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The Effects of Collaborative Learning on Problem Solving Abilities among Senior Secondary School Physics Students in Simple Harmonic Motion

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Abstract
The study investigated the effects of collaborative learning on problem solving abilities among senior secondary physics students in simple harmonic motion(SHM). The sample was made up of 112 physics teachers and 81 physics students drawn from two urban and one rural school. The research instruments employed for the study were Physics Teachers Questionnaire on Simple Harmonic Motion (PTQSHM) and Simple Harmonic Motion Achievement Test (SHMAT). Statistical data analysis tools utilized were the simple percentage, four point Likert-Scale of 2.50 criterion mark and t-test at 5% level of significance. The result of the findings showed that: mathematical calculations involved in SHM make students to shy away from the topic, students are motivated when they cooperatively solve problems in physics, there was significant difference in problem solving abilities among students taught using collaborative learning strategy and those taught with the conventional method, there is no significant difference between boys and girls in their problem solving abilities using the collaborative strategy. Based on the findings, It was recommended that teachers encourage group learning, group projects, tasks and assignments which facilitate collaborative learning and improves problem solving abilities among the students.
Keywords: Simple Harmonic Motion (SHM), Problem Solving, collaborative learning.

1. Introduction

Physics is the study of matter, energy and their interactions. It is an enterprise, which plays a key role in the progress of mankind. It generates fundamental knowledge, which is essential for the required technological advancement needed to propel the economic engine of the world. It extends and enhances human understanding of scientific disciplines, exciting intellectual adventures and inspires dynamic frontiers of human knowledge about the environment. This means that the ultimate aim of physics teaching and learning should be the understanding of its scientific processes and application in everyday activities. The Nigerian physics curriculum (FME, 2009) highlights the general objectives at the secondary school level as to:

- Providing basic literacy in physics for functional living in the society.
- Acquisition of basic concepts and principles of physics as a preparation for further studies.
- Acquisition of essential scientific skills and attitudes as a preparation for further studies.
- Stimulating and enhancing creativity.

It then becomes imperative that what is taught, how it is presented and to whom it is presented, should be to achieve the stated objectives. Physics instructions should be prepared in a manner that it will cause change in the behaviour of the learner. This change should be in cognizance of the student's self confidence in solving problems in physics. In fact, the problem centered instruction is frequently built around collaborative learning strategies.

It is evident from the foregoing that science educators and indeed all stakeholders in the teaching and learning of science are in search of better teaching and learning strategies that will enable physics students gain proper understanding and application of physics concepts and principles. Several science educators have outlined methods of teaching science (Gbamanja, 1999; Alamina, 2001; Achuonye and Ajoku, 2003; Dayal, 2007). Some of the methods mentioned include lecture, problem solving, play-way, discovery, field trip, demonstration, project method, Computer Assisted Instruction (CAI) and collaborative approach. The choice of any or some of these methods in science teaching depends on the age, content availability of resources, previous knowledge and the teacher's versatility (Gbamanja, 1999; Alamina, 2008).

Collaborative learning is a situation in which two or more people learn or attempt to learn something (Dillenbourg, 1999). Collaborative learning is a constructivist strategy. More specifically, collaborative learning is based on the model that knowledge can be created within a population where members actively interact by sharing experiences and take on asymmetry roles (Mitnik, Recabarren, Nussbaum and Soto 2009). Collaborative learning refers to methodologies and environments in which learners engage in a common task where each individual depends on and is accountable to each other. It is a learning strategy which involves groups of learners working together to solve a problem, complete a task, or create a product. Using this approach in learning requires students to be active participants in the learning processes in which they assimilate information and relate the new knowledge to their cognitive structure for future utilization and subsequent task. From the above, collaborative learning can be regarded as student centered learning. Here, students inevitably identify a problem, and the gap that exists between the identified problem and the solution to give a clear direction of the problem solving process.

Ahiakwo (2006) stated that, problem solving is to identify the gap between a problem and a solution using information (knowledge) and reasoning. Therefore, a problem exists when there is no immediate solution to proffer. Consequently, a task is done following systematic steps taken or employed to arrive at a solution. Several models have been suggested in applying problem solving techniques. Some of them are 'the cognitive apprenticeship model' (CAM), 'simple linear model' (SLM), 'developed Program of Action and Methods' (PAM), 'Ashmore, et al models'. These models differ in their applications depending on the nature of the problems encountered in physics. However, there are certain commonalities identified in the models (Okey, 2007). For instance:

- Problem solving processes are useful and can be applied across different context.
- A definite problem is primary of a choice for a definite model.
- A model is targeted at proffering solution to a particular problem, and is stepwise is nature.
- Application of any model depends on student's cognitive knowledge of the concept of object matter.

Frazer (1982) cited in Ahiakwo (2006) defined two common types of problems encountered in learning sciences; these are the open and close-ended problems. In open-ended problem type, there is no fore knowledge of the solutions while in the close-ended problems, the solutions are known. Close ended problems are commonly encountered in physics creating the need for the acquisition of problem solving abilities by students if sufficient knowledge of the patterns of solving questions is understood. Problem solving develops higher thinking order, disciplinary knowledge based and skills by placing the learner in an active role of a practitioner (problem solver) when confronted with situations that reflect the real world. Problem solving abilities also enables students to recollect known relationships and facts about concept and topics in physics like simple harmonic motion.

Simple harmonic motion (SHM) is a topic in physics which consists of content knowledge and calculation. The sub content includes period, frequency and amplitude of SHM, relationship between SHM and circular motion, speed and acceleration of SHM, relationship between linear acceleration and angular velocity energy of SHM, free vibration, damped vibration, force vibration and resonance. Effective understanding of SHM entails that, both the theoretical presentations and calculations should be understood by the students. Iwuoha (2005) stressed that the cardinal principle of teaching is *"the whole is greater than the sum of its part"*. The implication is that both theoretical experiences and calculations of SHM are important for the overall understanding of the topic. However, Agina-Obu (2008) revealed that teachers concentrate more on the theoretical instructions at the expense of the calculations involved in certain topics. This may cause some problem solving difficulties in the understanding of a topic.

2. Objectives of the study

This study investigated the effect of collaborative learning strategy on problem solving abilities among senior secondary physics students in simple harmonic motion. Pursuant to this goal, the objectives of the study are to:

- sample physics teacher's qualification in the area of study.
- determine the effect of collaborative learning strategy on students problem solving abilities.
- investigate gender effect on student's performance in solving SHM.
- compare school location on student's performance.

3. Research Questions/Hypothesis

In an attempt to analyze the effect of collaborative learning strategy and problem solving abilities among senior secondary physics students in simple harmonic motion, the following research questions have been raised.

i What are the qualifications of physics teachers?
ii What difficulties do students encounter solving problems in SHM?

4. Research Hypotheses

Ho$_1$: There is no significant difference between the performance of Experimental Problem Solvers (EPS) and that of Control Problem Solvers (CPS).

Ho$_2$: There is no significant difference of Experimental Problem Solvers (EPS) between the performance of boys and that of girls' problem solving abilities in SHM.

Ho$_3$: There is no significant difference between urban and rural students problem solving abilities in SHM of the experimental group.

5. Methods and Techniques

The methods employed for this study are survey and quasi-experimental research design. The research design was used to obtain both qualitative and quantitative data for the study. The tables (1a and 1b) below show the number of respondents used for the study.

The total number of senior secondary (2) physics students used for the study is eighty-one (81) respectively from three (3) schools. Sixty (60) students were drawn from two separate schools in Port Harcourt City Local Government Area, while twenty-one (21) students were drawn from a school in Emohua Local Government Area, all in Rivers State of Nigeria. The teachers were one hundred and twelve (112). A pre-test was administered to all the students involved in the study. The respondents in the experimental group were then divided into five per group (except one group with six students in the rural school) during the teaching and learning process. During evaluation (problem solving) stage of the teaching process, tasks were presented to each group to solve.

At this stage, the teacher goes around the groups giving clues and guidelines and motivating each group to interact with themselves, thereby strengthening collaborative learning. The control group was exposed to the conventional teaching strategy and problems on SHM were solved both by the teacher and the students together. Both groups were taught by one instructor, using the same number of periods consisting of 40 minutes each for 4 periods per week, therefore, the entire classroom instruction lasted for 20 periods a total of 5weeks. At the end of the fifth week, the students were subjected to a simple harmonic motion achievement test (post-test) administered to them individually.

6. Instrument for Data Collection

Two sets of questionnaires were employed for the study; Physics Teachers Questionnaire on Simple Harmonic Motion (PTQSHM) and Simple Harmonic Motion Achievement Test (SHMAT). PTQSHM is a questionnaire consisting of two sections. Section A includes the personal data of the teachers including their qualifications. While section B primarily focuses on the difficulties students encounter while solving problems on simple harmonic motion. This was employed to obtained response from the physics teachers used for the study. This specifically produced data for answering the research questions. The SHMAT was administered to the students immediately after the instructional process. SHMAT consist of 25 objective questions having a score of 2 marks each, and 5 essay questions having a score of 10 marks each, therefore, a total of 100 marks were used.

A statistical tool utilized to establish the reliability was Pearson Product Moment Correlation Coefficient (PPMCC), and then a reliability of 0.89 was generated for PTQSHM. While a reliability of 0.91 was obtained for SHMAT which were suitable for the study. The test procedure employed provided in-depth problem solving abilities and originality of methods used by the students to work collaboratively during the study. SHMAT covered all contents on simple harmonic motion stipulated in the physics curriculum.

7. Data Collection and Analysis

Out of the hundred and twelve (112) PTQSHM questionnaires given out, ninety-two (92) were returned making a total of 82% return rate, while the SHMAT was administered to all seventy-five (75) students used for the study . The research questions set for the study were analyzed using a simple percentage for question one, while a four point likert scale mean rating method was used for question two. A criterion mark of 2.50 was employed as the benchmark for decision making for the likert scale. Therefore, a calculated mean greater than or equal to 2.50 ($\dot{x} \geq 2.50$) is accepted, while a calculated mean less than 2.50 ($\dot{x} \leq 2.50$). The parametric statistics of t-test was used at 5% level of significance to analyze the null hypothesis.

8. Results and Discussion

Research Question 1.

- What are the qualifications of physics teachers in the area of study?

Table 2 revealed the teachers qualifications in the area of study. It was observed that 60.9% of teachers presently teaching in the sampled schools possess degrees and diplomas which are in non- teaching areas, while 39.1% of teachers possess teaching qualifications. The Federal Government of Nigeria (2004) stated that “the teacher shall be the individual who has been professionally trained in any of the following Colleges of Education, Faculties of Education, Institute of Education, National Teachers Institute (NTI), Schools of Education in the polytechnics, the National Mathematical Centre etc to qualify for teaching appointment”. This is to say that any product outside these categories of institutions would not be regarded as teachers (Aluede, 2009). The implication therefore is that most teachers currently teaching Physics in schools are unqualified. This finding is not different from that of Omosewa (1998) who discovered that many schools do not have physics teachers. In the same line,

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Adeyemi (2009) reported that shortage of qualified teachers had been a recurring problem in Nigerian schools. These views support the findings of Nwadiani (1996) and Fideler and Haselkorn (1999) who reported that the standards in schools have become difficult to maintain because of the problem of inadequacy of qualified teachers.

Umoren (2010) also warns that a teacher who lacks professional experience or qualification endangers the entire school system and his handling of the curriculum and teaching methods largely depends on outdated methods which do not include innovation and skillfulness. The goal of education is to improve students' performance through the utilization of qualified teachers. So, the effective teacher is one who should have deeper teachers' knowledge of the subject being taught, sharpened teaching skills in the classroom, keep up with developments in the subject (field) and in education generally, generate and contribute new knowledge to the profession.

Research Question 2.

(ii) What difficulties do student encounter solving problems on SHM?

The responses obtained and analyzed from the teachers used in the study are shown in table 3 below. Item statement 1,3,4,6,7 and 8 with mean ($\dot{x}$); 2.63; 2.67; 2.59; 2.54; 2.78; and 2.63 respectively were accepted by the respondents, While item statement 2 and 5 with mean ($\dot{x}$) 2.12 and 2.33 were rejected. The implication of the results analyzed is that there was lack of understanding of the scientific terms among students. They also lack basic mathematical skills and calculations, students are not able to identify required parameters for calculation and lack self- confidence in solving problems on SHM. The table above also shows that when students collaborate while learning, and employ computer aided animations, they understand the topic effectively. These findings agree with those of Yeo (2009) who discovered difficulties experienced by Secondary 2 students that prevented them from obtaining correct solution as: (a) lack of comprehension of the problem posed, (b) lack of strategy knowledge, (c) inability to translate the problem into mathematical form, and (d) inability to use the correct mathematics. That the study of Physics without a sound knowledge of mathematics can be difficult cannot be argued. McGinn and Boote (2003) suggested that the level of difficulty of the problem depended on problem solvers‟ perceptions of whether they had suitably categorised the situation, interpreted the intended goal, identified the relevant resources and executed adequate operations to lead toward a solution.

Hypotheses.

Ho$_1$: there is no significant difference between the performance of Experimental Problem Solvers (EPS) and Control Problem Solvers (CPS).

Table 4 is the analysis of t-test between the Experimental Problem Solving (EPS) group and the Control Problem Solving group (CPS). It revealed that at 5% level of significance, the t (table) is 2.000, while the t-cal is 3.496. Decision: we reject the null hypothesis and uphold the alternative hypothesis stating that, there is significant difference between the performances of Experimental Problem solvers (EPS) to the Control Problem Solvers (CPS). This finding agrees with those of Brownstein (2001) and Dayal (2007) who posited that collaborative learning approaches that are more learner-centered with the teacher as a guide and facilitator enhances longer retention of learned concepts. Such Strategies develop higher order thinking, disciplinary knowledge base and practical skill by placing the learner in the active role of problem solvers.

Ho$_2$: There is no significant difference in the problem solving ability on SHM of boys and girls in the Experimental group

Result from table 5 shows that at 5% level of significant and at 64 degree of freedom, the calculated t-value was 1.6667 while the t- table value was 1.9977. Decision: Since the value for t-table is greater than the t-cal, the null hypothesis was therefore accepted. This implied that there is no significant difference between the performance of boys' and girls' problem solving abilities in the experimental group. This agrees with the findings of Adolphus (2013) and Adaramola(2011) that gender is insignificant in the performance of students using student-oriented approaches. However, the finding does not agree with that of Onah and Ugwu (2010) who indicated that performance in physics at the secondary school level is dependent on gender.

Ho$_3$: There is no significant difference between urban and rural students problem solving abilities in SHM of the experimental group.

From table 6, the t-test at 5% level of significance and 64 degree of freedom are given as t-table =1.9977 while the t-cal = 1.1176. Decision: Since the calculated value of t-cal = 1.1176 is less than the table value t-table = 1.9977, we therefore accept the null hypothesis. This means that, there is no significant difference between urban and rural students problem solving abilities. This agrees with that of earlier researchers who posited that school location had no significant influence on students' academic performance (Yusuf & Adigun, 2010) The findings however contradicted the views of Ajayi (1999) who in his own study revealed that school type make a difference in students' academic performance. These contradictions may have resulted from the locations and samples used for the different studies.

9. Recommendations

In light of the research findings, it is imperative that instructional approaches that strengthens student's problem solving abilities should be encouraged. Therefore, the researchers recommend that;

- Teacher should explain all scientific terms used in the teaching of the topic so that there will exist continuity in conceptual understanding making the topic devoid of difficulties.
- Teachers should ensure that examples and analogies should be drawn from the real life experiences to aid students understanding.
- There should be a synergy between the mathematics and Physics teacher in syllabus planning and more emphasis should be laid on the mathematical aspect of SHM because the effective understanding of the topic rely on strong foundation in mathematics.
- Teachers should encourage group learning, group projects, tasks and assignments thereby facilitating collaborative learning and improving problem solving abilities among the students.

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List of Tables

Table 1(a). Showing sample of students in Experimental and Control groups.

Groups	Boys	Girls	Total
Experimental	40	26	66
Control	9	6	15

Table 1(b). Showing sample of students and school locations.

School Location	Boys	Girls	Total
Urban school	27	18	45
Rural school	13	8	21

Table 2. Showing Teacher's Qualifications

Teaching Qualification	No	Non-Teaching Qualification	No
M.Ed	3	M.Sc	1
B.Ed/B.Sc (Ed)/B.SC+PGDE	22	B.Sc / B.A / HND	51
NCE	11	OND	4
Total	36	Total	56
Percentage	39.1%	Percentage	60.9%

Table 3. Teachers response on student encountered difficulties solving SHM

S/N	Item Statement	Mean ($\dot{x}$)	Decision
1	Students find scientific terms used in SHM abstract leading to difficulties in understanding the topic.	2.63	Accepted
2	Most students can interpret questions, identify the required parameters necessary in solving problems on SHM.	2.12	Rejected
3	Students don't possess the basic mathematical skills ie, change of subject formulae, approximation, arithmetic manipulation etc necessary for solving problems in SHM.	2.67	Accepted
4	Mathematical calculations involved in SHM make students shy away from the topic.	2.59	Accepted
5	Most students have individual confidence in solving problems on SHM	2.33	Rejected
6	Students are motivated when they are collaboratively solving problems on physics.	2.54	Accepted
7	Students find SHM difficult because the topic is not related to their direct real life experiences	2.78	Accepted
8	Use of computer animation in explaining SHM will aid students understanding of the topic.	2.63	Accepted

Table 4. Analysis of t-test between EPS and CPS.

Group	Mean	N	Df	t-cal	t-table
EPS	63.7	66	79	3.496	2.000
CPS	53.2	15			

Table 5. Analysis of t-test between boys' and girls' problem solving abilities in the experimental group.

Group	**Mean**	**N**	**Df**	**t-cal**	**t-table**
Boys	63.0	40	64	1.6667	1.9977
Girls	60.0	26			

Table 6. Analysis of t-test between students performance in urban and rural areas.

Group	Mean	N	Df	t-cal	t-table
Urban	61.7	45	64	1.1176	1.9977
Rural	59.8	21			