THE EFFECT OF STEM PROBLEM-BASED LEARNING ON ACHIEVEMENT IN SIMPLE MACHINES, INTEREST IN LEARNING SCIENCE AND SELF-REGULATED LEARNING IN SCIENCE AMONG JUNIOR SECONDARY SCHOOL STUDENTS IN NIGERIA

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by

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DEDICATION

This thesis is dedicated to God the father, God the Son and God the Holy Spirit.

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LIST OF ABBREVIATIONS

3C3R	Content, Context and Connection
	Researching, Reasoning and Reflecting
ADDIE Model	Analysis, Design, Develop, Implement and Evaluation Model
ANCOVA	Analysis of Covariates
APSP	African Primary Science Programme
BSNSS	Basic Science for Nigeria Secondary Schools
CESAC	Comparative Education Studies and Adaptation Centre
EDL	Education Development Centre
ESI	Educational Services Incorporated
ETE	Engineering Technology Education
HA	High Ability
ILS	Interest in Learning Science
LA	Low Ability
NGSS	Next Generation Science Standards
NISP	Nigerian Integrated Science Project
NRC	National Research Council
NSES	New Science Education Standards
NSF	National Science Foundation
NSSSP	Nigerian Secondary Schools Science Project
PBL	Problem-Based Learning
RTTT	Race To The Top
SPSS	Statistical Package for the Social Sciences
SRL	Self-Regulated Learning

STAN	Science Teachers Association of Nigeria
STEAM	Science Technology Engineering Arts and Mathematics
STEM	Science, Technology, Engineering and Mathematics.
STEM PBL	Science, Technology, Engineering and Mathematics Problem-Based Learning

KESAN PEMBELAJARAN BERASASKAN MASALAH STEM TERHADAP PENCAPAIAN ASAS SAINS, MINAT DAN PEMBELAJARAN REGULASI KENDIRI DALAM KALANGAN PELAJAR SAINS SEKOLAH MENENGAH DI NIGERIA

ABSTRAK

Objektif kajian ini adalah untuk mengkaji kesan STEM PBL terhadap ujian pencapaian Sains Asas, minat dalam pembelajaran sains dan pembelajaran kendiri dalam sains. Secara khususnya, kajian ini adalah untuk menilai kesan STEM PBL ke atas dua kumpulan pelajar yang melibatkan pelajar berkemampuan rendah dan pelajar berkemampuan tinggi. Kajian ini juga cuba untuk menentukan sama ada kesan STEM PBL ke atas ujian pencapaian Sains Asas, minat dalam pembelajaran sains dan pembelajaran kendiri dalam sains adalah lebih tinggi pada pelajar yang rendah kemampuan atau pelajar berkemampuan tinggi atau sama ada kesannya sama untuk kedua-dua kumpulan. Kajian ini menggunakan pensampelan rawak berstrata untuk menyusun atur kelas pelajar berkemampuan rendah dan satu lagi kelas pelajar berkemampuan tinggi. Kajian ini menggunakan reka bentuk penyelidikan pra-eksperimen. Terdapat dua kumpulan pelajar, ujian pra, ujian pasca dan ujian pasca lanjutan untuk pelajar berkemampuan rendah dan pelajar berkemampuan tinggi. Kajian ini dijalankan di luar waktu sekolah; justeru itu ia tidak memerlukan kumpulan kawalan. Intervensi kajian ini berlangsung selama tiga bulan. Pembolehubah bebas adalah STEM PBL, manakala tiga pembolehubah bersandar adalah ujian pencapaian Sains Asas, minat dalam pembelajaran sains dan pembelajaran kendiri dalam sains. Keupayaan pelajar adalah pemboleh ubah penyederhana. Kajian ini mendapati bahawa STEM PBL secara positif mempengaruhi ujian pencapaian Sains Asas, minat dalam

pembelajaran sains dan pembelajaran kendiri dalam sains. Kesan Pembelajaran STEM Berasaskan Masalah pada ujian pencapaian Sains Asas, minat dalam pembelajaran sains dan pembelajaran kendiri dalam sains adalah lebih tinggi untuk pelajar berkemampuan rendah berbanding untuk pelajar berkemampuan tinggi. Kajian menunjukkan bahawa Pembelajaran STEM Berasaskan Masalah merupakan satu pendekatan yang boleh digunakan untuk meningkatkan pencapaian pelajar dalam sains, minat dalam pembelajaran sains dan pembelajaran kendiri dalam sains.

THE EFFECT OF STEM PROBLEM-BASED LEARNING ON ACHIVEMENT IN SIMPLE MACHINES, INTEREST IN LEARNING SCIENCE AND SELF-REGULATED LEARNING IN SCIENCE AMONG JUNIOR SECONDARY SCHOOL STUDENTS IN NIGERIA

ABSTRACT

The objective of this study was to examine the effect of STEM PBL on the Basic Science achievement test, interest in learning science and self-regulated learning in science. Specifically, the study was to assess the effect of STEM PBL on two groups of learners. These are the low ability learners and high ability learners. The study also tried to determine whether the effect of STEM PBL on Basic Science achievement test, interest in learning science and self-regulated learning in science was higher on low ability learners or high ability learners or whether the effect is the same for both groups. The study used stratified random sampling to compose a class of low ability learners and another class of high ability learners. The study employed pre-experimental research design. There were two groups of learners, a pretest, post-test and a delayed post-test for low ability learners and high ability learners. The study was conducted as an out-of-school experiment so there was no need for a control group. The treatment was lasted for three months. The independent variable is STEM PBL, there were three dependent variables are Basic Science achievement test, interest in learning science and self-regulated learning in science. Learners' ability was the moderating variable. It was found that STEM PBL positively affects Basic Science achievement test, interest in learning science and self-regulated learning in science. The effect was more for low ability learners than high ability learners. The study

showed that STEM PBL could be a very good approach that will enable low ability learners to perform better in Basic Science.

CHAPTER 1

INTRODUCTION

1.0 Introduction

On successful completion of 9-year of formal schooling in Nigeria, a student shall sit for the Basic Education Certificate Examination (BECE) and/or Junior Arabic and Islamic Studies Certificate Examination (JAISCE) (Ochuba, 2010; Salau, 2007; The Federal Republic of Nigeria, 2004). A student who wishes to study science in the tertiary institution must have to obtain a credit pass in Basic Science at Basic Education Certificate Examination before proceeding for post basic education. The Nigerian National Policy on Education (The Federal Republic of Nigeria, 2004), section 3, paragraph 38.1, stated that the core subjects are fundamental subjects which will qualify a student to offer arts or science subjects at the tertiary education level. For a student to gain admission to the university to study any of the courses in the Sciences, Engineering, Technology or Mathematics, he/she must first obtain 5 credits in the Senior Secondary Certificate Examination. This must, of course, include English Language, Mathematics, Chemistry, Biology and/or Physics depending on the students' choice of course (Onasanya, 2009; The Federal Republic of Nigeria, 2004).

Given the poor achievement of students in Basic science, it is important to explore means of improving students' achievement in Basic science in other to make sure that in this period of increased knowledge in the area of science and technology that the country do not lag behind (Awosiyan, 2006; Bakracevic Vukman & Licardo, 2010; Beishuizen & Steffens, 2011; Mamalanga & Awelani, 2014). If junior secondary school students do not have high achievement in Basic science, the

implication is that they will not be able to obtain high achievement in science at the senior secondary level and therefore will not be able to gain admission to the university to study science courses (Akinsanyo, Ajayi, & Salomi, 2014; Ndioho, 2007; Osonwa, Adejobi, Iyam, & Osonwa, 2013). Literature has shown that several factors contribute to the poor performance of students in Basic Science. Two of these reasons are students' lack of interest in learning science (Dimulsecu & Dessalles, 2009; Fadigan & Hammrich, 2004; Klassen, 2006b; Klassen & Froese Klassen, 2014) and the fact that students lack self-regulated learning in science(Heo, 2009; Kyun, 2010). In teaching Basic Science, it is important to use an approach that will improve students' achievement, interest in learning science and self-regulated learning in science.

When it comes to ways of teaching science for better understanding, integrated STEM approach stands out (Elliott, Oty, Mcarthur, & Clark, 2001; Nnebue, 2007; Yoloye, 2010).Integrated means uniting or combining different, distinct or isolated or entities in other to provide or produce a unified, interconnected, organized and interrelated whole. According to some authors integrated STEM education connotes a an approach of teaching and learning some combined, coordinated and interrelated concepts of science, technology, engineering, and mathematics in other to study global problems, find solution to somedifficult, multifaceted and real-life problems and develop solutions or answers for life challenges (Heil, Pearson, & Burger, 2013; Honey, Pearson, & Schweingruber, 2014; Kelley & Knowles, 2016; Sanders, 2009; Seifert, 2017; Stohlmann, Moore, & Roehrig, 2012).Integrated STEM approach is a method of teaching and not a curriculum. It is a recipe for helping learners apply their knowledge, work together with their peers, and see the relevance in what they are learning (Carter, 2013;

Vasquez, Sneider, & Comer, 2013). In integrated STEM approach, the teacher is only asking students to make additional connections, not only between the STEM subjects but also with other knowledge, ideas, and concerns that they bring into the classroom. One of the ways to introduce STEM is through Problem-Based Learning.

The main basis of Problem Based Learning (PBL) is the fact that the problem is always unique. The situation offers the vehicle for developing understanding(Altshuler & Bosch, 2003; Mergendoller, Maxwell, & Bellisimo, 2006). PBL creates real life conditions by providing learners with a purposefully ill-structured problem before learners have been given the needed information for solving such a problem (Altshuler & Bosch, 2003; Barrows, 2002; Putnam, 2001). If STEM is to be introduced to students through problem-based learning, then it has to be STEM problem-based learning (STEM PBL). STEM problem-based learning is simply the act of integrating STEM learning into PBL using engineering design. To teach students using only science as a knowledge is troublesome to students, therefore, it is more authentic to use STEM. STEM emphasises how scientists and engineers think and work.

This study was carried out to determine the effect of STEM PBL on achievement in simple machine test scores, interest in learning science and self-regulated learning in science among junior secondary form 2 students of Nsukka local government area in Enugu state, Nigeria. The study employed a pre-experimental research design. Random sampling was used to select the school and stratified random sampling was used to select the classes that were used in the study. The participants were classified into low ability and high ability learners. STEM PBL was the intervention that was administered to both groups of learners by the same teacher. This was done as an after-school experiment, therefore, there was no

control group. Three instruments were used to collect data on the study. The data so collected were analysed using ANCOVA, ANCOVA with repeated measures and paired sample t-test. The results showed that STEM PBL improved achievement in simple machine test scores and interest in learning science but did not improve self-regulated learning in science.

1.1 Background of the Study

Basic Science is the first form of science a child comes across at the secondary school level in Nigeria (Ezugwueze, 2011; The Federal Republic of Nigeria, 2004). Basic science is a core subject in the National curriculum at the upper basic level (Ajagun, 2015; Obieze, 2006). All students from upper basic 1 - 3 classes must offer and study the subject. Basic science is believedto be the foundationof all science subjects at the senior secondary school (SSS) level. The subject equips students at the upper basic level for the study of core science subjects (Biology, Chemistry and Physics) at the senior secondary school level (Azuka, 2014; Chukwuneke & Nwachukwu, 2015). That is why Ochuba (2010) further emphasised that for a student to be able to study single science subjects at the senior secondary level successfully; such a student has to be well grounded in Basic Science at the upper basic level. Based on this, it is generally taught as a single science subject, until in the SSS level, and then split into specialized science subjects (Biology, Chemistry and Physics). It is expected that those students who achieve well in Basic Science should be given the opportunity to study the separate science subjects at the SSS level(Dajili, 2001; Ozaji, 2016).

Basic science emphasises scientific literacy and research-oriented learning. The subject encourages exploration of student's immediate environment. The teaching of Basic Science is therefore, based on the philosophy of active learner-

participation in the process whereby, students are encouraged to learn by constructing their own knowledge based on what they already understand as they make connections between new information and old information, guided or facilitated by the teacher (Achor, Kurumeh, & Orokpo, 2012; Ugwueze, 2009). Under this philosophy, students are encouraged and led to discover concepts and generalizations based on their experiments. Agbo and Mankilik (2011) in their research rightly pointed out that, when children learn science using the process and activity approaches, they improve their ability to apply intellectual skills to solve problems, improve their language development, become more creative, master science content better and develop positive attitude towards science and scientists.

Researches by Odili (2009) and Attama, Obodoechi, and Mgbodile (2016) have shown that the above desires are not being achieved as expected. The learning environment is expected to be democratic, the activities are interactive and student-centred, and the teacher facilitates the process of learning in which students are encouraged to be responsible and autonomous. Though the curriculum of Basic Science in Nigeria specifies hands-on and activities and skill acquisition, most students are not exposed to these real situations in the schools (FRN 2004).Basila (2016), in his research discovered that Basic Science is generally taught using conventional strategy which does not follow the theories of learning process. He further explained that, the use of conventional method in teaching Basic Science has compounded the problem of effective learning of the concepts, skills and ideas.

According to Attah, (2015), Papinczak, Young, Groves, and Haynes (2016) and Klassen and Froese Klassen (2014) interest in learning Basic science is an important factor in achievement in Basic Science. Over time, the Basic Science curriculum has been reviewed to make it more functional and interesting(Dimulsecu

& Dessalles, 2009). The student should be interested in Basic Science that would stimulate his interest to learn. It is only when the teacher is able to sustain the student's interest that the student can meaningfully interact with the teaching and learning materials. Interest is a quality that arouses concern and curiosity that holds one's attention.

Interest in learning science is a condition of wanting to study and learn more about a science topic. Interest in learning science naturally leads to attention, and that attention ensures the acquisition of the knowledge or ideas being imparted(Barnes, Mclnereney, & Marsh, 2005; Hofstein & Kesner, 2006; Ke & Carafano, 2016). Interest in learning science also strengthens retention of knowledge and facilitates recollection and retrieval from memory. If anyone is interested in a thing, he tends to get fully involved in doing it, and ensuring that it is done well so as to sustain his desire to carry on with that thing. The students should be encouraged to develop interest in learning science by involving themselves in the learning process. The teacher should appreciate their efforts, which will motivate them to great performance. Students should also be guided to ensure that they apply knowledge and skills learnt and acquired to meet societal needs. Students' interest in learning science can be fostered through instruction. According toBybee, Fensham, and Laurie (2009) a student who is interested in learning science will have a good self-regulated learning in science. Self-regulated learning in science refers to self-generated thoughts, feelings and behaviours that are oriented to attaining academic goals in science. Self-regulated learning is an active process that enables the learner to set and control his learning activities, cognition, motivation and behaviour.

Students who have interest in learning science are also conscious of their ability and their weak point and are active in their efforts to study science. These

students can effectively monitor their learning behaviour in setting up their academic goals, and in the process of learning, they can increase their effectiveness. As a result, self-regulated learning in science can enhance their self-satisfaction and motivation and they are more likely to succeed academically. Stoeger and Ziegler (2011) and Fadigan and Hammrich (2004) have established that there is a correlation between students' academic achievement, interest in learning science and self-regulated learning in science by Nigerian students. Researchers repeatedly emphasize three components of self-regulated learning in science(Klassen, 2006a; Palmer, 2004). First, self-regulated learning in science includes students' metacognitive strategies for planning, monitoring and modifying their cognition, which refers to the awareness and control of thought processes. Second, students' management of their academic task efforts has been proposed as another important component. The third aspect is the actual cognitive strategies that students use to learn the actual material in science.

Students who have self-regulated learning in science will likely use strategies to help them think about and solve new problems. This means that, they cannot rely on previous knowledge to assist them on their performance on the new task. They will recognize that they lack expertise and utilize learned strategies to assist them in completing challenging tasks. Panadero, Jonsson, and Botella (2017); Sun, Xie, and Anderman (2017), pointed out that many students have problems with self-regulated learning in science. Self-regulated learning in science is an important characteristic of a good student. When students fail to self-regulate their learning in science, they have problem with effective learning and academic achievement in science (Cho, Kim, & Choi, 2017; Karaduman, 2013). According to Bruin and Merri (2017) and

Foster, Rawson, and Dunlosky (2017) majority of students who are poor on self-regulated learning in science are low ability learners.

Researches have shown that self-regulated learning in science is closely linked to academic outcomes including achievement in science. In a study conducted by Zimmerman and Martinez-Pons (1986) self-regulated learning strategies like reviewing text, environmental structuring, seeking information, and goal settings were found to significantly contribute to students' achievement. In addition, it was found that some high ability students and low ability students do not tend to use self-regulated learning strategies that can help improve their achievement. Ee, Moore, and Atputhasamy (2003) revealed that high ability students may have greater disposition to use self-regulated learning strategies.

Self-regulated learners in science, who are active in their own learning motivationally, behaviourally, and metacognitively, are likely to achieve at high levels (Risemberg& Zimmerman, 1992). These students monitor and control their learning against their goals by using different strategies and managing their time and study environment effectively. They hold positive beliefs about their abilities and future successes (Dembo& Eaton, 2000). Therefore, self-regulated learners in science have high motivation to use cognitive and metacognitive strategies to regulate their cognition and effort. Indeed, McCoach and Siegle (2003) suggested that if students have no motivation to use various cognitive and metacognitive strategies, possessing knowledge on these strategies will not be sufficient for them to learn and perform effectively. In other words, students must have both skill and will to improve their academic functioning (Zusho&Pintrich, 2003).

The participants in this study will be classified into two groups: low ability learners and high ability learners. This is because research has revealed that the

problem of low achievement is worse with low ability learners (Allen, 2014; Fong, Kim, Davis, Hoang, & Kim, 2017; Freeman et al., 2014b; Goldhaber, Gratz, & Theobald, 2017; Sheppard, Manalo, & Henning, 2017; Tarbetsky, Collie, & Martin, 2016; Weiman, 2014).Researches have shown that when high ability students are bored and frustrated, they lack interest in learning science and therefore obtain poor achievement(Homer & Ryder, 2015; Koh, Tan, Wang, Ee, & Liu, 2007; Shirazi, 2017). This study will examine the effect of STEM PBL on the achievement of low ability learners. Low ability students have been found to have problem retaining or remembering what they learnt (Knight, Porcellato, & Tume, 2014). According to Neihart (2007), Ugwuanyi, Onyemauwa, Ekwueme, and Onwuegbuchu (2010), and Mei and Pajares (2010) low ability students perform very low academically because they do not find it easy to internalize and retain information that they have learnt.

Literatures by Estes, Liu, Zha, and Reedy (2014); Mong and Ertmer (2013) and Karaduman (2013) suggested that STEM PBL can be used to teach difficult topics. This is because, it is believed that STEM PBL help learners to probe into the topic, examine issues in the problem, try to develop a means or model for solving the problem, carry out some research into the problem, analyse, interpret information gathered on the problem, use mathematical thinking, and evaluate and disseminate or communicate information.

The trend of integrated STEM Education in United States of America (U.S.A) is discussed below. There has been some transformations or reforms in integrated STEM education in the United States of America. These reforms comprise of Science for all Americans, Architectural Construction and Engineering (ACE) Mentor Programme, Race To The Top (RTTT) and Educate to Innovate (Gomez & Albrecht, 2013; Siew & Yang, 2014). The struggle for Education reform has

continuously increased in the United States to comprise of advancement in the quality of education, making science and mathematics relevant to real-world situation at education level. In America, it is believed that for the security and prosperity of the U.S.A. to be better, it is important to improve the STEM education workforce. This is important because there is a high demand for specially trained STEM professionals in industries and government offices (Carlson, Celotta, Curran, Marcus, & Loe, 2016). The concern of the United States is to have a STEM educated workforce that is provide labour for their science and technology driven economy and cause the nation to take charge of national security threats, not just to provide economic opportunities for citizen.

1.2 Problem Statement

It is necessary to have a look at the Basic Education Certificate Examination (BECE) results for Enugu North Senatorial Zone within the past few years in other to understand the reason for this study at this time. In 2009, only 3,125 students representing 38.30% of students who sat for BECE obtained credit in Basic Science in the zone (Enugu State Ministry of Education, 2009). By 2010, 37.17% representing 2,118 of the students that sat for BECE were able to obtain credit pass in Basic Science in the zone (Enugu State Ministry of Education, 2010). In 2011 and 2012, the results were no better since only 2,630 students representing 38.92% (Enugu State Ministry of Education, 2011b) and 2,853 representing 29.37% (Enugu State Ministry of Education, 2012) obtained credit and above respectively. The Basic Science results for 2013, 2014 and 2015 were even worse than the previous years (Enugu State Ministry of Education, 2013, 2014, 2015).

Sellers, Roberts, Giovanetto, Friedrich, and Hammargren (2007) concluded that a lot of the reason why children fail Simple machines is because of the way students learn the concepts in schools. They explained that students learn to be automated calculation machines, instead of learning to find out thought-provoking things with Simple machines. Students consequently, justifiably, dislike Simple machines, so they don't try to study it, so they can't do it (Araz & Sungur, 2007b; Bulger, Mohr, & Walls, 2002; Yip, 2002). Students who learnSimple machines in the traditional situations are worried by equations and rules that they are required to study and understand, even though these cannot be applied to solve real-life simple machine projects (Birk & Kurtz, 2009; Bishop & Berryman, 2009; Harold & Ertmer, 2007). Previous studies have shown that one of the reasons for poor achievement in a subject is when students are not able to retain information that they have studied (Alquraini & Gut, 2012; Fyson & Cromby, 2010; Paschler, McDaniel, Rohrer, & Bjork, 2010; Tirri & Nokelainen, 2011).

Literature has revealed that some topics or concepts in Simple Machines are very difficult for students to learn and this has contributed to why students continue to fail Simple Machines.The following examples can be given for the topics of pulley, kinetic theory, pneumatic machines, wheel and axel (Oyedokun, 2002), wheel and axel, pneumatic machine, work, energy and power, crude oil and petrol chemicals (Oyedeji, 2009), kinetic theory, pulley, thermal energy, pneumatic machines (Adedayo, 2006), crude oil and petrol chemicals, pulley, pneumatic machine, wheel and axel, kinetic theory and thermal energy (Akinsola, 2007). Other difficult topics include, wheel and axel, petrochemical and pulley (Ekeokpala, 2011); pneumatic machine, pulley, wheel and axel, work (Eze, 2012); pulley, energy and power, wheel and axel and pneumatic machine (Obetta, 2012); pulley and pneumatic

machines (Johnson, 2013); pneumatic machine, energy and power, pulley, wheel and axel (Olayanju& Oladipo, 2013), matter, habitat, air pollution and pulley (Obi &Attama, 2014) and excretory system, pneumatic machine, pulley and power (Musa, 2015).It should be noted that Basic Science is a subject while Simple Machine is a major topic in Basic Science.

The researcher selected the difficult topics from the above list for this study. These three topics are pulley, pneumatic machines, wheel and axel. These three topics are under a bigger topic called simple machine. This necessitated why the study was carried out using the bigger topic simple machine.Since students perceive these topics as difficult, they also lack interest in studying them (Adedayo, 2006).

Arising from students' poor achievement in Simple Machine is the fact that students do not have interest inlearning science (Chamundeswari, 2013). This dearth of interest in the learning of science has contributed to the poor achievement in the subject. This is because, one's performance in a subject is poor if he is not interested in the study of the subject(Hasni, 2015). Literature has shown that students' lack of interest in the learning of science has resulted in their abysmal performance in science(Ainley & Ainley, 2011; Anderman, Noar, Zimmerman, & Donohew, 2004; Christidou, 2011; Desy, Peterson, & Brockman, 2013; Hasni, 2015). It is imperative to see how the students' interest in learning science can be increased in other to increase their achievement in the subject. The most active element contributing to learners' determinations to learn science is their interest in the subject (Barnes et al., 2005; Bybee et al., 2009; Eilks, Marks, & Feierabend, 2008).

If a student is interested in learning a subject, the student will also have a good self-regulated learning in that subject (Sweller & Paas, 2017). Self-regulation

models try to studythe way that students initiate, stimulate, motivate,change, and maintain their study habits by utilizing a range of self-related methods (Laskey & Hetzel, 2010; Liou & Kuo, 2014). Many students who have poor academic achievement are also poor in self-regulated learning (Dinsmore, Alexander, & Loughlin, 2015; Isiguzo, Otagburu, & Ikeagwuche, 2015). A student who is not able to self-regulate his learning will not be able to have a good achievement in a subject(Abar, Carter, & Winsler, 2009; Bushman, Friedlander, Saddler, Frizzelle, & S., 2005; Foster et al., 2017; Onwutalu, Ikwumelu, David, & Omemma, 2012). The problem is, a good number of learners are not able to self-regulate their learning in science especially low ability learners(Akinoglu & Tandogan, 2007; Alper, 2008; Onwuama, 2004; Sweller & Paas, 2017). From existing literature, students who experience difficulty with some of the topics in Simple Machine also have problem with self-regulated learning in science (Ekeokpala, 2011; Eze, 2012; Johnson, 2013; Obi &Attama, 2014; Musa, 2015). According to Ekeokpala (2011), lack of self-regulated learning in science is one of the major reasons why these students cannot study Simple Machine and therefore cannot obtain high achievement in Simple Machines.

When a student's self-regulation in learning science is well developed, the student will have a greater achievement in the subject and see connection existing between the subject and other subject or topic and other topics (Foster et al., 2017). Students view the subjects they take in school as entirely separate because they are typically based on different standards and taught with curriculum materials that were developed without reference to each other (Araz & Sungur, 2007a; Simon & Charles, 2010). One of the great promises of Integrated STEM Education is in breaking down the isolation of science and mathematics from each other and from technology and

the world outside of school(Egarievwe, 2015b; Suchman, 2014; Swaid, 2015a). There is the need to learnSimple Machine in such a way that it will have a relationship with the real-world. Simple Machine should be learnt in the context of Integrated STEM Education. The learning of Simple Machine should be such that will give students the opportunity of seeing a relationship between what is done in the classroom and the real-world situation(Suchman, 2014)..

This is why this study wants to examine the effect of STEM PBL in teaching Simple Machine. Problem-based learning is atechnique of teaching which enables learners to solve unclear and real-life problems while giving the students opportunity for active participation in the learning process. It is a constructivistmethod to instruction, it helps in promoting reflection, communication skills and collaboration among students while enhancing students participation in learning(Loyens, Magda, & Rikers, 2008; Usulor, 2011). PBL is a method that uses real-life problems as a base or foundation for students to improve their understanding and skills and to facilitate learning(Massa & Donnelly, 2009; Promentilla, Lucas, Aviso, & Tan, 2017; Uden & Beaumont, 2005).

STEM PBL is planned and designed for the integration of the elements of STEM into the process of PBL(Attah, Ugwuokanya, Ezeomenma, & Uwabunkeonye, 2017; Bicer, Boedeker, Capraro, & Capraro, 2015; Erdogan, Navruz, Younes, & Capraro, 2016; Johnson & Ogbonna, 2016; Ugwueze, 2009). STEM PBL uses design thinking. STEM PBL involves using PBL to implement integrated STEM approach.

If high ability students do not enjoy a lesson or become bored, they can become uninterested and even behave badly (Shirazi, 2017). This behaviour is not

what many teachers expect of students with high ability. Certainly, in most countries such behaviour would be undesirable, as it would result in the student not doing as well as might be expected. Teachers and administrators then focus on either punishing the student or better, trying to correct the undesired behaviour. However, they may still miss the underlying cause that, in this instance, may lie within the classroom, the school or the programme, and not with the child. According to Koh et al. (2007) high ability students are frustrated when teaching is boring. When a wrong method is used by a teacher to teach high ability students, the classroom becomes boring and frustrating to high ability students.

High ability students lack interest in learning science because of the teaching approach that is used in teaching simple machines (Homer & Ryder, 2015). This lack of interest in learning science make it difficult for high ability students to study the concepts that were taught in class. The implication of this is that high ability students obtain poor achievement in simple machine (Otti, Ugwu, & Ezechime, 2013).

STEM PBL is challenging to low ability learners (Erdogan et al., 2016; Johnson & Ogbonna, 2016; Mei & Pajares, 2010; Oner, Michael, & Magaret, 2011; Sheppard et al., 2017; Stadler, Aust, Becker, Niepel, & Greiff, 2016). In this study, STEM will be conducted using PBL to improve students' performance on the three dependent variables of this study. This study is based on the proposition that STEM PBL has potential to help students overcome low attainment in simple machines, dearth of interest in learning science and lack of self-regulated learning in science. This is because STEM PBL has capacity for hands-on activities which increases students' interest, students' active participation in the learning process, STEM activities are always related to real-life problem scenario (Tafoya, 2014; Welch, Dunbar, & Rickels, 2015; Wells, 2013).Therefore, the problem of this study is to

compare the effect of STEM PBL in Simple Machine achievement test scores, interest in learning science and self-regulatedlearning in science of low ability learners and high ability learners among Junior Secondary form 2 students.

1.3 Research Objectives

The study will be carried out to determine the following objectives:

1.3.1 To compare the effect of STEM PBL on achievement test scores in simple machines between Low ability and High ability learners who follow STEM PBL.

1.3.2 To compare the effect of STEM PBL on the retention of achievement test scores in simple machines between Low ability and High ability learners who follow STEM PBL.

1.3.3 To compare the effect of STEM PBL on the interest in learning Science between Low ability and High ability learners who follow STEM PBL.

1.3.4 To compare the effect of STEM PBL on the retention of interest in learning science between Low ability and High ability learners who follow STEM PBL.

1.3.5 To compare the effect of STEM PBL on the self-regulated in science between Low ability and High ability learners who follow STEM PBL.

1.3.6 To compare the effect of STEM PBL on the retention of self-regulated in science between Low ability and High ability learners who follow STEM PBL.

1.4 Research Questions

To fulfil objective 1.3.1, the following three research questions under 1.4.1 were answered:

1.4.1 (i) Is there any significant difference in the mean achievement test scores in simple machines between Low ability and High ability earners who follow STEM PBL on Post-test after controlling for the effect of Pretest?

(ii) Is there any significant difference between the effect of STEM Problem Based Learning in the mean achievement test scores in simple machines pretest and post-test of low ability learners?

(iii) Is there any significant difference between the effect of STEM Problem Based Learning in the mean achievement test scores in simple machines pretest and post-test of high ability learners?

To fulfil research objective 1.3.2 the following three research questions under 1.4.2 were answered:

1.4.2(i) Is there any significant difference in the mean score of delayed post-test of simple machines between low ability and high ability learners who follow STEM PBL after controlling for the effect of pretest?

(ii) Is there any significant difference between the effect of STEM Problem Based Learning on the retention of achievement in simple machine post-test and delayed post-test scores of low ability learners?

(iii) Is there any significant difference between the effect of STEM Problem Based Learning in the mean score of achievement in simple machines post-test and delayed post-test of high ability learners?

To fulfil research objective 1.3.3, the following three research questions under 1.4.3 were answered:

1.4.3(i) Is there any significant difference in the mean score of interest in learning Science between Low ability and High ability learners who follow STEM

PBL on Post-questionnaire after controlling for the effect of Pre-questionnaire scores?

(ii) Is there any significant difference between the effect of STEM Problem Based Learning on students' mean score of interest in learning science, pre-questionnaire scores and post-questionnaire scores of Low ability learners?

(iii) Is there any significant difference between the effect of STEM Problem Based Learning on students' mean score of interest in learning science, pre-questionnaire scores and post-questionnaire scores of High ability learners?

To fulfil the research objective 1.3.4, the following three research questions under 1.4.4 were answered:

1.4.4(i) Is there any significant difference in the mean score of delayed post-questionnaire of interest in learning science between Low and High ability learners who follow STEM PBL after controlling for the effect of pre-questionnaire scores?

(ii) Is there any significant difference between the effect of STEM Problem Based Learning in mean score of interest in learning science, post-questionnaire scores and delayed post-questionnaire scores Low ability learners?

(iii) Is there any significant difference between the effect of STEM Problem Based Learning on mean score of interest in learning science, post-questionnaire scores and delayed post-questionnaire scores of High ability learners?

To fulfil research objective 1.3.5, the following three research questions under 1.4.5 were answered:

1.4.5(i) Is there any significant difference in the mean score of self-regulated in science between Low ability and High Ability Learners who follow STEM PBL on Post-questionnaire scores after controlling for the effect of Pre-questionnaire scores?

(ii) Is there any significant difference between the effect of STEM Problem Based Learning in the mean score of self-regulated in science pre-questionnaire scores and post-questionnaire scores of Low ability learners?

(iii) Is there any significant difference between the effect of STEM Problem Based Learning in the mean score of self-regulated in science pre-questionnaire scores and post-questionnaire scores of High ability learners?

To fulfil research objective 1.3.6, the following three research questions under 1.4.6 were answered:

1.4.6(i) Is there any significant difference in the mean score of delayed post-questionnaire of self-regulated learning in science between Low ability and High ability learners who follow STEM PBL after controlling for the effect of Pre-questionnaire scores?

(ii) Is there any significant difference between the effect of STEM Problem Based Learning in the mean score of self-regulated learning in science post-questionnaire and delayed post-questionnaire scores of Low ability learners?

(iii) Is there any significant difference between the effect of STEM Problem Based Learning in the mean score of self-regulated learning in science post-

questionnaire and delayed post-questionnaire scores of High ability learners?

1.5 Research Hypotheses

Twelve hypotheses guided this study. These hypotheses are formulated at 0.05 level of significance.

To answer research question 1.4.1, the following three research hypotheses Ho_{1a}, Ho_{1b} and Ho_{1c} were tested:

Ho_{1a}: There will be no significant difference on the mean achievement test score in simple machines between Low ability and High ability learners who follow STEM PBL on Post-test after controlling for the effect of Pretest.

Ho_{1b}: There will be no significant difference in the mean achievement test scores in simple machines pretest and post-test of students taught using STEM PBL of Low ability learners.

H_{O1c}: There will be no significant difference in the mean achievement test scores in simple machines pretest and post-test scores of students taught using STEM PBL of High ability learners.

To answer research question 1.4.2, the following three research hypotheses Ho_{2a}, Ho_{2b} and Ho_{2c} were tested:

Ho_{2a}: There will be no significant difference in the mean score of delayed post-test of simple machines between low ability and high ability learners who follow STEM PBL after controlling for the effect of pretest.

Ho_{2b}: There will be no significant difference in the mean achievement test score insimple machines post-test and delayed post-test of students taught using STEM PBL of low ability learners.

H_{O2c}: There will be no significant difference in the mean achievement test score in simple machines post-test and delayed post-test scores of students taught using STEM PBL of high ability learners.

To answer research question 1.4.3, the following three research hypotheses Ho_{3a}, Ho_{3b} and Ho_{3c} were tested:

Ho_{3a}: There will be no significant difference in the mean scores of interest in learning science between low ability and high ability learners who follow STEM PBL on Post-questionnaire scores after controlling for the effect of Pre-questionnaire scores.

Ho_{3b}: There will be no significant difference in the mean scores of interest in learning science, pre-questionnaire and post-questionnaire of students taught using STEM PBL of low ability learners.

H_{O3c}: There will be no significant difference on the mean scores of interest in learning science pre-questionnaire and post-questionnaire of students taught using STEM PBL of high ability learners.

To answer research question 1.4.4, the following three research hypotheses Ho_{4a}, Ho_{4b} and Ho_{4c} were tested:

Ho_{4a}: There will be no significant difference in the mean scores of delayed post-questionnaire of interest in learning Science between low ability and high ability learners who follow STEM PBL after controlling for the effect of pre-questionnaire scores.

Ho_{4b}: There will be no significant difference in the mean scores of interest in learning science post-questionnaire and delayed post-questionnaire of students taught using STEM PBL of low ability learners.

H_{O4c}: There will be no significant difference in the mean scores of interest in learning science post-questionnaire and delayed post-questionnaire of students taught using STEM PBL of high ability learners.

To answer research question 1.4.5, the following three research hypotheses Ho_{5a}, Ho_{5b} and Ho_{5c} were tested:

Ho_{5a}: There will be no significant difference in the mean score of Self-regulated in science between low ability and high ability learners who follow STEM PBL on Post-questionnaire after controlling for the effect of Pre-questionnaire scores.

Ho_{5b}: There will be no significant difference in the mean scores of self-regulated in science pre-questionnaire and post-questionnaire of students taught using STEM PBL of low ability learners.

H_{O5c}: There will be no significant difference in the mean score of self-regulated in science pre-questionnaire and post-questionnaire of students taught using STEM PBL of high ability learners.

To answer research question 1.4.6, the following three research hypotheses Ho_{6a}, Ho_{6b} and Ho_{6c} were tested:

Ho_{6a}: There will be no significant difference in the mean score of delayed post-questionnaire of Self-regulated in science between low ability and high ability learners who follow STEM PBL after controlling for the effect of Pre-questionnaire scores.

Ho_{6b}: There will be no significant difference in the mean score of self-regulated in science post-questionnaire and delayed post-questionnaire of students taught using STEM PBL of low ability learners.

Ho_{6c}: There will be no significant difference in the mean score of self-regulated in science post-questionnaire and delayed post-questionnaire of students taught using STEM PBL of high ability learners.

1.6 Significance of the Study

This study will have added value to already existing literature in this area of study. The few studies that have so far been done on Basic science in Enugu North Senatorial Zone has mostly been in the area of Basic science curriculum development. Ezeja and Ezeja (2005), studied Basic science curriculum in Enugu State of Nigeria. They examined the prospects and the problems facing Basic science at the junior secondary school level. Okonkwo, Ezeukwu, Udechukwu, and Maduegbucha (2003), investigated the problems of Basic science curriculum implementation in ObolloAfor Education Zone, Otti et al. (2013) studied factors responsible for students' poor performance in Basic science in Enugu state while Lawrence (2009) investigated the conceptual knowledge of junior secondary school Basic science teachers.

Taik (2006), examined the Impact of Inquiry-based Teaching on Students' STEM Achievement and Attitude; James (2014), investigated Science, Technology, Engineering and Mathematics Curriculum and Seventh Grade Mathematics and Science Achievement; and Ezenwata (2010)studied the Influence of Blended E-learning on Basic science and Computer Attitudes in junior secondary school 1. This present study is different from all of them because the present study involves using

problem-based learning and portfolio to teach Basic science in the context of STEM and their effect on students' interest, academic achievement, and self-regulated learning.

This study will help teachers to fill the gap that is existing in the performance of students in Simple machine as teachers use STEM problem-based learning in teaching Simple machines. Teachers will be able to use STEM PBL to improve the achievement, interest in learning science and self-regulated learning of low ability students when they use STEM PBL in the classroom. Moreover, as the study helps in improving students' academic achievement, it will also help students retain their achievement. The study will be of help to students because it will help in increasing students' interest in learning science. However, if learners' interest in learning science is increases as expected, the study will help in the retention of learners' interest in learning science. The study will help student to improve on their self-regulated in science. It will help in the retention of self-regulated in science. The study will help curriculum planners to integrate into the curriculum the teaching of simple machines using STEM problem-based learning.

This study will help students to be active learners in the classroom. When students are active in the learning process, they get engaged in the material they are learning thereby increasing their understanding of the material. This is because, students were involved in hands-on activities. By this the students will not be passive in the classroom.This study will help to enhance the achievement of low ability learners in simple machines since it is anticipated that the activities the learners will be involved in will be of interest to the students. If the foregoing is achieved, it will also facilitate the interest of the students in having interest in learning science.

This study will help the curriculum planners in terms of what effective teaching approach to recommend in the curriculum for teachers to adopt during the implementation of the curriculum. As the importance of this teaching approach is highlighted, curriculum planners will be able to organize in-service training and workshops for teachers using the approach.

In terms of theoretical perspective, this study will help both curriculum planners and teachers who implement the curriculum to understand that it is important to have a good knowledge of theories that enhance teaching and learning effectiveness. Teachers should apply their knowledge of such theories in the classroom to facilitate active learning. In this study, the principles of Social constructivism theory and Situated learning theory will be applied. The rightful application of the principles of these theories may likely improve achievement.

According to Dunne, Humphreys, and Sebba (2007) time constraint is a challenge in implementing any student-centered teaching approach in the classroom. This is because students need a lot of time to do things their own way and understand to concept or topic or subject of instruction. Because of time constraint, this study was carried out as an after-school programme. In Enugu State secondary education system, after school programme can be permitted if permission is obtained from the Post-Primary Schools Management Board (Enugu State Ministry of Education, 2011a). As a result of the fact that the study was an after-school programme, there was no comparison between STEM PBL and Conventional teaching method.