6-29-2017

Project-Based Learning: Investigating Self-Directed Learning Readiness Skills And Content Knowledge Retention In An Urban Jamaican High School Eighth Grade Integrated Science Cohort

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DOI: 10.25148/etd.FIDC001950

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PROJECT-BASED LEARNING: INVESTIGATING SELF-DIRECTED LEARNING READINESS SKILLS AND CONTENT KNOWLEDGE RETENTION IN AN URBAN JAMAICAN HIGH SCHOOL EIGHTH GRADE INTEGRATED SCIENCE COHORT

A dissertation submitted in partial fulfillment of

the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

CURRICULUM AND INSTRUCTION

by

Carolyn Reid-Brown

2017

To: Dean Michael R. Heithaus
College of Arts, Sciences and Education

This dissertation, written by Carolyn Reid-Brown, and entitled Project-Based Learning: Investigating Self-Directed Learning Readiness Skills and Content Knowledge Retention in an Urban Jamaican High School Eighth Grade Integrated Science Cohort, having been approved in respect to style and intellectual content, is referred to you for judgment.

We have read this dissertation and recommend that it be approved.

Patricia Barbetta

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Date of Defense: June 29, 2017

The dissertation of Carolyn Reid-Brown is approved.

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Vice President for Research and Economic Development
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Florida International University, 2017

DEDICATION

I dedicate this dissertation to my husband Colin D. Brown. Without his patience, understanding, unconditional support, and most of all love, the completion of this work would not have been possible.

ACKNOWLEDGMENTS

First and foremost I would like to thank God for His unfailing grace and mercy that has sustained me throughout this process. Without Him this dissertation would not have been possible.

I would like to express my deepest gratitude to my committee chair Dr. Linda Spears-Bunton for her excellent guidance, care and patience. She continually and convincingly conveyed a spirit of adventure in regards to scholarship and research, and unfettered excitement in regards to teaching. Her guidance and persistent help made this dissertation a reality.

In addition, a special thank you to my committee members for their valuable guidance and unfailing belief in my abilities. Thank you to Dr. Patricia Barbetta for her thought provoking questions that pushed me to the next level of scholarship; to Dr. Haiying Long who patiently and meticulously ensured the statistical integrity of the analysis; and to Dr. Sarah Mathews who shared her invaluable knowledge of methodology and treatment implementation. Their collective feedback not only improved the quality of this dissertation, but made me a better scholar.

A very special mention to Mrs. Patricia Wright-Clarke of Mico University College where this journey all began. Her desire to see her students succeed was only paralleled by her tenacity in making it happen. The example she has set is one that I will spend the rest of my professional life trying to exemplify.

Lastly I would like to thank my family and friends for their unwavering support and wise counsel. Our deliberations over the ridiculous to the sublime made this doctoral experience and dissertation process worthwhile.

ABSTRACT OF THE DISSERTATION

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Self-directed learning (SDL) readiness skills and the command and/or retention of content knowledge have been identified as key factors for success in post-secondary settings. The Government of Jamaica (GOJ) has stated that two in three Jamaican secondary school graduates lack the requisite content knowledge and self-directed learning skills needed for advancement in the work space and in postsecondary education (Vision 2030 Jamaica National Development Plan, 2009). This dissertation examined the efficacy of project-based learning (PBL) as a method of instruction for improving SDL readiness skills and content knowledge retention. More specifically, the phenomenon was explored within the context of a developing country – in this case – Jamaica. The difference in SDL readiness skills and content knowledge retention was investigated among 8^{th} grade students in an urban high school under PBL conditions (N = 30) and under Traditional Direct Instruction (N=35) using a quasi-experimental design. Data on students' SDL readiness skills, knowledge comprehension and content knowledge retention were collected using validated instruments. Scores on all three measures were

recorded pre-intervention and post-intervention with a follow-up on content knowledge retention.

One way repeated measures mixed ANOVAs were run. Results showed that on SDL readiness skills, the difference over time for the PBL group was significantly different from the difference over time for the TDI/control group (p <.001), η_p^2 = .504. There was greater improvement for the PBL group on the post-test when compared to the TDI/control group. It was also shown on content knowledge retention that the difference over time for the PBL group was significantly different from the difference over time for the TDI/control group (p <.001), η_p^2 = .407. Specifically, the PBL group retained more content knowledge that the TDI/control group over time. On knowledge comprehension, the results showed that despite pretest to posttest improvement for both groups, PBL was not significantly different to TDI/control (p = 0.798), η_p^2 = .001. The results suggest that PBL as a method of instruction may improve SDL readiness skills and content knowledge retention over time.

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CHAPTER I

INTRODUCTION

"Let's be clear–we are failing too many of our children. We're sending them out into a 21st century economy by sending them through the doors of 20th century schools" Barack Obama, (2005)

The major goal of education from pre-school to high school is for the learner to achieve post-secondary success in higher education and/or the world of work. There has been a rapid and continuous change occurring in the world from more labor intensive manufacturing and mass production to more science and technology knowledge-based economies (Powell & Snellman, 2004). This directly impacts the change in skills demanded of learners to function and to contribute effectively and efficiently in society. The change in skills demanded is perhaps more critical currently, as the 21st century presents vastly different challenges and opportunities than those of previous centuries. Educational systems today function with less hierarchy and supervision. Autonomy and responsibility, and greater collaboration are becoming normative (Jerald, 2009). Two factors identified as imperatives for post-secondary success and laying the foundation for the knowledge and flexibility that system-wide shifts require are: self-directedness, and content knowledge (Casner-Lotto & Barrington, 2006; Gordon-Brydson, 2013; Rotherham & Willingham, 2010). These factors should inform not only what is taught in the classroom, but also how instruction is delivered to maximize these desired outcomes. A need to understand these factors within the context of the Jamaican secondary classroom and their implication for student performance, laid the foundation for this study.

Self-directedness, as defined by Cloninger, Svrakic and Przybeck (1993), is a skill referred to as one's ability to regulate and adapt behavior as a situation demands, for the achievement of personally chosen goals and values. The ability to self-regulate and adapt, also extends to meeting extrinsically set goals and objectives; it allows one to self-evaluate and determine what will be required to accomplish real world tasks and implement them. Becoming a self-directed learner, whereby learners take initiative and responsibility for their learning, is an important step to achieving self-directedness, thus making readiness skills for self-directed learning, an imperative. Simply put, self-directed learning (SDL) readiness refers to one's perception of the extent to which she or he possesses the attitudes and skills needed to be an effective self-directed learner. Improvement in these readiness skills would more likely increase the chances of achieving self-directedness.

Content knowledge has been defined as the body of knowledge and information taught by teachers, and expected to be learned by students in a specific subject or content area, such as, science, mathematics or English Language Arts (Glossary of Education Reform, 2014; Houseal, Abd-El-Khalicj & Destefano, 2014). It refers generally to facts, concepts, theories and principles taught and learned in academic courses and not related skills such as reading or writing. A distinction must be made, however, between acquiring knowledge and comprehending knowledge. Knowing information is important for factual recall, but comprehending or understanding information is important for application, analysis, and synthesis in real contexts (Rotherham & Willingham, 2010). Additionally, being able to retain content knowledge over time allows for recall and use of said knowledge at later points as required. Retention is essential for performance both inside and beyond the classroom setting (Casner-Lotto & Barrington, 2006; National Research Council, 2013). It can be argued, therefore, that requisite content knowledge, knowledge comprehension, content knowledge retention, and SDL skill for regulation and adaptation present collectively, as integral elements of 21st century education necessary for post-secondary success.

Project-Based Learning

Educators, policy makers, and all relevant stakeholders need to ensure that what is taught in the classroom – content knowledge or skills – reflects and prepares the learner for the dynamics of the real world. These shifts need to be reflected in not only what is taught in the classroom, but also how this instruction is delivered. Thus, determining the best instructional methods to maximize students' learning outcomes becomes an imperative.

Project-based learning (PBL) has emerged as an effective method of instruction for 21st century learning and improved post-secondary success (Cakici & Turkmen, 2013; Mergendoller, Maxwell & Bellisimo, 2006; Schneider, Krajcik, Marx & Soloway, 2002; Thomas, 2000). It has been presented in the research as an effective instructional method to address SDL readiness skills, knowledge comprehension and content knowledge retention, as well as a way to address the needs of diverse learners (Cakici & Turkmen, 2013; Hill, 2013; Kim, 2014; Schneider, Krajcik, et. al. 2002; Stefanou, Stolk, Prince, Chen & Lord, 2013). Project-based learning is an instructional method with an approach that is built on authentic learning activities (Mergendoller,et. al 2006 ; Strobel & von Barneveld, 2009; Terenzini, Cabrera, Colbeck, Parente & Bjorklund, 2001; Thomas2000); authentic learning activities are those activities which are designed to solve a problem or answer a question that generally mirrors the types of learning and work engaged in the real world outside of the classroom (Harris & Katz, 2001). Joyce, Weil & Calhoun (2009), argued that the goal of any form of instruction is to assist students in becoming better at thinking, analysis, comprehension and retention of subject matter, and ultimately to function independently in the real world – key for post-secondary success.

Importantly, PBL is a student empowerment tool for teaching and learning and facilitates creativity, interest, independent thinking, and problem solving (Krajicik, Blumenfeld, Marx & Soloway, 1994). Through PBL practices, it is assumed that the learner is more likely to form autonomous learning attitudes of self-directed learning (SDL) (Liu, Hsieh, Cho &Schallert, 2006). It is the view of some scholars that students exposed to PBL practices, retain more information, have a greater depth of understanding of subject content, and demonstrate improved academic performance, when compared with students under traditional instruction conditions (Chang, 2001; Dods, 1997, Liu et al, 2006; Schneider, Krajcik, Marx & Soloway, 2002).

It should be noted, that this researcher's review search of the literature on PBL and its effectiveness in addressing SDL and the learning and retention of content knowledge, it reflected studies conducted primarily in developed countries such as the United States, the United Kingdom, and Denmark. There is a dearth of any such published information from developing countries. The absence of balanced or comparable perspectives from developed and developing jurisdictions has implications for equity in resources, technological access, and even culture. Through this study, this researcher sought primarily to investigate the efficacy of PBL as a method of instruction for improving SDL readiness skills and content knowledge retention. More specifically, the phenomenon is explored within the context of a developing country – in this case – Jamaica.

Background and Rationale

In 2009, the Government of Jamaica (GOJ) launched the country's first long-term national development plan captioned *'Vision 2030 Jamaica - National Development Plan'*. The stated purpose of this plan was to position the country to achieve "developed country" status by 2030 (Vision 2030 Jamaica - National Development Plan, 2009) and make the country more regionally and globally competitive. The plan highlighted the nation's challenges across 13 government sectors, primarily, education, commerce, industry, social security, and labor. The plan set national goals and provided strategies for accomplishing its overarching goal. The plan included strategies to mitigate challenges toward meeting those goals, as well as specific time bound sector strategies for implementation, monitoring and evaluation of national goals. The national development plans for the Education Sector, and the Science Technology and Innovation Sector were integral to the investigation for this study.

In the Vision 2030 Jamaica - Education Sector Plan (2009), the GOJ stated that more than 65% or two-thirds of Jamaica's secondary school graduates lacked the skills and competencies necessary for post-secondary success. Specific reference was made concerning the lack of content knowledge, individual initiative, and self-directedness. These skills were understood to be integral to advancement in the work place, success in post-secondary education and ultimately becoming globally marketable. The importance of a focus on self-directedness for post-secondary success was further elucidated by

Gordon-Brydson (2013), who reported that as of January 2013, problem-solving and initiative (21st century skills) were listed in the top 10 skills and competencies required by the Jamaican and Caribbean labor markets. The Education Sector plan also indicated that student performance in the Science, Technology, Engineering and Math (STEM) areas were below a standard that would allow for increased local innovations, or make the island globally competitive in science and technology driven industries.

The Jamaican education system. The Jamaican education system originated from the British system of education. As early as the 1850's schools were established in a state-church partnership through the church (e.g., Anglican, Baptist, Roman Catholic), or bequeathed trusts. Such schools were known traditionally as 'grammar schools', focusing on a curriculum of the natural sciences, foreign languages, history, and geography, for example. The increased demand for equitable access to secondary education in post-independent Jamaica[1] resulted in the establishment of state-funded schools beginning in the 1970s. A variety of school types emerged, namely: (a) technical schools; (b) comprehensive high schools; (c) vocational schools; and (d) new secondary schools. The latter became popularly known as the 'non-traditional' high school, with the distinction being the offering of a broader curriculum than that offered in the 'traditional' high schools (Miller, n.d.), and these schools are referred to as 'government schools'. In Jamaica, high school begins at the 7th grade, with the average 7th-grader being 12 years old. The process to enter high schools includes an exit examination from the primary (elementary) school. Placement in high school is merit or performance-based. Of the choice of five (5) schools, students are placed in their desired school, on

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[1] Jamaica gained independence from Great Britain in 1962.

the basis of exam performance. Over the years, most 'traditional' high schools have developed a reputation of excellence, and are sought after as preferred choice. The performance-based merit placement system yields first choices to students in the higher performance ranks. Students whose performance fell below expected cut-scores, are often placed in 'non-traditional' schools. All high school students pursue an intense five-year course of study that leads to graduation at the 11^{th} grade. Terminal regional external examinations are administered by the Caribbean Secondary Examination Council (CSEC) and taken at the 11^{th} grade. The CSEC is considered the major mechanism for certifying students at the secondary level (Bloomfield & Soyibo, 2008; Reid, 2011), and are used across the Caribbean to meet the basic requirements for access to post-secondary education and employment. Expected exit requirement for students at the secondary level is: with passes in five or more subjects, inclusive of mathematics and English which are compulsory subjects (Evans & Burke 2006; University Council of Jamaica, 2003). Grades 12 and 13 are optional and are for advanced study through the Caribbean Advance Proficiency Examinations (CAPE). The CAPE specifically allows students the option to earn an associate's degree upon completion of an intense and targeted program of study.

Students at the secondary level have shown fluctuations in performance in key subject areas such as mathematics, English Language, and the sciences. The GOJ and other stakeholders in the Jamaican education system have, over time, examined the results of both internal and external examinations (Nelson, 2014; Reid, 2011) as benchmarks for current and future success. Table 1.1 shows the performance trend for Jamaica in the compulsory subjects of English language and mathematics in CSEC for the period 2009 – 2016. This trend reflects fluctuations in performance in both subjects with math achieving a pass rate above 50% only twice in the nine-year period.

Table 1.1
Student CSEC Performance English Language and Mathematics 2009-2016

Subject	Year							
	2009	2010	2011	2012	2013	2014	2015	2016
English Language	69.9%	63.9%	46.2%	46.1%	56.6%	66 %	60%	67%
Mathematics	39.5%	33.2%	31.7%	32%	34.1%	62%	57%	44%

The 2013 CSEC Report produced by the Ministry of Education (MOE), reported that 45.9% of the cohort recorded passes in one to four subjects, and 14.1% failed to pass any subjects; while a total of 60% failed to meet the benchmark of five subjects. Examination of the 2016 CSEC Report by the MOE showed only marginal improvement over the three-year period. Forty-four percent (44.7%) of the cohort recorded passes in one to four subjects, and 13.8% failed to pass any subjects; and a total of 58.5% failed to meet the five subject benchmark.

Caution must be exercised in drawing conclusions from the reported numbers in Table 1.1. Although not sanctioned by the MOE, Brooks (2011) highlights a common practice in schools in Jamaica of keeping students in the cohort from sitting for the examination if it is believed that they will fail. The premise is that if they do not sit the examination, then they cannot fail it (Brooks, 2011). The pass rate generally reported with this practice was the pass rate of those who actually sat the examinations, as opposed to the full cohort of those who should or could sit the examination. The discrepancy between the sitting and enrolled cohort, was most stark in the results reported for the science subject areas, and will be addressed in greater detail in a subsequent section in this chapter.

Why Eighth Grade?

The eighth grade is a critical transitional year in a student's education. Addressing issues of academic performance as well as the development of skills and competencies for 21st century education at the eighth grade level is, therefore, significant. Christie & Zinth (2008) posited that performance at the eighth grade level is a good predictor of performance in higher grades. They further assert that each course failed at this grade level increases the odds of failure at subsequent grade levels. These performance indicators have implications for students' knowledge base and independent functioning in post-secondary education and employment. Logically, it is important that educators consider the curriculum and pedagogy at this level.

Why Integrated Science?

Integrated science is a compulsory sub ect for students in 9 in the Jamaican education system. Traditionally the disciplines of biology, chemistry, physics, and environmental science are taught as discrete subjects. In the Jamaican system, integrated science is a subject that is an amalgamation of the areas of the physical and biological sciences. It exposes the learner to the skills of scientific inquiry such as observation, experimentation, and analysis and also provides a foundation for the study of the aforementioned discrete science subjects. The focus on the integrated science area for the present study was informed by the Vision 2030 Jamaica -Education and Science, Technology and Innovation Sector plans (2009). The education sector plan highlighted a concern regarding student performance in the areas of Science, Technology, Engineering, and Math (STEM). The MOE reported the pass rates for 2009 and 2010 respectively in the following science areas: 80% and 82.1% for biology; 76.9% and 70% for chemistry; 75.2% and 72.8% for Physics; 82.9% and 72.8% for integrated science. However, there was a significant discrepancy in the reported results. In 2011, Johnson Survey Research conducted a detailed analysis of the results in these subject areas for the same period using data from the grade 11 cohort of students from high schools across the island. Brooks (2011) presented the findings which included results that differed greatly from that reported by the MOE (See Table 1.2).

Table 1.2
Student CSEC Performance Science Areas 2009-2010

Subject	2009		2010	
	MOE	Johnson	MOE	Johnson
Biology	80%	8.9%	82.1%	9.4%
Chemistry	76.9%	7.9%	70%	7.9%
Physics	75.2%	7.3%	72.8%	7.9%
Integrated Science	82.9%	13.3%	72.8%	13%

Johnson's findings showed the more sobering and realistic pass rates for 2009 and 2010 respectively (accounting for the full cohort of students who should sit for these examinations): 8.9% and 9.4% for biology; 7.9% both years for chemistry; 7.3% and 7.9% for physics; 13.3% and 13% for integrated science. If one accepts Johnson's findings, then the cause for concern is heightened exponentially; either way, the report showed a general decline in performance over both years in these subject areas. The MOE has indicated that there has been some improvement in the area of integrated science and they have actively targeted this subject area through public/private partnerships in an effort to achieve greater success in all the science areas.

The Science, Technology and Innovation sector plan (2009) presented another focus for the selection of integrated science. A low capacity for enquiry-based approach to learning, as well as the lack of scientific inquiry as components of teacher training, were presented as key issues affecting science, technology and innovation (STI) in Jamaica. The cited concerns have implications for the instructional approaches teachers in these areas may employ in the learning environment, and by extension impact the acquisition of 21st century skills and student performance.

The Science, Technology and Innovation sector plan also highlighted the importance of STI as it asserted that STI: (a) serves as critical underpinnings of rapid economic and industrial growth; (b) plays a fundamental role in the creation of wealth, economic development and in the improvement of the quality of life for all citizens; (c) is critical in driving productivity and competitiveness; (d) generates employment and well-being; (e) helps to reduce poverty, improve education, health, nutrition and trade; and (f) is essential for building new capacities important for the 21st century.

The GOJ perceived the building of capacity for science in Jamaica as a means of enabling the country to transform from an economy that depends on subsistence agriculture, enclave extraction industries, and low skilled manufacturing, into one that is focused on production and knowledge-intensive activities. The sector plan further indicated that capacity building in the sciences would also enable the country to tackle health and nutrition problems, avoid and/or mitigate the impacts of natural disasters, safeguard fragile ecosystems, and improve quality of daily life for the rural and urban poor. (Vision 2030 Jamaica Science, Technology &Innovation Sector Plan, 2009).

Instructional Factor

The discrepant performance data reported by both the MOE and the Johnson Survey cannot escape the questions of instructional methodology and pedagogy in the area of STEM. Evans and Burke (2006) and Jennings, (2014) suggested that another factor contributing to poor student performance was the perceived unwillingness of teachers at the high school level to vary their instructional methods and delivery. As the 2011 MOE *Education Statistics* reported, 82.6% of teachers at the secondary level have undergraduate training (that is at least a bachelor's degree) in their respective sub ect areas. The expectation therefore would be that these teachers have been exposed to a variety of instructional methods in the course of their teacher training. Jennings (2014) presented the findings of a series of studies conducted at various times between 1984 and 2012 that looked at instructional methods in the Jamaican classroom. In each study, teachers from the primary and secondary levels were asked about their knowledge and use of different instructional methods, particularly more child-centered methods. While they were able to talk about different methods, observations of these teachers in their practice revealed that the majority employed traditional teacher-centered methods. Jennings cited inadequate physical, material and human resources along with inadequate teacher training as some of the factors that impacted the teacher's choice of instructional method and, ultimately, student performance.

The commonly identified method of instruction in most public Jamaican schools, particularly the ‘non-traditional’ schools, has been the teacher-centered Traditional Direct Instruction (TDI) approach (Hsieh & Knight, 2008; Mantri, Dutt, Gupta & Chitkara, 2008), a “broadcast” method often called didactic (Brunton, Morrow, Hoad-Reddick, McCord & Wilson, 2000), conventional or teacher-guided teaching (Acar& Tarhan, 2011). It consists primarily of teacher directed chalk-and-talk with limited differentiation or learner engagement, often leading students to the ‘swatting’ Jamaican for cramming 6 content for the purpose of near verbatim responses on tests including the CSEC. The static, repetitious protocols of the TDI lectures often result in recitation of facts (Acar & Tarhan, 2011) with limitations as it pertains to effectively developing the learner’s ability to apply, analyze, and synthesize knowledge gained. It is not being implied here that as a method TDI lacks effectiveness (Schwerdt & Wuppermann, 2011), however, it may not be the most suitable method for all learners in the classroom given variations in student learning abilities and styles, as well as its limitation in developing some requisite 21st century skills and competencies. While the TDI method was also employed in the more successful traditional public schools, it was often used in conjunction with other instructional methods (Jennings, 2014) thus achieving pedagogical flexibility and diversity, which is not generally characteristic of urban non-traditional Jamaican schools. The trend in the performance data in the science areas presented previously would suggest that a change in approach may, in fact, be necessary.

Statement of the Problem

Relative to other Caribbean nations, the cohort of Jamaican high school students, by virtue of the island’s population density, represents the second largest cohort of high school students in the Caribbean taking the mandatory regional CSEC exams, (Caribbean Examination Council Annual Report, 2014). However, Jamaica records some of the lowest scores in the core subjects of mathematics and English language (Knight & Rapley, 2007), as well as the science areas (Stockhausen & Soyibo, 2004). The Vision 2030 Jamaica Education Sector Plan of the GOJ (2009) reports that more than 65%, or two in three of Jamaica's high school graduates lacked the skills and competencies necessary for post-secondary success. The sector plan for education further identified the lack of content knowledge, individual initiative, and self-directedness, – that is, taking initiative and responsibility for one's own learning – as barriers to advancement in the work place as well as in post-secondary education. The concern regarding poor student performance in the STEM areas was expressed as an issue primarily associated with students from public, 'non – traditional', urban/inner city high schools, compared with students from traditional high schools (Reid, 2011). The Vision 2030 Jamaica Science, Technology and Innovation Sector Plan (2009) suggested that a low capacity for enquiry-based learning, and the lack of scientific inquiry, are key components that affect teacher training, and, consequently, science, technology and innovation in Jamaica.

The use of the TDI method which is commonly used in most Jamaican public schools (Jennings, 2014), while not an ineffective method, often lacks creativity and leads students into survival tactics, such as the cramming of content to produce near verbatim responses on tests and examinations. The TDI methods, therefore, may not be best suited to improving self-directed learning, improved knowledge comprehension, and the sustaining of content knowledge over time.

Project-based learning is drawn from a teaching/learning model that empowers students to be more creative and more interested in becoming independent thinkers and problem solvers, when compared with the traditional teaching/learning models; that is, the students are more likely to be self-directed learners (Lynch, Kuipers, Pyke, & Szesze, 2005; Strobel & van Barnveld, 2009). In comparison to students under conditions of traditional methods of instruction, PBL also helps the learner to: (a) retain more information over time; (b) have a greater depth of understanding of subject content; and (c) demonstrate improved academic performance (Chang, 2001; Dods, 1997; Liu et al, 2006 & Schneider, Krajcik, Marx & Soloway, 2002). Given this, it is reasonable to assume that these outcomes would appeal to educators of all levels.

The literature on the effectiveness of PBL is extensive as this method has been in use for more than 35 years. However, a search of the literature showed that a significant portion of the research was conducted with populations at the tertiary level and not at the lower levels. Holm (2011) reviewed research on the effectiveness of PBL for the period 2000 to 2011. Her focus was to identify articles that presented research in preschool, elementary, and secondary school classroom settings. Of the 768 peer-reviewed articles produced from a preliminary search of "pro ect method" and "teaching" only 17 met the criteria of school type and instructional effectiveness of PBL in the classroom. Importantly, while the studies were conducted primarily in public institutions, they were all conducted in countries with access to more financial resources, e.g. US, Israel, Qatar, and Turkey; no studies were identified from developing regions such as the Caribbean for example. Also of note, only three of the articles presented in the Holm's review of the research focused on science and/or technology.

A closer look at PBL and science shows a substantial amount of research with demonstrated rigor, focused on students at the tertiary level in engineering, nursing, and computer science to name a few, but, by comparison, fewer studies examining its success in middle and high school (the secondary level). This is not to say that additional literature on PBL and its effectiveness with the pre-tertiary level population is non-existent. The literature reviewed for this current study has delivered some preliminary, but promising results on PBL and middle grade students. It indicates that these students instructed under PBL conditions perform better on end of unit and state-level achievement science tests, than those students instructed under traditional instruction conditions (Harris, Penuel, DeBarger, D'Angelo & Gallagher, 2014). The current study proposed theoretically, that PBL-oriented teaching would improve the performance of a group of eighth graders in a selected urban, non-traditional high school in Jamaica on a specific integrated science instructional unit. The expected outcomes were that the PBL-oriented teaching would: (a) improve the learner's self-directed learning readiness skills; (b) facilitate improved knowledge comprehension in terms of application, analysis; and synthesis, and (c) improve content knowledge retention over time.

Purpose and Significance of the Study

The purpose of the present study was to examine whether being instructed using PBL conditions leads to improved SDL readiness skill and content knowledge retention among urban Jamaican eighth grade students within a science class context. The study examined the efficacy of PBL as an instructional method in an eighth grade science class in Jamaica and specifically focused on three primary objectives:

1. To determine if instruction under PBL conditions would lead to improved self-directed learning (SDL) readiness skills, that is the extent to which subjects perceive themselves to possess the readiness skills to manage their own learning
2. To determine if better knowledge comprehension in terms of application, analysis, and synthesis occurred using the PBL approach as compared to the TDI approach.
3. To determine if instruction under PBL conditions would lead to a statistically significant difference in science content knowledge retention over time.

Herein SDL readiness was defined as the degree to which individuals are ready to engage ‘the process in which [they] take the initiative...[for] choosing and implementing learning strategies, and evaluating learning outcomes’ (Knowles 1970, p.7). Knowledge comprehension was operationalized as the level of understanding gained after instruction as measured by responses to application, analysis and synthesis, questions, and content knowledge retention was defined as the maintenance of knowledge acquired through instruction for an extended amount of time (Smith, 2007); that is, after instruction, how much content the learner has retained after a specified period of time of not engaging with that content

The study is important as there is no evidence of published research done in Jamaica involving PBL or SDL readiness among high school students. Importantly, integrated science is compulsory in the Jamaican school up to the ninth grade and is the foundation subject for the discrete subjects of biology, chemistry and physics. The integrated science curriculum lends itself to flexibility and compatibility with a project-based approach to teaching and learning, and may lead to improved student performance. The present research added to the literature on instructional methodology in Jamaica, informed instruction for teacher education, and informed policy at the school and MOE levels. It also provided baseline evidence for future research in PBL and SDL readiness skills in Jamaica.

Research Design

A quasi-experimental design was used for this study. A quasi-experimental design examines the causal effect of an intervention on the target population without random assignment (Wiersma & Jurs, 2009; Williams, Cook & Campbell, 2002). Two classes from an eighth grade cohort were randomly selected; one class was the treatment group and the other class served as the control. Students were not randomly selected because, typically, at the eighth grade in Jamaican schools, students remain with their assigned classes for all subject instruction. As such the design was best suited for the study. Both groups of students were engaged in a unit on PBL-based water filtration, designed by the Buck Institute for Education (in partnerships with the New York Hall of Science). This unit was selected as this was the topic being covered in the school's eighth grade integrated science curriculum at the time the research was conducted. For the five-week duration of the study, the treatment group was instructed through a prescribed PBL unit. The control group engaged the same content being exposed only to the traditional direct instruction method over the same period of time. The sessions for both groups were conducted during their regularly scheduled integrated science classes.

Prior to the intervention, the teacher for the treatment group and other cooperating staff, received two weeks of training in the planning, implementation and assessment of PBL. Consultations were also done with the eighth grade coordinator for integrated science to ensure that the standards and objectives of the subject area were addressed.

The researcher was also available for consultations over the course of the intervention. Further details on the intervention and how it was conducted are presented in Chapter III which specifically addresses the methods employed in carrying out the study.

The *Guglielmino Self -Directed Learning Readiness Scale – ABE* (SDLRS-ABE) (1977), also known as the Learning Preference Assessment (See Appendix A)was administered to both groups, in week three of the study to establish a baseline of SDL readiness skills, and then again at the end of week eight to measure change if any. The SDLRS instrument was selected because, according to Merriam, Caffarella, and Baumgartner (2007), it is the most widely used instrument in the field of SDL. It measures the complexities of attitudes, abilities, and characteristics that comprise readiness to engage in self-directed learning.

Measurement of content learned/knowledge comprehension was ascertained by a pre-test and post-test approach, and content-knowledge retention was ascertained by a post-test and follow-up test approach. The instrument used was the content area unit test, *The Water Filtration Test*. (See Appendix B.) Form A of the unit test was administered as a pre-test to determine students' background knowledge on water and filtration, and as a means of establishing a baseline. At the end of the instruction period, week eight, Form B of the unit test was administered immediately as a post-test to both the control and experimental groups. At the end of twelve weeks, Form A of the unit test was again administered to both the control and experimental group as a follow-up. Statistical analysis was conducted using one way repeated measures mixed-design ANOVAs to test for effect of the instructional method and significant differences in student performance.

Research Questions and Hypotheses

RQ1. Is there a significant difference in participants' pre- and post SDL readiness skills scores between PBL and TDI conditions as measured by the SDLRS?

- H1a. Participants under PBL conditions have significantly higher SDL readiness skills than those under TDI conditions.
- H1b Participants under PBL and TDI conditions have significantly higher SDL readiness scores in the post-test than in the pre-test
- H1c There is a significant interaction effect between time and group on students' SDL readiness skills.

RQ 2. Is there a significant difference in participants' pre- and post-test knowledge comprehension scores between PBL and TDI conditions as measured by the 14 designated test items on Forms A and B of the integrated science unit test?

- H2a. Participants under PBL conditions will have better knowledge comprehension than those under TDI conditions.
- H2b Participants under PBL and TDI conditions have significantly higher knowledge comprehension scores in the post-test than in the pre-test
- H2c There is a significant interaction effect between time and group on students' knowledge comprehension.

RQ3. Is there a significant difference in participants' integrated science content knowledge retention over time between PBL and TDI conditions as measured by Forms B and A of the unit test in post and follow-up tests?

- H3a. Participants under PBL conditions retain more content knowledge than those under TDI conditions.

- H3b Participants under PBL and TDI conditions have significantly higher content knowledge retention scores in the follow-up than in the post-test
- H3c There is a significant interaction effect between time and group on students' content knowledge retention.

Operational Definitions

The terms which were used frequently throughout this study in discussion, are operationalized as follows:

Content knowledge retention:

maintenance of knowledge acquired through instruction for an extended period of time measured as the difference in score on the unit assessment administered immediately at the end of the instruction period and six weeks later (follow-up)

Integrated science:

a course of study that combines basic concepts of the natural sciences including biology, chemistry and physics

Knowledge comprehension:

the level of understanding gained after instruction as measured by the students' ability to apply, analyze, and synthesize knowledge gained

Non-traditional high school:

schools established by the Government of Jamaica (GOJ) post 1970, solely funded and operated by the GOJ and characterized by limited resources

Project based learning:

a systematic teaching method that engages students in learning knowledge and skills through an extended inquiry process structured around complex, authentic questions and carefully, designed tasks and products

Self- directed learning:

individuals take initiative and responsibility for their learning; they actively participate in the selection, management and assessment of their own learning activities

Self-directed learning readiness:

the degree to which one perceives oneself to possess the attitudes and skills needed to be an effective self-directed learner

Traditional direct instruction:

teacher-centered instruction that engages a primarily lecture approach

Urban school:

schools located in the city serving primarily students from low socio-economic households

Summary

Two thirds of Jamaican students leave high school without the requisite 21st century education skills and competencies for post-secondary success (Vision 2030 Jamaica - National Development Plan, 2009). The country's national development plan identified the lack of content knowledge, self-directedness, as well as poor student performance in the STEM subjects as three key areas of concern. Data gathered from the CSEC performance showed fluctuating and, often poor performance among Jamaican

11th grade cohorts, particularly in the areas of mathematics, English Language, and the science subjects, particularly among students from non-traditional high schools.

A possible major contributing factor was the perceived unwillingness of teachers at this level to engage a variety of instructional methods, opting for TDI as the primary method of instruction, which, research suggested, leads to limited improvement in content knowledge retention, or the development of SDL readiness skills. This researcher proposed that a different approach in engaging student learning was needed, and PBL provided a suitable alternative. As a student-centered approach to teaching and learning, PBL allows students to engage in the investigation of real-world problems with greater autonomy for their learning.

The purpose of the present study was to investigate the efficacy of PBL as a method of instruction for positive improvement in SDL readiness skills, knowledge comprehension, and content knowledge retention. A quasi-experimental design was used for this study with two classes from an eighth grade science cohort engaging a selected integrated science instructional unit. Chapter II, the review of literature, focused on the theoretical foundation and established a conceptual framework for the elements that were addressed by this study.

CHAPTER II

LITERATURE REVIEW

In the introductory discussion of Chapter 1, the researcher articulated the premise for using Project-Based Learning (PBL) in the context of an eighth grade science unit of instruction in an urban high school in Jamaica. Having chosen PBL as the instructional methodology to be examined, the conceptual grounding and supporting review of literature are addressed in this chapter.

The scope of literature reviewed was gleaned from primary sources accessed from articles from on-line databases, peer-reviewed journal articles and course-related text-books, and other material from the university library. The search parameters used to identify and select the contributing literature for the study were: 'constructivism'; 'pro ect-based learning'; 'self-directed learning'; content-knowledge; content knowledge retention; 'situated learning'; and 21st Century skills. The search yielded material related to the main search parameters dating back to as early as 1916. Careful sorting of the sourced literature resulted in a more manageable array of reference materials such as peer-reviewed articles, experimental studies, and opinion articles on the merits or cautions of the use of PBL. A significant portion of the material reviewed directed the researcher to explore constructivism, or built their arguments on the constructivist ideology as an integral orbit to the PBL approach and methodologies.

The refined selection of related literature is presented in this chapter. Here the researcher introduced the definition of PBL, traced its background, the social, cognitive, and psychological perspectives of PBL, and its use as an instructional model and methodology. The discussion introduces self-directed learning (SDL) as a goal of PBL, categories and elements of SDL, the relatedness of situated learning theory, and its connectivity to project-based learning. The review also presents, perhaps most importantly, a review of empirical research in PBL focused on the identified variables of this current study. The reviewed literature sets the background for the investigation of the success of PBL in the targeted context and population for this study.

Project-based Learning Defined

Markham (2003) defined PBL as an instructional strategy which empowers learners to pursue content on their own, and demonstrate their new understanding through different presentation modes. In its methodology, PBL is a dynamic, student-centered approach to teaching in which students investigate real-world problems and challenges, and in which students may be engaged in realistic, thought-provoking problem-solving activities (Harris & Katz, 2001; Savery, 2015). The PBL model is a multi-faceted approach that incorporates authentic (that is, trustworthy and keeping with real world problems) content and assessment (Krajcik, Blumenfeld, Marx, & Soloway, 1994), teacher facilitation as opposed to direction, unambiguous educational objectives[2] (Moursund, 1999), cooperative learning, reflection, and the incorporation of adult skills (Diehl, Grobe, Lopez & Cabral, 1999, Worthy, 2000).

A few of the leading scholars in the field of instructional methods and PBL have presented it as a viable model of instruction. Some of these scholars include Bas and Beyhan, (2010); Chen (2006), Markham; (2003), Meyer 1997, Savery, (2015); Seidel, Aryeh and Steinberg (2002); Thomas, (2000); Thomas, Mergendoller, and Michaelson,

[2] Objectives which clearly state the intended educational outcomes for the student, the conditions under which they will occur, and the criteria for acceptable performance

(1999); and Wang & Eccles (2013). These scholars posit that as an instructional model, its teaching/learning process empowers students leading to increased creativity and interest thereby they become improved as independent thinkers and problem-solvers.

Backed by theory and research, PBL has grown significantly as a successful part of the instructional landscape with demonstrated effectiveness. As an effective method of teaching and learning, and the development of, successful learners, PBL has been argued as particularly practical for varied content areas, including science (Marx, Blumenfeld, Krajcik, & Soloway, 1997), history (Hoover & Taylor, 1998; Levstik & Barton, 2001), or other areas of instruction which require high levels of interaction and experimentation (Dodge, 1998; Starr, 2000; Yoder, 1999). Reference to the subject areas is integral to this study as the investigation was conducted in a science class engaging an instructional unit that required interaction and experimentation.

The present study focused on the variables of: (a) self-directed learning readiness skills; (b) knowledge-comprehension; and (c) content-knowledge retention. The Government of Jamaica (GoJ's) Vision 2030 Jamaica-National Development Plan, (2009) identified these areas as critical competencies lacking in high school graduates. The learning context of an eight-grade science unit in an urban high school in Jamaica created the learning context in which PBL, the elements SDL, and the variables of knowledge-comprehension, and content-knowledge retention were examined.

Conceptual Framework

The theoretical assumption applied to the PBL methodology is that in authentic learning contexts, active engagement increases knowledge and improves student outcomes. Through application, and the development of the specific skills of motivation, self-management and self-monitoring, students can become autonomous learners (Thomas, 2000). The discussion continues here with the conceptual and theoretical framework which was guided by the theories of constructivism (Dewey’s 1933; Piaget 1926; Vygotsky 1978), situated learning theory (Lave & Wenger, 1991), and now les’ (1975) notions of SDL. They are explored as the conceptual foundation for the current study.

The Theory of Constructivism

The constructivist educator uses problem-based, adaptive learning that integrates new knowledge with what exists, and leads to the creation of original work or innovative procedures. Learning is accomplished through a process of questioning, exploration and assessment. Proponents of constructivism believe that the acquisition of knowledge is not sufficient for learning. They argue, rather, that it is the sense the student makes of the knowledge that matters most. As the learner encounters new information or a new experience, for example, s/he reconciles it with previous ideas and experiences, leading to a change in what is believed, or perhaps discarding the new information as irrelevant (Benaim, 1995).

Dewey (1916; 1933), Piaget (1964) and Vygotsky are often recognized in the related literature, as the architects of constructivist ideology. The theory of constructivism, derived from the works of Dewey, Piaget, and Vygotsky, explains how a learner acquires knowledge, the underlying belief being that learning best takes place when the learner is actively engaged (Perkins, 1991; Piaget, 1964; Vygotsky, 1962). According to scientific observation and inquiry, constructivism allows individuals to construct their own understanding of the world through real-life experiences. Their knowledge is conditioned further on the reflection of these personal experiences. Within the concept of constructivism, the learner is viewed as one whom: (a) acts on objects and events within their environment; (b) builds an internal illustration of knowledge and a personal interpretation of the experience; and (c) gains understanding and derives meaning of those objects and events. In this context, learning is an active process in which meaning is accomplished based on experience, and the opportunity to engage directly with information. By constructing from the inside, the learner acquires knowledge through interaction with the environment. Learners build theories or hypotheses as they learn by putting things into 'relationships.' The process of putting associations learned previously into new associations creates meaningful explanations of new ideas (Kami, Manning & Manning 1991). Strommen and Lincoln (1992) stated that constructivism explains how the learner creates and develops ideas, reflecting reasoning that grows in complexity and power. With the support of prior knowledge s/he develops critical insight into how s/he thinks, and what the connected thoughts about the world grows in depth and detail.

Social, cognitive and psychological perspectives of project-based learning. Dewey (1916; 1933), Piaget (1926) and Vygotsky (1962) advanced the application of constructivism to the classroom. Social constructivism and cognitive constructivism are proposed under the constructivist theory as further explanations for how the learner engages with information. For example, social constructivism places emphasis on the importance of the influence of culture on learning, and one's understanding of society. Cultural understanding forms the basis for knowledge construction (Atwater, 1996; Kim, 2001; Murphy, Alexander & Muis, 2012). The perspective of cognitive constructivism explains ideas as knowledge that is constructed through the personal process of creating understanding of new information by mapping onto prior knowledge or understanding (Martin & Sugarman, 1996; Powell & Kalina, 2009). Although they differ as theoretical perspectives, the basic foundational assumptions about learning are similar. That is, from both perspectives, the individual's development and experience ought to be central to the goals of instruction.

Dewey (1916) believed that education depended on meaningful action and engagement. He contended that, for the learner, knowledge and ideas emerged from situations in which the learners applied meaningful and important experiences to the learning context. Learning situations, he suggested, had to occur in the social setting of a classroom, in which interaction, involvement, and manipulation of materials created a community of learners; with knowledge being formed within that community. Vygotsky (1962) also purported that social interaction was integral to the learning process and the construction of knowledge. He explained that students first work on their own, then with the assistance of the teacher, and also, work cooperatively with others. Through scaffolding, he suggested, students learn new concepts based on what they are actually doing. These notions of constructing knowledge in the learning process expressed by Vygotsky are foundational to PBL (Thomas, 2000).

Piaget (1953) built his concept of constructivism on the cognitive developmental phases through which a child must pass until s/he can reason logically. Underdevelopment of cognitive schema, or failure to attain a stage of development, prevents the child's advancement to subsequent stages. Powell and alina (2009) argued that Piagetian principles had implications for reasoning ability and cognitive performance in the classroom context. According to Powell and Kalina, Piagetian principles in the classroom should reflect the following:

- The provision of an environment in which children can:
    - experience spontaneous research; access authentic opportunities to challenge their minds;
    - be free to understand and construct meaning at their own pace through personal experiences as they develop through individual developmental processes.
- The understanding that learning is an active process in which errors will be made and solutions will be found:
    - errors and solutions are both important to assimilation [*congruence of new, with existing knowledge*] and accommodation [*modification of existing knowledge*]to achieve equilibrium; and, finally
- The understanding that learning is a social process that should take place among collaborative groups, with peer interaction in as natural as possible settings.

Advancing the discourse of Piagetian principles on cognitive development and classroom practice, Powell and Kalina (2009), also affirm the importance of the environment, learning as an active process, and learning as a social process. In his analysis of the Piagetian view, Wadsworth's (1971) argues that the development of the learner's knowledge of the world and reality is not a copy of the real world. He posits that knowledge and reality are individually constructed over the course of one's development, through the complementary and adaptive processes of assimilation and accommodation.

Assimilation refers to the incorporation of new information into a framework that already exists without changing the framework. Accommodation on the other hand refers to the modification of existing schema or organized pattern of knowledge, derived from new information. Initially proposed by Jean Piaget, assimilation and accommodation as learning processes, allow the learner to create and internalize said knowledge. Through assimilation, the learner incorporates what is perceived in the outside world into his/her internal world. Adjustments in the internal world are made on the basis of evidence or [new] information, thus resulting in accommodation. According to Wadsworth then, we construct our "knowing" through the process of absorbing from, and adapting to our social, real-world experiences. Knowledge, therefore, is not transmitted directly, but it is constructed as learners navigate social and cognitive processes toward the discovery of knowledge. Wadworth's analysis aligns with the primary tenet of PBL which is to provide the structure and opportunity for the learner to engage in authentic activities and collaboration. The discussion continues with attention to the opinions which support or refute the application of the principles of constructivism in the instructional process.

Constructivism and Instruction

The reviewed literature indicates collectively, that constructivism influences how instruction is conducted by encouraging discovery, hands-on, experiential, collaborative, project-based, and task-based learning (Duffy & Cunningham, 1996; Duffy & Jonassen, 2013; Mvududu & Theil-Burgess, 2012; Sufiana, Fauzia, Ruqyya & Fareena, 2013). Operating on the stated premise, learning should then take place in a rich context that is reflective of the real world, thereby allowing the constructive process to happen, creating transference to environments beyond the school and the classroom. Learning through cognitive apprenticeship, or learning by doing (Aziz, 2003; Brown, Collins, & Duguid, 1989; Collins, Brown & Newman, 1988; Khan, 2014), modelling the collaboration of real-world problem-solving, and using the tools available in problem-solving situations are foundational to the constructivist approach. Cognitive apprenticeship is a theory that attempts to bring implicit processes out in the open. The assumption is that people learn from one another, through observation, imitation and modelling. With the elements of cognitive apprenticeship, modelling, collaboration, problem-solving, Duffy and Jonassen (2013), suggest that learning could be assessed by how the learner uses existing knowledge in facilitating thinking in a particular content field. While there is support for constructivism applied to instructional approaches, it is not without its critics.

Criticisms of Constructivism

Psychologists and educators alike, such as Holloway (1999), Kirschner, Sewell and Clark (2006), and Liu and Matthews (2005) have questioned constructivist approaches. The objections to the broad-based used of constructivism are countered by neo-Piagetian theories which maintain that cognitive development and learning are dependent on the availability of age-appropriate processing and representational references which enhance and facilitate learning. Proponents of constructivism argue that without a frame of reference or representation with which to assimilate, the learner is unable to engage with the concept, and the concept becomes un-learnable. In their counter-argument, however, Hubbard and Armstrong (2005), suggest that the presumption of total dependence on prior knowledge as a pre-requisite for learning impedes the learner from reasoning, and engaging meaningfully with new information.

Constructivists assert that “learning by doing” enhances learning (DuFour & DuFour, 2013). Criticism applied to instructional design is placed mostly within the context of the development of instruction for novice learners, regardless of age. The counter-argument is that there is little empirical evidence to support ‘learning by doing’ as an irrefutable claim for enhanced learning (Kirschner, Sweller & Clark 2006; Mayer, 2004). Sweller (1999) suggested that novice learners do not possess the schema necessary for “learning by doing.”

Mayer (2004) fixed his criticism on the teaching/learning element, in what he referred to as the “constructivist teaching fallacy”, which he said equates active learning with active teaching. He argued that not all constructivism-based teaching techniques are efficient or effective for all learners. He perceived that using teaching techniques that required learners to be behaviorally active was a misapplication of constructivism.

Kirschner et al., (2006), in their analysis of the failure of constructivist, discovery, problem-based, experiential and inquiry-based teaching, concluded that minimal guidance during instruction is ineffective. They described constructivist teaching methods as “unguided methods of instruction,” and suggested that novice learners be given more structured learning activities. Kirschner and his colleagues suggest that under constructivist methods the teacher takes a hands-off approach, or provides insufficient guidance. The teacher in this example is presented as a passive and perhaps disengaged observer in the classroom rather than a facilitator/coach helping to guide the learning process and providing the requisite supports.

The importance and the integrity of the research process required presentation of supporting and opposing views from the reviewed literature. Both sets of opinions and observations are important to the process and the proof or disproof of the hypotheses which guided this study. The extent to which the proposed hypotheses were challenged by the discourse on constructivism will be addressed in Chapter V.

Situated Learning Theory

According to Clancey (1995), the theory of situated learning makes the claim that "every idea and human action is a generalization adapted to the ongoing environment, because what people see and what they do arise together" (p. 49). Clancy further stated that it originated as the study of "how human knowledge develops in the course of activity and especially how people create and interpret descriptions of what of they are doing" (p. 49). The basic assumption of situated learning as an instructional model is that knowledge should be presented in an authentic context, i.e., a real or genuine situation, which involves its application. Its goal is to improve learning by motivating students, providing a context rich environment and usually engages the learner in tasks that parallel real-world applications; for example, having students design a sprinkler system for the school garden. Heeter (2005) purports that situated learning theory emphasizes context and knowledge application, rather than the memorization of facts. Parallels can be drawn between the constructivist view of engaging learning through authentic real-world instruction and situated learning as a model of learning.

Lave and Wenger (1991) proposed situated learning as a model of learning in a community of practice. They posit that learning is not just the transference of hypothetical knowledge from one person to another, but occurs as a social process whereby knowledge is co-constructed. They go further to suggest that this learning is 'situated' in a specific context and fixed within a particular social and physical environment. Heeter (2005) stated that Lave and Wenger emphasized social interactions and authentic learning where tasks parallel real world situations, a view which aligns itself with the basic premise of PBL.

Hung (2002) in his study on how important being social is to learning, connected situated learning theory to the works of Dewey and drew compelling connections between situated learning and PBL as an instructional process. He argued that PBL is aligned to situated learning at its most fundamental level. With a foundational belief that learning is social, Hung added that learners who gravitate to communities with common interests are more likely to benefit from those with more knowledge and experience than themselves. He also suggested that these social experiences provide people with authentic experiences. Real-life situations will compel students to learn. Hung concluded that engaging a PBL approach to designing curriculum moves students to a higher level of thinking.

The notions of an authentic learning environment and authentic learning tasks are integral to situated learning theory. Given authentic learning tasks, students learn associated facts and skills needed to accomplish the task. As they engage in context, culture, and activity, they are better able to acquire, understand, develop and implement cognitive instruments in authentic learning activities. This would meet the primary post-secondary outcome of schooling which is for students to be able to apply the knowledge and skills gained in the real world in the context of their career or vocation (Richardson 2010). It is imperative that they are able to apply these skills to complete work goals. Situated learning enables them to learn and use the skills, and gain experience through the doing; the experience allows for an easier transition to the work world. The discussion of the reviewed literature continues with attention to the foundations of PBL, SDL and the connections between them.

Foundations of Project-Based Learning

Project-based learning started in England in the 1920's as an early childhood teaching strategy. Later, through the work of Dewey and Kilpatrick it became a part of the American education system (Kain, 2003; Katz & Chard, 1989), and more recently, its use has been advanced by Brown, Collins, and Duguid (1989), Lave and Wenger (1991), Thomas, Mergendoller and Michaelson (1999) and Bos and Krauss (2014). There are two major developments which have been attributed to the evolution of PBL: (1) the knowledge of how students learn and how they engage knowledge; and (2) the need for "real-world" skills for post-secondary life. According to the literature, learning is a social activity that engages the culture, community and experiences of the child (Thomas, Mergendoller, & Michaelson, 1999). Children construct knowledge through feedback. As a means of interpreting and understanding new information and situations, past personal experiences are utilized. Thomas et al., theorized, as follows:

> …the need for education to adapt to a changing world is the primary reason Project-Based Learning is increasingly popular. Project-Based Learning is an attempt to create new instructional practices that reflect the environment in which children now live and learn. (p. 2)

The changes in, and evolution of the education system, respond to the constant changes in the needs of the real world. These real world needs dictate the relevant methods of instruction that can adapt to, and meet the changes desired. One such change is that of student assessment and high stakes testing. Project-based learning, as a model of instruction, addresses the need for self-assessment by the students. As improved test scores on standardized tests and accountability of educators continue to take center stage in the field of education, PBL is increasingly demonstrating itself as an effective tool for meeting these demands (Thomas et al., 1999).

In the broader application of the role education plays in preparation for the workforce, schools have to ensure instruction in content areas. They must ensure also that instruction includes the requisite skill development that effectively prepares the student for the work-world. The main work-force related skills for the 21st century (Pink, 2005), include solving problems creatively, thinking critically, communication, the ability to work cooperatively within a team and achieve common goals, as well as being prepared to understand, interpret, and respect varying perspectives in a multicultural setting. In the selection of methods of instruction, it is imperative that work-force related skills be taken into account.

Project-based Learning as an Effective Teaching Model

An effective teaching model is one that allows all learners to learn (Joyce, Weil & Calhoun, 2009). Research shows that for a student to learn and improve academic achievement, active engagement in the learning process and environment is fundamental (Carini, Kuh & Klein 2006; Wang & Eccles 2013; Willms 2000). As stated previously, PBL has its theoretical underpinnings in Dewey's theory of 'learning by doing', Piaget's and Vygotsky's constructivist theories, and Lave and Wenger's perspective of 'situated learning'. Dewey (1938) argued that curriculum should be relevant to students' lives, and advocated for the "learning by doing" approach to instruction. He believed that successful education is measured in student experiences, where learning is a necessity and connected to their real-world experiences; and not an “unwelcomed imposition.” Therefore, if the teachers’ goal is student learning, it makes sense to create effective learning environments where the content is relevant to the “real world” of the students, and students are actively participating and engaged with the environment, as well as the material. In asking the student to do more than ust take in or ‘learn’ and reproduce information verbatim, one increases the chances of the student learning and retaining more. This PBL environment should include activities that will improve learning as students explore applications and implications of content in context. By this measure, PBL may be said to be an effective teaching strategy.

Thomas (2000) gave focus to the nature of the project and student engagement with the project. According to Thomas, the projects do not exist outside of the curriculum, but are grounded in it. Projects are based on the concepts and experiences of the curriculum, but are designed from real-world challenges for real world application. Through the projects, students are engaged in constructive investigation through questions or problem solving which lead them to interact directly with the central concepts of the subject-matter. As much as possible, the project and the experience should reflect real world situations. Markham (2003) identified six (6) key characteristics of effective PBL that align with Thomas’ view. Project-based learning projects (1) lead students to investigate important questions and ideas; (2) are framed around the inquiry process; (3) are differentiated according to students’ needs and interests; (4) are driven by student production and presentation rather than teacher delivery of information; (5) require the use of creative thinking, critical thinking, and informational skills to investigate, draw conclusions about, and create content; and (6) connect to real-world and authentic problems and issues.

Markham (2003) also distinguished activities associated with the curriculum from PBL by identifying clear attributes incorporated into PBL:

> …students' inherent drive to learn; pro ect work is central rather than peripheral to the curriculum; in-depth exploration of authentic and important topics; essential tools and skills, including technology, for learning; products that solve problems, explain dilemmas, or present information generated through investigation, research, or reasoning; multiple products that permit frequent feedback and consistent opportunities for students to learn from experience; performance-based assessments; and collaboration. (pp. 4-5)

Like Thomas, Markham puts the focus on the nature of the project, learning engagement of the student, and the connections to the real world as integral to the effectiveness of PBL as a teaching strategy.

The gains made when students work on projects that are relevant was explored in the literature review. Caine, Caine & McClintic 2002; Curtis 2002; Kozminsky & Kozminsky 2003; Zimmerman, Bandura & Martinez-Pons 1992, report that students show increased interest as they work on projects relevant to their lives and experiences. Project-based learning also allows for greater student-engagement as it creates connections between classroom content and the real world (Csikszentmihalyi, 2002), and ultimately results in greater academic achievement (Blumenfeld, et al 1991; Thomas 2000). Studies have shown that the more effort invested by the student, the greater the academic achievement (Dupeyrat & Marine, 2005; McKenzie, Gow & Schweitzer, 2004;

Wolters, 2004). High effort input is considered a trait of effective self-directed or regulated learners, often resulting in higher academic achievement. Effort management, as the term suggests, refers to how a learner manages this effort input. As such, any degree of success would be dependent on the effort input. The main characteristic in self-directed learning (SDL) is seen in how much active control is maintained by the learner during the learning process. The very premise of SDL is that the learner takes responsibility for his/her learning. The discussion is extended to examine the elements of SDL within PBL.

Self-directed Learning Theory

Self-directed learning (SDL) is any instructional forum in which learners have primary responsibility for planning, implementing, and even evaluating the effort (Hiemstra (1994), or situations where information is to be experienced. Such experiences are under the control of the learner via their ongoing decisions (Gureckis & Markant, 2012). SDL theory has its foundations in the field of andragogy, which is the art and science of helping adults learn (Merriam, 2001). Presented by Knowles (1975), andragogy is a model that distinguishes teaching methods for adult learners as different from children. Knowles (1970) defined SDL as:

> The process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing learning strategies, and evaluating learning outcomes (p.7).

While developed around adult education, there is some literature to show that SDL has been used effectively with students from the elementary, middle and high school grades (Della-Dora, McGovern & Wells 1980; Fahnoe & Mishra, 2013; Liu, Horton, Olmanson & Toprac, 2011). SDL usually involves exploration and decision-making in a project-based environment where the students can work alone or with others. The expected result should be the acquisition and development of motivation, self-management, and self-monitoring; skills specific to SDL, and necessary for engagement in independent and social learning processes (Dawson, Macfadyen, Risko, Foulsham & ing stone, 2012; Brookfield, 1993). The teacher's role in the process (as guide and support) is to stimulate the student to the awareness in the student of his/her role in their learning; encourage students' initiative in their learning process, and provide opportunities for help and discussion (Abdullah, 2001). The categories that comprise the broader context of SDL are addressed in the following paragraphs.

Categories of Self-directed Learning

In their review of the literature related to SDL, Merriam and Caffarella (1999) explored its widespread existence, its goals and ethics, clarification of its nature, the process by which it occurred, model building, and the ways it may be assessed. Their review yielded the following three clear elements behind SDL, namely: (1) the goals; (2) the process and; (3) the learner. In subsequent sections of this chapter the interconnectedness of these three categories are identified, and their relation to PBL will be addressed.

Goals. The literature identifies three main process-related goals: self-directed learning, transformational learning, and emancipatory learning as variations in the goals of SDL. The learner's capacity to be self-directed is the primary goal of SDL; that is a perspective held by Knowles (1975) and Tough (1967; 1971). According to what is referred to as the humanist perspective, Knowles and Tough assert that, under the guidance of the teacher, the learner is proactive, and accepts responsibility for his/her learning.

The second goal, transformational learning suggests a change from within. Transformational learning is achieved through the process of critical reflection on the part of the learner. As students engage with content and processes through PBL group activities, opportunities are presented for them to learn about themselves; and, ultimately, experience transformational learning (Seidel, Aryeh & Steinberg, 2002). Project-based learning also provides opportunities for the learners to establish self-motivational capabilities, maintain their own learning process, or set completion goals for their performance or task/activity (Filcik, Bosch, Pederson & Haugen 2012; Liu, Hsieh, Cho & Schallert, 2006). As more autonomous learners, students are able also to draw on their strengths and create projects that incorporate their own interests, cultural background, abilities, and preferences for media types through which to present products of learning (Thomas, 2000).

The third goal for SDL is promoting emancipatory learning and social action. Emancipatory learning is learning that results in the understanding and knowledge of the nature and cause of unsatisfactory circumstances, with a view of developing real strategies to effect change (Thompson, 1997). Emancipatory learning, therefore, cannot occur without social action; that is, the former must lead to the latter. These three goals form part of the process to hone the skills of the self-directed learner, engage knowledge, cultural awareness, personal experience, and the elements of critical reasoning for the purpose of creating a more informed and vested learner.

Process. Many models of the process of the SDL experience have been developed and evolved over time. The focus of the process in instructional models is on what instructors can do to engage self-direction and student control of learning, specifically in the classroom (Merriam & Caffarella, 1999). There are three models of the process that teachers may engage. The linear model (Knowles, 1970) sees the learner moving through a series of steps, planned from start to finish, as a means of accomplishing the learning goals. Song and Hill (2007) describe the interactive process as the learner engaging in the process through what is in the environment, his/her personality, cognitive processes, and the learning context. The interactive instructional model, according to Song and Hill, recognizes the evolving learner through the four stages of engagement: (a) dependent learner: generally prefers a teacher/instructor to provide most of the information; (b) interested learner: begins to think about what they can add to what the teacher/instructor is providing and perhaps entertaining input from other learners; (c) involved learner: engages in collaborative learning and like the social interaction of learning through group work, and, finally; (d) self-directed learner: likes to direct their own learning and use multiple resources available. The process makes allowance for learner differentiation, as dependent learners may need more introductory material and welcome lecture, drill and immediate feedback. Self-directed learners, conversely, may engage more readily in independent projects, student- directed discussions, and discovery learning. The instructional model to be used, therefore, would be dependent on the nature of the learner, and style of learning.

Learner. Merriam and Caffarella's (1999) review of the related literature also focused on the learner specifically, and self-directedness an *a priori* characteristic, associated with the variables of educational level, learning style, and creativity. It is important, therefore, to consider the implications of learner autonomy on SDL. Two primary instruments that have been used in empirical studies on SDL are the Oddi Continuing Learning Inventory (OCLI) Scale and Guglielmino's Self-Directed Learning Readiness Scale (1997). The OCLI scale (Oddi, 1986) measures personal characteristics, such as proactive/reactive learning drive, cognitive openness/defensiveness, and commitment/aversion to learning; Guglielmino's Self-Directed Learning Readiness Scale measures readiness. Evaluating the personal characteristics and SDL readiness of the learner provides a measure of their autonomy that may inform the approach to instruction. Candy (1991) argues that the learner's autonomy is likely to vary from one situation to another.–It should not be assumed, therefore, that a learner who demonstrates self-directed behavior in one situation will automatically transfer this behavior successfully to a new area. As Candy suggests, to ensure success for the learner, the first stages of a learning project may require orientation, support, and guidance.

The theory of SDL has evolved over time, but the basic assumption remains, that while the learner may construct learning pulling on personal awareness and knowledge, learning is the responsibility of the learner. The extent to which the learner becomes more self-directed in learning is presumed to increase as s/he matures. The connections between PBL and the elements of the learning characteristics required for the self-directed learner are discussed in the following paragraphs.

A Brief Review of Empirical Research on Project-based Learning

Research on the efficacy of PBL as an instructional approach and its impact on achievement and other dimensions such as affective competencies for setting and achieving one’s goals have mainly been positive (David, 2008; Holm, 2011; & Thomas, 2000). Benefits have been noted in the areas such as SDL, content knowledge gains as well as content knowledge retention. Research on content knowledge gains and content knowledge retention will be presented later in this section.

Research on PBL and SDL. As previously explained there are three categories of self-directed learning. These are goals, process, and learner. Merriam and Caffarella (1999) presented the goals of SDL as: (1) the learner’s capacity to be self-directed, (2) the fostering of transformational learning; and (3) the promoting of emancipatory learning and social action. Project-based learning aligns clearly with the first goal of the learner’s capacity to be self-directed, as at its core, PBL is about the learner demonstrating the capacity to be self-directed. Project-based learning has been purported to provide opportunities for growing students’ basic skills such as self-directed learning readiness skills (Thomas, 2000). This claim is supported by research in the field. Studies have shown that students engaged in PBL experience benefits of affect in this particular area. Harding et al., (2007) conducted a quasi-experimental study on SDL perception in PBL contexts with a group of university engineering students. In the Harding study, there were 33 students in the experimental group who were instructed under PBL conditions, and the control group consisted of 34 students instructed under a traditional method. The duration of the study was ten-weeks. Findings revealed that the learners who were instructed in PBL situations perceived themselves to be more self-directed as measured by the Self-Directed Learning Perceptions Scale than their counterparts in the control group. Similar findings were reported in the Bagheri, Ali, Binti Abdullah and Daud (2013) study. Seventy-eight educational technology university students were randomly assigned to one of the two groups: the experimental group engaged in the PBL strategy, and control group engaged in a conventional teaching strategy. The SDLRS was administered as a pretest, post-test one and post-test two. Analysis conducted using a two-way repeated measures ANOVA test showed significantly better performance by the students instructed under PBL conditions than students instructed under the conventional teaching strategy.

The findings of Harding's study were also supported by a study conducted by Zhou and Lee (2009). They investigated possible differences between the SDL readiness skills of students exposed to the PBL strategy, and those under traditional instruction. Participants were 100 university sophomores majoring in computer science; 50 in the experimental group and 50 in the control. The study utilized a quasi-experimental pretest/posttest design to assess for readiness for self-directed learning before and after experiment. The SDLRS set the criterion for the assessment. Findings from Zhou and Lee's study led to the conclusion that the improved SDL level in the experimental group was significantly larger than the control group. The assumption therein is that PBL is more effective for enhancing SDL in students than traditional direct instruction. Zhou and Lee reported also that students' instructed under PBL conditions perceived that they were more actively involved in exploration, as the process of PBL provided them with better understanding of the course concepts.

Other studies investigating PBL and SDL reported similar results. Savage et al. (2009) stressed the importance of SDL readiness, as an essential and important skill of the 21st century, and studied the effect of PBL on the enhancement of self-directed readiness skills. Their study used engineering students as their target group and found a significant positive difference between the readiness skill level of those engaged in PBL, compared to those engaged in teacher-centered learning. In the aforementioned studies, participants were university students. Studies on PBL and SDL in the reviewed literature tended to focus on student at the university level with fewer such studies found on students at the middle or high school level. Studies investigating PBL at these levels were more likely to focus on student achievement while addressing some aspects of student affect inclusive of students' ability to be self-motivated and determining and achieving intrinsically or extrinsically set goals; SDL is seldom stated specifically. One such study was conducted by Hernandez-Ramos and De La Paz (2009) with a group of eighth grade history students. In addition to investigating student achievement, they looked at students' ability to be responsible for their learning through engagement and attitude. The intervention group engaged the PBL approach while the control group engaged the more traditional methods. Pre-/post-tests assessment of attitude and engagement, as well as content knowledge was administered. Results showed the PBL group achieving higher content knowledge score, but also reporting much higher demonstrations of engagement and taking responsibility for their learning. In 2000, AutoDesk Foundation conducted a study with a group of teachers across the middle and high school grades examining teachers' perceptions of the effectiveness of PBL as an instructional model. Teachers who participated in the study agreed that PBL was an effective instructional method. These teachers concurred that as a method of instruction, PBL established a foundation for students' autonomy in driving the decision-making process for their learning, which resulted in greater self-direction. During the PBL activities, students engage a problem and find solutions through their own inquiry. For successful outcomes, students are required to build on their strengths, using teachers as one of many available resources, to create an end product.

Despite the disparity in the number of studies investigating the impact of PBL on SDL at the middle to high school levels, the research with tertiary level students offers plausible grounds for engaging PBL approaches to improve SDL and SDL readiness skills with younger learners. The findings of these studies provided a trustworthy platform which directed this researcher into further exploration of the retention of content-knowledge as an outcome of PBL.

Research on PBL and Content Knowledge Retention. Content-knowledge retention can best be defined as the maintenance of knowledge acquired through instruction for an extended amount of time (Smith, 2007). Retention is more than simply capturing knowledge. Retention requires that knowledge be captured, stored for a specified period of time, and is retrievable. The amount of content retained signifies the level of thinking at which the student acquired the information. Smith states that knowledge retention is a crucial aspect of any learning environment. The literature review yielded limited material describing standards for retaining knowledge. For the purpose of this study, content-knowledge retention as a measure refers to the difference in scores of the unit assessment on the test administered at the end of the intervention, and a second test administered four weeks later. Administering the test was intended to ascertain how much content knowledge was retained over time. Studies have shown that PBL, if effectively implemented, can increase retention of content, and improve students' attitudes towards learning, a key aspect of SDL, among other benefits.

Research into the efficacy of PBL in public school settings is still in the preliminary stage. Gallagher and Stepien (1996) found that secondary students using PBL in American Studies did as well on multiple-choice tests as students using a traditional model of instruction. The study found, however, that PBL students showed better depth of understanding of the content when compared to students instructed using a traditional model. The finding regarding the degree of depth of content understanding prompted the researcher to extend the study to investigate knowledge comprehension within the context of PBL. A search of the literature for knowledge comprehension failed to produce any related material using knowledge comprehension as the search parameter. Knowledge comprehension was therefore operationalized as the level of understanding gained after instruction as measured by the students' ability to apply, analyze, and synthesize knowledge gained. These categories come from Bloom's Taxonomy's cognitive domain which involves knowledge and the development of intellectual skills (Bloom, 1956). Application, analysis and synthesis as discussed by Hoy (2007), is explained as follows. Application is demonstrated by the student's ability to use concepts learned in the classroom in new situations. Analysis requires that the student be able to distinguish between facts and inferences and demonstrate their ability to separate concepts and/or material into constituent parts to better understand how the structure is organized. Synthesis brings together all aspects of what was learned into creating new meaning or structure. The connections between PBL and content knowledge have been investigated in many studies showing improvement in student content knowledge and retention under PBL conditions.

The most significant study on PBL effectiveness according to Thomas (2000) addressing content knowledge was conducted by Boaler (1998). Thomas stated that

> One of the most powerful designs for conducting research on instructional practices involves comparing students' performance on some criterion measure before and after an experimental treatment, while at the same time being able to compare these gains to those of a comparison group that is similar to the experimental group in all respects except the nature of the treatment (p. 13).

Boaler's longitudinal study involved mathematics instruction in two secondary schools in Britain. A cohort of students from each school totaling 300 participants, were followed for a period of three years from the 9th grade to the 11th grade. In the experimental school the instructional approach was PBL; the control school engaged in traditional instruction. Participants were closely matched though not randomly assigned. All students were comparable in ability and background, were of similar socioeconomic status, had been exposed to similar mathematics instruction in previous years, and demonstrated similar achievements in mathematics on a range of tests. A pre-/post-test design was used; the three-year time period allowed for multiple measures of growth using a variety instruments to assess achievement, attitudes and capabilities. Results showed that students from the PBL school performed as well or better than students from the traditional school overall on the national examination. Critically important, the PBL students performed as well as or better than traditional students on procedural[3] questions,

[3]Procedural questions may be answered by recalling a rule, method or formula from memory.

and performed at a higher level than the traditional students on conceptual[4] questions and applied problems. Through student interviews as well as test data collected, Boaler as cited in Thomas (2000) concluded that

> "Students taught with a more traditional, formal, didactic model developed an inert knowledge that they claimed was of no use to them in the real world. [In contrast], Students taught with a more progressive, open, project-based model developed more flexible and useful forms of knowledge and were able to use this knowledge in a range of settings. (Boaler, 1998a)." p. 15

Boaler's study formed the basis for the design of this current study.

Other studies showed comparable results on student achievement in terms of content knowledge. In a study with 10th grade earth science students, Chang (2001) reported that PBL instruction improved student knowledge of the material measured on an achievement test, compared to their peers in more traditional classes. Schneider, Krajcik, Marx, & Soloway, (2002) found that high school students using PBL in biology, chemistry, and earth science classes outscored their peers on 44% of the items on the National Assessment of Educational Progress (NAEP) science test given during their 12th-grade year. Gordon, Rogers, Comfort, Gavula, and McGee (2001) used PBL with an urban minority middle school population. These students showed increased academic performance in science and improved social behavior ratings over a two-year period. Liu, Hsieh, Cho, and Schallert (2006) also found that middle school students had a better understanding of science concepts and felt more confident about being successful learners after they completed a computer-enhanced PBL unit. Findings of the Liu, et al.,

[4] Conceptual questions require thought and the creative application and combination of mathematical rules.

study are also particularly relevant to the present study. Connections can be made relevant to the present study in three ways: (1) the common focus on a science area; (2) and the sample drawn from young high school students from an urban school; the subject population drawn from students from a lower socioeconomic background.

In Dods' (1997) study which analyzed the performance of students using PBL in a biochemistry course, students engaged in PBL did not perform at a higher level on the measure of content knowledge; in fact, they were found to have the same level of content-knowledge as those in a traditional lecture course. Importantly however, the PBL students demonstrated a greater depth of understanding of the material and retained more of the information. Strobel and van Barneveld (2009) highlighted PBL's effectiveness in promoting long-term content knowledge retention in their meta-synthesis of meta-analyses comparing PBL to conventional classrooms. Their findings indicated that PBL was superior on the measure of long-term retention while traditional approaches were more effective for short-term retention. Their meta-synthesis included eight meta-analyses and systematic reviews of studies from as early as 1993 across scientific and educational disciplines. This is significant as while achieving higher score is important, retaining the content knowledge over the long term has more benefit to the learner as it relates to transference and application of knowledge in practical real world settings.

What Does This All Mean?

The traits of self- directed readiness, self-direction in learning and content knowledge retention are becoming increasingly important as the need for lifelong learning continues to grow in strength (Dawson, Macfadyen, Risko, Foulsham & Kingstone, 2012). Educators are challenged to assist in the development of SDL readiness skills and to encourage learners to use self-direction more freely in their learning activities. This self-direction includes (as defined earlier) their taking primary initiative for planning, carrying out, and evaluating their own learning as a process of living rather than merely a preparation for living (Taylor, 1984). Content-knowledge and more so content-knowledge retention are also important for post-secondary functioning.

Carl Rogers (1969), an early respondent to the need for increased self-direction for younger learners, elaborated that in order to have citizens who can live constructively in a changing world, there must be a willingness to have them become self-starting, self-initiating learners (Bell, 2010). Students will live in a world of their own design doing what they want to do, the way they want to do it, making short-term and long-term choices that will affect their behaviors, success, and happiness. Given the foregoing, the goal of producing increasingly self-directed learners with a strong content knowledge base is defensible and appropriate.

As stated previously, the conceptual framework for this study was based on the fundamental theory of constructivism. The hypothesis is that student outcomes for becoming autonomous learners are improved when knowledge is built through active engagement in authentic learning contexts involving application, and the development of specific skills. The studies reviewed herein provided evidence of PBL's success in improving SDL readiness skills, facilitating a better understanding of content, and leading to greater retention of content knowledge. This is foundational to students becoming autonomous learners and improving their performance in post-secondary settings. However, there was a gap in the literature on studies in these areas being conducted with populations in developing regions such as the Caribbean. This current study sought to begin to fill this gap. It aimed to provide educators in general and Jamaican educators specifically, with an analysis of quantitative data, taken from urban Jamaican student-engagement in PBL, within the indicators of SDL readiness skills, knowledge comprehension, and content- knowledge retention.

Summary

This review of literature presented a full definition of project-based learning and then examined the conceptual framework of the study. It also presented the foundations of PBL, discussed the connections between PBL and SDL and examined PBL's relationship to content knowledge retention. A review of research on PBL and the indicators of SDL readiness skills, content knowledge and content knowledge retention showed the success of PBL in improving student outcomes on these measures. Chapter III will present the methods employed in conducting the study.

CHAPTER III

METHODOLOGY

The content of this chapter consists of a description of the methods and procedures including the research design, a description of the participants, the setting, instrumentation, the procedures, and analysis for the research study.

Research Design

This project served as an exploratory study (Nath, 2005) on the impact of PBL on the stated variables in a specific urban secondary school in Jamaica. It used a quasi-experimental non-equivalent group pretest- posttest research design with a control group for the purpose of measuring the effect of PBL intervention on PBL readiness skills, knowledge comprehension, and content knowledge retention in a group of eighth graders compared with the TDI approach. Quasi-experimental research engages the use of intact groups of subjects in an experiment rather than assigning subjects at random to experimental treatments (Wiersma & Jurs, 2009; Williams, Cook & Campbell, 2001). Random assignment of the subjects for this study was not possible because of fixed class schedules, as well as for the fact that students at this school remain in intact groupings for all subjects. A convenience sample of two eighth grade integrated science classes was used to establish a treatment and a control group. For the duration of the study, one teacher instructed the treatment group using PBL; another teacher engaged the control group with the TDI method of instruction as used in this school.

Participants

Given the varied types of secondary school programs in Jamaica, for example, traditional, technical, comprehensive, agricultural, public, private, etc. (Miller, 1992) this study considered a defined population of students enrolled in public, non-traditional comprehensive secondary schools in urban centers in the Kingston and St. Andrew (KSA) region at the eighth grade level. To minimize the selection threat to internal validity that can arise from non-equivalent groups and uncontrolled diversity among participants, the study was limited to 8^{th} grade students enrolled in one specific non-traditional comprehensive high school in an urban Jamaican setting ($N = 120$).

Participants, male and female, ranged in age from 13 to 15 years old with approximately 75% maintaining a C average in integrated science. A 'C' average is any grade from 50% - 59% in most public Jamaican schools. Approximately 65% of the school population receives government subsidized lunches; the racial and socioeconomic demographic characteristics are homogeneous. Students from two intact eighth grade classes (approximately 70 students) were recruited. A prospective power analysis was conducted to estimate a desirable sample size (Peng, Long, & Abaci, 2012). With $\alpha = .05$, power = .80, 2 groups and ES = .4, the suitable sample size computed to reject the null hypothesis was 64. Recruitment was done through letters sent to their parents with Informed Consent Forms attached to these letters for parents to sign indicating their agreement to allow their child/children to participate or not. As the members of each class could not be randomly assigned, the researcher utilized random selection (flipped a coin) to assign each of the eighth grade classes to the experimental group or the control group. The researcher was mindful of the importance of protecting subject confidentiality. To protect the privacy of the subjects, each student was assigned an alpha-numeric code which was used for all documentation. At no point were names or any other identifying descriptors used for any reason.

Sex x Group CHI-Square Analysis

Cross tabulation (Table 3.1) and chi-square analyses (Table 3.2) were run to test the null hypothesis that the percentage of males and females in the PBL group is similar to the percentage of males and females in the control group. These analyses were done to eliminate sex as a confounding variable. The chi-square analysis shows no significant difference in the percentages of males and females in the two groups ($\chi^2 = 0.711$, $df = 1$, $p = .399$). The null hypothesis is not rejected; on the basis of these results, it was determined that the sample did not differ in sex ratio.

Independent samples t-tests were also run to test the null hypothesis that the average age of students in the PBL group is similar to the average age of students in the control group. Table 3.3 shows the group statistics and Table 3.4 shows the independent samples test. The results are not significant ($t\ (63) = 0.101$, $p = .920$). The null hypothesis is not rejected on the basis of the results, which indicated that the age structure is similar across both groups.

Table 3.1
Group X Sex Crosstabualtion

			Sex		
			Female	Male	Total
Group	PBL	Count	15	20	35
		Expected Count	16.7	18.3	35.0
		% within Group	42.9%	57.1%	100.0%
		% within Sex	48.4%	58.8%	53.8%
		% of Total	23.1%	30.8%	53.8%
	TDI/Control	Count	16	14	30
		Expected Count	14.3	15.7	30.0
		% within Group	53.3%	46.7%	100.0%
		% within Sex	51.6%	41.2%	46.2%
		% of Total	24.6%	21.5%	46.2%
Total		Count	31	34	65
		Expected Count	31.0	34.0	65.0
		% within Group	47.7%	52.3%	100.0%
		% within Sex	100.0%	100.0%	100.0%
		% of Total	47.7%	52.3%	100.0%

Table 3.2
Chi-Square Tests

	Value	df	Asymptotic Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.711	1	.399		
N of Valid Cases	65				

Table 3.3
Descriptive Group Statistics for Age

	Group	N	Mean	SD	SD Error
Mean AGE	PBL	35	13.49	.562	.095
	TDI/Control	30	13.50	.572	.104

Table 3.4
Independent Samples Test for Age

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
AGE	Equal variances assumed	.018	.892	- .101	63	.920
	Equal variances not assumed			.101	61.133	.920

Setting

The study was conducted in a comprehensive (non- traditional) high school (Wilkins & Gamble, 2000) in an inner city community in Kingston, Jamaica. The school is situated in an area that has an extended history of gang violence. It is bordered to the north, south and west by rival communities that have in the past used the school as a thoroughfare for access to these communities. Fears about the location and the stigma attached to non-traditional high schools have long been an issue in Jamaica (Barrett, 2010). The school was chosen as an exploratory case because of its overall improvement record and demonstrated willingness for change when compared to similar schools in urban centers in Jamaica. According to A. Chambers, Education Officer, (personal communication, March 15, 2016), in the past ten years through the successful efforts of the principal working with the students, stakeholders and the community, the school no longer contends with gangs and gang activity. It has recorded a steady improvement in academic achievement (Cunningham, 2014) despite the fact that students placed there have registered poor scores on the Grade Six Achievement Test (GSAT), averaging below 55% in overall scores. In 2014 efforts were targeted at math performance in CSEC and registered a pass rate of 59%, up from 18% in the previous year. The growth rate has been slow but steady for subsequent years in this subject area but so far, there has been no such targeted effort for the areas of science.

The PBL intervention was conducted in one of the two eighth grade integrated science classes and was scheduled for three times per week for 1 hour each session. The control group continued with the traditional direct instruction approach but covered the same instructional unit. All classes were coeducational and consisted of participants of mixed academic ability as academic streaming is not done in this school.

Instrumentation

Self-directed learning (SDL) readiness skill was used as a dependent variable for the study. It was measured using the *Guglielmino Self-Directed Learning Readiness Scale-ABE* (1977). The *SDLRS-ABE* is a self-report questionnaire with 34 Likert scale test items developed to determine the extent to which subjects perceive themselves to possess the readiness skills to manage his/her own learning. The ABE version of this instrument is used for persons with low reading levels or non-native English speakers. It was selected based on the students' low reading ability and the fact that most students from this geographical demographic typically communicate in the Jamaican dialect (Campbell, 2014); many of these students often lack the requisite proficiency in Standard Jamaican English. Subjects responded to test items using one of the following:

1 = I never feel like this.

2 = I feel like this less than half the time.

3 = I feel like this about half the time.

4 = I usually feel like this.

5 = I feel like this all the time.

Sample test items include:

- I know what I want to learn.
- When I see something that I don't' understand, I stay away from it.
- If there is something I have decided to learn, I can find time for it, no matter how busy I am.

- I am good at thinking of new ways to do things.
- I learn many new things on my own each year.
- I like to see if I can solve hard problems.

A reliability coefficient of .94 was reported from a split-half Pearson product moment correlation with a Spearman-Brown correction (Delahaye & Choy, 2000), as well as test-retest reliability coefficients of .82 (Finestone, 1984) and .79 (Wiley, 1981). According to Wiersma and Jurs (2009), reliability coefficients take on values of 0 to 1.0, inclusive. A reliability coefficient of 0 would indicate that the observed score would be made up entirely of error; a score of 1.0 would indicate an observed score of no error, i.e. a true score. While coefficients of 1.0 are rare in educational measurements, obtaining high-reliability coefficients is desirable (Wiersma & Jurs, 2009). The reliability and validity of this instrument have been supported by many studies (example Delahaye & Choy, (2000); Delahaye & Smith, 1995; Durr, 1992; Finestone, 1984; Graeve, 1987; Hassan, 1982; Long & Agyekum, 1984; McCune & Guglielmino, 1991). The literature indicates widespread acceptance of the reliability and validity of the SDLRS, which further supports the decision to use the instrument.

Knowledge comprehension and content knowledge retention were the other dependent variables addressed by this study. Content knowledge retention was measured using the Form A and Form B of a 20-item test of the instructional unit content area, *The Water Filtration Test*. It was measured by the difference in performance between the total score on the post-test and follow-up with Form B being administered as the post-test and Form A at the follow-up. Form A was also administered as the pre-test. This test was constructed by a veteran science teacher in Jamaica with 15 years of experience teaching 7th to 12th grade integrated science. The tests measured students' knowledge of the facts as well as application, analysis and synthesis of the various scientific concepts introduced in the lessons. now ledge comprehension was measured by students' performance on the 14 items testing application, analysis and synthesis.

The two forms of the test were reviewed by four eighth grade integrated science teachers and one science education professor. Feedback was provided and items adjusted accordingly to reflect the knowledge and skills the designer and the reviewers considered as important for the students to acquire after instruction. The test questions included factual knowledge items (n=6), application (n= 6), analysis (n= 4) and synthesis (n= 4). Examples of the questions include:

Factual: Turbidity refers to:

a) the level of disturbance in the water.

b) a measurement of the clarity of the water.

c) how much light can shine through the water

d) how much soil is in the water

Application: A farmer in rural St. Andrew is seeking to reduce turbidity levels in the drinking water for his livestock. What filtration method would best filter the water while saving him the most money?

a) Ultraviolet (UV) Radiation

b) Distillation

c) Microporus screen filtration

d) Installation of a carbon filtration system

Analysis: What step would you take to reduce the turbidity of the water flowing in your community?

a) Remove the particles using a fine meshed fabric

b) Pass the water over activated carbon.

c) Add chemicals to the water.

d) Boil the water.

Synthesis: Consider your community. Determine whether chemical or biological filtration would be best for the residents then briefly state the factors that make it a better choice.

The tests were administered once to two groups of students, Form A to one group and Form B to the other, in an urban setting with demographics similar to the target school. Cronbach's alpha was used to estimate the internal consistency (intercorrelations among test items) of each test form. Form A reported $\alpha = .828$ and Form B reported $\alpha = .839$ suggesting that the items have a relatively high internal consistency. A reliability coefficient of .70 or more is considered as acceptable in most educational research situations (George & Mallery, 2003).

Intervention

The intervention was guided by a developed PBL unit on water which was used for the duration of the instructional period of the study. The treatment group utilized the PBLU.org *Design It Clean: The Water Filter Challenge* (2014) designed by the Buck Institute for Education (BIE). (See Appendix C for sample material.) The BIE is a nonprofit organization that focuses on showing educators how to engage PBL in all grade levels and subject areas. They have collected, established and shared high quality PBL instructional practices and products over the past 25 years, and have provided professional development for teachers and administrations across the world. The National Education Association (NEA), in their review of the research on best practices in education, highlighted the work of the BIE in their "Research Spotlight on Pro ect-Based Learning" (2015). The NEA is currently the largest organization for education professional in the US.

The selection of this BIE unit was made because it is built around a project that addresses real-world problems. Students work in teams to develop dependable and affordable water filters that can provide water for specific communities in the real world. Students actively research a region where people lack access to potable water and design and build a working solution. Their solution must be aligned with the needs of the respective community, culture, environment and local government, and the final product, their water filtration prototype, along with relevant data, is presented to adults who play various roles. These include but are not limited to end users, aid workers, government officials, venture capitalists and environmental scientists.

The unit is a complete PBL instructional guide with the full scope and sequence of the science content along with a project guide, lesson plans, student handouts, and teacher materials. The unit also meets the criteria of Markham's (2003) six characteristics of effective PBL in that it leads students to investigate important questions and ideas, is framed around the inquiry process, is differentiated according to students' needs and interests and is driven by student production and presentation rather than teacher delivery of information. It also requires the use of creative thinking, critical thinking, and informational skills to investigate, draw conclusions about, and create content through its connection to real-world and authentic problems. Table 3.5 shows eight essential PBL elements addressed by this unit.

Table 3.5
Essential PBL Elements of the Design It Clean Unit

Significant Content	Focuses on developing students' skills to ask questions, conduct empirical research, craft evidence-based explanation, define problems and solution, and develop and refine solutions; provides extensions into a variety of classes and disciplines e.g. chemistry, environmental science, civics and social science.
21st Century Skills	Develop critical thinking and problem solving skills within real-world contexts; communicate and critique ideas effectively to a broad range of people; work collaboratively in teams to develop and present ideas, critique and refine prototypes, exhibit work, and share feedback; engage computers and web-based technology to design affordable and easy to maintain filters.
In-Depth Inquiry	Use an empathetic problem-solving mindset to engage a range of academic concepts; engage the needs and perspectives of a variety of stakeholders and constituents through meaningfully considering the academic content and subject matter.
Driving Question	Be guided by a driving question that calls for a multidisciplinary solution; address the question on multiple levels throughout the ' course of the project.
Need to Know	Engage relevant issues and develop applicable solutions; learn specific science content to solve a challenge or consider important cultural or geographical knowledge to male solutions more appropriate to stakeholders.
Voice and Choice	Problems offer multiple opportunities for solutions – students will collaborate to find ways to effectively communicate decisions on which concepts to follow or ideas to develop; develop roles within their teams that accentuate strengths, and develop a plan to showcase their work to a critical audience.
Revision & Reflection	Encourage and require revision of work based on empirical evidence, real-world feedback from users, and team-based critiques; ongoing reflection is used to improve solutions, better communicate the merits and challenges of their work to a public audience and build more efficient cohesive teams.
Public Audience	Culminating event – persuade adults of the feasibility of their solution from technological, financial, and cultural perspectives; physical examples of the water filtration prototypes, along with

marketing materials and original scientific literature are presented.

Procedures

All requisite IRB approvals were gained for the execution of this research. Students received from the researcher a letter for their parents/guardians forwarded by their school principal which informed the parents and students about the study and sought permission for the students' participation in the study. (See Appendix D.) Of the 65 letters sent to the parents, 75% of the parents/guardians signed and returned the attached consent within a week of receipt of the letter. All signed forms were received within two weeks of receipt of the letter; no parent or student declined to participate. In the week prior to the implementation of the intervention, the SDLRS and the content pre-test was administered by the researcher to both groups. Participants were assigned an alphanumeric code which they used for the duration of the study to ensure confidentiality. At no point were the students' names used or attached to any documents related to the study.

The study lasted for twelve weeks. During weeks one and two, the integrated science teacher for the treatment group, along with the cooperating English, math and technology teachers, and the school librarian received training in the planning, implementation and assessment of PBL prior to the intervention. While the intervention was carried out primarily by the integrated science teacher, the cooperating teachers were included in the training as some of the content that was included in the unit required students to seek assistance from these teachers. Importantly, even though these cooperating teachers were aware of the study and the specific project, they were not part of any of the instructional aspects of the project. The training was conducted by the researcher. All teachers received the training material in advance for review and preliminary practice. Informal discussions were conducted between the researcher and the teachers prior to the face-to-face training using Google Hangouts and Skype which allowed for preliminary queries and clarification. The researcher conducted 90-minute face- to- face training sessions with the teachers for four days during the week prior to the implementation of the intervention. It followed the *Project Based Learning Professional Development Guide* (2007), a fully developed workshop designed by Edutopia/The George Lucas Educational Foundation (GLEF) on how to use PBL in the classroom. The decision to use this training guide was guided by the fact that GLEF has over twenty years of demonstrated experience in training, providing and encouraging innovation in K-12 schools (Kroll, 2011; Pondiscio, 2010). The development guide provided instruction in the foundations of PBL as well as hands-on activities in the development of good projects, lesson and class organization, assessment, and collaboration with teachers from other disciplines. The training was divided into two parts. Part One guided the teachers through the fundamentals of PBL and how it works. These sessions focused on: 1) Introduction to PBL; 2) Why is PBL Important?; 3) What is PBL About?; 4) How Does PBL Work? Sessions were done via online training modules. Part Two focused on readings and hands on activities engaging group collaboration and technology. Training entailed a series of workshop activities which had session participants reviewing PBL units, as well as working collaboratively to design a PBL unit. These sessions were done face to face. Session participants also reviewed videos of PBL in action in various schools at different levels with a focus on the science disciplines. The professional development guide provided PowerPoint presentations with presenter notes and session schedules. At the end of the training period the teachers were required to make a presentation on what they had learned. Included in their presentation was a model PBL unit. They were rated using the PBL Essential Elements Checklist (See Appendix D) assessing their understanding and use of the eight essential elements of PBL. Teachers were required to meet 95% of the requirements on the checklist to be deemed as prepared for PBL implementation. If they fell below the 95% then retraining would be done in the areas of deficit. Only one of the cooperating teachers required remediation after the initial training. Training was also provided to the teacher of the PBL group and the TDI/control group on scoring the subjective-type items on the *Water Filtration Test*. The teachers were trained to look for key terms/content and processes that are critical to the responses of these test items. The training was important as both teachers were responsible for scoring the test and the training was an effort to establish standards.

During week three, the SDLRS-ABE and the Form A of the content area test were administered as pretests to the treatment group and the control group and the scores recorded. Readers and/or scribes were provided for four students with an identified disability requiring these accommodations. Two students in the control group needed readers while one student in the experimental group needed a reader and one needed a scribe. Participants completed each pretest on two different days. Both groups engaged in a unit on water filtration; three 1-hour sessions a week for five weeks. The treatment group utilized the PBLU.org *Design It Clean: The Water Filter Challenge* (2014). The control group engaged the same content on water filtration but follow the TDI method with prescribed lectures and labs following the regular school curriculum unit. Teachers for both groups submitted weekly plans to the researcher as a means of ensuring consistency in subject content and that each teacher was being true to the respective methods. A checklist was used to measure consistency in this regard. The researcher had weekly debriefing sessions with the teacher of the treatment group via Skype, and two in person observation visits. A fully trained research assistant also assisted in biweekly monitoring of the instruction using the PBL Essential Elements Checklist, as well as data collection for the duration of the intervention. The teacher implementing the intervention kept a journal to record best practices used following the training materials, challenges faced, as well as queries or concerns which were addressed with the researcher. On the basis of the information gathered from the PBL Essential Elements Checklist, observation by the research assistant, and feedback from the teacher implementing the intervention, retraining was conducted by the researcher with the teacher at the end of the second week of instruction on how to be an effective facilitator/coach instead of engaging in teacher-centered direct instruction.

In week eight following the intervention, participants were given a post-test using the Form B of the content area test and scores were recorded; the SDLRS was re-administered. Four weeks later, in week twelve of the study, a follow-up test using Form A of the content area test was re-administered and scores recorded to measure content knowledge retained over time. Kohn (2014) posits that people retain only about 10% of new information presented by the end of one week if the information is not consistently engaged. The notion presented here would suggest that next to nothing would be retained after four weeks of non-engagement. The decision to conduct the follow-up test at week twelve was to allow for enough time to lapse between the last interaction with the content, as well as to coincide with the school's regular testing period.

Data Analysis

Data were analyzed using SPSS. Descriptive statistics were obtained for the demographic variables and for each of the test scores overall and by group. The hypotheses were tested using one-way repeated measure mixed ANOVAs, with time as a within-subjects factor and group as a between-subjects factor. The mixed ANOVA is used when two or more independent groups are tested for differences with the dependent variable being measured repeatedly (Gamst, Meyers, & Guarino, 2008). It addresses the concern of errors associated with within- group variance and eliminates bias arising from individual differences among participants. The statistical significance of the interaction between time and group was assessed using an alpha level of .05. The effect size was assessed using a partial eta squared. According to Richardson (2010), Cohen (1969) provides partial eta squared values of .0099, .0588, and .1379 as benchmarks for small, medium, and large effect sizes, respectively. A partial eta squared level of .0588 was set for this study, meaning the interaction between group and time must account for at least 5% of the variance in test scores.

Data Management

All data collected, both paper and electronic forms, were secured in a locked file cabinet in the office of the school principal. All electronic data were password protected; written data was scanned and stored along with other electronic data to an external back-up drive kept by the researcher. Data will be retained for a period of 3 years after the study ends and will then be destroyed.

Researcher in the Field

The researcher is a native of Jamaica. She has worked as an educator and administrator in the Jamaican education system at the primary, secondary and tertiary levels, and in the Ministry of Education (MOE) as an education officer. In her capacity at the MOE she served as a supervisor of schools and had responsibility for informing education policy specifically relating to special education instruction and services. The study was important to the researcher as she has a vested interest in the success of the education system in Jamaica.

Being mindful of potential for bias, measures were put in place to mitigate this bias. Data collection was done by the teacher who was implementing the intervention as well as the research assistant. The collection was monitored by a research assistant residing in Jamaica with the researcher giving oversight of the entire process. Additionally, the instrument to measure content knowledge and content knowledge retention was designed by a Jamaican high school science teacher. It was reviewed by experienced Jamaica science educators and duly tested for reliability.

Summary

This chapter presented in detail the method employed in conducting this study. It included the study design and a full description of the population, the setting, instrumentation, intervention and procedures engaged. The results of the data analysis are presented in Chapter IV.

CHAPTER IV

RESULTS

Chapter IV describes the findings of the study. It presents a brief overview of the purpose of the study, the problem that was addressed, and the instruments used for data collection. This is followed by the results of the study, including the demographic information about the participants and the data analysis outcomes.

As articulated in chapter one, the Vision 2030 Jamaica Education Sector Plan of the Government of Jamaica (2009) reports that more than 65%, or two in three of Jamaica's high school graduates lacked the skills and competencies necessary for post-secondary success. It further identified the lack of content knowledge, individual initiative, and self-directedness as barriers to achievement in the work place as well as in post-secondary education. Poor student performance in the STEM areas was also expressed as an issue, and was primarily associated with students from public, non-traditional, urban/inner city high schools. The researcher sought to look at the method of instruction to be employed that would more effectively address these identified issues. As such, the purpose of the study was to examine whether being instructed under project-based learning (PBL) conditions lead to improved self-directed learning (SDL) readiness skills and content knowledge retention among urban Jamaican eighth grade students within a science class context. Its primary objectives were:

1. To determine if instruction under PBL conditions would lead to improved SDL readiness skills, which is the extent to which students perceive themselves to possess the readiness skills to manage his/her own learning.

2. To examine if better knowledge comprehension, as determined by the student's ability to apply, analyze and synthesize the knowledge gained, occurred using the PBL approach as compared to the Traditional Direct Instruction (TDI) approach.
3. To determine if instruction under PBL conditions would lead to a significant difference in science content knowledge retention over time.

The study focused on three research questions concerning the efficacy of PBL as a method of instruction for positive improvement in SDL readiness skills, knowledge comprehension, and content knowledge retention. These questions will be restated later in this chapter.

Data were collected using the Guglielmino Self-Directed Learning Readiness Scale -ABE (SDLR) and the Water Filtration Test (Forms A and B). The SDLR scale is a self-report questionnaire with 34 Likert scale test items with the maximum number of points a subject may earn is 170 and a minimum of 34. It was used to determine the extent to which subjects perceive themselves to possess the readiness skills to manage his/her own learning. The score is a measure of the sub ect's *current* level of SDL readiness (Guglielmino, 1978). This instrument was administered pre and post unit instruction to both the treatment and control group. Table 4.1 shows how the SDLRS score is interpreted. Persons with high SDLRS scores usually prefer to determine their learning needs and plan and implement their own learning; persons with average SDLRS scores are likely to be successful in relatively independent learning situations, but are not fully comfortable with handling the entire process of identifying their learning needs and planning and implementing the learning; persons with below average SDLRS scores usually prefer very structured learning options such as lecture and traditional classroom settings (Guglielmino, 1978).

Table 4.1
How to Interpret the SDLRS Score

If your score is between:	Then your readiness for self-directed learning is:
34-106	More than one standard deviation below the mean
107-145	Within one standard deviation of the mean
146-170	More than one standard deviation above the mean

The *Water Filtration Test* (Forms A and B) was constructed by a veteran Jamaican science teacher. The test was made up 20 items - 16 objective-type and 4 open ended discussion-type questions – and measures the student's knowledge of the facts as well as application, analysis and synthesis of the subject content. Knowledge comprehension was measured by performance on the 14 items testing for application, analysis and synthesis, and content knowledge retention was measured by the difference in performance between the total score of Form A and B between post-test and follow-up. Pilot testing on this test instrument was previously conducted and reliability testing showed a Cronbach's alpha for Form A as $\alpha = .828$ and Form B as $\alpha = .839$ suggesting that the items have a relatively high internal consistency. Reliability testing was conducted again on this instrument during this study. Results were similar to those of the pilot test with a Cronbach's alpha for Form A as $\alpha = .822$ and Form B as $\alpha = .835$. George and Mallery (2003) indicate that a reliability coefficient of .70 or more is considered as acceptable in most educational research situations. Form A was administered to both the treatment and control group before unit instruction began; Form

B was administered as a posttest to both groups at the end of instruction, and Form A was administered to both groups as a follow-up test.

The treatment and control groups were from two intact coed eighth grade classes and ranged in age from 13 to 15 years old with approximately 75% maintaining a ‘C’ average in integrated science. Both groups were racially and socioeconomically homogeneous. The unit on Water Filtration was taught to both groups with the treatment group using the *Design It Clean: The Water Filtration Challenge* PBL unit guide, while the control group engaged the unit under the TDI approach.

Descriptive Characteristics of Respondents

The setting of this study was a high school in an urban area of one of Jamaica’s main cities. A total of 65 students that were enrolled in the eighth grade at the school selected were invited to participate in the study. All 65 students received parental consent to participate in the study and all 65 were engaged for the full ten-week period. A total of 35 students were in the treatment group and 30 students were in the control group. (See Table 4.2.) Both groups were homogenous in the areas of race, socioeconomic backgrounds and academic performance. Due to the homogenous nature of the groups Tables 4.3 and 4.4 show the frequency and percentages of the combined groups of students for age and sex respectively. The age distribution showed 53.8% of the students were age 13 and 43.1% were age 14. Only 3.1% were age 15. There were slightly more males than females in total with 47.7% of the students being female and 52.3% being male.

Table 4.2
Frequencies and Percentages of Students Participating by Group

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	PBL	35	53.8	53.8	53.8
	TDI/Control	30	46.2	46.2	100.0
	Total	65	100.0	100.0	

Table 4.3
Frequencies and Percentages of Students Participating by Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	13	35	53.8	53.8	53.8
	14	28	43.1	43.1	96.9
	15	2	3.1	3.1	100.0
	Total	65	100.0	100.0	

Table 4.4
Frequencies and Percentages of Students Participating by Sex

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	31	47.7	47.7	47.7
	Male	34	52.3	52.3	00.0
	Total	65	100.0	100.0	

Research Questions and Associated Hypotheses

The study was guided by the following research questions and hypotheses.

RQ1. Is there a significant difference in participants' pre- and post-SDL readiness skills scores between PBL and TDI conditions as measured by the SDLRS?

- H1a. Participants under PBL conditions have significantly higher SDL readiness skills than those under TDI conditions.
- H1b Participants under PBL and TDI conditions have significantly higher SDL readiness scores in the post-test than in the pre-test
- H1c There is a significant interaction effect between time and group on students' SDL readiness skills.

RQ 2. Is there a significant difference in participants' pre- and post-test knowledge comprehension scores between PBL and TDI conditions as measured by the 14 designated test items on Forms A and B of the integrated science unit test?

- H2a. Participants under PBL conditions will have better knowledge comprehension than those under TDI conditions.

- H2b Participants under PBL and TDI conditions have significantly higher knowledge comprehension scores in the post-test than in the pre-test
- H2c There is a significant interaction effect between time and group on students' knowledge comprehension.

RQ3. Is there a significant difference in participants' integrated science content knowledge retention over time between PBL and TDI conditions as measured by Forms B and A of the unit test in post and follow-up tests?

- H3a. Participants under PBL conditions retain more content knowledge than those under TDI conditions.
- H3b Participants under PBL and TDI conditions have significantly higher content knowledge retention scores in the follow-up than in the post-test.
- H3c There is a significant interaction effect between time and group on students' content knowledge retention.

Analysis of Data

Data were analyzed using descriptive statistics and one-way repeated measure mixed ANOVAs. Data were input in SPSS and statistical tests applied.

Statistical Analysis of Research Question 1

Research question one. Is there a significant difference in participants' pre- and post-SDL readiness skills scores between PBL and TDI conditions as measured by the SDLRS?

- H1a. Participants under PBL conditions have significantly higher SDL readiness skills than those under TDI conditions.

- H1b Participants under PBL and TDI conditions have significantly higher SDL readiness scores in the post-test than in the pre-test.
- H1c There is a significant interaction effect between time and group on students' SDL readiness skills.

Table 4.5 shows the descriptive statistics of the means, SDs, and N's for the PBL and TDI/control groups on the SDLRS pre- and post-tests. The same instrument was used for both groups pre- and post-intervention. The maximum number of points a student could earn on this self-report questionnaire was 170. From the descriptive statistics table it can be seen that both the PBL and control groups scored higher on the posttest than the pretest, but that the pre-to-post difference was much larger for the PBL group (from 109.94 to 140.77) than for the control group (from 116.90 to 124.97).

Table 4.5
Descriptive Statistics for SDLRS Pre- and Post-test

	Group	Mean	SD	N
SDLRS PRE	PBL	109.94	18.205	35
	TDI/Control	116.90	16.251	30
	Total	113.15	17.548	65
SDLRS POST	PBL	140.77	9.726	35
	TDI/Control	124.97	18.408	30
	Total	133.48	16.335	65

A Levene's Test was run to check for assumption of homogeneity of analysis of variance, that is, each population should have the same error variance (Field, 2005). This tests the null hypothesis that the error of variance of the dependent variable is equal across group. The Levene’s Test yielded non-significant results, $p > .05$, (Table 4.6); therefore, the assumption of equal error variance across groups is tenable.

Table 4.6
Levene’s Test of Equality of Error Variances

	F	df1	df2	Sig.
SDLRS PRE	1.575	1	63	.214
SDLRS POST	1.763	1	63	.189

A one-way repeated measure mixed ANOVA was used to analyze the effect PBL conditions had on SDL readiness scores of the students in the treatment versus TDI/control groups. The analysis yielded three results: two main effects, one from group, one from time, and the interaction between group and time. The between-subject variable was treatment/control while the within-subject variables were the scores on the SDLRS pre-test and post-test. There was no significant main effect for group, (F [1, 63] = 1.430, $p = .236$), $\eta_p^2 = .022$. This effect tells us that if we ignore time (pre- versus post-test) PBL was not significantly different to TDI/control. There was a significant main effect of time (F [1,63] = 186.690, p = .000), $\eta_p^2 = .748$. This effect tells us that if we ignore group, pre-test was significantly different to post-test. However, the tests of within-subjects contrasts indicate that the interaction between group and time was statistically significant (F [1,63] = 63.936, p = .000), $\eta_p^2 = .504$) . While a medium effect size based on Cohen's benchmark was expected, a large effect size was yielded with 50% of the variance in the difference being explained by the interaction. These results indicate that the difference over time for the PBL group was significantly different from the difference over time for the control group. More specifically, while there was an increase in SDLRS scores for the control group between pre- and post-test, the increase is not as high as the increase for the treatment group between pre- and post-test. The hypotheses that participants under PBL conditions would have significantly higher SDL readiness skills in the post-test than those under TDI conditions, and that there is a significant interaction effect between time and group on students' SDL readiness skills were supported. However, the hypothesis that participants under PBL conditions have significantly higher SDL readiness skills than those under TDI conditions on the group effect was rejected. Table 4.7 presents the SDLRS Test on this measure.

Table 4.7
One-Way Repeated Measure Mixed Analysis of Variance SDLRS Test

Source	Mean Square	df	F	Sig.	Partial Eta Squared
Between Subjects					
Intercept	1959752.264	1	4433.780	.000	.986
Group	632.264	1	1.430	.236	.022
Error	442.005	63			
Within Subjects					
SDLRS ABE$_1$	12219.089	1	186.690	.000	.748
SDLRS ABE * Group	4184.689	1	63.936	.000	.504
Error	65.451	63			

1. Main effect of time

Statistical Analysis of Research Question 2

Research question two. Is there a significant difference in participants' pre- and post-test knowledge comprehension scores between PBL and TDI conditions as measured by the 14 designated test items on Forms A and B of the integrated science unit test?

- H2a. Participants under PBL conditions will have better knowledge comprehension than those under TDI conditions.
- H2b Participants under PBL versus TDI conditions have significantly higher knowledge comprehension scores in the post-test than in the pre-test
- H2c There is a significant interaction effect between time and group on students' knowledge comprehension.

Participants' knowledge comprehension was measured before instruction on the water filtration unit using the 14 specified test items on the *Water Filtration Test* Form A for both groups to establish a baseline. After five weeks of instruction a post-test was given and knowledge comprehension was measured using the14 specified test items on the *Water Filtration Test* Form B for both groups. Table 4.8 shows the descriptive statistics of the means, SDs, and N's for the PBL and TDI/control groups on the knowledge comprehension pre-test and post-test. Knowledge comprehension was measured by the 14 items testing for application, analysis, and synthesis with the maximum number of points a student could earn being 14. From the descriptive statistics table (Table 4.8) it can be seen that both the PBL and TDI/control groups scored higher on the post-test than the pre-test, but that there was not much difference between the PBL and TDI/control groups in pre- (from .14 versus .17) and in post- (8.46 versus 8.30). The results showed that while both groups scored higher on the post-test, the TDI groups scored just as well as the PBL group on the post-test.

Table 4.8
Descriptive Statistics Knowledge Comprehension Pre- and Post-test

	Group	Mean	SD	N
KCOMPPRE	PBL	.14	.355	35
	TDI/Control	.17	.379	30
	Total	.15	.364	65
KCOMPPOST	PBL	8.46	3.109	35
	TDI/Control	8.30	2.667	30
	Total	8.38	2.892	65

The Levene's Test (Table 4.9) yielded non-significant results, $p > .05$; therefore the assumption of equal error variance across groups is tenable.

Table 4.9
Levene's Test of Equality of Error Variances

	F	df1	df2	Sig.
KCOMP PRE	.272	1	63	.604
KCOMP POST	1.973	1	63	.165

A one way repeated measure mixed ANOVA was used to analyze the difference PBL conditions had on knowledge comprehension scores of the students in the treatment versus TDI/control groups. Table 4.10 presents the knowledge comprehension test on this measure. For hypothesis 2, there was a significant main effect of time (F [1,63] =

545.159, p = .000), η_p^2 = .896. This effect tells us that if we ignore group, pre-test was significantly different to post-test. However, there was no significant main effect for group, (F [1,63] = .031, p = .861), η_p^2 = .000 which was also reflected in the effect size. This effect tells us that if we ignore time (pre- versus post-test), PBL was not significantly different to TDI/control on the knowledge comprehension measure. In addition, there was no significant interaction between group and time (F[1,63] = 0.066, p = 0.798), η_p^2 = .001. This effect tells us that time did not have a different effect on group on the measure of knowledge comprehension (see Table 4.8). Results support the hypothesis that participants under PBL and TDI conditions have significantly higher knowledge comprehension scores from pre- to post-test. However, they do not support the hypotheses that the difference in knowledge comprehension scores between the PBL group was significantly different from the knowledge comprehension scores for the TDI/control group, or that there was a difference in the time/group interaction. This would indicate that on the measure of knowledge comprehension, students instructed under PBL conditions did not perform better than students instructed under TDI conditions.

Table 4.10
One Way Repeated Measure Mixed Analysis of Variance Knowledge Comprehension

Source	Mean Square	df	F	Sig.	Partial Eta Squared
Between Subjects					
Intercept	2352.574	1	509.437	.000	.890
Group	.144	1	.031	.861	.000
Error	290.933	63			
Within Subjects					
$KCOMP_1$	2185.003	1	545.159	.000	.896
KCOMP * Group	.264	1	.066	.798	.001
Error	4.008	63			

1. Main effect of time

Statistical Analysis of Research Question 3

Research question three. Is there a significant difference in participants' integrated science content knowledge retention over time between PBL and TDI conditions as measured by Forms B and A of the unit test in post and follow-up tests?

- H3a. Participants under PBL conditions retain more content knowledge than those under TDI conditions.
- H3b Participants under PBL and TDI conditions have significantly higher content knowledge retention scores in the follow-up than in the post-test

- H3c There is a significant interaction effect between time and group on students' content knowledge retention.

Participants' content knowledge was measured using the *Water Filtration Test* Form A for both groups before the unit on water filtration was taught. After five weeks of instruction a post-test was given and content knowledge was measured using the *Water Filtration Test* Form B for both groups. A follow-up test was given four weeks later to measure content knowledge retention using the *Water Filtration Test* Form A. *Table* 4.11 shows the descriptive statistics of the means, SDs, and N's for the PBL and TDI/control groups on the content knowledge retention post-test and follow-up test.

Table 4.11
Descriptive Statistics Content Knowledge Retention Post-test & Follow-Up

	Group	Mean	SD	N
CKRPOST	PBL	13.69	3.288	35
	TDI/Control	12.47	3.298	30
	Total	13.12	3.324	65
CKRFOLU	PBL	11.51	3.364	35
	TDI/Control	8.50	3.401	30
	Total	10.12	3.681	65

The PBL group reported mean scores of 13.69 on the post-test and 11.51 on the follow-up. The TDI/Control group reported mean scores of 12.47 on the post-test and 8.50 on the follow up. The PBL group had a mean difference in scores between post-test and follow-up of 2.18 while the TDI/Control group had a mean difference in scores between post-test and follow-up of 3.97. This indicated that the PBL group lost less content knowledge, or conversely retained more content knowledge than the TDI/Control group.

Further analysis was conducted. A one way repeated measures mixed ANOVA with time as an independent factor and PBL or TDI as a within-subjects factor was run. This ANOVA was used to analyze the difference PBL conditions had on content knowledge retention of the students in the treatment versus TDI/control groups over time. A Levene's Test (Table 4.12) yielded non-significant results, $p > .05$, therefore the assumption of equal error variance across groups is tenable.

Table 4.12
Levene's Test of Equality of Error Variances

	F	df1	df2	Sig.
CKR POST	.074	1	63	.786
CKR FOLU	.000	1	63	.997

There was a significant main effect for group, (F [1,63] = 6.679, p = .012), $\eta_p^2 = .096$ with a medium effect size. This effect tells us that if we ignore all other variables, PBL was significantly different to TDI/control group. There was also a significant main effect for time, (F [1,63] = 504.922, p = .000), $\eta_p^2 = .889$ with a large effect size. This tells us that if we ignore all other variable, post-test was significantly different to follow-up. The tests of within-subjects contrasts indicate that the interaction between group and time was statistically significant (F [1,63] = 43.192, p = .000), $\eta_p^2 = .407$ with a large effect size.

Results indicate that time had a different effect on group and 40.7% of the variance in the difference can be explained by the group/time interaction. The difference over time for the PBL group was significantly different from the difference over time for the control group. Table 4.13 presents the Content Knowledge Retention on this measure.

Table 4.13
One Way Repeated Measures Mixed Analysis of Variance Content Knowledge Retention

Source	Mean Square	df	F	Sig.	Partial Eta Square
Between Subject					
Intercept	17214.840	1	794.366	.000	.927
Group	144.747	1	6.679	.012	.096
Error	1365.283	63			
Within Subject					
CKR_1	304.308	1	504.922	.000	.889
CKR * Group	26.031	1	43.192	.000	.407
Error	.603	63			

1. Main Effect of Time

Taken together, the hypotheses that participants under PBL conditions retained more content knowledge over time than those under TDI conditions, and that there is a significant time/group interaction effect, are accepted.

Summary

This chapter briefly reviewed the purpose of the study and the problem being investigated. It presented the research questions, the research hypotheses, demographics of the study participants and the data analysis. It also included the mixed-design ANOVA of the study to examine the between-subject and within-subject effects of PBL on the improvement in SDL readiness skills, knowledge comprehension and content knowledge retention over time. A discussion of the results will be conducted in detail in the following chapter and suggestions for future studies will be made.

CHAPTER V

DISCUSSION, IMPLICATIONS, AND RECOMMENDATIONS

Introduction

The purpose of this chapter is to discuss the findings of this study which examined the efficacy of project-based learning as a method of instruction for positive improvement in SDL readiness skills, knowledge comprehension, and content knowledge retention within the context of an eighth grade science class in an urban Jamaican high school. A brief summary of the study is presented followed by a discussion of the results from the research hypotheses, implications of these results, as well as recommendations for future research. The review of the results from the data analysis is presented in the same sequence as they were presented in Chapter IV.

Summary of the Study

The study used a quasi-experimental design to measure the effect of a PBL instructional unit on SDL readiness skills, knowledge comprehension, and content knowledge retention within a Jamaican context. The study was conducted in two eighth grade integrated science classrooms in an urban Jamaican high school with two teachers. The two classrooms were randomly assigned to PBL/treatment and TDI/control. Participants were pretested using the Self Directed Learning Readiness Scale –ABE (Guglielmino, 1978) as well as the Form A of the unit test, The *Water Filtration Test*, which was created for this study. The analyses conducted on the instruments established that the SDLRS should provide valid and reliable measures of SDL readiness skills and the *Water Filtration Test* should prove valid and reliable measures of knowledge comprehension and content knowledge retention.

Students in the PBL and TDI/control group participated in a 5 week long instructional unit on water filtration. The PBL group engaged PBLU.org *Design It Clean: The Water Filter Challenge* unit which was built around a project that addressed real world problems. Students worked collaboratively in teams to develop water filtration prototypes that could provide water for specific communities in the real world. They engaged in research of regions that are challenged with access to potable water and designed the water filters as a working solution to the problem. Their research, all relevant data, and final products were presented at a mini exposition with adults playing various roles such as end users, aid workers, environmental scientists and government officials. The TDI/control group followed the regular school curriculum unit on the topic following the standard lesson plans and lab experiments.

Students from both groups were post-tested on the SDLRS and the Form B of the *Water Filtration Test* in week six following the intervention. In week ten of the study a follow-up of the content test was administered to both groups using the Form A of the *Water Filtration Test*.

Demographic Analysis

Demographic data on the students' age and sex were collected at the beginning of the study. Crosstabulation and chi square analyses were run to test the null hypothesis that the percentage of males and females in the PBL group is similar to the percentage of males and females in the TDI/control group. Independent samples t-tests were also run to test the null hypothesis that the average age of students in the PBL group is similar to the average age of students in the control group. These data are summarized in Table 3.1,

Table 3.2 and Table 3.3. Results showed no statistical significance on either variable indicating that sample did not differ in sex ratio and were similar in age structure.

Discussion of Research Question 1

RQ 1. Is there a significant difference in participants' pre- and post-SDL readiness skills scores between PBL and TDI conditions as measured by the SDLRS?

The SDLRS score is a measure of one's readiness for self-directed learning. Scores falling between 107 and 145 of a possible 170, places the individual within one SD of the mean or in the average range. In reviewing the mean scores for both groups presented in Chapter IV, they show that students instructed under PBL conditions started with a mean score of 109.94 pre intervention, and achieved a mean score of 140.77 post intervention. This score placed them within one SD of the mean or in the average score range. Students instructed under TDI conditions (control) started out with a mean score of 116.90 on the pretest and achieved a mean score of 124.97 on the posttest, also remaining in the average score range. Persons in the average range are likely to be successful in relatively independent learning situations. However, they are not fully comfortable with taking on the entire process of identifying learning needs or planning and implementing what is to be learned. It could be argued that they are perhaps still functioning at the dependent learner's stage of the evolving learner as purported by Song and Hill (2007). The dependent learner generally prefers a teacher/instructor to provide most of the information and be part of a large group of learners with the teacher/instructor as the main instructional source. This is typical of many adolescents at this stage who, while they think and act as if they are independent learners, expect the teacher to give instructions on what is to be done.

The results show however, that while students in both groups remained within the average range, the PBL group had a greater pre/post difference than the TDI/control group after the intervention. The TDI/control group had a mean difference in scores between pre- and post-SDLRS of 8.07; the PBL group had a mean difference in scores between pre- and post-SDLRS of 30.83 with their mean post-test score falling only 5.23 points out of the high SDLRS score range. Persons with a high SDLRS score may tend towards a preference to determine their learning needs and plan and implement their own learning. It would be reasonable to assume that perhaps these students are moving to the stage of interested or involved learner (Song & Hill, 2007). The interested learner begins to think about what they can add to what the teacher/instructor is providing and perhaps entertaining input from other learners; the involved learner engages in collaborative learning and appreciates the social interaction of learning through group work.

According to the results of a one way repeated measures mixed ANOVA, the tests of within-subjects contrasts indicated that the interaction between group and time was statistically significant (F [1,63] = 63.936, p = .000), η_p^2 = .504 and yielded a large effect size. This supports the hypothesis that there is a significant interaction effect between time and group on students' SDL readiness skills. Specifically, the PBL group had better SDLRS scores on the post-test than the TDI/control group. The effect size also led the researcher to conclude that the improved SDL readiness skill level in the PBL group was significantly larger that the TDI/control group. The one way repeated measures mixed-design ANOVA used to test hypotheses 1a-c provided tests of significance for main effects of group and time, in addition to interaction tests for test scores and group. Main effect for group was not significant while main effect for time was significant. This means that there was no difference between groups and they both showed improvement but there was a significant difference in scores over time from pre-to post-SDLRS. It can be concluded from the results of the interaction effect between group and time that instruction under PBL conditions had a positive effect on the scores for SDL readiness skills in the PBL versus the TDI/control group as measured by the SDLRS.

The results of this study supports the findings of previous studies which investigated SDL readiness and perception of self directedness, e.g. Bagheri, Ali, Binti Abdullah and Daud (2013), Harding, Vanasupa and Stolk (2007), Hernandez-Ramos and De La Paz (2009), Savage , Chen and Vanasupa (2009); and Zhou and Lee (2009). These studies showed that students instructed under PBL conditions achieved a significant positive difference between readiness skill levels when compared to students engaged in teacher-centered learning. Looking deeper at the connections between SDL readiness and PBL, scholars such as Dawson, Macfadyen, Risko, Foulsham and Kingstone, (2012), and Brookfield, (1993) posit that SDL typically involves decision-making and exploration in a project-based setting. In a project-based setting knowledge is co-constructed (situated learning) and is presented in an authentic real-world context (constructivism) which involves its application for real-world solutions. These scholars however, discussed these connections within the context of adult learners. Additionally, the aforementioned studies were conducted in the US and other developed world countries. As stated in the review of the literature, a search of the literature did not produce any studies investigating SDL and PBL among high school students in developing regions. This current study extends and adds to the literature as it studied students at the secondary level and in a developing country. It targeted eight grade students in Jamaica in an integrated science class in an urban setting. The study examined if SDL readiness skills improved under PBL conditions and the evidence supports the fact that PBL as an instructional method facilitates and fosters improvement in SDL readiness skills of learners.

The students in this current study being instructed under PBL conditions engaged in activities which facilitated the improvement in their capacity to be self-directed, fostered transformational learning, and promoted social action – the three goals of SDL (Merriam, Caffarella, & Baumgartner, 2007). Students worked in teams and collaborated on a project to develop a prototype of a dependable and affordable water filter that can provide water for specific communities in the real world. Here they were required as a team to decide on the where, why, how, what, and then what of the project and the learning process. In taking responsibility for their project, the goal of self-directedness was being addressed. Through teacher guidance and team research, each team identified a community anywhere in the world that has a challenge of access to potable water. They investigated areas in South East Asia, Africa, and the Caribbean and once their selection was made, their research and design was targeted toward the specific community. The design was informed by subject content on water filtration, engineering design, as well as an understanding of the social, economic and political climate of the region. Students at the school where the study was conducted all come from low socioeconomic households. Additionally, the school resources were limited. The end product was their prototype which was presented, along with their research, in an exposition to adults playing the role of key stakeholders such as end users, environmental scientists, engineers, government officials, etc. As part of the process, students had to think creatively and show resourcefulness in selecting and acquiring materials to build their prototypes. The school helped but only after each group had exhausted their options.

A key component of PBL is that the project objectives are determined by the learners (as stated above) and they implement the project in accordance with the concepts of the lessons. In their groups the students evaluated themselves and their teammates, and based on their perceived or identified strengths or weakness, they decided on the roles that each member played in the team. They engaged in critical reflection based on feedback from peers and the teacher for the purpose of personal improvement as well as improvement of their process and product. This self-assessment and reflection met the goal of transformational learning which was explained in Chapter II. According to scholars such as Filcik, et. al. (2012) and Seidel, Aryeh and Steinberg (2002), as the learner engages the content and processes through the PBL activities, they begin to learn about themselves and begin to effect a change from within, ultimately experiencing transformational learning. They also are able to utilize their strengths to develop the project and incorporate their own interests and the interests of their group members in the project, including but not limited to the medium that will be used to present the learning product. This is evidence of their growth and development as autonomous learners.

The final goal of social action was met through the process and the product of the PBL instructional unit. As the students conducted their research and engaged in the activities of the unit, they gained knowledge and developed an understanding of the 'what and why' of unsatisfactory circumstances (Thompson, 1997). They read field reports on their community of interest and the geographical area in which it was situated, watched videos, documentaries and movies pertaining to the challenges of access to potable water in the community/region, and kept a journal of what they saw, heard, felt and thought they could do in spite of distance or limited resources. In designing and constructing the water filtration prototypes, they developed strategies to effect real life change which moved the learners in the direction of engaging in social action. As part of the presentation of their pro ect, students included their "Next Steps: Taking Care of Home" which articulated what each person or team would commit to doing locally to address the issue of potable water in rural communities of Jamaica. This aligns with the view of Seidel et. al (2002) of social action emerging from transformational learning as a goal of SDL. Taken together, the discussion presented here on question one shows an alignment between PBL as an instructional method and its efficacy in facilitating and fostering improvement of SDL readiness skills. Additionally, this fact is supported by both theory and empirical studies.

Discussion of Research Question 2

RQ 2. Is there a significant difference in participants' pre- and post-test knowledge comprehension scores between PBL and TDI conditions as measured by the 14 designated test items on Forms A and B of the integrated science unit test?

The *Water Filtration Test* is a measure of students' knowledge of the science content covered over the 5-week instructional period. In its design it tests for recall of facts, analysis, synthesis and application. Knowledge comprehension was operationalized as the level of understanding gained after instruction as measured by the students' ability to apply, analyze, and synthesize knowledge gained. Arguably, the ability to recall facts is not on its own a measure of understanding or comprehension. The ability to recall facts is in part one's ability to memorize. However, the nature of any science subject requires that the student be able to not only recall the facts, but to use those facts in new situations and construct their own knowledge; this is application. Science subjects require students to conduct analysis; that is, to examine the elements in detail for the purpose of discussion or interpretation. They are also required to synthesize information based on the facts presented; that is, to put ideas together into a unique plan or product.

A review of the mean scores for both groups in their performance on items testing these skills as presented in Chapter IV showed that students instructed under PBL conditions had a mean score of .14 on the pretest (M = .14, SD = .355, N = 35) and a mean score of 8.46 on the posttest (M – 8.46, SD = 3.109, N = 35). Their mean percentage post-test grade was 60%. Pre- and post-test scores for students instructed under TDI/control conditions had mean scores of .17 (M = .17, SD = .379, N = 30) and 8.30 (M = 8.30, SD = 2.667, N = 30) respectively. Their mean percentage post-test grade was 59%. These descriptive statistics showed that while both groups improved significantly from pre- to post-test on the knowledge comprehension component, the degree of improvement over time was approximately the same across both groups. In other words, there was no significant difference in the pre- versus post-test scores across groups.

According to the results of a one way repeated measures mixed ANOVA the tests of within-subjects contrasts indicated that the interaction between group and time was not statistically significant, ($F[1,63] = 0.066$, $p = 0.798$), $\eta_p^2 = .001$. Specifically, the increase for the TDI/control group between pre- and post-test is just as high as the increase for the PBL group between pre- and post-test. The main effect for group also showed no statistical significance, (F[1,63] = .031, p = .861), η_p^2 = .000. This means that both the PBL and the TDI/control group performed equally well. Both measures of significance led the researcher to conclude that knowledge comprehension under PBL conditions was not significantly different from knowledge comprehension under TDI/control conditions. As such the hypotheses that participants under PBL conditions will have better knowledge comprehension than those under TDI conditions, and that there is a significant interaction effect between time and group on students' knowledge comprehension are both rejected. It can be concluded that there was no difference in the effect on the scores for knowledge comprehension in the PBL versus the TDI/control group as measured by the 14 designated test items on the *Water Filtration Test* testing for application, analysis, and synthesis.

The results of this present study on the measure of knowledge comprehension adds to the literature as a search of the literature did not produce any studies on PBL specifically addressing knowledge comprehension as a construct. Due to the limited scope of this study it provides an opportunity for further study on this measure. The literature reviewed produced studies which focused on student academic performance and understanding in different content areas but primarily science and mathematics and was addressed in Chapter II. These studies showed mixed results on performance under PBL conditions when compared to TDI conditions, with more studies reporting improved overall academic performance. Boaler's (1998) study perhaps came closest to addressing knowledge comprehension as operationlized for this current study. In assessing students' performance on mathematics exams, this study showed that while the PBL students did just as well or better than students using a traditional model of instruction, PBL students performed better on conceptual questions. Conceptual questions require thought and creative application and combination of content area rules. This would engage the students in application, analysis and synthesis on some level. However, the results of the current study do not support the findings of Boaler's study on this measure.

The Gordon, et.al (2001) and Liu, et.al (2006) studies conducted with urban middle school students reported increased academic performance with the Liu, et.al study reported better understanding of science concepts. In the Chang (2001) and Schneider, et.al (2002) studies conducted with high school students, results showed improved student knowledge of the material and in the Schneider, et.al study, the 12th grade students outscored their peers on the National Assessment of Educational Progress (NEAP) science test by 44%. A study by Dods (1997) however reported results that indicated no difference in the level of content knowledge between students instructed under PBL than those in a traditional lecture course. This study also showed that the students instructed under PBL conditions did in fact retain more information over time. This finding is important to this current study as this measure was also investigated.

The results of the current study on the measure of knowledge comprehension could be attributed to many factors. However, this researcher will address only two: (1) the scientific method under PBL and TDI conditions, and (2) the teacher factor. Table 5.1 shows a side by side comparison of the steps in the scientific method in the TDI and PBL approaches. Both approaches involve investigation around a question, research, application of knowledge to conduct testing, analysis, and synthesis to varying degrees.

Table 5 1
A Side By Side Comparison of the Scientific Method in Traditional Direct Instruction and Project-Based Learning

Traditional Direct Instruction	Project-Based Learning
Ask a question about something observed	A project is framed by an essential question that asks students to respond to a complex question relevant to their interests or community.
Do background research such as textbook, library or internet searches	Engage in sustained inquiry. Students utilize a variety of primary and secondary sources such as library or internet searches, speaking to experts, visiting sites of historical or scientific experience, conducting experiments, utilizing technology. Sources are evaluated and data collected and analyzed over weeks or months.
Construct a hypothesis with an explanation that can be tested and make a prediction that is measurable.	Collaborate with peers or industry experts to solve a real-world problem - authenticity
Conduct hypothesis testing by doing a lab experiment	Students determine the topic and final form of their project using outside knowledge and skills to synthesize their research –student voice and choice.
Analyze data and draw conclusion. Was the hypothesis supported or not? Modification of the experiment and retesting is optional.	Engage in feedback and revision of project drafts with peers, teachers or resource persons. Students may be guided by a rubric to evaluate their work product.
Communicate the results in a final lab report. This often follows a standard format.	Submit final work to an outside audience as a public product. The product and the medium for

	presentation is the decision of the student and reflects his/her personal interests and skills.

Sources: Steps of the Scientific Method, www. sciencebuddies.org;
Six Steps to Project Based Learning, www.esparkle.com

In this present study, methods were effectively applied as shown in Table 5.1 and this researcher believes that good teaching, when controlling for confounding variables, should result in good student performance.

Students in the TDI/control group were instructed on the water filtration unit content from the eighth grade integrated science curriculum. They learned about related vocabulary and filtration methods, conducted lab testing of water samples and filtration methods, analyzed their data and wrote up their lab reports for each experiment. The students were fully engaged in the process. As stated previously, the post-test results showed that all students in this group achieved a mean percentage grade of 59% on the test items measuring for application, analysis and synthesis. (It should be noted that 50% is the pass grade in this school.)

Students in the PBL group engaged in sustained inquiry around an essential question, and through class discussion, research and presentations for professionals in the field, they learned key vocabulary and engaged various filtration methods through demonstrations, media and a site visit to the National Water Commission organized by the teacher. They gathered data from various sources, conducted lab experiments, and applied the knowledge gained as they analyzed the data collected over time. This information was used to synthesize and refine their research and project product.

This aligns clearly with the constructivist ideology of Dewey (1916; 1933), Piaget (1964) and Vygotsky (1962) which purports that as the learner acquires knowledge, the underlying belief is that learning best takes place when the learner is actively engaged.

As stated earlier, students had to be creative in the selection of their material for their prototypes as they did not have the financial resources for state of the art material. Soda bottles, coffee filters, pvc piping, and meshed wire were some of the material used in their designs. There was ongoing collaboration with peers, the teacher and the school librarian. Working with the librarian was an important part of the process as many of these students do not have internet access at home or the resources to visit different sites to conduct research. The presentation of their research and prototypes to a public audience in their exposition took the form of talks, power points, videos filmed by the students, demonstrations of the prototypes and discussions on how they would address the targeted real-world problem of the community/region they chose. They too were fully engaged in the process and the post-test results showed that all students in this group achieved a mean percentage grade of 60% on the test items measuring for application, analysis and synthesis.

In addressing the teacher factor, both teachers were highly qualified science teachers with teaching degrees in the subject and an average of seven years teaching science at the high school level. The teacher of the PBL group had a background in engineering was beneficial to the project. The teacher of the TDI/control group is also the head of the school's sports department and demonstrated commitment to student success through her enthusiastic engagement with the student body. Through observation by this researcher, the research assistant and feedback from regular meeting with the teachers, this researcher believes that they conducted the instruction in both groups and followed the requisite protocols to ensure the integrity of the research. In scoring the *Water Filtration Test*, each teacher served as the second marker for the other group. This means that the PBL teacher reviewed the grades of the TDI/control group on the instrument and the teacher of the TDI/control group also reviewed the grades of the PBL group on the instrument.

This researcher is cognizant of the fact that competition to do well could play a part in teacher performance. As such, each teacher may have made extra effort to engage best practices and ensure that the students learned the content. While this would prove beneficial to the students, it may impact the study. However, the scores reported for both groups were not too far from average to warrant this as a concern by the researcher.

While the results of the study on this measure do not align with the seemingly typical results of the literature, it should not be determined that the literature is wrong or that this research is flawed. It could mean that there are other factors that may affect instruction, delivery or student performance and further investigation may be necessary. The evidence at this time does not support that PBL as an instructional method facilitates better knowledge comprehension as measured by students' performance on test items measuring application, analysis and synthesis.

Discussion of Research Question 3

RQ 3. Is there a significant difference in participants' integrated science content knowledge retention over time between PBL and TDI conditions as measured by Forms B and A of the unit test in post and follow-up tests?

Smith (2007) provided the explanation for content knowledge retention as the maintenance of knowledge acquired through instruction for an extended amount of time. Smith further states that knowledge retention is a crucial aspect of any learning environment. As discussed in Chapter II, retention goes beyond the simple capture of knowledge; it requires that knowledge also be stored for a period of time, and is retrievable. How much content is retained indicates the level at which the information was acquired. In this study, content knowledge as a measure referred to the difference in scores of the unit assessment on the test administered at the end of the intervention and a follow-up test administered four weeks later. Form B of the *Water Filtration Test* was administered as the posttest and Form A of the same instrument was administered as the follow-up. The time delay was to ascertain how much content knowledge was retained over time after not engaging the material for a while.

As presented in Chapter IV, the descriptive statistics showed the PBL group with a mean difference in scores between post- and follow-up of 2.18. The TDI/control group had a mean difference in scores between post- and follow-up of 3.97. This indicated that the PBL group retained more content knowledge than the TDI/control group. The results of a one way repeated measures mixed ANOVA also showed that there is a statistically significant difference. The tests of within-subjects contrasts indicated that the interaction between group and time was statistically significant (F [1,63] = 43.192, p = .000), η_p^2 = .407 with a large effect size. This indicated that the difference in the follow-up score over time for the PBL group was significantly different than for the TDI/control group with improved content knowledge retention score being significantly larger for the PBL group than for the TDI/control group. There was also a significant effect for group and time. It can be concluded that instruction under PBL conditions had a positive effect on the scores for content knowledge retention in the PBL versus TDI/control group as measured by the follow-up test of the *Water Filtration Test*.

The results of this current study on the measure of content knowledge retention support and add to previous studies which investigated the effectiveness of PBL in improving long-term content knowledge retention. Dod's (1997) study reported that PBL students retained more knowledge than students taught using traditional methods. More significantly, it supports the findings of the studies reviewed in Strobel and Van Barneveld's (2009) meta-synthesis of meta-analyses comparing PBL to conventional classrooms. They reported that all the studies reviewed showed PBL as an effective method of instruction for improving content knowledge retention in students. This measure is perhaps the most significant of the three variables investigated in this current study. Students are more likely to learn when the method of instruction is properly implemented and aligns with their learning style. However, it is critically important that learners information for longer periods of time. Logically, it is the combination of learning, retaining and transferring knowledge from one context to another that facilitates the application of what is learned and remembered. Chapter I highlighted the issue presented in Vision 2030 (2009) of students lacking in knowledge to function effectively in post-secondary settings. Engaging a method of instruction that, supported by theory and empirical studies, facilitates and fosters improvement in content knowledge retention in learners would be a key step in addressing such an issue.

Some scholars posit that students are more likely to retain information if they are actively engaged in the learning process (Csikszentmihalyi, 2002; Curtis, 2002;

Markham, (2003); and Thomas, (2000). PBL as a model and method of instruction facilitates student engagement at all stages of the process. The activities and active engagements in learning motivate the student to acquire a deeper knowledge of the content, which in turn enables them to retain more. The personal connections with the content and/or materials utilized through the learning process, and the connectivity of academics to real-world applications, makes retention over time even more probable.

Foundational to PBL is the essential question that drives investigation and the learning process. As shown in Table 5.1, the question as posed connects the learner to a complex real-world problem. It is also intentionally open ended thereby allowing the student to think on a deeper level and demonstrate their understanding of the concepts that are being taught. It can be argued that at the high school level, the constraints of time may not allow for a teacher to entertain this type of session as they seek to teach for the purpose of end of course or national examinations. If the purpose of the teacher however, is to facilitate student learning, then proper planning is their basic requirement. Teachers need to understand the nature of the essential question, and the fact that it is open ended and taps into the natural cycle of a learner's mind. With this understanding it should follow that the teacher as a facilitator would want to engage this natural process. The natural progression in the cycle is wonder, exploration, discovery, reflection, and more wonder. As they move through the cycle their knowledge becomes more complex and thinking, more sophisticated. In this study the PBL group was driven by the following essential question: "How can we help a specific group of people easily increase the safety (drinkability, usability) of their water? By having the students think about what he/she can do to help enables them to put themselves in the equation, making the information more personal and more likely to be retained over time.

The more time the student spends engaged with the content and information, the better they will remember it and the longer it will be retained. Sustained inquiry of PBL allows for greater integration of the content knowledge into the student's schema and their experiences will allow for deeper engagement of the knowledge. The discussion of constructivism and situated learning in Chapter II supports this point. The PBL group in this study was engaged in sustained inquiry for a period of 5 weeks. They conducted individual and team research in accordance with their assigned roles in the group. It was reported by the PBL teacher that students were actively talking about their project and seeking to have time with him outside of the class sessions as there was always something new they wanted to share or something more they wanted to ask about. This demonstrated a great level of student investment in the learning process. Additionally, when the academic standards are related to student's interests and goals they may better engage the learner. Connecting content and student interest to their community provided context and exigency to the mastery of content allowing for greater retention over time. This connectivity is what is referred to in PBL as authenticity. According to Hung (2002) real-life situations will compel students to learn and authenticity and sustained inquiry extends and deepens this learning which also leads to more content knowledge being retained over time.

Content knowledge retention is further improved when students are personally invested in the topic and the product, and are responsible for determining what is done, how, why, when and by whom. In PBL this is what is called student voice and choice.

The students in the PBL group decided at the group level on their group name, the region and community they wanted to research, the scope and sequence of their research, the design of their prototype and the format of their presentation. Having a voice and making it matter builds confidence in the student and leads to action; research shows that by doing, we learn more (Liu, Hsieh, Cho & Schallert, 2006; Gordon et.al, 2001; Schneider et. al, 2002) and retain more (Dod, 1997). Again the argument that may be presented may be the time factor within the rigid structure of a high school program. This study provides evidence that it is not only possible, but that the end result is content knowledge retained for a longer period of time. Feedback and revision work along with student voice and choice. The PBL group engaged in peer reviews, sought guidance from the teacher and other resource personnel such as the librarian and the information technology department to improve their process and product as well as learn how to effectively engage the public for the exposition. This continual improvement in process and product reinforces the content and enables greater retention over time.

Finally, the last step in PBL requires that the student present their product to a public audience. In presenting the product to the public, students have to be prepared to answer questions from viewers representing different interests. This requires extensive preparation and comfort level with the material. In this present study, students did practice sessions with their peers, mock presentations to other groups as well as academic and administrative staff. They read and reread their notes and did repeated testing on their prototypes. This level of preparation helped to reinforce the content and increased the comfort level with the material. This also suggests that the high level of preparation was a contributing factor to this group retaining significantly more content knowledge over time as compared to the TDI/control group.

The limitations of the study and implications of the findings of this study will be presented in the subsequent sections. It will highlight implications for post-secondary success, addressing practice and policy in the Jamaican context.

Limitations

There are two limitations to this study. First, the researcher and the research assistant were not able to independently verify if the cooperating teachers were providing assistance outside of what was typically given. Their role was to provide support as needed without unduly giving and edge to either the PBL or TDI/control group. This teacher factor was not studied as a part of this present study. Implementing similar studies using different schools for the treatment and control groups may allow for the control of this variable or for its investigation.

The second limitation of this present study was that it did not include any analysis of work produced by participants nor were there any interviews with participants or teachers. This goes beyond the scope of the investigation at this time.

Implications for Post-Secondary Success: Policy and Practice

The public and private sectors of Jamaica have become more project driven and depend on the self-directedness and problem-solving skills of those in the workforce. This has resulted in more positions opening up that require higher levels of creativity and problem-solving skills; persons with higher levels of SDL skills tend to be more competent in these areas. Education's role therefore is to prepare students to meet the needs of the sectors. PBL creates opportunities to engage the afore-mentioned skills and facilitate their growth and development to meet these needs. The findings of this study positions PBL as a model and an instructional method to address these concerns.

The future of education has to lend some focus to the engagement and implementation of PBL from the standpoint of both policy and practice. The policy issues include student success, school/community support for projects, and increased funding. If policymakers are mindful of the fact that the intended goal of education reform is success for all learners then policies should be directed at connecting all key stakeholders with resources that foster student success. In its national long-term plan, the Government of Jamaica (GOJ) in the *Vision 2030 Jamaica - National Development Plan* (2009) identified the following as areas of lack for Jamaican high school graduates: (a) content knowledge; (b) self-directedness; (c) performance in STEM areas; (d) capacity for enquiry-based approach to learning; and (e) scientific inquiry as components of teacher training. Policy should therefore reflect these needs within both the national and local contexts and be flexible in language to allow for adaptability at different local level.

Policy should provide support for school/community partnerships. Community-based organizations seeking to partner with schools on projects that connect the students to finding solutions to community problems may be provided tax considerations for projects that meet the PBL criteria.

Finally, a policy is only a document on paper unless it is backed by adequate funding. Adopting a PBL approach in schools and communities will require funding for research, resources, training, implementation and product development. While creativity in problem-solving is a key outcome of PBL, adequate resources will allow for better execution of projects thereby leading to more and better solutions. The government may seek funding from international agencies as a means of meeting the financial requirements to advance PBL in the education system.

Issues of practice include implementation of PBL, instructional process, and student assessment. PBL inherently goes against the grain of the traditional instructional models. Looking at PBL through the prism of the education system in Jamaica, employing and implementing this method of instruction will require a paradigm shift for teachers, and stakeholders, in general. They will need to have a clear understanding of what this method would look like in their settings and what their new roles would be. It will require that all stakeholders be sensitized to the new method, informed of its goals and how it will affect student performance. Teachers will need to undergo training in the PBL method with a full understanding that PBL requires much preparation and planning. Stakeholder sensitization may be done through workshops, information sessions, practice sessions or observations of PBL in practice. Sensitization will enable teachers and policy makers to be more informed on the development of and validation for programs, curricula and resources engaging PBL to improve student outcomes.

In addressing instructional process, it must be understood that a move from a teacher-centered learning environment to a learner-centered environment is an imperative of PBL. The teacher will have to adopt and adapt to a learning facilitation instructional mode rather than focus on their 'ability to teach'. This necessitates teacher buy in and a belief in the PBL method to do what it claims to do. Teachers will need significant support as only the highest level of commitment to the process will result in the success for all. These supports include but are not limited to pedagogical support, ongoing training, access to online PBL training opportunities, and of course adequate resources to facilitate student engagement.

Student assessment and high stakes testing are major concerns in education. ‘Teaching to the test’ has become the norm; while this may result in high test score, another result is loss of information in a very short time. PBL has been shown to be effective for helping students learn content and improve content knowledge retention over time. Teachers will need to design instruction around projects that connect to the curriculum to effect positive change in students’ performance on tests in the short, medium and long term.

Future Research

As this study was exploratory in nature, it creates many of opportunities for future research. This was a fairly small sample size, however, investigations could be conducted on a larger populations size across more schools. It could be investigated across school types or across regions. This would allow for the possible generalizability of the study.

Second, follow up, tracer studies or longitudinal studies could be conducted with the same population. This would examine if the student gains were maintained or if the results accounted for the novelty effect. The study could be extended to include other factors such as student motivation, student and/or teacher perception of the PBL method in the Jamaican classroom, or the impact of group dynamics on PBL outcomes.

Third, the study could be repeated to account for the teacher factor. In conducting research there is the possibility that participating teachers may adjust their normal way of engagement which may affect the study. Further studies may be conducted with different teachers or with the same teacher engaging both the PBL and TDI approach to the same group of students. Interviews and observations may be conducted to ascertain the teachers' perceptions of the intervention and the efficacy of the method.

Finally, a search of the literature failed to produce research on SDL and PBL with adolescents in Jamaica. Empirical evidence as provided by this study's findings could help in extending and expanding the research in this population. This is important in keeping with the stated goals of the Jamaica Vision 2030 Development Plans for improving the requisite skills of self-directedness and problem solving and thereby increasing the possibilities for post-secondary success.

Summary

The purpose of the study was to examine whether being instructed under project-based learning (PBL) conditions lead to improved self-directed learning (SDL) readiness skills and content knowledge retention among urban Jamaican eighth grade students within a science class context. It also sought to investigate if students instructed under PBL conditions had better knowledge comprehension than those instructed under TDI conditions. Knowledge comprehension was measured by the 14 test items on the content knowledge test which assessed the student's ability to apply, analyze and synthesize knowledge.

The results showed that the difference over time for the PBL group was significantly different from the difference over time for the TDI/control group (F [1,63] = 63.936, p = .000), $\eta_p^2 =$ .504 on the measure of self-directed learning readiness skills. It was also shown that the difference over time for the PBL group was significantly different from the difference over time for the control group (F [1,63] = 13.480, p =

.000), η_p^2 = .176 on the measure of content knowledge retention. On the measure of knowledge comprehension, the results showed that despite the fact that both groups improved from pre-test to post-test, PBL was not significantly different to TDI/control ($F[1,63] = 0.066$, $p = 0.798$), η_p^2 = .001.

It was concluded that PBL was an effective instructional method for improving self-directed learning readiness skills and content knowledge retention over time. However, testing did not show any difference in knowledge comprehension between the PBL group and the TDI/control group.

Implications of the study for policy and practice were addressed on the issues of student success, school/community project support, increased funding, PBL implementation, instructional process, and student assessment. This was followed by recommendations for future research which included expanding the target group, extending the time of the study, as well as investigating other factors such as motivation and student/teacher perceptions.

The findings of this study may be able to help expand the outlook of teachers, administrators, and policy makers on the choice of instructional methods best suited for student achievement and post-secondary outcomes as a national priority.

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Appendix A

Guglielmino Self-Directed Learning Readiness Scale

Name ____ Age _________
Sex ________________ Race _________________ Date of Birth _____________
Learning Center ____________________________ Today's Date _____________

LEARNING QUESTIONAIRE

INSTRUCTIONS: These are some questions about how you like to learn best and how you feel about learning. Read each sentence and choose the one answer which is most true for you. Be sure to answer every question.

There are no wrong answers, so be sure to mark the answer which tells you how you feel. Usually the answer that comes to your mind first is the answer that is true for you.

RESPONSES

Use the following responses:

1. I never feel like this
2. I feel like this less than half the time
3. I feel like this half the time
4. I usually feel like this.
5. I feel like this all the time.

Sample Item:

I like Chocolate. 1 2 3 4 5

ITEMS:

	I feel like this all of the time.	I usually feel this way.	Half the time I feel like this.	the time. I feel like this less than half	I never feel like this.
1. I know what I want to learn.	1	2	3	4	5
2. When I see something that I don't understand, I stay away from it.	1	2	3	4	5
3. If there Is something I want to learn, I can find a way to learn it.	1	2	3	4	5
4. I love to learn.	1	2	3	4	5
5. I believe that a big part of my education should be thinking about what kind of person I am and what kinds of things I want to do with my life.	1	2	3	4	5
6. I know where to go to get information when I need it.	1	2	3	4	5
7. I can learn things by myself better than most people my age.	1	2	3	4	5
8. If there is something I have decided to learn, I can find time for it, no matter how busy I am.	1	2	3	4	5
9. Understanding what I read is a problem for me.	1	2	3	4	5
10. I know when I need to learn more about something.	1	2	3	4	5
11. I think books are boring.	1	2	3	4	5
12. I can think of many different ways to learn about something new.	1	2	3	4	5
13. I try to think about how the things I am learning will fit in with the plans I have for myself.	1	2	3	4	5
14. I really enjoy looking for the answer to a hard question.	1	2	3	4	5
15. I have a lot of questions about things.	1	2	3	4	5
16. I'll be glad when I'm finished learning.	1	2	3	4	5

Use the following responses:

1. I never feel like this
2. I feel like this less than half the time
3. I feel like this half the time
4. I usually feel like this.
5. I feel like this all the time.

ITEMS:

	RESPONSES: I never feel like this.	I feel like this less than half the time.	Half the time I feel like this.	I usually feel this way.	I feel like this all of the time.
17. I'm not as interested in learning as some other people seem to be.	1	2	3	4	5
18. When I decide to find out something, I do it.	1	2	3	4	5
19. I like to try new things, even if I'm not sure how they will turn out.	1	2	3	4	5
20. I'm good at thinking of new ways to do things.	1	2	3	4	5
21. I like to think about the future.	1	2	3	4	5
22. A hard problem doesn't stop me.	1	2	3	4	5
23. I can make myself do what I think I should.	1	2	3	4	5
24. I am really good at solving problems.	1	2	3	4	5
25. I become a leader in learning groups.	1	2	3	4	5
26. I like talking about ideas.	1	2	3	4	5
27. I don't like learning things that are hard.	1	2	3	4	5
28. I really want to learn new things.	1	2	3	4	5
29. When I learn more, the world becomes more exciting.	1	2	3	4	5
30. It's really my ob to learn- the school and the teachers can't do it for me.	1	2	3	4	5
31. I learn many new things on my own each year.	1	2	3	4	5
32. I am a good learner in the classroom and on my own.	1	2	3	4	5
33. People who keep learning are leaders, because they know what's happening.	1	2	3	4	5
34. I like to see if I can solve hard problems.	1	2	3	4	5

Appendix B

<u>The Water Filtration Challenge</u>

Form A

Pre Test on Design It Clean

Section A

Read each question carefully and select the most suitable response by circling the corresponding letter.

1. What property of water does pH measure? Its
   A. Turbidity
   B. Acidity
   C. Transparency
   D. Potability

2. Which of the following is TRUE about potable water? It has been
   I filtered
   II heated
   III made safe for drinking

   A. I and II
   B. II and III
   C. All of the above
   D. I and III

3. Turbidity refers to
   A. The level of disturbance in the water
   B. A measurement of the clarity of the water
   C. How much light can shine through the water
   D. How much soil is in the water

4. Which of the following is NOT true of chemical reactions?
   A. Collision of particles
   B. Rearrangement of atoms
   C. Breaking of bonds only
   D. Absorption and release of energy

5. A good water filter is one that is

   I   easy to use
   II   inefficient
   III reliable
   IV   easy to maintain

   A. All of the above
   B. I, III and IV
   C. I, II and III
   D. I and II

6. A prototype is a
   A. kind of font
   B. Machine
   C. Preliminary version of a device
   D. Water filter system

7. The Brita filter used in homes uses the same principle as which of the following filtering systems?
   A. Biological filter
   B. Chemical filter
   C. Physical filter
   D. Sedimentation

8. An aquaculture farmer has discovered that the fish in his ponds are being killed. The source of his water is a river that flows close to a sugar factory. The possible cause of contamination is
   A. Raw sewage
   B. Soil erosion
   C. Dunder
   D. Naturally occurring minerals

9. A scientific investigation involves several steps. Which of the steps below do you consider to be the most important step in the process?
   A. Stating a testable scientific statement
   B. Outlining the procedure
   C. Listing the variables
   D. Identifying the problem

10. A farmer in rural St. Andrew is seeking to reduce turbidity levels in the drinking water for his livestock. What filtration method would best filter the water while saving him the most money?
    A. Ultraviolet radiation
    B. Distillation
    C. Microporous screen filtration
    D. Installation of a carbon filtration system

11. The community of Castleton depends on the water from the Wag Water river for their domestic use. The river originates in a limestone mountain. How can the water be purified to become safe for drinking?
    A. Boiling
    B. Distilling
    C. Using activated carbon
    D. Using beneficial bacteria

12. Contaminated water is responsible for some diseases. Which of the following are water-borne diseases?
    I Guinea worm infestation
    II Cholera
    III Chikungunya
    A. III only
    B. II and III
    C. I and III
    D. I and II

13. Your community is situated in the hills close to a river. After prolonged rainfall, the turbidity level of the river increased significantly. What could be the possible cause?
    A. Plant material
    B. Soil erosion
    C. Pollutants
    D. Limestone

14. What step would you take to reduce the turbidity of the water flowing in your community?
    A. Remove the particles using a fine meshed fabric
    B. Pass the water over activated carbon
    C. Add chemicals to the water
    D. Boil the water

15. Which of the following uses of water require the least level of cleanliness?
    A. Washing clothes
    B. Irrigation
    C. Drinking
    D. Manufacturing

16. Many changes in ecosystems are induced by human activity. Which of the following reflects this type of change?
    A. Habitat formation
    B. Under exploitation
    C. Climate change
    D. Seasonal changes

Section B

Answer all the questions in this section.

17. Consider your community. Determine whether chemical or biological filtration would be best for the residents then briefly state the factors that make it a better choice.

18. How can scientists and engineers make major contributions to the problem of water quality in developing countries around the world. Briefly explain your answer.

19. Several criteria must be considered when seeking solutions to water quality issues. State three of these criteria and say why you consider them to be important.

20. Briefly describe how anthropogenic changes can have adverse effects on biodiversity.

<u>The Water Filtration Test</u>
Form B
Post Test on Design It Clean
Section A

Read each question carefully and select the most suitable response by circling the corresponding letter.

1. A pH value of 4 indicates a measure of
A. Turbidity
B. Acidity
C. Transparency
D. Potability

2. Which of the following is TRUE about potable water? It has been
I treated
II heated
III made safe for food preparation

A. I and II
B. II and III
C. All of the above
D. I and III

3. Turbidity refers to
A. The level of disturbance in the water
B. How much light can shine through the water
C. How much soil is in the water
D. The cloudiness or haziness of a fluid

4. All of the following are true about chemical reactions except:
A. There is a change in the physical form
B. Collision of particles
C. Rearrangement of atoms
D. Absorption and release of energy

5. A good water filter is one that is
I difficult to use
II efficient
III reliable
IV easy to maintain

A. All of the above
B. I, III and IV
C. I, II and III
D. II, III and IV

6. The best term for a preliminary version of a device is
A. kind of font
B. machine
C. prototype
D. water filter system

7. The filter used in a fish tank uses the same principle as which of the following filtering systems?
A. Biological filter
B. Chemical filter
C. Mechanical filter
D. Sedimentation

8. An aquaculture farmer has discovered that the fish in his ponds are being killed. The source of his water is a river that flows through a community with limited indoor plumbing. The possible cause of contamination is
A. Raw sewage
B. Soil erosion
C. Dunder
D. Naturally occurring minerals

9. A scientific investigation involves several steps. Which of the steps below would be your first step in the process?
A. Stating a testable scientific statement
B. Outlining the procedure
C. Listing the variables
D. Identifying the problem

10. An aqua farmer in an urban area of Kingston is seeking to reduce turbidity levels in his fish tanks. What filtration method would best filter the water while saving him the most money?
A. Ultraviolet radiation
B. Distillation
C. Microporous screen filtration
D. Installation of a carbon filtration system

11. The community of Castleton depends on the water from the Wag Water river for their domestic use. The river originates in a limestone mountain. How can the water be purified to become safe for drinking?

A. Boiling
B. Distilling
C. Using activated carbon
D. Using beneficial bacteria

12. Contaminated water is responsible for some diseases. Which of the following are water-borne diseases?

I Guinea worm infestation
II Cholera
III Typhoid

A. III only
B. II and III
C. I and III
D. All of the above

13. The community of Mavis Bank is situated in the hills close to the Hope River. After prolonged rainfall, the turbidity level of the river increased significantly. What could be the possible cause?

A. Plant material
B. Soil erosion
C. Pollutants
D. Limestone

14 How would you advise the community leaders of Mavis Bank on the best way to reduce the turbidity of the water flowing in their community?

A. Remove the particles using a fine meshed fabric
B. Pass the water over activated carbon
C. Add chemicals to the water
D. Boil the water

15. Which of the following uses of water require the second highest level of cleanliness?
A. Washing clothes
B. Irrigation
C. Drinking
D. Manufacturing

16. Human activity is responsible for many of the changes in our ecosystems. Which of the following reflects this type of change?
A. Habitat formation
B. Under exploitation
C. Climate change
D. Seasonal changes

Section B

Answer all the questions in this section.

17. Consider the community of Mavis Bank and its water challenges. Determine whether chemical or biological filtration would be best for the residents then briefly state the factors that make it a better choice.

18. Scientists and engineers have been making major contributions to the problem of water quality in developing countries around the world. You have been hired as an advisor to a team of scientists. What recommendations would you give to address common problems? Provide justification for your answer.

19. Several criteria must be considered when seeking solutions to water quality issues. State three of these criteria and say why you consider them to be important.

20. Briefly describe some anthropogenic changes and describe how they can have adverse effects on biodiversity.

Appendix C
Sample Materials from Design It Clean

Project Overview

Subject: Science

Project Idea
Think of the water you used today to shower, cook, or brush your teeth. Although most people in developed nations like the U.S. simply turn on the faucet, approximately three quarters of a billion people worldwide lack access to clean water and millions die each year from causes directly related to this problem.

In ***Design It Clean: The Water Filter Challenge,*** students work in teams to develop water filters that are dependable, affordable, and can provide clean water for specific communities in the real world. Students are challenged to learn about a region where people lack access to clean water, and to design and build a working solution. They must ensure that their solutions align with the needs of the community, culture, environment, and local government. They will also present their water filtration prototypes, along with relevant data, to adults playing the roles of local end users, government officials, aid workers, venture capitalists, and other key stakeholders.

Content and Standards
The ***Design It Clean*** project teaches students how to apply Next Generation Science Standards, scientific content, and other skills to a real-world scenario. Students will learn:

- How to ask questions for scientific inquiry;
- How to define problems and design solutions as engineers;
- How to plan and carry out investigations;
- How to analyze and interpret data;
- How to construct scientific explanations;
- How to develop and use models and prototypes;
- How to present engineering solutions and scientific data to a public audience; and
- How to consider the needs of various stakeholders who seek solutions to specific problems.

Furthermore, the ***Design It Clean*** project teaches students to do important research in nonfiction texts, highlighted in the Common Core Standards for Science and Technical Subjects and Reading Informational Texts.

Sequence of the Project

Preparing for the Project

0 Teacher prepares for successful project implementation.

Launching the Project

1 Entry event: Students engage with an example of how an interdisciplinary team addressed a problem in a developing nation.

2 Students engage with water quality issues.

3 Students read Field Reports and form teams.

4 Students read Area Profiles and develop Need to Know Lists.

5 Conduct a brainstorming session around the Field Reports and Area Profiles.

Scaffolding and Managing the Project

6 Facilitate a discussion in which students consider a Driving Question.

7 Develop the roles and identity of each team member.

8 Students analyze examples through a jigsaw reading exercise.

9 Students review basic filtration methods.

10 Students experiment with materials and develop rapid prototypes.

11 Students test their rapid prototypes.

12 Students retest their rapid prototypes.

13 Students expand their Field Report by researching and reporting the social issues that inform the problem and solution.

14 Challenge students to develop a problem statement that gets to the heart of the matter.

15 Students make a technical drawing of a viable prototype.

16 Students build a mock-up of their prototype.

17 Students critique design plans, materials, and other project elements by conducting a gallery walk.

18 Students build initial prototype.

19 Students test initial prototype.

20 Students record and analyze data.

21 Students revisit and revise problem statement, designs, materials, and Field Reports as necessary.

22 Continue to develop iterations of the students' water filters.

Assessing and Showcasing Student Work

23 Refine a body of work to showcase for the public showcase.

24 Students select and develop the showcase format.

25 Secure a space for the showcase.

26 Students practice their presentations.

27 Prepare for showcase.

28 Assign students roles and jobs to execute the showcase.

29 Showcase the work.

30 Teacher uses supplied rubric for student and/or teacher assessment.

31 Teacher reflects on the successes and areas for adjustment for the next time the project is conducted.

Professional Analysis Form

Name:

Professional example:

Use this space to draw a picture of the water filter and its important or working mechanisms:

What was the filter system comprised of? What materials were used?

What were the problems that the engineers identified?

How did the filter system address the problem?

How well did the filter system address the needs of the people using it?

What scientific, social, economic, or ethical issues are raised by this particular article?

What was successful about this filter system?

What was unsuccessful about this filter system?

How might this filter system be better designed?

What ideas can we take for our project from this filter system?

Mock-Up Critique Sheet

Use this sheet to evaluate design mock-ups, materials selected, presentation, and other project aspects.

Team members receiving the critique:
Project title:

Critiqued by:

Your classmates are in the progress of designing a water filter, and need your feedback to perfect it. Make sure that your feedback to them is kind, specific to the materials in front of you, and helpful to making the next draft better.

1. What stands out positively about the mock-up prototype?

2. What stands out positively about the accompanying designs and written work?

3. What are the most interesting, intriguing, or unique parts? Why do you think so?

4. What questions do you have about how this filter works or how the community it was intended to serve might use it?

5. Overall, how can this filter be improved?

6. What ideas can you take from this critique to help make your own work better?

Appendix D

FLORIDA INTERNATIONAL UNIVERSITY

27th April, 2016

INVITATION TO PARTICIPATE IN A RESEARCH STUDY

PROJECT BASED LEARNING: INVESTIGATING SELF-DIRECTED LEARNING READINESS SKILLS AND CONTENT KNOWLEDGE RETENTION IN AN URBAN JAMAICAN HIGH SCHOOL EIGHTH GRADE INTEGRATED SCIENCE COHORT

Dear Parent/Guardian:

Students at the eighth grade level are invited to participate in a research study using a project-based learning approach to integrated science. This study is being conducted by the undersigned, Carolyn Reid-Brown, a doctoral student from Florida International University with the Department of Teaching and Learning.

The purpose of this study is to examine if being taught using a project-based learning approach will lead to students at the eighth grade level being more ready to take responsibility for their own learning, and being able to remember more of what they have learned after a period of time has passed. I also want to find out if using a project-based learning approach will lead to a better comprehension of what has been taught compared to the traditional method of teaching often used in Jamaica.

Participants in this study will be asked to do the following things:

1. Complete an evaluation of him/herself on how ready he/she thinks he/she is to take responsibility for his/her own learning. This will be done at the beginning and end of a 5 week instruction period.
2. Complete a science quiz on water filtration at the beginning of the 5 week period to see what he/she already knows, take another quiz at the end of the 5 week period to see what he/she has learned, and then 4 weeks later take a quiz to see how much he/she remembers.
3. Attend all class sessions relating to this study. Some students will be assigned to groups for the duration on the research study and asked to work on projects.
4. Participate in all class activities related to the study such as lab experiments, model building, commenting on reports.

The only criterion for participation is that the student be in the eighth grade at ypur current high school. The research study will be conducted during the regularly scheduled integrated science class times for a duration of 5 weeks. Participants will conduct lab experiments and construct models based on the focus of the class project. No extra time outside of class time will be required and participating will not add to the general work load of those who choose to participate. There will be no financial compensation but there will be new knowledge and all work completed will count towards regular class grades.

If you are interested in having your child/ward participate please complete and sign the requisite consent form and return it to the school office. Should you need any further information or clarification you may contact me, Carolyn Reid-Brown via email, creid003@fiu.edu or telephone, 305-814-336.

Sincerely,
Carolyn Reid-Brown
Carolyn Reid-Brown
Florida International University
College of Arts, Science and Education
Department of Teaching and Learning

Appendix E
PBL Essential Elements Checklist

PBL Essential Elements Checklist

Whatever form a project takes, it must have these Essential Elements to meet BIE's definition of PBL.

Does the Project …?	√	X	**?**
FOCUS ON SIGNIFICANT CONTENT At its core, the project is focused on teaching students important knowledge and skills, derived from standards and key concepts at the heart of academic subjects.			
DEVELOP 21ST CENTURY SKILLS Students build skills valuable for today's world, such as critical thinking/problem solving, collaboration, and communication, which are taught and assessed.			
ENGAGE STUDENTS IN IN-DEPTH INQUIRY Students are engaged in a rigorous, extended process of asking questions, using resources, and developing answers.			
ORGANIZE TASKS AROUND A DRIVING QUESTION Project work is focused by an open-ended question that students explore or that captures the task they are completing.			
ESTABLISH A NEED TO KNOW Students see the need to gain knowledge, understand concepts, and apply skills in order to answer the Driving Question and create project products, beginning with an Entry Event that generates interest and curiosity.			
ENCOURAGE VOICE AND CHOICE Students are allowed to make some choices about the products to be created, how they work, and how they use their time, guided by the teacher and depending on age level and PBL experience.			
INCORPORATE REVISION AND REFLECTION The project includes processes for students to use feedback to consider additions and changes that lead to high-quality products, and think about what and how they are learning.			
INCLUDE A PUBLIC AUDIENCE Students present their work to other people beyond their classmates and teacher.			

VITA

CAROLYN ANN LEVY REID-BROWN

Born, Kingston, Jamaica

1992-1995	Dip. Ed. Special Education	
		MICO TEACHERS' COLLEGE
		Kingston, Jamaica
1998-2000	B. Ed. Educational Assessment, Special Education	
		University of the West Indies
		Mona
		Kingston, Jamaica
2006-2007	M.S., Curriculum & Instruction	
		Florida International University
		Miami, Florida
2013-2017	PhD. Curriculum & Instruction	
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		Miami, Florida

PUBLICATIONS AND PRESENTATIONS

Spears-Bunton, L., Reid-Brown, C., Jean, R. and McIntyre-McCullough, K. (2017), "Sankofa: African-Americans' Continuing Struggle for a Quality Education." Article in review.

McIntyre-McCullogh, K. and Reid-Brown, C. (2017), "Remaining Current: The Tide of Prospective Cultural and Economic Death." Paper presented at 42nd Annual Caribbean Studies Association Conference, Nassau, Bahamas, June 5 – 10, 2017

Boyce-Davies, C., Spears-Bunton, L. and Reid-Brown, C. (2017). Education for Economic Sustainability in the Caribbean. Roundtable at 42nd Annual Caribbean Studies Association Conference, Nassau, Bahamas, June 5 – 10, 2017

Mathews, S. and Reid-Brown, C. (2015), "Out of Many, One: Jamaican Teachers' Perspectives of Global Education." Paper presented at Florida International University School of Education and Human Development Brown Bag session, Miami, FL February 15, 2017

Preparing Haitian Teachers and Students for Economic Sustainability, Caribbean Studies Association Conference, Port au Prince, Haiti, June 6 - 11, 2016.

Romero-Sardinas, A., Spears-Bunton, L. and Reid-Brown, C. (2015), “Passing Notes: Choral-tivity, Literacy and Meaning Creation in Word, Song and Performance.” Paper presented at Florida Music Educator Association Professional Development Conference and All-State Concerts, Tampa, FL, January 2016

“Education for Transformation” workshop. Hosted by the Institute of Development Studies (University of Sussex), Midhurst West Sussex, UK July 28 - 30, 2009.

Landorf, H., Reid, C. and Robinson, S. (2007), “Environmental Sustainability as a Human Right.” Paper presented at National Council for the Social Studies Conference (NCSS), International Assembly, San Diego, CA, November 30 - December 2