THE IMPACT OF PEER INSTRUCTION ON STUDENTS' CONCEPTUAL UNDERSTANDING IN MECHANICS IN CENTRAL REGION OF GHANA

Victor Antwi[1], Kolawole Raheem[2] & Kennedy Aboagye[3]
[1]Department of Physics Education, University of Education, Winneba
[2,3]Centre for School and Community Science and Technology Studies (SACOST), UEW

ABSTRACT

In this study, two science classes from two senior high schools in the Central Region of Ghana were selected and put into two groups (Control and Experimental). Students from experimental group were introduced to peer instruction and students from the control group were introduced to the same topics by the use of the traditional lecture method. Students in these two groups were made to answer standardised tests of Force Concept Inventory (FCI) and Mechanics Baseline Test (MBT) to assess students' improvement. The results did indicate that students from the experimental group have better conceptual understanding in Mechanics than the students from the control group. It was found that the peer instruction have a significant impact on students' scores in both FCI and MBT than traditional lecture method. These could suggest that peer instruction could effectively improve students' conceptual understanding and quantitative problem solving skills in teaching Mechanics in the senior high school.

Keywords: Peer Instruction, conceptual understanding, Traditional lecture, Ghana.

INTRODUCTION

Physics has a long tradition for being regarded as a particularly difficult school subject (Angell, Guttersrud, Henriksen & Isnes, 2004; Carlone, 2003). Physics appears difficult because it requires students to cope with multiple representations and to manage the translations between these multiple representations (Angell, Kind, Henriksen & Guttersrud, 2008). Harlow, Harrison and Meyertholen (2014) found out that students have attitudes, beliefs and expectations about learning physics that can affect the way they behave and learn during Physics class. Students find it difficult to understand the concepts of Mechanics because teaching methods used by teachers have not resulted in good academic performance (McDermott, 1997, 1998). They are often unable to apply the concepts that they have studied to the task of solving quantitative problems, which is the usual measure for students' achievement in a Physics course. The lack of conceptual understanding usually goes unnoticed because students can solve many standard problems in spite of the difficulties; they are talented and have memorized rules that are often true. Buabeng (2012) in his work showed that in Ghana teaching science in Senior High Schools generally appears to be through lectures, notes-giving and taking, chalkboard illustration, demonstrations and other teacher-centred methods which enable students to only form mental models of concepts presented to them. This method of presentation of concepts may lead to loss of interest in learning as students tend to forget what they learn easily. In this study, "peer instruction" is used as an instructional teaching approach on Senior High School students in the Central Region of Ghana to see whether it could improve their conceptual understanding in the study of Mechanics.

REVIEW OF RELATED LITERATURE

Physics teaching in Ghana

Physics is an effort to provide logical and orderly explanation of the events in nature. It therefore aims at developing better understanding of the natural and physical world, preparing for better citizenship and to make effective use of resources. Notwithstanding a teacher can motivate students to study science by arousing the science-oriented interests of the student by choosing phenomena relating to students' interests and life agendas.

Investigations however, have shown that physics education is in crisis as the number of students studying physics at all levels is declining rapidly (Fillmore, 2008; Smithers & Robinson, 2007). It has also been found that of all the sciences, physics is the subject in which the increase in number involved has been particularly low (Barbosa, 2003; Donnellan, 2003). The reason may include lack of specialist physics teachers and the perception that physics is a difficult subject (Buabeng & Ntow, 2010; Fillmore, 2008; Isola, 2010). Good teaching makes use of a variety of teaching methods and teaching-learning materials to facilitate the acquisition of skills and understanding of concepts (Talabi, 2003). Some teachers find it quite complex to use other teaching methods apart from the traditional lecture method while others perceive the use of other teaching methods as waste of time. Since most students consider Physics as an abstract subject, the use of other teaching methods like peer instruction should be a requirement for every physics teacher if the aim of the teacher is to guide the students to master concepts in the subject (physics).

Reports from the Chief Examiner of the West African Examination Council (2004; 2008) confirm that many students have poor knowledge in Physics. They stressed that students cannot go beyond stating of definitions and principles in Physics. The students try as much as possible to avoid answering questions which demand deductive thinking and reasoning. The examiners attributed this problem to the theoretical nature in which teachers teach our students without involving them in the teaching and learning process. They are of the view that the use of activity-based tuition such as hands-on activities, practical approach and deductions to get to the conclusion as well as more student-student and teacher-students interactions in the teaching and learning process will help improve students' performance. Teachers must therefore employ a variety of teaching strategies and methods to ensure that learners have equal opportunities to learn. It must however be stated that teaching methodology in education is not a new concept in the teaching and learning process but rather helps to improve the performance and the understanding of concepts being taught.

Students' Misconceptions in Physics

In its simplest form, a misconception is a concept that is not in agreement with our current understanding of natural science. Often these can be private versions of student's understanding of particular concepts that have not been tested extensively via scientific methodology. In the science education literature there is a dilemma about the word "misconception". It implies that there is something seriously wrong with an idea. Although, a misconception may not be in agreement with our understanding of science, they might nevertheless have varying degrees of logic and truth. Therefore many science education researchers resort to the term "alternate concept" (Wandersee, Mintzes, & Novak, 1994). An alternate concept, then, is part of the student's private knowledge that is strictly speaking not completely consensual by scientific standards, though it may make sense to the student himself. In the 1970's a movement towards researching the specific difficulties and conceptions that students brought with them to the physics classroom began (Johnston, 2010). This change occurred mainly because, while general principles on how to teach for developmental reasoning and how students learned was useful, they provided few insights into specific students' alternative conceptions or difficulties experienced in physics. There is a need to learn what students actually understand as opposed to our perception as instructors of what they understand (McDermott, 1991). Students enter our classrooms having had years of experience of physics from their everyday lives. Students have developed common-sense theories of the physical world that have proven satisfactory for their day-to-day existence (Knight, 2004). However, many of the students' common-sense theories turn out to be wrong or incorrect. These student beliefs are sometimes called misconceptions. The terms preconceptions, alternative conceptions, children's scientific intuitions, children's science, common sense concepts and spontaneous knowledge are also commonly used (Johnston, 2010). Regardless of the term used, the central ideas of these conceptions are that they;

- are strongly held, stable cognitive structures.
- differ from expert conceptions.
- affect how students understand natural phenomena and scientific explanations.
- must be overcome, avoided, or eliminated for students to achieve expert understanding (Hammer, 1996).

Furthermore, science educators are now realizing that what we teach and what students learn are actually two different things (Mazur, 1992). It turns out that many students are still holding the same misconceptions that they had prior to teaching. Despite being able to solve advanced problems, students often fail to comprehend the most basic concepts (Mazur 1997). Currently, a small group of physicists and physics education researchers are studying how students learn selected physics concepts (Zirbel, 2005b). What is needed now, are more collaborative studies between educators, cognitive scientists, and content specialists (professional scientists), that focus on the details of how students really learn concepts, how they construct knowledge, and how they make sense of the world in which they live.

Students' Conceptual Understanding in Mechanics

One of the earliest and most widely studied areas in physics education research is students' conceptual understanding. Starting in the 1970s, as researchers and instructors became increasingly aware of the difficulties students had in grasping fairly fundamental concepts in physics (e.g., that contact forces do not exert forces at a distance; that interacting bodies exert equal and opposite forces on each other), investigations into the cause of those difficulties became common (Docktor & Mestre, 2014).

The high school and undergraduate students are generally found to have an understanding that is not scientifically accepted according to their world, known also as the *alternative conception* (Trowbridge & McDermott, 1987, 1993; Halloun & Hestenes, 1985). Clement (1982) used written tests and video-taped interviews to show that many physics students have an alternative view of the relationship between force and acceleration. Many students applied the idea that continuing motion implies the presence of a continuing force in the same direction as the motion; the "motion implies force" misconception. Clement also noted that it is not likely that this misconception disappears simply because students are exposed to a Physics course. Newtonian ideas can be misperceived or distorted to fit students' existing preconceptions or they may be memorized separately as formulas with little connection to the fundamental concepts. When misconceptions arise it is, according to Clement, necessary for the student to express them and to actively work out their implications.

Many students see the Physics they learn in Mechanics as unrelated to the real world, and applicable only in a special ''Physics'' world of rigid objects on frictionless surfaces connected by massless strings in an airless environment. It is easy to see how students can develop this viewpoint, because they are not asked to participate in the process of modelling complex, real-world systems by making simplifications, idealizations, approximations, estimates, and selecting a fundamental principle from which to start (Chabaya & Sherwood, 2004). Since a good understanding of concepts seems to be a prerequisite for expert problem solving, much effort has gone into the identification of fundamental concepts and student difficulties in a variety of specific areas. McDermott and other Physics Education researchers have documented that even after studying Physics; student understanding of fundamental concepts is often weak (McDermott, 1984).

The most commonly observed alternative conceptions or common-sense beliefs related to Mechanics are the following:

- Students believe that heavier objects fall faster than lighter ones.
- Students often interpret interaction via a conflict metaphor, where strength is attributed to those who are bigger, heavier, or more active. Objects with greater mass, or a more active object are thought to exert a greater force.
- Students sometimes think that, when a force acts on an object, the object gains, what is called, impetus. The object continues to move until the initial "force" (impetus) is used up.
- Students believe that a force is needed to keep an object moving. As a consequence they think that it should be a force in the direction of motion which is the opposite.
- Students cannot discriminate between position and velocity and between velocity and acceleration (Bayraktar, 2009).

Research has shown that these preconceptions are very robust, interfere with learning, and are extremely difficult to change without proper intervention (Arons, 1990). They make the learning of the Newtonian view of force and motion very challenging, and old conceptions often reappear after a short time (Singh & Schunn, 2009).

Mechanics teaching in Ghana

Although students' conceptual understanding of Mechanics is sometimes recorded very low, teachers are aware that students learn in different ways and have different ways of absorbing information and of demonstrating their knowledge to grasp the concept being taught (Tamakloe, Atta, & Amedahe, 2005). Antwi (2013) discussed in his work that lecturers start their physics (Mechanics) teaching by lecturing on general principles. They then use the principles to derive mathematical models, show illustrative applications of the models and give students some practice question(s) in similar derivations and finally test their ability to do the same during examination. Qualitative problems are mostly based on "define, state and list", which does not call for better understanding of concepts. Discussions, demonstrations, experiments and practical work, where students can interact among themselves, teachers and teaching assistants, to confirm and validate principles and results presented during lectures, and solidify their understanding of fundamental principles in physics are rarely done, usually due to a lack of equipment, an overload of course work and limited time at students' disposal. Students in courses like this typically end up with limited conceptual understanding (Hestenes, Wells, & Swackhamer, 1992), and a limited ability to transfer what they have learnt to new settings (Anyaehie, Nwobodo, & Njoku, 2007). The physics teacher is therefore required to design teaching sequences with appropriate teaching pedagogies that has the potential to develop students' interest in the subject and their abilities to properly respond to situations they may encounter in their world of life that their knowledge in physics may be of benefit (Buabeng, Ossei-Anto, & Ampiah, 2014). This is the more reason why peer instruction teaching method is chosen in this study to enhance students' conceptual understanding in Mechanics.

Peer instruction

Peer instruction is an approach in which students serve as teachers or coaches to other students in the same or different grade levels (Mazur, 1997). Mazur explained some of the techniques involved in peer instruction; he was of the view that the older or more advanced children can often teach other students. It is frequently effective because learners use their own language patterns during their interactions. Peer teaching also develops the peer leader's self-confidence. The peer leader should understand his or her roles clearly. He or she should be well organised and prepared. Peer teaching can also be used to develop practical skills related to farm work, road safety, sports and first aid. Peer teaching is useful in managing situations because the peer teacher can assist by working with individual students in groups while the teacher is with another class. Peer Instruction from Crouch and Mazur (2001) engages students during class through activities that require each student to apply the core concepts being presented, and then to explain those concepts to their fellow students. Unlike the common practice of asking informal questions during a lecture, which typically engages only a few highly motivated students, the more structured questioning process of peer instruction involves every student in the class.

According to Mazur (1997), *Peer Instruction* is a pedagogical approach in which the instructor stops lecture periodically to pose a question to the students. These questions (or Concept Tests as he called it) are primarily multiple-choice, conceptual questions in which the possible answer options represent common student ideas. Mazur describes the *Peer Instruction* process as follows (Mazur, 1997; Crouch, Watkins, Fagen, and Mazur, 2007):

- Question posed
- Students given time to think
- Students record or report individual answers
- Neighbouring students discuss their answers
- Students record or report revised answers
- Feedback to teacher: Tally of answers
- Explanation of the correct answer

If the percent of students getting the question correct is low after peer discussion, the concept is discussed again and another question cycle follows. In this way, the class adapts to the level of student understanding in the class. Mazur does specify a particular technology hands raised; coloured cards, or personal response systems to be used to collect students' votes in his descriptions of Peer Instruction. This pedagogical strategy has many components, even within this short description.

In his studies, Mazur (1997) showed that students who normally struggle below the 50% mark in traditional examinations are lifted into a higher bandwidth in peer instruction: the grade distribution shows a positive change. Mazur's research indicates that a student who does not yet understand a concept is helped by talking the concept question through with a student who is in the early stages of his or her own comprehension. Crouch and Mazur (2001) analysed 10 years of teaching a single, calculus-based physics course at Harvard using peer instruction. This longitudinal research demonstrated improved student mastery of conceptual reasoning and quantitative problem-solving over time and in a variety of contexts. It also showed that, after peer discussion, the number of students giving correct answers to a concept re-test substantially increased. According to Crouch, Watkins, Fagen and Mazur (2007), peer discussion is critical to the success of peer instruction, it encourages active engagement by students with the subject matter, a condition they feel is necessary for the development of complex reasoning skills. When an instructor engages students in an active learning technique such as Peer Instruction, the instructor is not idle. Mazur (1997) notes that, listening to student conversations allows him to assess the mistakes being made and to hear students who have the right answer explain their reasoning. Duncan (2006) notes that listening to students conversations can provide unexpected insights into students' ways of thinking. Typically, students within a group will argue their various opinions and intuitions, work out a solution if required, and continue discussing and elaborating until satisfied with their answer (Beatty, Gerace, & Dufresne, 2006).

Many researches have been done around the world concerning this problem of using the right teaching strategy to teach but Eric Mazur who adapted peer teaching in Stanford University proved a progress in the area of learning of Mechanics (Crouch, Watkins, Fagen & Mazur, 2007).

Research questions

1. To what extent will the use of peer instruction improve the academic performance of senior high school students in the Central Region in the teaching and learning of Mechanics?

   Null hypothesis
   H_o1: There is no significant difference in academic performance of senior high school students in the Central Region using peer instruction and traditional lecture method in the teaching and learning of Mechanics.

2. How will senior high school students' conceptual understanding in Mechanics help them improve their quantitative problem solving skills using peer instruction?
3. What influence will the use of peer instruction have on the attitudes of senior high school students towards the teaching and learning of Mechanics?

Method

Quasi experimental research design was adopted for this study. In Ghana, the traditional lecture method is mostly used in the senior high schools (Quarcoo-Nelson, Buabeng, & Osafo, 2012). This is due to perhaps the way the SHS syllabus is loaded and instructors think using a different method apart from the traditional lecture will not help them to finish with the syllabus which will be a great disadvantage to the students. Also, majority of the teachers are influenced by the way they were taught while at school and they managed to go through and came out successfully hence applying the same traditional lecture approach on their students they teach as well will be beneficial. The diagrammatic representation of the design is shown in Figure 1.

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O_1 X_1 O_2 Experimental group

O_3 X_2 O_4 Control group

Figure 1: Diagrammatic representation of Quasi-Experimental Design

O_1, and O_3 represent pre-test
O_2, and O_4, represent post-test
X_1 represents treatment (Peer instruction)
X_2 represents treatment (traditional method)

Form two science students from two senior high schools in the Central Region of Ghana were purposely selected for this study. These schools were selected due to equal qualities they both have. Equal qualities in terms of numbers and passes in West African Examination Council (WAEC) results and are also found in the capital cities of two municipalities. The two schools were also selected based on the following assumptions that all the schools selected are rated grade 'A' which are usually known as first class schools. This means that the schools meet all the requirements of the Ministry of Education and produce good academic results likewise good products (intellectuals).

- offer Physics as an elective subject. This means that the Physics subject is taught in-depth in these schools and students write final exams on it in the WASSCE.
- have good facilities. For example, such schools have well-equipped laboratories which suggest that students are further given extra tuition on topics learned in the form of hands-on activities (practical works).
- had form two science students who have had one year course in Physics and are so familiar with the numerous concepts in the course.
- had students who have had basic knowledge about Mechanics in their previous year of SHS and some basic knowledge at the basic school level. Some of the topics can be found in the Integrated Science Syllabus of the Junior High Schools.
- had resource persons to help the researcher in conducting this study.

A total of 74 physics students in SHS formed the sample size for the study of which 51 were males and 23 were females. The two selected schools were designated experimental and control group. They were separated by a distance of about 40 kilometres. The distance was highly considered such that the use of interventions in one school might not affect the other. There were 37 students in the experimental group and 37 in the control group.

Given the purpose of the study, data were to be collected to evaluate students learning outcomes and students' attitude towards Physics on the use of peer instruction in teaching. Instruments used for data collection were the Force Concept Inventory (FCI), Mechanics Baseline Test (MBT) and questionnaire. Students used about 45 minutes to answer the FCI questions and about 75 minutes to answer the MBT questions. The MBT requires calculation hence more time was allotted to it.

Force Concept Inventory (FCI)

The Force Concept Inventory covers the central concepts of Newtonian mechanics. No calculation is needed to answer the questions. The non-correct answers correspond, according to Hestenes, Wells & Swackhamer (1992), to common students' misconceptions that have been found in physics education research. The FCI focuses on issues of force, and is designed to monitor students' understanding of the conceptual field of force and related kinematics (Hestenes, Wells, & Swackhamer, 1992). Even though it can be used for several purposes, the most important one is to evaluate the effectiveness of instruction (Halloun, Hake, & Mosca, 1995). Questions on the inventory were designed to elicit students' preconceptions about the subject.

Mechanics Baseline Test (MBT)

Mechanics Baseline Test (MBT) is also a standardized test to assess students' understanding of the most basic concepts in mechanics. It comprises 26 multiple-choice questions with possible answers (Hestene & Wells, 1992). The MBT which is recommended as a companion of the FCI is necessary, because it helps determine whether students have gained insightful problem solving capabilities in Mechanics. The Baseline emphasizes concepts that cannot be grasped without formal knowledge about mechanics. Unlike the FCI, some computation is required in MBT, so students use more time in answering MBT than FCI.

Questionnaire

Students' attitudes towards the study of Mechanics before and after the interventions (peer instruction and traditional lecture method) were sought using the Student Attitude Questionnaire (SAQ) adapted from Martin-Dunlop and Fraser (2007), and modified to suit this study. The questionnaire consisted of seven (7) questionnaire items on students' attitudes towards the teaching and learning of Mechanics. The students were briefed on how to answer the questionnaire items after which they were left on their own to complete them. Students' attitudes towards the study of Mechanics were assessed after the interventions to determine attitudinal changes due to the new instructional approach. The questionnaire was categorised into pre and post. Pre refers to students' attitude towards Mechanics teaching before the intervention, and post was their attitudes towards Mechanics teaching after the intervention. The questionnaire had two sections for both pre and post which was answered simultaneously by the students. This was done to allow students to make fair comparisons on which the peer instructional teaching strategy has had a better impact on their attitude towards Mechanics teaching and learning environment (Antwi, 2013). According to Antwi (2013), when the questionnaire items are answered at different times for the pre-test and post-test, they are both rated high by students, hence the statistical difference become insignificant. Thus students answered the items at the same time to find the significance in their attitudes.

Analysis of Data

In this section, we will look at students' overall learning results in pre- and post-FCI and MBT, and questionnaire to determine students' attitude towards Physics teaching and learning.

Analysis of data with respect to the Research Question One

RQ 1: To what extent will the use of peer instruction improve the academic performance of senior high school students in the Central region in the teaching and learning of Mechanics?

This question raised in this study was to find out if the use of Peer Instruction had any impact on students' academic performance in the study of Mechanics. As already indicated, students were put into control and experimental groups where the control group was exposed to the traditional lecture method of teaching whiles the experimental group experienced Peer Instruction. All the students in these groups were given pre- and post-test of the FCI to check the effect of each teaching strategy on students' academic performance. Students' scores in pre- and post-tests were used to calculate their average normalised gain <g>, in Mechanics.

Table 1: Hake Gain <g> for Control group and Experimental group

	N	Mean % Pre-FCI (SD)	Mean % Post-FCI (SD)	Gain (SD)
FCI (Control)	37	17.84 (8.90)	23.87 (8.26)	0.07 (0.08)
FCI (Experimental)	37	18.02 (9.21)	54.32 (15.53)	0.45 (0.15)

* N = Number of Students * SD = Standard Deviation *All the scores were converted to percentages * % = percentage

Table 1 shows the gain for the pre- and post-FCI of both control and experimental group. Questions on the inventory were designed to elicit students' preconceptions about the subject. Students' pre and post-test scores were used to calculate gain, $\langle g \rangle$, on the level of Peer Instruction and traditional lecture method approaches used in the teaching. A substantial use of Peer Instruction in the teaching should give a gain; $\langle g \rangle$, between 0.36 and 0.70, i.e. $0.36 < \langle g \rangle < 0.70$ (Hake, 1998). In comparison, the gain for the control group gave 0.07 which expresses the lack of effectiveness of traditional lecture method to improve students' academic performance because it falls below the medium gain interval. The gain for the experimental group was 0.45 which falls in the medium gain interval suggesting that the use of the Peer Instruction really had an impact on the students' academic performance.

Testing of hypothesis with respect to Research Question One

It was hypothesised that:
H_o1: There is no significant difference in academic performance of senior high school students in the Central Region using peer instruction and traditional lecture method in the teaching and learning of Mechanics.
To determine whether there was a significant difference in the academic performance of students, paired-sample t-test was used to analyse the percentage scores between the control and experimental group in the post-FCI test, MBT and questionnaire.

Table 2: Performance of Control and Experimental groups in Pre-FCI, Post-FCI and MBT

	Students' group	N	Mean	Std. Deviation	Std. Error Mean	Sig. (2-tailed)
%Pre-FCI	Control	37	17.8381	8.89650	1.46257	
	Experimental	37	18.0181	9.21121	1.51431	.932
%Post-FCI	Control	37	23.8743	8.25907	1.35778	
	Experimental	37	54.3243	15.53335	2.55367	.000
%MBT	Control	37	21.1719	11.07114	1.82008	
	Experimental	37	58.7416	18.34613	3.01609	.000

*Significant at 0.05, p<0.05

Table 2 indicates that there is statistically significant difference between the control and experimental group in both post-FCI test and MBT test since the p-value in both cases showed 0.000 (2-tailed) which is less than 0.05 but there was no significant difference in the pre-FCI. This signifies that before the introduction of the two interventions, both groups performed almost equally which was below average. After the introduction of the two interventions, students who were exposed to peer instruction (experimental group) performed better than students who experienced traditional lecture method approach (control group). Therefore, it was concluded that there was a statistically significant difference in academic performance of senior high school students in the Central Region using peer instruction in the teaching and learning of Mechanics. The null hypothesis (H_o1) was thus rejected in this case.

Analysis of data with respect to the Research Question Two

RQ 2: How will senior high school students' conceptual understanding in Mechanics help them improve their quantitative problem solving skills in the Central Region using peer instruction?

The MBT, which is recommended as FCI companion was used in assessing quantitative problem solving skills among students (Antwi, 2013). This was necessary so as to determine whether students have gained insightful problem solving capabilities in Mechanics by looking at their scores. The MBT emphasizes concepts that cannot be grasped without formal knowledge in Mechanics. A scatter-plot of MBT against Post-FCI was drawn to see the relationship between the two.

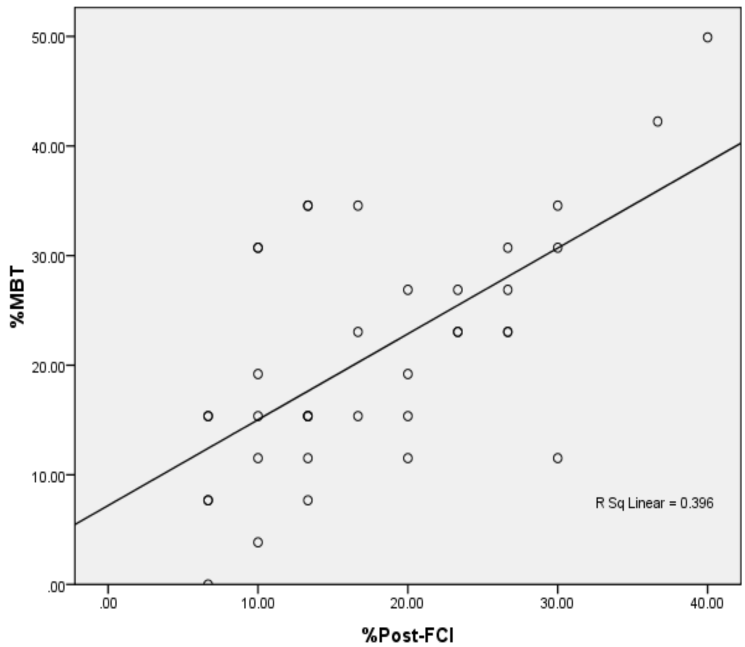

Figure 2: A scatter-plot of %MBT against %Post-FCI (Control)

Figure 2 shows a scatter-plot of MBT against post-FCI of the control group. From the graph the resulting R^2 Linear is given as 0.396 (in percentages as 39.6%). This means that there is 39.6% dependence on the post-FCI to improve on the MBT. This suggests that students did not perform well in the post-FCI consequently, affecting their performance in the MBT in the same manner.

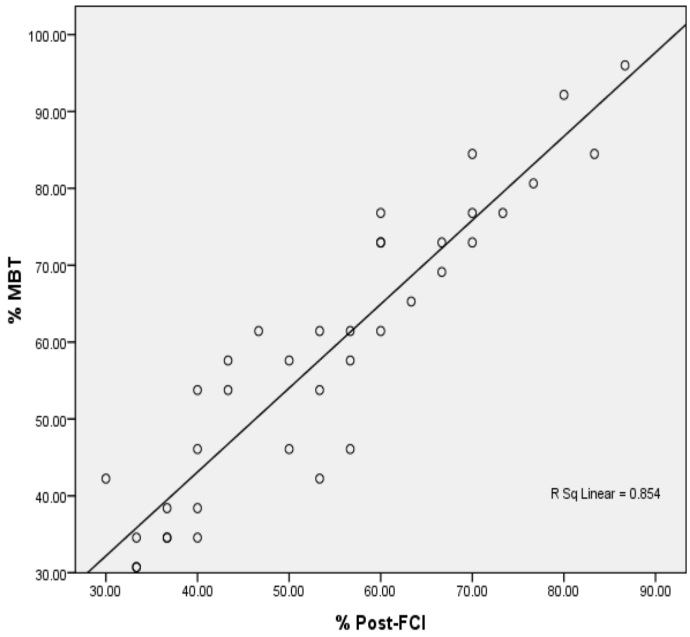

Figure 3: A scatter-plot of %MBT against %Post FCI (Experimental)

Figure 3 shows a scatter-plot of MBT against post-FCI of the experimental group. From the graph the resulting R^2 Linear is given as 0.854 (in percentages as 85.4%). This means that there is 85.4% dependence on the post-FCI to improve on the MBT. This suggests that students perform very well in the post-FCI consequently, increasing their performance in the MBT. The graph also shows a positive correlation between %post-FCI and %MBT where R=0.924.

Analysis of data with respect to the Research Question three

RQ 3: What influence will the use of peer instruction have on the attitudes of senior high school students towards the teaching and learning of Mechanics?

This question sought to find out if the attitude of students would change when peer instruction is used in teaching. Students' attitudes towards Mechanics teaching and learning were determined through the use of questionnaire. On the questionnaire, students answered pre- and post- items about their attitudes towards Mechanics teaching and learning. Their pre- and post-responses were compared to see if there were any significant differences in their mean values. Pre- is the reflection of the students' responses on their attitudes towards Mechanics teaching and learning before the intervention and the post- is the reflection of students' position after going through the lessons with the interventions. To avoid equal rating as suggested by Antwi (2013), the pre- and post-responses of students were compared at the same time after the interventions.

Table 3: Pre- and Post-responses on Students' Attitude

		Pre/Post	N	Mean	Sig.	Std. deviation
Students'	Control	Pre	37	2.08		
attitude	Experimental	Pre	37	2.07	.072	1.64
	Control	Post	37	2.10		
	Experimental	Post	37	3.55	.000	0.73

*p<0.05 significance (α=0.05)

In Table 3, the students' mean values of pre- and post-responses on attitudes towards Mechanics teaching and learning were compared. The mean scores of the pre- and post-responses of the control group were almost the same but the mean score of the students' pre-responses was relatively lower than their mean score in the post-responses for the experimental group. To determine whether the differences in the pre- and post-responses were statistically significant, a paired sample t-test analysis was used in both cases. From Table 3, there was no significant difference in students' attitude in the pre-responses of the questionnaire between the control and experimental group. This is to show that students in both group had negative attitudes towards the teaching and learning of Mechanics and Physics in general before the introduction of the two interventions. In analysing the post-responses between the control and experimental group, there was a statistically significant difference between them (p-value < 0.05). This suggests there was a change in students' attitude after the introduction of the two interventions. In comparison the mean scores, students in the experimental group (Mean = 3.55) liked Mechanics as a course in Physics than the control group (Mean = 2.10). In conclusion students in the experimental group showed more positive attitude in the teaching and learning of Mechanics because the students were exposed to peer instruction.

CONCLUSIONS

Findings of this research indicate that, Peer Instruction provided an equal support for every student to eventually achieve an enhanced conceptual understanding of Mechanics. Through the activities of Peer Instruction, it was revealed that the improvement in students' performance was due to intense student-student interactions, peer support, active participation of all students in the lessons, maximum teacher support and increased teacher-student interactions. From the study, it was also revealed that the students introduced to Peer Instruction enjoyed the lessons and participated actively in the lessons. Since the lesson was activity oriented, the students learnt collaboratively and provided opportunity for them to interact and discuss with their colleagues intensively.

Again, the results indicate that Peer Instruction is more effective than the lecture teaching approach. It was found out that integration of Peer Instruction in Physics topics help students to understand the process of solving Physics problems and to also avoid misconceptions. It can also be deduced from the study that, when appropriate teaching and learning materials (TLMs) and methods, such as the hands-on activity, question and answer and demonstration are used to teach Mechanics, they bring out the best in learners and make them the discoverers of their own knowledge as far as learning is concerned.

RECOMMENDATIONS

From the findings of this study, the following guidelines are recommended for teachers and schools who would like to set up interactive physics courses in a similar context. These suggestions apply to courses which make considerable use of peer instruction.

Firstly, a common problem with many students in Senior High Schools is their laziness towards learning especially in the Science subjects. It is a common experience for most physics teachers that students often come to class unprepared. In this study, we found that an effective measure that could promote students to do their preparatory assignment before coming to class is to adopt the use of concept quizzes at the beginning of every lesson and a problem solving session after the lesson, with the scores being part of the final assessment.

Secondly, teachers should ensure that students are made more responsible for their own learning through group activities and discussions, sharing of ideas and cooperating with peers with some guidance from the teacher. This implies that Physics teachers should model their instructions to enforce student-student interactions. For instance, using Peer Instruction package that will enhance group discussions or active learning among students.

Finally, heads of schools could consider offering opportunities for their teachers to be trained in how to use Peer Instruction in teachings. They could liaise with educational researchers in Ghana, who are familiar with the techniques of Peer Instruction to make them available to their teachers with requisite materials and teach them how to implement the techniques and materials in classrooms.

Recommendations for CRDD, Ghana Science Association (GSA), the Ghana Association of Science Teachers (GAST) and Ghana Education Service (GES)

Based on the findings of this study, the following recommendations are made for the stakeholders in Science Education in Ghana:

Curriculum planners and developers in Physics Education in Ghana should introduce more effective and innovative methods of teaching when developing the syllabus to help students quit rote learning in favour of meaningful learning. This would motivate the Physics students to develop positive attitude towards the subject. From this study it was concluded that the use of Peer Instruction increased the academic performance and conceptual understanding of students. Therefore, it is recommended that peer instruction should be integrated in teaching of challenging Physics concepts at the senior high school level in Ghana.

CRDD, Ghana Science Association (GSA), the Ghana Association of Science Teachers (GAST) and Ghana Education Service (GES), which function to support and improve science education in Ghana provide should support in gathering and distributing exemplary teaching materials to teachers, as Peer Instruction in the teaching of Physics might be hard to implement by most teachers, due to the amount of time involved in developing such a course.

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APPENDIX

STUDENTS' ATTITUDE QUESTIONNAIRE (SAQ)

FORMAT

This questionnaire is aimed at soliciting your views and opinions on your attitudes towards the teaching and learning of Mechanics your school. You are assured that your responses would be confidential and used for academic purposes only. Please tick (√) the response which appropriately suits your opinion from the list of responses provided for each question.

Part A

1. Sex: Male [ ] Female [ ]
2. Age:________

Part B

Students' Attitudes towards Mechanics Teaching and Learning

SD- Strongly Disagree **D-**Disagree **NS-**Not Sure **A-**Agree **SA-**Strongly Agree

Pre-Intervention						**Post-Intervention**				
SD	**D**	**NS**	**A**	**SA**		**SD**	**D**	**NS**	**A**	**SA**
					1. I looked forward to (eagerly anticipate) physics lessons.					
					2. Lessons in the class were fun.					
					3. The lessons made me interested in physics.					
					4. Lessons in the class bored me.					
					5. The class was one of the most interesting classes.					
					6. I enjoyed lessons in the class					
					7. Lessons in the class were a waste of time.					