory, and research that informed the content and the choice to the study. The choice of using program evaluation was appropriate because the fundamental purpose of the study was to find out the benefits, the value and the effectiveness of hands-on pedagogy on the STEM education to assist in making decisions to the school administrator and the teachers in the research site. According to Spaulding et al. (2009), program evaluation is conducted to examine program of activities to determine the worth for decision-making and recommendation purposes. Through the use of qualitative approach, program evaluation was to help explore specific facts and provide in-depth information about the actively engaged instructional strategy to improve STEM education (Spaulding, et al., 2009). The summative findings of the study would be useful for the school administrators and the stakeholders in the school district by concentrating on hands-on instructional strategy as a tool to improve students' performance in STEM subjects.

The study made good use of good Journal Articles, Theses, Dissertations and books from the Walden University Library database, Questia, Google Scholar, ERIC, ProQuest Central, EBSCO host and Sage full-text database. The following terms in a variety of combinations and truncations were used to conduct the literature review: *journal of information technology, educational researcher, educational psychology, the technology teacher, American journal of evaluation, journal of pan-pacific association of applied linguistics, transportation research part A, new directions for evaluation New Directions for Evaluation, educational evaluation, educational leadership, educational psychology, journal of chemical education, journal of staff development, educational communication & technology journal* and *the evaluation exchange.* The literature used to be as current as possible falling within a five year period. Saturation point was reached.

Program Evaluation

The objective of the study was to help the school administrator, the STEM teachers of the school, the students, and the stakeholders of the school to have a deep understanding about the effectiveness of professional development using hands-on approach in the teaching of STEM subjects. The study provided sufficient information for the school administrators and the stakeholders about the need to improve professional development by actively involving students in the teaching of STEM subjects. Clement & Bigby (2011) are of the view that, program evaluation has the ability to assess the quality of a program that is being implemented and how it meets its purpose and mission to have an impact. Program evaluation was chosen to find out how well students were performing in STEM being implemented and whether professional development focusing on realistic and direct instructional approach was effective.

According to Ben-Elia and Shiftan (2010), program evaluation helps to carefully collect information about a program in order to make necessary decisions about the program as to whether to continue with the program or not. And with program evaluation, researchers are able to examine into details of a specific program being implemented leading to establish a strong basis for decision-making (Merriam, 2009; Yong-Lyon, 2011; Zohrabi, 2012). The program evaluation project was conducted to provide findings about the implementation of the STEM program with kinesthetic and active learning approach facilitated by professional development to the school administrators and stakeholders for decision-making in an attempt to meet the school's goal. Program evaluation is categorized into three levels based on the implications for approaches to evaluation. They are mega, macro and micro levels of evaluation (Wright, et al., 2012). The mega level evaluation is a whole government program which involves sub-programs offered by multiple agencies and the overall impact on the people. Macro level evaluation involves evaluations of programs within multiple agencies or departments. The micro level evaluation is the responsibility of agency units or individuals. The study was based on micro-level evaluation approach. Sometimes, the outcomes of programs and the impacts are hard to discover (Miller & Dalton, 2011). Using a program evaluation approach to conduct the study was very appropriate to discover the effectiveness of professional development with hands-on approach in the implementation of STEM program.

Summative Evaluation

The study focused on summative evaluation, which assessed the efficacy of the program activities to ensure worth, value, effectiveness, and impact (Lodico, Spaulding, & Voegtle, 2010. The program evaluation approach is based on the outcome of the program as evidence for judgement and decision making (Stone, et al. 2010). Summative evaluation becomes more or less the conclusion of the program of activities going through a series of formative evaluation to assess the effectiveness of the program. The findings of summative evaluation are to be used to help decide whether a program is to be continued as a long term project or adopted or modified for improving (Sawyer, 2012; Biron & Karanika-Murray, 2013).

The study was conducted to determine the success of the STEM program using an interactive and actively engaging teaching approach and in-service training. The outcome helped to make recommendations to the school administrators to maximize the use of hands-on as a long term project with long term benefits to improve STEM education among students at the elementary level.

Evaluation Report

An evaluation report is a product of an evaluated or monitored program which represents the findings, conclusions, and recommendations of a particular evaluation to guide a program improvement or decision-making for program staff, stakeholders and the funders for further improvement (United Nations, 2012; Lavinghouze & Jernigan, 2013).

Evaluation results are to be communicated with transparency and clarity about the rationale, the program, evaluation design, activities and recommendations (United Nations, 2012). Evaluation report in turn creates awareness and the basis for asking questions for support, to facilitate growth, and to make improvement (Lavinghouze & Jernigan, 2013). According to Merriam (2009) a project has to be communicated in order to have an impact. Lavinghouze and Jernigan (2013) added that evaluation results are to provide credible evidence to strengthen the evaluation process and to increase the likelihood for decision making and improvement.

Reports of evaluation results are very significant in the program evaluation process. Information from reports, suggestions and recommendations are to be made to strengthen the evaluation process for decision making (UNFPA, 2012). The findings from this project were peer debriefed and communicated with some level of accuracy and credibility to the school administrators, the STEM teachers and the stakeholders of the school for decision making and improvement.

Implementation

According to Luo (2010), an evaluator's role is not to give a summative judgement of a study, but to make recommendations for incremental changes according to feedback. Essentially, evaluators should have frequent meetings with the program administrators (Volkov, 2011). Therefore, meetings were scheduled with the school administrators, the STEM teachers and the stakeholders of the school to present to them the results of the study about the value of hands-on activities needed by professional development training to make the implementation of the STEM program in the school effective. Again, a great effort was made to be an ex-officio member of the STEM program administrators to continue to offer insight into the results of the study.

Potential Resources and Existing Supports

By virtue of the position as an investigator of the effectiveness of hands-on instruction in STEM education, a request was made to be an ex-officio member of the STEM program committee to provide an opportunity to be a resource for the local school and the school district. Furthermore, as an ex-officio member of the STEM program committee, a meeting has been requested to meet the STEM program administrators and instructors to share the findings of the evaluation report for implementation. The move to help to improve the STEM program in the school will involve having meetings with the school administrator, the STEM program administrators and the stakeholders of the school to explain the findings of the program evaluation through power point presentations and handouts.

Potential Barriers

Potential barriers in the implementation of the findings of the study would be time, financial, personnel, and material resources. Teachers struggle with time and resource constraints for strategizing and planning on making room for change in practice in the newly created STEM program as indicated in the interview process. As a result, teachers spend more time instructing students and less time and resources for professional development opportunities for hands on instruction (Editorial Projects in Education Research Center, 2011). According to the research participants, the setting up of manipulatives for learning may be cumbersome, leading teachers to be more comfortable lecturing than hands-on instruction. The over the engagement of students in the manipulatives can limit the minds-on factor possible to cause a loss of essential concepts in the area of study. Teachers perceived that sometime students manipulate hands-on materials to make fun and in so doing does not always result in learning.

Proposal for Implementation and Timetable

The findings of the evaluation report will be submitted to the school district when program evaluation has been completed as a working document to guide the STEM education program in the district. With the permission of the school district, copies of the report will be given to the stakeholders of the school. Once the program evaluation has been completed, the findings of the study will be shared, along with an evaluation report, with the program administrators of the local school. The program evaluation report will be revised when necessary to meet the needs of students at the elementary level for the future academic years.

Roles and Responsibilities of Students and Others

As a concerned researcher in the school, access to participants was easy. The process of peer debriefing and triangulation was reached to ensure validity of results. The informed consent procedure was carefully observed to ensure confidentiality and to protect participants from harm. In the course of the actual semi-structured interview process, open-ended questioning procedures were cautiously followed to give the participants the flexibility to provide open answers to avoid leading the participants to make objective contributions (Rubin & Rubin, 2011).

Science and math teachers were the interviewees of this qualitative study. The participants' worth of knowledge and experiences about the teaching of math and science with hands-on instructions needed by professional development training were very essential (Lodico, Spaulding, & Voegtle, 2010; Creswell, 2012). The participants' perceptions about the effectiveness of concrete learning on STEM subjects and their knowledge about the need for professional development training provided the basis for appropriate instruction to improve student's performance. The role of the researcher was to get a better understanding of the perceptions of the STEM teachers about the value of manipulative and direct learning strategy facilitated by professional development as depicted in the student's records.

Evaluation Project

The doctoral project study was program evaluation. The findings of the study for evaluation reported on the effectiveness of the STEM program with concrete and direct instructions. A program evaluation study has been serving as an important research tool to identify how a particular school program or intervention brings about improvement (Kettner, Moroney, & Martin, 2012). The study examined how the implementation of the STEM program with the inquiry and concrete based instruction has been effective in the science and math performance of students in the Grade 5. The evaluation will provide a guide for the school administrators for decision-making.

The data collection procedures, analysis processes and the findings for the recommendations were carefully recorded in the report list. The report has been thoroughly evaluated by colleagues and the University chairperson provided great editing services and feedbacks for the proposal audience. The report was well edited based on their recommendations. To ensure that the participants of the study were protected from harm and to ensure confidentiality the project was submitted to the International Review

Board for approval. The results of the study can serve as the basis for further evaluation to continue to improve the STEM education in the school.

Implications Including Social Change

Local Community

As the education system is rapidly changing to meet the changing needs of people, so also school programs put in place are being constantly updated and improved through an ongoing evaluation. Again, while being cautious of spending on programs, getting a progress report through program evaluation, data collection is very important (Darling-Hammond & Youngs, 2012). With expectation, the evaluation report, which highlights the findings of this project, will be of help to STEM teachers in the school; the elementary school students, the school administrators and educators in the district will also benefit the program. According to Pazey, et al. (2012), schools that collaborate with the community to ensure social change are the schools that make a great impact on students. To date, the school program administrators have shown positive encouragement toward the findings from the study results and there is a growing awareness of the need to search for additional opportunities to explore hands-on learning methods.

The theory of social change has too often been resisted against by the status-quo due to uncertainties, economic, social and political factors (Katzenmeyer & Moller, 2001; Partington, 2012). Fortunately, the study has not faced any resistance of any kind. The study has been warmly accepted as an important document for school improvement. Discussions about the study with the program administrators have gone on very smoothly for adoption. The school district where the study was conducted has already agreed to intensify the principles of hands-on instruction needed by professional development training to improve students' performance in STEM subjects. The attitudes of the STEM teachers are also a positive indication of belief in the study and readiness to effect social change.

Far-reaching Social Change Impact

Apart from the local school, which will benefit from the study for change and improvement, the school district is an opportunity for STEM improvement. The local school has been designed for STEM program and the findings of the evaluation project are to serve as a guide for STEM programs in the school district. The math and science teachers at the elementary level in the school district were invited to the sharing session to have a better understanding of how professional development training is effective in the implementation of the STEM program using hands-on instructional strategy. According to Huang (2010), because learning is a social venture it has to be shared and taken beyond the gate-keeping of professional knowledge makers. Importantly, schools are to be viewed as linked together to have a shared responsibility in the society (Lee, 2010). Researchers and educators therefore become socially responsible to share and communicate educational ideas with each other to effect a change in the classrooms, schools, counties, states, and in the international levels.

Students and teachers develop the intrinsic motivation to learn with the intention of effecting social change (Weimer, 2013). The schools, the parents, the learning community and the stakeholders then have the obligation to support this great effort of change. Senge et al. (2012), are of the view that if students' inner-drive to learn is supported by the community-wide culture; combined responsibility of students, parents, educators, and the school stakeholders will bring about social advancement. With the pace of economic, social, and technological change, children need a safe place of learning to get through the transition. Educators, coming together to share new educational ideas and resources are to help make positive outcomes. A culture dedicated to learning would need to devote resources to remind people of real educational endeavors with the continuous growth and improvement (Senge et al., 2012). When educators, teachers and students think of effecting social change at the school level, the entire community can be transformed.

Conclusion

Section 3 discussed the description and goals, rationale, literature review of the program evaluation report and implementation of social change. The program evaluation report intended to inform the school district's administrators and program administrators about the values in professional development programs in the implementation of STEM using hands-on instructional strategy based on teachers’ perceptions and students’ records.

The program evaluation report included recommendations about investing in professional development programs with kinesthetic and concrete instructional strategy to improve STEM education in the school district. The report included general and local analysis of professional development programs in making use of interactive instructional strategy in the teaching of STEM to improve students’ performance. The implementation of social change was to begin from the local school, in the school district, the state and then to the national level by development programs using hands-on instructional strategy to improve STEM education. Areas that expect change includes students’ performance in math and science which form the basis for advancement in technology and engineering.

Section 4 discussed the reflections and conclusions, including scholarly manner grounded in appropriate literature, recommendations to address the problem, analysis of what was learned and the importance of the study, implications, application and direction for future research. In the appendices include the interview and focus group protocol and data analysis and coding, the White Paper of the evaluation of professional development programs using hands-on instructional strategy to improve STEM education, along with the district permission letter supporting my doctoral study and the principal's permission letter.

Section 4: Reflections and Conclusions

Introduction

Section 4 describes the reflection and conclusion of the project study. Project strengths and weaknesses in addressing the research problem were included in the discussion. In addition, discussions on recommendation to address the limitation, scholarship, development and evaluation of the project were also included. Furthermore, there were discussions on the reflections on self as a scholar, practitioner and project developer. The conclusion focused on the potential impact of social change, the implications, applications, and the directions for future research.

Project Strength

The strength of the project revealed the value of hands-on instructional strategy supported by professional development in the implementation of STEM education. The findings of the project study may help the school administrators to guide the STEM program in the local school, the school district and the state at large.

The program evaluation was conducted through the analysis of data collected from the one to one semi-structured interviews, the focus group semi-structured interviews and students' records to illustrate the value of interactive and experiential teaching and learning strategy in the teaching of STEM facilitated by professional development. The school administrators were able to derive useful information from the study to take decision for future practice. As a guide for decision making, the project outlined the evaluation of the study, including the findings and recommendations for future practice.

The strength of the project expresses the ability to make recommendations to increase efforts in professional development to improve STEM education using concrete learning activities in the local school, the school district and schools everywhere that intend to implement the STEM program. The project revealed the assurance of the potential benefits in hands-on instruction and professional development to increase student's performance in STEM. The program evaluation focused on making recommendations to help improve students' performance in STEM subjects through active and kinesthetic instruction enhanced by professional development training. Although the study revealed possible problems associated with the use of hands-on facilitated by professional development, the focus was on making recommendations for the improvement of students' performance in STEM education.

Recommendations for Remediation of Limitations

One of the major limitations of the study was the exclusion of students in the collection of data. Although students' academic records were used for the analysis, the student perspectives through survey would have added much more information to strengthen the triangulation process with the reason that the students were the direct beneficiaries of hands-on instruction and in the STEM program.

Additionally, students' performance in math and science could not only be attributed to hands-on activity sourcing its strength from professional development. There might have been areas such as students' intellectual abilities, hard work, previous schooling, parents' education and home school support, family income and self-motivation as factors that might have had a significant effect on the student's performance in math and science. The family, economic, and academic backgrounds of students were not included in the analysis. The background information about the students might have been sought through surveys.

Another limitation about the study was that data were collected once, which prevented confirmation and further clarification of specific concepts and might reduce the validity of the results. Although the focus group interview was conducted to support the individual interview results, multiple data collection would better provide additional information to strengthen the validity of the study and for further clarification of results.

Further limitation discovered was concerned with the small sample size. Although qualitative study requires a small sample size, the number of science and math teachers should have been a little more to gather much more information about the value of the program under study. The smaller the number of math and science teachers for the interview, the narrower the amount of perception to be heard. The large number of math and science teachers for the interview would be more likely to gather sufficient and diverse perceptions that were needed to be known. A possibility that could help remediate the limitation would be to involve science and math teachers from grade one to six that use hands-on instructions to teach.

Finally, the approval of the study by the Walden University IRB to conduct the study was so close to the conclusion of the school year. Although the teachers provided good information, the amount of information was limited, which could provide information to better determine how valuable professional development in the implementation of STEM using hands-on instructional strategy. In order to remediate this limitation, the project could have begun at the beginning of the year to allow for field observations to be conducted, as well as conducting a pilot study and the actual study from the teachers at the beginning and the end of the year respectively.

Scholarship

The doctoral study process has helped to discover scholarship as the acquisition of new knowledge through a systematic collection and analysis of data, the development of new interpretation of the knowledge and the means of applying the new knowledge through teaching. The discovery of scholarship therefore called for greater efforts into thinking, questioning and looking for knowledge. In the course of the research study, all the necessary protocol and time management with personal commitments were carefully observed.

The study provided great learning opportunities to know about the other existing studies made about the study through the literature review and the need for scholarship for integration to bring about new insights. The study helped to discover credible, valid and reliable sources of information from peer reviewed journal articles on the internet, books, and published dissertations. A great deal has been learned about how to include the findings in the study as empirical evidence.

The doctoral study process provided another learning opportunity in knowing about the skills of critical thinking through active involvement in data collection, data analysis, forming ideas, synthesizing, evaluating and applying information gathered from teachers' perceptions. With the availability of books and internet sources and the critical supervision, reviews and edits, much has been learned about how to compose scholarly writings. Learning about how to gather data, code them, formulate themes and present report of the program evaluation findings for decision making provided a great learning opportunity.

There has been a tremendous learning experience about all that is necessary with scholarly writing with regard to the style of writing, the language used and how to construct a scholar's knowledge base. The doctoral process has helped to learn about the skills in knowledge creation and how to share knowledge through teaching and publishing to add to knowledge in the academic world to help future researchers.

Project Development and Evaluation

The project development in the doctoral study became necessary when an idea was conceived and through a process actively engaged all the necessary research procedures and protocols to construct knowledge. When deciding on the right project for the study, a lot of ideas came to mind. In selecting the most appropriate idea, the focus was on the project, which will be able to address a problem in the school district.

The prospectus writing began the process by proposing the idea to the committee chair. Through a series of feedbacks and edits, the committee chair helped to identify the appropriate project that could help the stakeholders of the school to improve students' performance in math and science subjects. The prospectus included in the planning of the steps and the methodology needed to complete the project. With the help of the committee chair, a program evaluation project was finally settled on. The approved steps in the prospectus provided a guide in the whole research process.

As part of the project development was an evaluation report which consisted of the findings and the recommendations for the stakeholders of the school. The evaluation report was developed to include the perceptions of teachers about the value of professional development in the implementation of STEM using hands-on instructional strategy necessary for decision making. The information was shared with the stakeholders and recommended to the stakeholders that professional development programs have great benefits for teachers in the implementation of STEM using hands-on instructional strategy.

The whole study has helped to understand program evaluation. Tracking the progress of the STEM program using hands-on instruction became a concern for the educators in the school district. According to Spaulding (2009) the reason for evaluating a program is to determine the program’s worth. Based on the agreement with the local school, the STEM program had been implemented in the school for 10 years and the principal wanted to find out whether or not the program using hands-on facilitated by professional development was worth the cost the resources invested and whether to continued or not. A summative evaluation was conducted by interviewing teachers on the value of hands-on instruction and professional development training and their impact on STEM education. Data were also gathered from the students’ results in math and science at the state of the district/school report. Data were analyzed and the findings reported along with the recommendations to the stakeholders for decision making.

Leadership and Change

On reaching the final stage of the project study, there has been a better understanding of leadership and how effective the chain of command in the school administration worked to effect changes. The findings of the study had to be reported to the school administrators who will then see the need to continue to promote kinesthetic instruction at the school with in-service training for teachers. The science and math teachers will use the information about the results of the study to improve math and science subjects. The directors of Curriculum Planners of Science and Technology and Teaching and Learning Department in the school district will also use the information to improve STEM education in the school district.

After having reported the findings of the study, the real change will come from the direction from the school administrators at the school level. A major concern is about the change that will impact the larger community. If the other school communities will get a better understanding of how kinesthetic instruction can have a great impact on STEM education, the potential of making the program cost effective to improve outcome will be realized. Moreover, based on the success of the program in math and science education, students may pursue careers in technology and engineering.

There is the hope to become a strong proponent of making the instruction of STEM more practical and interactive with support of regular professional development opportunities upon completion of the study. According to the perceptions of the math and science teachers, hands-on instruction has the potentiality to improve STEM education.

In other words, kinesthetic instruction is capable of bringing about positive change in students' performance in math and science.

Analysis of Self as Scholar

Upon completion of the project study, there has been a strong determination to achieve a desired goal in the midst of frustrations and challenges in the doctoral process. Much has been learned about all the necessary research skills to conduct further research.

At the start of the doctoral process, a lot of struggles have gone on about the doctoral writing, the alignment of the idea running through the research and the right terminologies. Choosing the right topic and picking the right doctoral writing style for the prospectus had to take a lot of reviews and edits. Again, getting a good proposal, took a lot of feedback to make corrections more often than not and sometimes one had to rewrite. Several reviews took place before getting the IRB approval. In spite of all these frustrations, perseverance was the driving force for the completion of this doctoral project study.

The committee chair assisted greatly to be able to move through the steps one at a time. In the course of the doctoral journey and with all its challenges, there was a great improvement with the determination to complete the project. Then again, there has been a huge improvement in being a critical reader and a writer. This doctoral study has been very beneficial in developing the skills in critiquing journal articles, books, and in looking for credible materials to provide quality information for the study.

My writing and reading skills as a scholar have been greatly improved. There have been some improvements in my oral communication skills. The presentation of the oral defense, the report of the findings, and the white paper of the study to the stakeholders of the school, saw a great improvement in confidence and communication levels.

Analysis of Self as Practitioner

As an educational leader, there has always been a strong desire to be at the forefront of providing quality education to students struggling with math and science. There is always a strong feeling of providing a great support to the nation's efforts to improve students' performance in the STEM subjects to continue to sustain the economy technologically. With anticipation, opportunities will be made available to be able to assist the school administrators and math and science teachers in helping students who struggle to succeed.

The doctoral project study with Walden University has helped to improve scholarship and research skills as an educator leader. Some professionalism has enriched one's career as an educator to improve students' performance in math and science. With the expertise in identifying a research problem, data collection, data analysis the data, and finding a solution to make improvement in students' performance has helped to see the need to provide research based intervention and strategies to support struggling students in math and science. The research knowledge gained from the doctoral process has helped as a school administrator.

Ever since the start of this doctoral study, great amount of information has been obtained and shared with school administrators, educators and teachers in the school district about the value of hands-on instructions and the necessity of professional development to improve students' performance. Every opportunity has been taken to share information from journal articles, peer reviewed articles, books, and dissertations with colleagues in teaching. With the research experience gathered from the doctoral project study, there is the intention to be an educational practitioner stronger than before.

Again, as an educational leader in the teaching and learning, the main purpose is to produce research based innovative instructional strategies to improve students' learning. By completing this research study under the guidance of the committee chair in Walden University, there is an opportunity to be well equipped in establishing a research plan. Although, the start of the doctoral project was not easy, the academic goal had to be accomplished. Progressing through the study with the proper guidance of the committee chair, a great effort was made to produce with an appropriate research goal that satisfied the main objective as an educator leader. And through summative evaluation, the goal of the research was fulfilled.

After having completed the project and created an evaluation report, including the findings and recommendations to be presented to the stakeholders of the school, the experience of being equipped with how hands-on instruction can improve students' performance in STEM has been enormous. There is the hope that the stakeholders of the school will be able to implement the recommendations for the benefit of students in math and science.

Being aware of the importance of this project to the stakeholders of the school, much attention has been devoted to come out with accurate and detailed information. There was much collaboration with the Assistant principal of Instruction of the school and the director of Division of Data Analysis, Research and Technology to provide support until the goal of the study was satisfied. There is now much anticipation in getting a positive feedback from the stakeholders if the recommendations from the findings of the study are implemented.

The Project's Potential Impact on Social Change

This study is seen as an important piece of work created to benefit students who are and will be in STEM education. From the perceptions of math and science teachers, this study revealed the value of hands-on instruction as a teaching strategy to improve

STEM education fueled by professional development. The study focused on the evaluation of the effectiveness of the STEM program using hands-on instruction facilitated by professional development among the students in the local school. Although, the local school is the center of the study, other literature related to the study revealed that the nation's schools are struggling with math and science. The purpose of the study was to create an evaluation report to examine the effectiveness of professional development in the implementation of the STEM program using hands-on instruction. The study concluded that the effective promotion of professional development programs and the proper application of hands-on instructional strategy can help improve students' performance in STEM education.

Findings from this program evaluation project were based on the perspectives of the science and math teachers. Data taken through the one to one and focus group interviews indicate that in-service training focusing on hands-on instructions is very effective in the implementation of STEM. Evidence from the students' document further supported the perception of the teachers that professional development focusing on direct and concrete activities is very necessary for the successful implementation of STEM.

The project report, including the findings and the recommendations indicated that there is a great value in hands-on instruction as a tool for the successful implementation of STEM. If these recommendations and those for future research are well executed, students' performance in science and math will greatly improve. Science and math teachers in the school district will also realize the value of making the teaching of STEM interactive and beneficial.

There is a high possibility to have social change occurred as the teachers receiving professional development training on hands-on instructions work hard to improve themselves, the local school students and the students in the community schools in the performance in STEM subjects. The main objective of the study was to help students to improve their performance in math and science so that they could continue to high school, college and pursue their careers in STEM fields. People who would be gainfully employed would improve the economy and be better able to inspire their children to be in the STEM fields to achieve equal success. Schools will be interested in students' successes and would invest many more resources in the STEM program to increase performance. Other schools can take inspiration from this study to promote professional development activities needed in the use of hands-on instruction to improve students' performance in STEM education nationwide.

Implications, Applications, and Directions for Future Research

Since there has been a great discovery in the potentials of hands-on instruction as an innovative strategy in the teaching of STEM subjects, future researchers may use it in the other subject areas in the field of teaching and learning. Future research may be conducted in the school district by the local school where the STEM program is put in place. The study may help future researchers to look into the dynamics of training teachers in hands-on instructional strategies and the effective application in the teaching and learning environment. Again, future researchers may do a quantitative experimental study as a comparison between the control group and the non-treatment group to determine the difference between hands-on instructional strategy and students' performance in math and science which will meet the same goal in a numerical way. After all, the study is an extension of a previous study which focused on hands-on instructions without particular reference to the ongoing training of teachers through professional development.

The findings and the recommendations on the results of the study may allow the implementation and the application of hands-on activities in the teaching of science and math in the other elementary schools in the school district. The principals and teachers in the other schools may apply kinesthetic instructional strategy in the other subject areas. The administrators in charge of professional development programs can establish ongoing development programs on hands-on instructional strategy to improve students' learning in science and math. General education teachers and teachers in the field of teaching and learning may benefit from how to use and apply the hands-on instruction as innovative teaching strategies to improve students' performance not only in STEM subjects but also in the other content areas.

The work can be expanded by future research into the effectiveness of hands-on instruction in the teaching of math and science at the middle and high school levels. The future implications for the expansion of the study at higher levels are that students may perform excellently well in the advanced math and science courses. Additionally, the expansion of the study may demand many more materials, financial, human (well-seasoned teachers and educators) resources. Future researchers who will conduct the same research may inform the stakeholders about the changes in hands-on instructional strategy that may occur. With anticipation, limitations that were discovered in the study will be addressed to meet the goal of the research in the changing times.

Conclusion

In this section, reflections, analyses of the project's strengths and limitations, analysis of myself as a scholar, practitioner, and project developer are addressed. Recommendations for remediation of the project's limitations, scholarship, project development and evaluation, and leadership and change are included. The project's potential impact on social change is examined. The section concludes with an examination of the implications, applications, and directions for future research.

After finalizing the study, there has been a strong need to become a fervent advocate for hands-on instructional activities. Understandably, the value of hands-on instruction will maximize STEM learning outcomes while meeting the academic and social needs of all students. The doctoral experience has been enlightening and rewarding at the same time. A tremendous deal of learning experience about scholarship has gone on while working with the committee chair and colleagues. Lastly, a great effort will be put into promoting and sharing the knowledge about the benefits of hands-on professional development to meet the academic and social needs of all students.

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Appendix A: Executive Summary

The Effectiveness of Hands-on Pedagogy in STEM Education

by

John Kyere

Walden University

September 2016

Table of Contents

The Effectiveness of Hands-on Pedagogy on STEM Education

Overview

The analysis of student documents and the perceptions of science and math teachers on professional development needed in the implementation of (STEM) program using hands-on pedagogy are the findings of this program evaluation. The program evaluation using qualitative approach, helped to assess program goals, activities and outcomes. The frame of Kellogg's logic model as an evaluation tool to ensure effective program planning, better documentation of resources/inputs, activities, outputs, outcomes, and impact to determine what works and why was used for the study. The conceptual framework included a combination of Piaget, Vygotsky, Dewey and Kulns' constructivism theory in relation to hand-on instruction. Through purposeful homogenous sampling, science and math teachers were selected for the study. Data collection strategies included one-on-one semi-structured interviews, focus group semi-structured interviews, and students' document analysis. The research questions related to professional development needed in the implementation of the STEM program using hands-on instruction guided the study:

RQ1: what are the teachers' perceptions of the effectiveness and the value of the innovative hands-on inquiry based pedagogy on the achievement of students in STEM subjects?

RQ2: what knowledge, experiences and support do teachers need to effectively teach STEM subjects?

Research questions addressed the problem of the effectiveness of hands-on pedagogy on the achievement of students in STEM subjects and the support teachers need to effectively teach STEM subjects. The discussions with the teachers revealed the need for professional development in the implementation of STEM using kinesthetic learning. Students' test scores confirmed the impact of in-service training in the use of hands-on instruction on STEM education. Two themes emerged indicating that hands-on pedagogy increases students' learning integrated into professional development activities. The final analysis of data recommends efforts to school administrators, and stakeholders of the school and other schools in the school district to make professional development necessary for kinesthetic learning as an integral component implementing a STEM program.

The program evaluation, data collection, and analysis were based on the perceptions of teachers on the effectiveness of professional development relating to hands-on instruction and the impact on STEM education. During the one-on-one semi-structured interview lasting for about 45 minutes each with 6 participants, data were collected, analyzed and arranged into categories and themes. For more information to be able to triangulate the analysis, the focus group semi-structured interview which lasted for about 1 hour 15 minutes to elicit the perceptions of teachers on hands-on instruction and the support and experience needed to effectively implement the STEM program. Students' test scores were analyzed to affirm the results. Two themes emerged indicating that hands-on pedagogy increased students' learning and professional development activities supported teachers using hands-on pedagogy to inform decision-making.

The summary displayed the perceptions of the teachers based on their experience in the teaching of science and math using hands-on and the support derived from the professional development programs. Through member checks, peer debriefing, and analytic triangulation, the credibility and the accuracy of results were established. The consistency and transparency of results from multiple sources ensured the credibility of the study. All the findings from the one-to-one semi-structured interview and the focus group semi-structured interview and the students' test scores were accurately triangulated to ensure the validity of the results. The summative evaluation was used to assess the progress of the STEM program objective and to provide feedback for future improvement of the STEM program by maximizing efforts in the use of hands-on instruction.

Summary of Findings

By employing triangulation strategy, data collection from the 6 science and math teachers for the one-on-one semi-structured interview and 4 science and math teachers for the focus group semi-structured interview and the students' science and math records was complete for the analysis. A total of 10 participants freely and willingly provided answers to all the interview questions. Though each individual participant provided the answers from different perspectives, they eventually turned out to provide similar answers to the interview questions. The participants were encouraged to provide very precise, but deep and quality answers to the interview questions. Based on the experience of the participants, the finding was that professional development has the potentials to equip teachers with new and modern skills to effectively implement STEM by the interactive learning approach irrespective of the challenges. The themes emerged from the data analysis include: Theme 1: Effectiveness of Instructional strategy and Theme 2: Enhancing teacher quality through in-service training. The following are the research questions, the relational data findings, and the discussions of the themes.

RQ1: One-on-one and focus group science and math teacher interview and Theme 1. Theme 1, Effectiveness of Instructional Strategy was developed from the research question: what are the teachers' perceptions of the effectiveness and the value of the innovative hands-on inquiry based pedagogy on the achievement of students in STEM subjects? The study revealed that hands-on pedagogy has proven to be very beneficial when well applied to the study of STEM subjects guided by continuous professional development. Students' performance in STEM subjects is more likely to improve when the concrete learning approach is used in a more appropriate way. After a thorough data analysis of the participants' perception, an agreement was reached that hands-on approach to the teaching of STEM subjects is very positive. The analysis of students' reports and documents supported and confirmed the perceptions of the participants. The participants felt that by actively involving students in the study of STEM, they were using the right instructional strategy. The findings of the study recommended that the high engagement of students in the teaching of STEM subjects through hands-on instruction should be promoted intensely in all the elementary schools in the school district.

RQ2: Individual and focus group science and math teacher interview and Theme 2. Theme 2, Enhancing teacher quality through in-service training was derived from the research question: what knowledge, experiences and support do teachers need to effectively teach STEM subjects? Responses revealed that professional development programs have the potential to provide current content knowledge and modern strategies of making the teaching and learning of STEM very interactive ready to compete in the technological world. Additionally, professional development program has the potential to improve teacher quality in the teaching of STEM with modern manipulative and concrete instructional strategies.

Significant project implications can be drawn from the study in relation to the impact of hands-on instructional strategy supported by professional development programs on improving students' performance in STEM education. The discussions with the teachers and the student test scores imply that hands-on pedagogy has the potential to improve students' learning in STEM education. The findings of the study provided a source of information to the school administrators, teachers, and the stakeholders of the school about the need to continue to maximize efforts in the promotion of kinesthetic instruction. Additionally, the information provided can also help other elementary schools in the implementation of STEM programs.

Purpose of the Program

The purpose of this program evaluation was to evaluate the implementation of the STEM program using hands-on instruction supported by professional development programs. Protocols and procedures necessary for the collection and evaluation of data were completed. Research data collected through one-on-one semi-structured interviews and focus group semi-structured interview provided a deep understanding of the perceptions of science and math teachers about the effectiveness of hands-on pedagogy enhanced through professional development programs. Students' test scores were analyzed to affirm the perceptions of the teachers. The program evaluation measured program input, outcome and impact to help make an informed decision to continue to improve STEM education by maximizing efforts in the use of kinesthetic learning strategies facilitated by in-service training.

Program of Activities

Finding solutions to the research problem creates an opportunity for discussion with the school administrators and decision makers that could lead to further improvement in the STEM program. The findings of the evaluation report will be submitted to the school district when program evaluation has been completed as a working document to guide the STEM education program in the district. With the permission of the school district, copies of the report will be given to the stakeholders of the school. Once the program valuation has been completed, the findings of elementary level for the future academic years.

Purpose of the Evaluation

Through triangulation analysis of data, findings were communicated with the study will be shared, along with an evaluation report, with the program administrators of the local school. The program evaluation report will be revised when necessary to meet the needs of students at the accuracy and clarity. Triangulated data were collected to assess the impact of the integration of professional development activities into hands-on pedagogy on the STEM program. Themes were resulted from perceptions of teachers derived from the one–on-one semi-structured interviews and the focus group semi-structured interviews. The results from the program evaluation indicated that hands-on instructional strategy linked to continuous in-service training has the potential to improve STEM education.

Evaluation Barriers

Though the data were actually collected from the right participants, by subjecting them to reflection, the validity of the study results may be weakened. For the lack of time, data collected through the individual and the focus group interviews occurred once without multiple follow ups. The lack of multiple data collections did not create enough room to confirm and clarify the specific concepts which might reduce precision and validity of the results. On the other hand, though there were no follow up interviews, there is a strong belief that the one-time interview could provide detailed and basic information needed to evaluate the STEM program. The sample used for the study included only students in grade 5 and teachers in a specific research site which is possible to affect generalization. In spite of the barriers that were discovered, a great effort in the areas of triangulation, member checking and objectivity were made to ensure the validity, accuracy and reliability of results.

Evaluation Plan

The hands-on pedagogy integrated into professional development activities will go through continuous assessment until the STEM needs of students are met. All professional development activities will produce specific outcomes to make sure to meet students' needs. Teachers will also be encouraged to produce outcomes upon the implementation of the program and make changes when necessary in the classroom. After every professional development session, an assessment will be made to make recommendations for continuous improvement.

Overview of Recommendation

The main purpose of the executive summary report is to determine if the integration of hands-on instruction and professional development programs put in place has had an impact on the student's performance in the STEM program. Additionally, the weaknesses and the strengths of the program are also determined so that proper recommendations will be made to the school leaders and administrators. The need for continuous evaluation of the program is also recommended to ensure that students' performance will continue to improve. School administrators both at the research site and the entire school district are also encouraged to put into practice the recommendations so that students' needs will be provided.

Program Intervention Purpose

The main objective for putting in place activities to promote the STEM program is not only to increase students' performance, but also to improve the elementary school math and science instruction and student learning in math, science, technology education. The underlying reason to promote STEM is to advance in innovation and in technology to build a solid economy. Therefore, putting in place measures to ensure the program effectiveness is very significant. As part of the recommendations is professional development for STEM teachers with the focus on math and science teachers.

Professional Development Training Curriculum

Considering a professional development training as an integral part of the STEM program, a three-year evolution in STEM professional training has been proposed for the school and the school district. The first year of the module will be spent on building leadership team comprising of math, science, technology education teachers, a guidance counselor, an administrator, and a university faculty. The second year, the team will run workshops, seminars in trying to create awareness of STEM professional development. The first two years on the monthly bases are to introduce teachers to current elementary school math and science content and hands-on pedagogy. The goal is to have all the teachers re-learn math and science concepts and how to create concrete understanding in the teaching process. Science and math teachers will be provided with hands-on methods of teaching to assist students to learn kinesthetically science and math contents. The formative evaluation process will be put in place to assess performance data of students.

The third year will focus on the refining of the approach to implementation and summative evaluation (See Appendix A1)

The STEM professional development training will be guided by: a) lesson plan design, implementation, feedback and revision, b) academic year implemented, and c) peer review and the learning community (Burghardt & Hacker (2004). When the professional development program is effective, teaching the STEM subjects with hands-on pedagogy will improve students' performance in the research site and the entire school district.

Summary

The executive summary of the study examined the overview of the study, the purpose of the program, the program of activities, purpose of evaluation and the overview of recommendations based on the findings of the research study to the school administrators and the stakeholders of the school and the school district about the need to make professional development an integral part of the STEM program using hands-on pedagogy. Program intervention activities have been suggested to improve STEM education which will not only benefit the students, but also for national development technologically and economically.

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Appendix A1: Professional Development Seminar

Instructor:		**Date:**
Subjects: Science/ Technology Engineering/Math	Target Audience: Principals, STEM teachers and Coordinators of the school and the school district.	Timeframe: September 2016 to September 2019
Course Title: Integrating hands-on instruction with professional development in the teaching of STEM **Program Goal** The goal of the professional development seminar is to have all the teachers re-learn math and science concepts and how to create concrete understanding in the teaching process to improve students' performance in the STEM subjects		

Building STEM Professional Development Leadership Team, 2017

Goal: Building STEM teachers capacities to engage in professional development assessment to improve instruction using hands-on pedagogy. **Objective:** Participants in the program will form a project team who will agree to be a part of the STEM Leadership Academy. The leadership team will structure the professional development in standards-based and inquiry in math and science instruction.	
January to April, 2017	Devote attention to understand the district's policies, histories of professional development and teacher learning and organizational development.
May to August 2017	Focus on time for professional development, ensuring equity, and building professional culture
September to December,	STEM leadership will be built by professional developers and participants as part of building a Professional Community

2017	

Responsibilities

- STEM Professional developers will nurture teacher leadership through a joint reflective process for teachers to share responsibilities as they work towards the implementation.
- Participants attend meetings in district teams, whole staff meetings and grade level groups.
- Attend statewide meetings

Workshop Seminars on Professional Development on hands-on pedagogy

Objectives (What our efforts are intended to accomplish**)**	**Action Steps** **(**Which specific steps should we follow to meet the growing need)	**Person (s) Responsible** (Who will be responsible to assure the completion of each action step**)**	**Assessment** (How will we know we have been successful**)**	**Resources** An action that may be adapted	**Timeline** (When, how long)
Improving student's performance in STEM subjects using hands-on pedagogy.	Identify and evaluate current professional development opportunities with the focus on STEM education	The professional growth team of the school district and the STEM teachers	List of all professional development opportunities	Current District professional development plans/opportunities	January to April, 2018
Understanding the effectiveness of professional development in the study of STEM using hands-on	Collect information on teacher participation in each of the professional development	The professional growth team of the school and the STEM teachers	Discuss the information collected concerning professional development and its impact	The experience of the teachers' integration of professional development with hands-	May to August, 2018

instruction.	identified		on STEM education	on instruction	
Discovering the best practices in STEM education	Sharing ideas with STEM education teachers regarding their knowledge about hands-on instruction.	The professional growth team in the school district and the STEM teachers	List of ideas shared by the teachers.	Group discussions	September to December, 2018

Professional Development of Formative Evaluation
Objectives:
Developing a formative evaluation strategy to provide teachers with ongoing use of evidence of learning to inform instruction and to guide feedback for students. For the professional development of formative evaluation to succeed there will be:

- Explicit goals
- Success Criteria
- Descriptive feedback to students about their performance
- Self and peer assessment, collaboration among teachers and students, assessment of evidence with reference to the expected learning progression
- Lesson plan for teachers, teacher's content knowledge, relationship between instruction and assessment process of grading and reports

The professional development of formative evaluation will be:

- Intensive and ongoing
- Connected to practice
- Content focus
- Active
- Coherent
- Leading to a professional culture of change
- Formats and strategies being parallel to those in the classroom
- Professional learning community

Assessment:
» More systematic note-taking and recordkeeping about students, so as to give more useful feedback;
» Increased student involvement in using assessment information;
» A shift from a focus on achievement to a focus on motivation, as teachers see students become excited about having control over their own learning;
» Increased instructional language to talk about formative assessment, linking formative assessment to differentiating instruction; and
» More creative use of a scripted reading program based on professional judgment, making adjustments to instruction on the basis of formative assessment information

Summative Evaluation: Refining of the Approach of Implementation

Goal of Summative Evaluation:
The goal of the summative evaluation is to assess the extent to which hands-on pedagogy met its intended goals for professional development in STEM education. Additionally, summative evaluation will provide feedback that informs teachers' practice, showing where they stand relative to standards and goals and what they can improve upon. The professional development goals for the project study are that:

- Teachers will feel comfortable engaging in math and science subjects with hands-on instructional strategies.
- Teachers will learn to facilitate the teaching of math and science using hands-on instruction
- Teachers will use hands-on pedagogy and engage math and science exploration.
- Teachers will re-evaluate their perceptions of the weaknesses in meeting the needs of students in the teaching of math and science using hands-on instruction.

Objective:
Develop and implement the effective teaching and learning of STEM through hands-on instruction.

How the Implementation Works
The use of observation and artifacts will be used as evidence to inform the summative evaluation. Observation will provide opportunities to assess teachers' performance and artifacts showing how STEM teachers will meet the goals and standards.

- ➢ Collect artifacts as the STEM program is implemented and use those artifacts to assess proficiency in each standard and progress in each goal.
- ➢ Clear rationale of how the artifacts demonstrate progress towards goals and proficiency and standards.
- ➢ Tags indicating relevant goals and elements.

Summative Evaluation of the Professional Development Training Using Kirkpatrick's model

Level	Focus	Assessment	Timeline
1. Reaction	Assess participants' initial reactions and attitudes to a workshop as well as perceived benefits from the training	Workshop Survey before and after workshop.	From January to March, 2019
2. Learning	Evaluate what participants learned specifically examining changes in knowledge and skills acquired based on the learning goals.	Workshop Survey before and after workshop.	April to June 2019
3. Transfer	Assess the extent to which participants transfer knowledge, skills and attitudes from training context to their workplace and how they use or incorporate what they have learned in their project.	Workshop Survey before and after workshop.	July to September 2019
4. Impact	Evaluate the project's impact on participating individuals and organizations	Follow up surveys and interviews	October to December 2019

Adapted from Kirkpatrick's model: Kirlpatrick D. L. (1998). Evaluating training programs: Four Levels, San Fransico . CA, Berret-Koehler Publisher. Inc.

Level 1	Expectation Met			
Reaction:	Missed	Nearly	Met	Exceeded
How well did this workshop meet your expectation?				
Suggestions for Improvement				

	% Suggested
1. Give more examples/modeling for effective facilitation	
2. Demonstrate more of kinesthetic teaching and learning materials in the teaching of math and science	
3. Spend less time reading the slides	
4. Allow more time for questions and discussions	
5. Allow more time in exhibitions	
6. Lengthen the workshop	
7. Allow more time for role play	
8. Other	

Level 2	Degree of Agreement					
Learning:	Disagree strongly	Disagree	Disagree somewhat	Agree somewhat	Agree	Strongly Agree
i. This workshop made me feel more prepared to facilitate the teaching of science and math with kinesthetic than I typically do						
ii. This workshop made me to feel more confident in my abilities to teach math and science with hands-on pedagogy						
iii. This workshop helped me to reflect on my own approach to the teaching of science						

and math						
Level 3	Frequency of Transfer					
Transfer:	Three or more days a week	One or two days a week	A couple of times a month	Only twice in total		
How often did you use hands-on pedagogy in the teaching of science and math.						
Level 4	Degree of Agreement					
Impact:	Disagree strongly	Disagree	Disagree somewhat	Agree somewhat	Agree	Strongly Agree
i. The skills I learned in the professional workshop helped me better facilitate the teaching and learning of science and math through hands-on instruction						
ii. Professional development workshops inspired my thinking about specific hands-on activities that I can incorporate into my school program within the next year or two						
iii. Workshop helped me reflect on						

the ways my school can increase in the use of hands-on instruction						
	Not all	Valuable	Somewhat valuable	Very Valuable	Not Sure	
iv. Overall, how Valuable professionally was it for you to participate in this project						

Appendix B: Protocol Procedures

Step 1	Seeking for permission from the Principal of the school with the help of the assistant superintendent.	About two weeks	Glastonbury-East Hartford Magnet School	Email and In person
Step 2	Getting permission from the Superintendent of Schools, Capital Region Education Council, Hartford.	About two weeks	Hartford	Email and In person
Step 3	Getting permission from the Director of data analysis, research, and Technology, Capital Region Education Council, Hartford.		Hartford	Email and In person
Step 4	Contacting the potential participants individually to determine their eligibility and willingness to participate in the study	Lasting for One Week	Glastonbury-East Hartford Magnet School	Letter
Step 5	Consent interview will be conducted with each potential participant to have a better understanding of the study. Detailed explanation of risk and benefits of the study will be provided. Additionally, a copy of consent document and question and answer sessions will be provided to measure the	One Week	Glastonbury-East Hartford Magnet School	In Person

	participants' understanding of the study			
Step 6	Every individual who will consent to participate in the study voluntarily will enter the date and signature on the consent form. A copy of the consent document will be provided to each of the participants and the original signed consent documents will be kept in the student records.	One Week	Glastonbury-East Hartford Magnet School	In Person
Step 7	Interviews with the six STEM teachers	50 minutes each	Glastonbury-East Hartford Magnet School	In Person
Step 8	Focus group interview with four STEM teachers	1 hour 10 minutes	Glastonbury-East Hartford Magnet School	In Person
Step 9	Follow up interview will be necessary for both individual and focus group interviews for clarity or additional information.	30 minutes	Glastonbury-East Hartford Magnet School	In Person
Step 10	Analyzing students' documents	About one week	Glastonbury-East Hartford Magnet School	In person
Step 11	Data Analysis: ▸ Audio recording and notes will be taken during interviews. ▸ Data will be transcribed, scrutinized, coded and	About two weeks.	Glastonbury-East Hartford Magnet School	In person

	analyzed to obtain categories and common themes for the report. ▸ Peer debriefing, analytic triangulation and member checking will be involved to ensure credibility			
Step 12	With regard to member checking, I will get permission from the participants before the interview.	One Day	Glastonbury-East Hartford Magnet School	
Step 13	Participants will be given completed electronic transcript copies of the study to provide approval and accuracy whether data analysis meets their experience.	One week		Email
Step 14	Individual member checking will be done with the individual participants of the interview.	One week		Email and in person
Step 15	Group member checking will be done with the focus group.	One Day	Glastonbury-East Hartford Magnet School	In person
Step 16	It is going to be a single event that will take place with verification		Glastonbury-East Hartford Magnet School	

Appendix C: District's Permission Letter for the Study

CREC | Excellence in Education

CREC MAGNET SCHOOLS
Dina Crowl
Superintendent of Schools

April 10, 2015

Dear John Kyere,

Based on my review of your research proposal, I give permission for you to conduct the study entitled "Effectiveness of Hands-On Pedagogy on STEM Education" within the Capital Region Education Council, Hartford. As part of this study, I authorize you to select six science and math teachers for face to face interview and four science and math teachers for focus group interview. I agree for you to use peer debriefing, analytic triangulation and learning community for validation. After results data has been collected, I agree to release the de-identified math and science test scores of students to you for research purposes. I agree that individuals' participation will be voluntary and at their own discretion. We reserve the right to withdraw from the study at any time if our circumstances change.

I confirm that I am authorized to approve research in this setting and that this plan complies with the organization's policies.

I understand that the data collected will remain entirely confidential and may not be provided to anyone outside of the student's supervising faculty/staff without permission from the Walden University IRB.

Sincerely,

Dina Crowl

Dina Crowl
Superintendent of CREC Schools

111 Charter Oak Avenue, Hartford, CT 06106 ■ 860-509-3603 ■ dcrowl@crec.org ■ www.crecschools.org

Appendix D: Objective of the Project Study to the Principal

Paul Ryan

The Principal
Glastonbury-East Hartford Magnet School

Dear Sir,

The Objectives of the Project Study

Elementary school students underperform in science and math, as the basis for science, technology, engineering, and mathematics (STEM) education. The continuous fall of students in science and math indicates a decline in the STEM workforce. The purpose of this qualitative program evaluation will examine professional development leading to the effective implementation of STEM using the application of hands-on instruction. The conceptual framework included a combination of Piaget, Vygotsky, Dewey and Kulns constructivism theory. The research questions will address the teachers' perceptions of the effectiveness of hands-on instruction on students' performance in STEM and the support teachers need to effectively teach science and math. Through purposeful homogenous sampling, 10 science and math teachers will be the focus of the project. Data collection strategies will include individual semi-structured interviews with 6 teachers, focus group semi-structured interviews with 4 teachers, and grade 5 students' science and math test scores analysis. Thematic coding, member checks, and peer debriefing will be employed for data triangulation. Two themes that will emerge will be used to analyze how hands-on pedagogy will allow students to become active learners and how professional development activities can provide teachers with the practical knowledge of the interactive learning to effectively implement the STEM program. The program evaluation report will recommend efforts to make professional development necessary for kinesthetic learning as an integral component implementing a STEM program. Social change is promoted by helping teachers to use proper kinesthetic learning approach to translate STEM concepts into reality to promote excellent performance of students.
Feel free to ask any question for clarification on my telephone number 860-706-6756 or through my email: jhnkyere51@yahoo.com

Thanks

John Kyere

Appendix E: Consent Form for the Individual Interview

Consent Form

You are invited to take part in a research study of the effectiveness of hands-on pedagogy on STEM education. The study will examine (a) the teachers' perceptions of the effectiveness and the value of hands-on inquiry based pedagogy on the achievement of students in STEM subjects and (b) whether the adequate provision of knowledge, experiences and support for teachers in hands-on instructional strategies can improve students' performance in STEM subjects. This study intends to evaluate the implementation of the STEM program using hands-on instruction facilitated by professional development programs. The researcher is inviting STEM teachers who have the experience in the teaching of Math and Science to take part in the focus group interview. The STEM teachers have much experience in the teaching of STEM subjects with hands-on methods in the school. It is believed that the teachers will be able to provide key and detailed information relevant to the study. This form is part of a process called "informed consent" to allow you to understand this study before deciding.

This study is being conducted by a researcher named John Kyere

Background Information:
The purpose of this study is to examine the problem of students' poor performance in STEM subjects. The problem that is to be addressed in the study is to find out from the teachers' point of view and their perceptions about the effectiveness of the implementation of STEM using hands-on inquiry based pedagogy enhanced by professional development.

Procedures:
If you agree to be in this study, you will be asked to take part in the focus group interview. The focus group interview will involve STEM teachers lasting for about 1hour: 10 minutes. Interviews will be audio recorded. I will be the only one who will listen to the audio recordings, which will be transcribed by me. Both audio recordings and transcripts will be kept for a minimum of 5 years and then be destroyed. Data will be written up and submitted for publication. Member checking will be used in the study to ensure credibility. By using member checking, you will be given completed electronic transcript copies to provide approval and accuracy whether data analysis meets your experience. You will be asked to edit, clarify and elaborate and if possible be asked to delete your own words.

The interview will be conducted once, but the further interview will be necessary for clarity or additional information.

Voluntary Nature of the Study:
This study is voluntary. Everyone will respect your decision of whether or not you choose to be in the study. No one at Glastonbury Magnet School for STEM in East Hartford will treat you differently if you decide not to be in the study. If you decide not to join the study along the line, you can still change your mind.

Risks and Benefits of Being in the Study:
This study presents minimal confidentiality risks. With a very small sample size, participants could be identified based on their responses. Risks will be minimized by using coding in the data analysis and any publication to protect the confidentiality of the participants.

The findings of the study may help the school (the research site), the Board of Education, the school administrators, the superintendents, the principals, the teachers, the parents, the community, and the stakeholders of the school district to support and to promote (a) intensive and in depth professional development programs for teachers in manipulative practices and (b) hands-on pedagogies to improve students' performance in STEM subjects.

Payment:
I will give thank you card to acknowledge and appreciate your participation towards the study. The thank you card will be delivered after the conduction of the interviews.

Privacy:
The principles of confidentiality will be carefully observed in this study. The researcher will not use your personal information for any purposes outside of this research project. Also, the researcher will not include your name or anything else that could identify you in the study reports. Data will be kept secured by creating a password or an access code on the computer in which the information is located. Data will be kept for a minimum of 5 years, as required by the university.

Contacts and Questions:
You may ask any questions you have now. Or if you have questions later, you may contact the researcher via 860-706-6756 or jhnkyere51@yahoo.com. If you want to talk privately about your rights as a participant, you can call Dr. Leilani Endicott, who can discuss this with you. Her phone number is 612-312-1210.

Statement of Consent:

Your signature indicates that you have read this consent form, had an opportunity to ask any questions about your participation in this research, and voluntarily consented to participate. You will receive a copy of this form for your records.

____
(Print) Name

__________________________________ Date: __________________________
Signature

Appendix F: Consent Form for Focus Group Interview

Consent Form

You are invited to take part in a research study of the effectiveness of hands-on pedagogy on STEM education. The study will examine (a) the teachers' perceptions of the effectiveness and the value of hands-on inquiry based pedagogy on the achievement of students in STEM subjects and (b) whether the adequate provision of knowledge, experiences and support for teachers in hands-on instructional strategies can improve students' performance in STEM subjects. This study intends to evaluate the implementation of the STEM program using hands-on instruction facilitated by professional development programs. The researcher is inviting STEM teachers who have the experience in the teaching of Math and Science to take part in the focus group interview. The STEM teachers have much experience in the teaching of STEM subjects with hands-on methods in the school. It is believed that the teachers will be able to provide key and detailed information relevant to the study. This form is part of a process called "informed consent" to allow you to understand this study before deciding.

This study is being conducted by a researcher named John Kyere

Background Information:
The purpose of this study is to examine the problem of students' poor performance in STEM subjects. The problem that is to be addressed in the study is to find out from the teachers' point of view and their perceptions about the effectiveness of the implementation of STEM using hands-on inquiry based pedagogy enhanced by professional development.

Procedures:
If you agree to be in this study, you will be asked to take part in the focus group interview. The focus group interview will involve STEM teachers lasting for about 1hour: 10 minutes. Interviews will be audio recorded. I will be the only one who will listen to the audio recordings, which will be transcribed by me. Both audio recordings and transcripts will be kept for a minimum of 5 years and then be destroyed. Data will be written up and submitted for publication. Member checking will be used in the study to ensure credibility. By using member checking, you will be given completed electronic transcript copies to provide approval and accuracy whether data analysis meets your experience. You will be asked to edit, clarify and elaborate and if possible be asked to delete your own words.

The interview will be conducted once, but the further interview will be necessary for clarity or additional information.

Voluntary Nature of the Study:
This study is voluntary. Everyone will respect your decision of whether or not you choose to be in the study. No one at Glastonbury Magnet School for STEM in East Hartford will treat you differently if you decide not to be in the study. If you decide not to join the study along the line, you can still change your mind.

Risks and Benefits of Being in the Study:
This study presents minimal confidentiality risks. With a very small sample size, participants could be identified based on their responses. Risks will be minimized by using coding in the data analysis and any publication to protect the confidentiality of the participants.

The findings of the study may help the school (the research site), the Board of Education, the school administrators, the superintendents, the principals, the teachers, the parents, the community, and the stakeholders of the school district to support and to promote (a) intensive and in depth professional development programs for teachers in manipulative practices and (b) hands-on pedagogies to improve students' performance in STEM subjects.

Payment:
I will give thank you card to acknowledge and appreciate your participation towards the study. The thank you card will be delivered after the conduction of the interviews.

Privacy:
The principles of confidentiality will be carefully observed in this study. The researcher will not use your personal information for any purposes outside of this research project. Also, the researcher will not include your name or anything else that could identify you in the study reports. Data will be kept secured by creating a password or an access code on the computer in which the information is located. Data will be kept for a minimum of 5 years, as required by the university.

Contacts and Questions:
You may ask any questions you have now. Or if you have questions later, you may contact the researcher via 860-706-6756 or jhnkyere51@yahoo.com. If you want to talk privately about your rights as a participant, you can call Dr. Leilani Endicott, who can discuss this with you. Her phone number is 612-312-1210.

Statement of Consent:

Your signature indicates that you have read this consent form, had an opportunity to ask any questions about your participation in this research, and voluntarily consented to participate. You will receive a copy of this form for your records.

____
(Print) Name

_________________________________ Date: _________________________

Signature

Appendix G: Principal's Letter of Cooperation for the Study

CREC | Schools of Excellence

GLASTONBURY-EAST HARTFORD MAGNET SCHOOL

June 11, 2015

Dear John Kyere,

Based on my review of your research proposal, I give permission for you to conduct the study entitled "Effectiveness of Hands-On Pedagogy on STEM Education" within the Capital Region Education Council, Hartford. As part of this study, I authorize you to select six science and math teachers for face to face interview and four science and math teachers for focus group interview. I agree for you to use peer debriefing, analytic triangulation and learning community for validation. After results data have been collected, I agree to release the de-identified math and science test scores of students to you for research purposes. I agree that individuals' participation will be voluntary and at their own discretion. We reserve the right to withdraw from the study at any time if our circumstances change.

I confirm that I am authorized to approve research in this setting and that this plan complies with the organization's policies.

I understand that the data collected will remain entirely confidential and may not be provided to anyone outside of the student's supervising faculty/staff without permission from the Walden University IRB.

Sincerely,

Ryan P. Donlon
Principal
Glastonbury East Hartford Magnet School
95 Oak Street, Glastonbury, CT 06033
(860) 633-4455

Appendix H: Data Analysis and Coding: One-on one Interview Results

Question	Categories
1a.As a teacher of STEM fields what are your perceptions of the effectiveness and the value of the innovative hands-on inquiry based pedagogy on the achievement of students in STEM subjects?	Learning connected to the real world, learning by touch, learning by physically doing, concrete learning experience, highly engaged learning, authentic learning approach, higher ordered learning and flexible learning leading to critical thinking
1b. How does hands-on instruction fit into textbook and lecturing approaches in STEM curriculum?	No perfect formula: students learn better either by conceptualization to concrete or through concrete to conceptualization depending on the teacher's goal based on content, students' learning styles, strengths, weaknesses and preferences.
1c. Why has there been a shift from textbook and lecturing approach to hands-on approach in STEM curriculum?	Though lecturing provides content and background knowledge of STEM topics, hands-on helps to build a better understanding. Emphasis on hands-on provides inspiration to the future youth to fill the jobs in the engineering and manufacturing industries in the global market. However, Computerized High State Testing gives schools less opportunity for hands-on.
1d. What are the resources available in making hands-on approach effective in the teaching of STEM subjects?	Field trips, gaming, robotics, science laboratory, interactive software that allow students to manipulate numbers, words and objects, gardening, after school enrichment programs and summer camps
1e. How do you integrate hands-on resources in the curriculum to make the teaching of STEM subjects effective?	Having a program design that supports hands-on activities.
1f. What factors characterize hands-on teaching and the potentials to cause students' learning in STEM subjects?	Active engagement of students' minds and hands, inquiry and investigation of objects or ideas, object-centered l, student centered learning, experiential learning, cooperative learning.
1g. How do the characteristic features and the potentials in hands-on	Active engagement of students' minds and hands to help students to translate what is

instruction enhance the teaching of STEM subjects?	learned into reality, inquiry and investigation of objects or ideas to promote discoveries and inventions, object-centered learning where manipulation of objects leads to in depth understanding of the subject matter, student centered learning where students construct knowledge through interaction, experiential learning to prove a discovery leading to critical thinking, cooperative learning where students learn on an experiment or laboratory activities together as a team.
1h. As a STEM teacher, what do you think are the benefits of hands-on instruction on STEM education?	Improves retention and retrieval levels of students, learning process of students is empowered, stimulates students to learn more, helps kids to learn and have fun doing it, helps kids to have the sense of accomplishment when an activity is completed, by doing it helps students to understand better, helps students to learn based on evidence rather than on authority, better interpretation of events instead of memorization and greater achievement in STEM content, increased skill proficiency, increased perception and creativity
1i. As a STEM teacher, what do you think are the negatives using of hands-on instruction in the implementation of STEM education?	It is messy and unpredictable, it is weather dependent which does not fit into the school schedule at all seasons. It also involves a lot of planning and time in getting things ready for the class, students easily lose focus as they misuse the materials given them to cause distractions as they use them as toys and play with them.
2a. What knowledge, experiences and support do teachers need to effectively teach STEM subjects?	Teacher competency, confidence, professional ability and being abreast with the modern strategy of teaching STEM using hands-on. STEM teachers need professional development programs at the school, district and statewide. Peer

	coaching, learning from teachers, in-service activities.
2b. As a STEM teacher what qualities do you exhibit in teaching STEM using hands-on approach?	STEM teachers must have the competency to handle STEM lessons to focus on real world problems to seek solutions, have the skill to involve students in hands-on inquiry and open ended investigation, have the ability to use hands-on in relation to their learning styles, have the competency to be able to connect and integrate content from math and science courses, have the skills be able to help students to use technology appropriately, have the ability to teach students to know that math and science are isolated subjects, but they work together to solve problems, have the collaborative attitude with their peers who in turn get students involved in team productive work and be able to exhibit skills in engineering design process.
2c. As a teacher in STEM subjects, how do the teaching experience, content knowledge, credential and academic ability levels of the teacher in hands-on impact the teaching of STEM	They promote effective teaching and the confidence in handling STEM subjects to ensure high achievement, high test scores.

Appendix I: Data Analysis and Coding: Focus Group Interview Result

1a. As a teacher of STEM fields what are your perceptions of the effectiveness and the value of the innovative hands-on inquiry based pedagogy on the achievement of students in STEM subjects?	Skilled learning approach, active learning, inquiry based-learning, creative learning and higher ordered learning.
1b. How does hands-on instruction fit into lecturing approaches in STEM curriculum?	Depending on the learning styles: Incorporate hands-on approach with students who easily learn kinesthetically to reach a higher level of understanding. Apply lecturing on verbal and visual learners with a higher learning, understanding translate learning into reality with hands-on. In all circumstances, the incorporation of hands-on instruction improves students' performance.
1c. Why has there been a shift from textbook and lecturing approach to hands-on approach in STEM curriculum?	Hands-on instruction provides a higher retention rate of elementary students than lecturing. Again, hands-on prepares the youth to occupy engineering and manufacturing industries in this modern technological world. In principle, there is a shift, it is not fully practiced. Most teachers are tempted to push aside hands-on in favor of textbook and lecturing methods.
1d. What are the resources available in making hands-on approach effective in the teaching of STEM subjects?	Creating opportunities for students: field trips, hands-on lab activities, video games/digital labs, gardening, outreach programs, partnering with a university, STEM related institution and museums.
1e. How do you integrate hands-on resources in the curriculum to make the teaching of STEM subjects effective?	By using hands-on resources that have the potential for authentic problem solving and students' interest to teaching STEM subjects. Implications of teacher preparation, curriculum development and coordinated public and private partnerships with the schools.

1f. What factors characterize hands-on teaching and the potentials to cause students' learning in STEM subjects?	Hands-on is characterized with multi modal/sensory learning, verification and demonstration approach, discovery approach and inquiry approach.
1g. How do the characteristic features and the potentials in hands-on instruction enhance the teaching of STEM subjects?	By promoting the teaching of critical thinking and real life problem solving skills in the study of STEM subjects.
1i. As a STEM teacher, what do you think are the benefits of hands-on instruction on STEM education?	Active learners, construction of knowledge, promotes high retention rate, relevant to today's industries, promotes critical thinking promoting real life problem solving skills.
1j. As a STEM teacher, what do you think are the negatives to the use of hands-on instruction in teaching STEM	It is messy and time consuming, causes students to lose essential concepts in the area of study, over engagement in hands-on limits the mind-factor.
2a.What knowledge, experiences and support do teachers need to effectively teach STEM subjects?	Professional development training with hands-on, conferences and workshops at the school/ state levels.
2b. As a STEM teacher what qualities are you expected to exhibit after benefiting from professional development in the teaching of STEM using hands-on approach?	Professionalism in using the current and emerging hands-on technology tools, new curriculum resources and teaching strategy and having mastery of teaching STEM subjects using hands-on.
2c. As a teacher in STEM subjects, how do the credential, professional ability, theoretical and practical knowledge and experience levels of teachers in hands-on pedagogy impact in STEM instruction.	The quality of teachers increases students' learning. Professional development becomes effective on students' performance when the teaching performance of teachers improves and teachers becoming better educators in STEM using hands-on.