UNIVERSITY OF EDUCATION, WINNEBA

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

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A Thesis in the Department of Science Education, faculty of Science Education, submitted to the School of Graduate Studies in partial fulfilment of the requirements for the award of the degree of Master of Philosophy (Science Education) in the University of Education, Winneba

OCTOBER, 2015

DECLARATION

STUDENT'S DECLARATION

I, ……………………………………., declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE:…………………………….

DATE:…………………………………….

SUPERVISOR'S DECLARATION

I / We hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of thesis / thesis/dissertation/project as laid down by the University of Education, Winneba.

Professor Kolawole Raheem (Principal Supervisor)

Signature…………………………

Date……………………………

Dr. Victor Antwi (Co-Supervisor)

Signature…………………………

Date……………………………

DEDICATION

This project work is dedicated to my family and my supervisors Prof. Kolawole Raheem and Dr. Victor Antwi.

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ABSTRACT

In this study, two science classes from two senior high schools in the Central Region 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.

CHAPTER ONE

INTRODUCTION

Overview

Physics is characterised by the search for deep, fundamental principles (Chabaya & Sherwood, 2004). Chabaya and Sherwood explained that the power of Physics is based on the idea that from a small number of fundamental principles it is possible to predict and explain a broad range of phenomena. They continue to elaborate on the point that for the past 20 years there have been significant researches on the learning and teaching of Physics, conducted by researchers within the university physics community. One of the central results of their research has been that effective teaching and learning does not come easily, but requires a significant investment of effort and time on the part of both instructors and students. Through such efforts, Physics education researchers have developed a variety of improved pedagogical approaches which do in fact improve students‘ learning of Physics topics. This chapter therefore explains some of challenges students encounter in learning physics due to pedagogies used by teachers. This chapter explains the problem faced at the study area and asks questions in the introduction of peer instruction as a teaching strategy in the study area.

Background to the Study

Physics has a long tradition for being regarded as a particularly difficult school subject (Angell, Guttersrud, Henriksen & Isnes, 2004; Carlone, 2003; Osborne & Collins, 2001). 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; Guttersrud, 2008).

Understanding Physics concepts requires the practice of scientific processes ranging from observation and measurement to data collection skill, organizing, analysing as well as interpreting them and finally experimentation (Zaytoon, 1994). Again, Conceptual understanding is an essential component of meaningful learning, without which physics students would not be able to construct meaning from instructional materials, and transfer their knowledge to solve problems or facilitate the learning of new materials (Siang, 2011).

In current practice, most Ghanaian schools place heavy emphasis on the use of lecturing without active student involvement, followed by drill and practice (Antwi, 2013). He also emphasized that in Ghanaian local parlance, this mode of teaching goes by the name of the ―chew and pour” method. Studies have shown that with such an approach most students depend on rote learning and rote problem solving, without having developed the conceptual problem solving skills that all scientists value (Antwi, 2013; Mazur, 1997; McDermott, 1993). Every student begins Physics with a well-established system of common sense beliefs about how the physical world works derived from years of personal experience (Hestenes, Wells, & Swackhamer, 1992). Mechanics, a section under Physics, contained in it are fundamental concepts like Newtonian Physics, which students need to understand before moving to higher levels in Physics. Conceptual understanding of Mechanics, in its most basic form, means understanding the principles of science, especially the concepts of Newtonian Laws used to explain and predict observations of the natural world and knowing how to apply this understanding efficiently in the design and execution of scientific investigations and in practical reasoning (National Assessment of Educational Progress [NAEP], 2005).

The problems of conceptual understanding are widespread among students which studies have found that they have naïve ideas about the concepts of Mechanics (Saleh, 2011; Trowbridge & McDermott, 1980, 1981; Halloun, & Hestenes, 1985; Van Heuvelen, 1991; McDermott, 1993; Brandsford, & Schwartz, 1999). Selah (2011) backed this problem that research findings have concluded that even if students have been exposed to Mechanics from the early stages of their schooling years, they are still sometimes unable to master the knowledge of Mechanics. Meaning those students still encounter difficulties when asked to apply a concept or line of reasoning to a situation different from which was learned (Boudreaux, 2004).

Donnellan (2003), Anamuah-Mensah (2004) and Buabeng (2012) all found out in their studies that there were low interest and poor performances of students in the study of Physics. One major cause or attribute that surfaced in all their studies was how Physics content knowledge was taught and learned at all academic levels. In recent years, Physicists and Physics educators have realized that many students learn very little Physics from traditional lecture method of teaching (Mazur & Crouch, 2001). Several investigators have carefully documented College Physics students‘ understanding of a variety of topics, and have concluded that traditionally taught courses do little to improve students‘ understanding of the central concepts of Physics (Halloun & Hestenes, 1985; Hake, 1998).

Peer Instruction is a simple and effective technique you can use to make lectures more interactive, more engaging, and more effective learning experiences (Butchart, Handfield, & Restall, 2009). Peer Instruction (PI) modifies the traditional lecture format to include questions designed to engage students and uncover difficulties with the material (Crouch, 1998). It engages students during class hours through activities that require each student to apply the core concepts being presented, and then to explain those concepts to their fellow students (Crouch, Watkins, Fagen, & Mazur, 2007). A similar questioning process is also used with Thornton and Sokoloff�much Interactive Lecture Demonstrations (Sokoloff & Thornton , 1997) and most recently Antwi‘s interactive teaching in Ghana (Antwi, 2013). One of the strengths of Peer Instruction is its adaptability to a wide range of contexts and instructor styles (Mazur & Crouch, 2001). The method has gone on to become reasonably well known and widely used in science as well as mathematics where it has been very successful (Fagen, Crouch, Yang, & Mazur, 2000).

In view of this, there is therefore the need for stakeholders in education to evaluate the effect of peer instruction in the teaching and learning of Physics, especially Mechanics, to help address falling academic achievements of Senior High School students in Ghana.

Statement of the Problem

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). 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. 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 memorised rules that are often true. For example, Antwi (2013) indicated that students know that in circular motion some force will be, $F=mv^2/r$ because that formula is usually highlighted in the textbook section on circular motion. They are not sure of the force‘s direction or cause, but can easily calculate for v, because the problem has specified F, m, and r and asked for v. Simple algebra yields v, whether or not the students understand the cause or direction of the force. So, while students will learn to do the standard problems, these approaches in science teaching do not help students to grow in their reasoning ability (Marbach-Ad, Seal, & Sokolove, 2001; Jungst, Licklider, & Wiersema, 2003). This problem is not an exception in the Central region because most senior high school students in the region do not understand most of the concepts in Mechanics and Physics in general. This has resulted in the poor academic performance in both internal and external examinations of theses students.

There is therefore the desire to find out the sort of misconceptions or alternative ideas students in Senior High Schools bring to Mechanics class and if peer instruction is a most effective instructional teaching approach to improve students‘ conceptual understanding in the study of Mechanics among Senior High Schools in the Central Region of Ghana.

Purpose of the Study

Force and motion concepts in Mechanics are closely related to our everyday experiences in a way that much research has focused on conceptual understanding or problem-solving performance and it has been found that students hold Mechanics misconceptions that are deeply rooted in their daily life experiences and are highly resistant to change (Duit & Treagust, 1998). These misconceptions are particularly true for many Mechanics concepts (Trowbridge & McDermott, 1981). Hence, the purpose of this study is to use peer instruction as an effective instructional teaching approach to enhance students' conceptual understanding in Mechanics in the Central Region of Ghana.

Objectives of the Study

The study sought to:

- Improve the academic performance of senior high school students in the Central Region using peer instruction in the teaching and learning of Mechanics.
- Use senior high school students' conceptual understanding in Mechanics to help them improve their problem solving skills.
- Assess the level of conceptual understanding in the teaching and learning of Mechanics of male students compared to their female counterparts in the senior high schools in the Central Region.
- Influence positively the attitudes of senior high school students towards the teaching and learning of Mechanics through the use of peer instruction.

Research Questions

The following research questions were addressed in the study:

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?
2. How will senior high school students' conceptual understanding in Mechanics help them improve their quantitative problem solving skills using peer instruction?
3. What is the level of conceptual understanding in the teaching and learning of Mechanics of male students compared to their female counterparts in the senior high schools in the Central Region?
4. What influence will the use of peer instruction have on the attitudes of senior high school students towards 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.

H_o2:

There is no significant difference between the levels of conceptual understanding of male students compared to their female counterparts in the senior high schools in the Central Region.

Significance of the Study

- This outcome of the study would help clarify the misconception students have in the study of Mechanics as well as Physics in general.
- The findings and recommendations of this study would be of much benefit to students which will go a long way to improve their academic performance both in internal and external examinations.
- Again the educational implication is that, as the use of peer instruction could show positive results among students in the school, they have the potentials of replacing the traditional lecture method of instruction. Since the benefits of peer instruction are becoming motivating factors for improving physics teaching and learning.
- This study would also help bridge the gap between boys and girls in terms of academic performance in the study of mechanics.
- Teachers on the other hand will gain the ability to identify students‘ problems as well as difficulties the face and then find remedies towards rectifying them. Again findings from this work could help teachers to adopt the best instructional teaching strategies in helping students to understand the concepts in mechanics.
- The study would make stakeholders in the educational sector to be conscious of the need and usefulness in adopting different instructional teaching strategies like peer instruction in teaching and learning in Ghanaian schools.
- Finally, this study could add to existing literature on methodologies of teaching mechanics as well as serve as a source of information for further research work.

The study will also go a long way to help curriculum developers to strategize the curriculum such that different strategies of teaching will be included in it.

Limitations of the Study

Limitations are matters or occurrences that arise in a study which are out of the researcher‘s control (Simon & Goes, 2013). The sample size taken for the study was very small to show more significant relationships from the data as statistical tests normally require a larger sample size to ensure a representative distribution of the population. Some students used for the study were not present for all the lessons which could have affected the data taken from them. again, bias on the part of the researcher in selection of area of study, sample size of the study and content (Mechanics) chosen for the study, this was due to the researchers interest and mastery in the content (Mechanics).

Delimitations of the Study

Delimitations of a study are those characteristics that arise from limitations in the scope of the study and by the conscious exclusionary and inclusionary decisions made during the development of the study plan (Simon & Goes, 2013). The study should have been conducted in all Senior High Schools in Ghana offering Science programmes to make a general conclusion instead the study was restricted to Senior High Schools in Central Region. Again, the scope of this study is to use all senior high schools in the Central Region of Ghana, however, this study targeted only two senior high schools in the Central region, Winneba and Swedru senior high schools as such could be representatives of all the other senior high schools and generalisation is also limited to the Central region of Ghana.

Organisation of the Study

This research report is presented in five chapters. This is briefly outlined as a reminder as follows:

Chapter 1

This chapter deals with the background to the study, statement of the problem, purpose of the study, objectives, research questions, null hypotheses, significance of the study, limitations, delimitations and organisation of the study.

Chapter 2

This chapter discusses the literature relevant to the study. This comprises; theoretical framework of the study, the teaching of Physics in Ghana with emphasis on students' conceptual understanding in Mechanics, and review of studies on peer instruction.

Chapter 3

A thorough discussion on the methodology used for the study is contained in this chapter. The research design, population and sample as well as data collection and analysis procedure are discussed.

Chapter 4

This chapter presents the analysis of the collected data and discusses the results of the study.

Chapter 5

The chapter contains the summary of the study, conclusions and recommendations.

CHAPTER TWO

LITERATURE REVIEW

Overview

This chapter discusses the relevant literature on the area of the study. Areas touched on include; theoretical framework of the study, students' misconceptions in Physics, students' conceptual understanding of Mechanics, Organisation of the Senior High School Physics Syllabus in Ghana, Physics teaching in Ghana, Peer instruction and the use of concept tests. The chapter ends with the summary of how to understand and analyse students.

Meaning of Literature Review

For any particular research to occupy the place in the development of a discipline, the researcher must be thoroughly familiar with both previous theory and research (Mahaboobjan, 2010). To Mahaboobjan, a review of literature is done to countenance the researcher to know the aggregate of work done in the concerned area. This means review of related literature provides some insights regarding strong points and limitations of the previous studies. It enables the researchers to improve their own investigations and to arrive at the perspective of the study (Boote & Beile, 2005).

Theoretical framework for the Study

The theory underpinning this study is deduced from the Constructivist theory of learning, Naïve theory and Conceptual Change theory.

Constructivist Theory of Learning

Constructivism is where knowledge is constructed in the mind of the learner based on one‘s experiences or by reflecting on one‘s experiences (Johnston, 2010). We construct our own understanding of the world we live in (Brooks & Brooks, 1999). Prior knowledge and understanding filter new learning. Active engagement in learning supports the construction of knowledge and understanding (Singer & Revenson, 1997). Constructivist theory puts the construction of knowledge in one‘s mind as the centre piece of the educational effort (Dori & Belcher, 2005). A basic assumption of teaching according to the constructivist learning approach is that knowledge cannot simply be transmitted from teachers to learners but rather, learners must be engaged in constructing their own knowledge (von Glaserfeld, 1987). In the constructivist theory, the learner is encouraged to create the knowledge in his/her mind. In so doing, the learner becomes the ―owner” of the knowledge. Such ownership enables the learner to understand the knowledge in an intimate way that cannot be achieved by mere memorization (Dori & Belcher, 2005). This process of learning is better than the outcome of instruction using a simplistic transmission model of teaching which is often rote learning, leading to inert knowledge (Bruer, 1993; Perkins, 1992).

Constructivism in another way attempts to describe how one ―comes to know”. This theory is based on the work of educational philosopher John Dewey (1938), and educational psychologists Jean Piaget (1950, 1951 and 1971), Lev Vygotsky (1978), Jerome Bruner (1966, 1990) among others. It refers to the notion that knowledge results from mental processes when individual ―schema” interact with the ―environment”. Cognitive structure thus organizes experiences by allowing the individual to "go beyond the information given" by connecting those experiences to ―prior knowledge". Real learning occurs when the learner actively engages in his or her own knowledge construction, integrates the new information into already present schema, and associates and interprets the new information into already present schema, and associates and interprets this information in a meaningful way. Our objective when teaching would then be to assure that the most fundamental concepts are well represented and connected in the students' minds and that the learners are provided with the necessary tools for constructing further knowledge upon those core concepts.

Narrowing it down to Piaget and Vygotsky, the roots of constructivism are most often attributed to the work of Jean Piaget, constructivist tenets emerged much earlier in history as seen in the writings of Giambattista Vico, who declared in 1710, "The human mind can know only what the human mind has made" (von Glasersfeld, 1995). Noddings (1990) maintains that constructivism also emerged from the work of Neisser (act psychology), and Chomsky (innate linguistic structures of mind). Noddings argues that constructivists emphasis on the learner as central emerges from Chomsky's and Piaget's theories of an epistemological subject: "an active knowing mechanism that knows through continued construction" (Jones & Brader-Araje, 2002). The meaning of constructivism varies according to one's perspective and position. Within educational contexts there are philosophical meanings of constructivism, as well as personal constructivism as described by Singer and Revenson (1997) (based on Piaget's constructivist theory), social constructivism outlined by Vygotsky (1978), radical constructivism advocated by von Glasersfeld (1995), constructivist epistemologies, and educational constructivism (Mathews, 1998). Social constructivism and educational constructivism (including theories of learning and pedagogy) have had the greatest impact on instruction and curriculum design because they seem to be the most conducive to integration into current educational approaches (Jones & Brader-Araje, 2002).

Piaget's theories tended to focus primarily on the development of the individual while ignoring the greater socio-cultural context, the roots of constructivism are clearly present in Piaget's focus on the active role of the individual in learning. For Piaget, knowledge construction takes place when new knowledge is actively assimilated and accommodated into existing knowledge. Learners ―learn by doing" to accommodate new knowledge through experiencing and assimilating newly acquired knowledge into their current conceptual understanding (Singer & Revenson, 1997). This is based on some basic assumptions in theory.

Basic Assumptions to Piaget's Theory

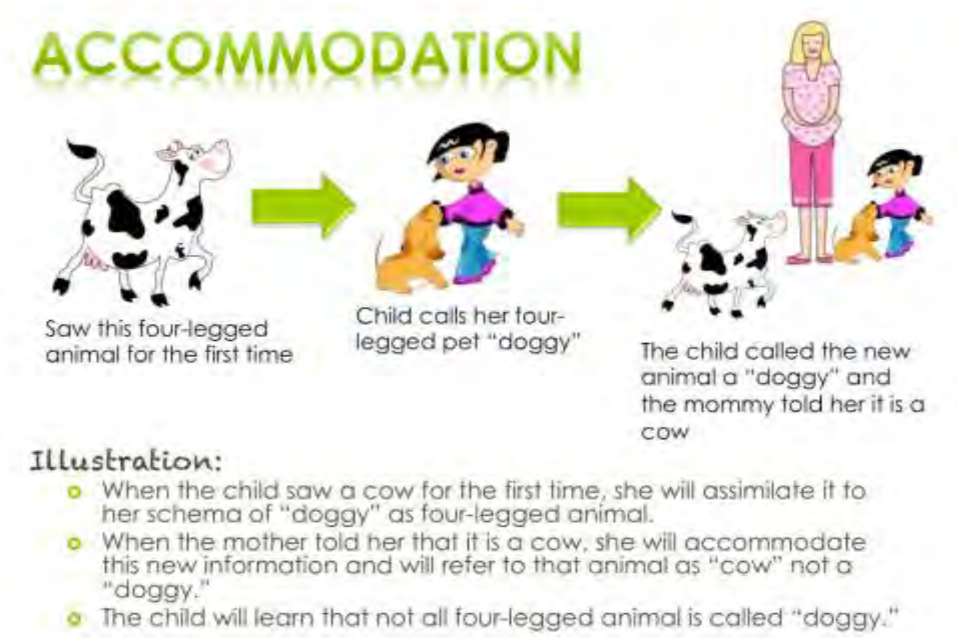
Basic assumptions that underlie Piaget‘s work;

- From infancy, the child voluntarily explores the environment. This is done by watching, touching and listening. Through these processes the child adapts to the environment. This assumption is technically referred to as adaptation.
- The second assumption is the result of the breakdown of the adaptation process into sub-processes: assimilation, accommodation and equilibration.
    - An object that has been observed before becomes recognised. This is technically called **assimilation**.

- when a child first sees a Dalmatian dog, the child will interpret this information based on his or her existing mental frameworks and will label it "doggy"

Figure 1: Process of Assimilation

— The mental picture or schema that the child holds about an object will change when a similar picture or idea is taken in through the process of **accommodation**.



- When the child saw a cow for the first time, she will assimilate it to her schema of "doggy" as four-legged animal.
- When the mother told her that it is a cow, she will accommodate this new information and will refer to that animal as "cow" not a "doggy."
- The child will learn that not all four-legged animal is called "doggy."

Figure 2: Process of Accommodation

— When finally it is categorised as a cow in the light of new experience, the child's mind would have reached **equilibration**.

Figure 3: Process of Equilibration

- The third assumption is that cognitive development occurs as the child goes through the process of assimilation, accommodation and equilibration.

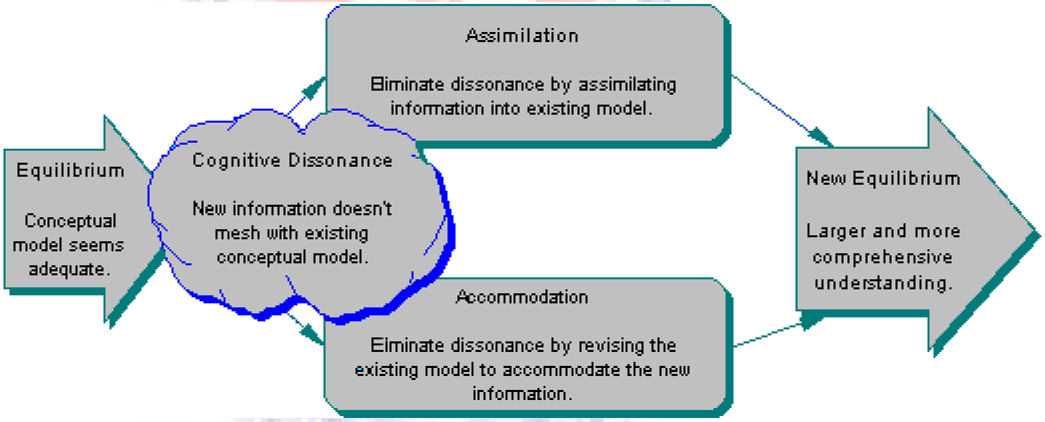


Figure 4: Piaget's Cognitive Processes of Adaptation

- The fourth assumption is that a child has a unified cognitive system. This is achieved through the child's regular attempts to achieve an understanding of the environment in a coherent manner (Southern African Development Community (SADC), 2000).

Furthermore, Piaget's constructivist stances are seen in his belief that our understandings of reality are constantly being revised and reconstructed through time and with respect to exposure to new experiences.

> "*What remains is construction as such, and one sees no ground why it should be unreasonable to think it is ultimate nature of reality to be in continual construction instead of consisting of an accumulation of ready-made structures*" (Piaget, 1970).

Constructivism's perspectives on the role of the individual, on the importance of meaning-making, and on the active role of the learner are the very elements that make the theory appealing to educators (Jones & Brader-Araje, 2002). They also argue that teachers are typically acutely aware of the role of prior knowledge in students' learning, recognizing that students are not blank slates or empty vessels waiting to be filled with knowledge. Instead, students bring with them a rich array of prior experiences, knowledge, and beliefs that they use in constructing new understandings. This process of idea testing can be seen in the classrooms of teachers who value students' ideas and promote the process of critical thinking (Jones & Brader-Araje, 2002)

Vygotsky is best known for being an educational psychologist with a sociocultural theory. This theory suggests that social interaction leads to continuous step-by-step changes in children's thought and behaviour that can vary greatly from culture to culture (Woolfolk, 1998). Basically Vygotsky's theory suggests that development depends on interaction with people and the tools that the culture provides to help form their own view of the world. There are three ways a cultural tool can be passed from one individual to another;

1. The first one is imitative learning, where one person tries to imitate or copy another.
2. The second way is by instructed learning which involves remembering the instructions of the teacher and then using these instructions to self-regulate.
3. The final way that cultural tools are passed to others is through collaborative learning, which involves a group of peers who strive to understand each other and work together to learn a specific skill (Tomasello, Kruger, & Ratner, 1993)

Zone of Proximal Development

Learning, according to Vygotsky, is best understood in light of others within an individual's world. This continual interplay, between the individual and others, is described by Vygotsky as the Zone of Proximal Development (ZPD) (Vygotsky, 1978). He defined the zone of proximal development as the intellectual potential of an individual when provided with assistance from a knowledgeable adult or a more advanced child. During this assistance process, an individual is "other regulated" by a more capable peer or an adult. "Other regulation" refers to cues and scaffolding provided by the more capable peer or adult. The individual, by means of this assistance, is able to move through a series of steps that eventually lead to "self-regulation" and intellectual growth. Vygotsky stressed the importance of the zone of proximal development because it allows for the measurement of the intellectual potential of an individual rather than on what the individual has achieved.

The concept of the More Knowledgeable Other is integrally related to the second important principle of Vygotsky's work, the Zone of Proximal Development. This is an important concept that relates to the difference between what a child can achieve independently and what a child can achieve with guidance and encouragement from a skilled partner. For example, the child could not solve the jigsaw puzzle by itself and would have taken a long time to do so (if at all), but will able to solve it following interaction with the father, and will develop competence at this skill that will be applied to future jigsaws puzzles (McLeod, 2007).

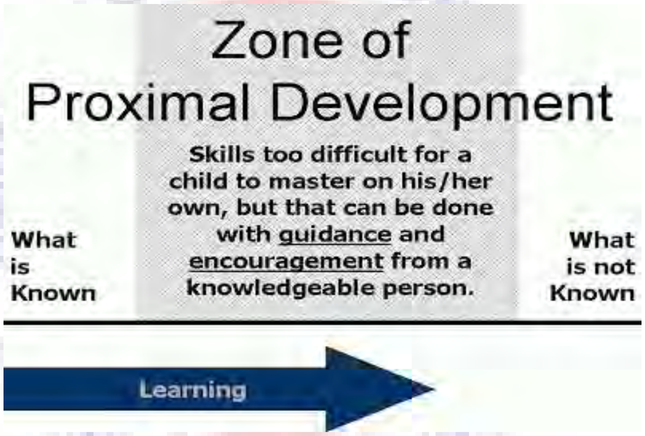


Figure 5: Zone of Proximal Development

Vygotsky (1978) sees the Zone of Proximal Development as the area where the most sensitive instruction or guidance should be given that is, allowing the child to develop skills which they will then use on their own, developing higher mental functions. Vygotsky also views interaction with peers as an effective way of developing skills and strategies. He suggests that teachers use cooperative learning exercises where less competent children develop with help from more skillful peers - within the zone of proximal development.

Evidence for Vygotsky and the ZPD

Freund (1990) conducted a study in which children had to decide which items of furniture should be placed in particular houses of a dolls house. Some children were allowed to play with their mother in a similar situation before they attempted it alone (zone of proximal development) whilst others were allowed to work on this by themselves (Piaget's discovery learning). Freund found that those who had previously worked with their mother (ZPD) showed greatest improvement compared with their first attempt at the task. The conclusion being that guided learning within the ZPD led to greater understanding/performance than working alone (discovery learning).

Classroom Applications

McLeod (2007) pointed out that a contemporary educational application of Vygotsky's theories is "reciprocal teaching", used to improve students' ability to learn from text. In this method, teacher and students collaborate in learning and practicing four key skills: summarizing, questioning, clarifying, and predicting. The teacher's role in the process is reduced over time. Also, Vygotsky (1978) is relevant to instructional concepts such as "scaffolding" and "apprenticeship", in which a teacher or more advanced peer helps to structure or arrange a task so that a novice can work on it successfully. Vygotsky's theories also feed into current interest in collaborative learning, suggesting that group members should have different levels of ability so more advanced peers can help less advanced members operate within their ZPD (McLeod, 2007).

In conclusion, for social constructivists, the process of knowing has at its roots with social interaction (von Glasersfeld, 1992). That is, an individual's knowledge of the world is bound to personal experiences and is mediated through interaction (language) with others (von Glasersfeld, 1989). Thus, learning from a social constructivist perspective is an active process involving others:

> *Knowledge is never acquired passively, because novelty cannot be handled except through assimilation to a cognitive structure the experiencing subject already has. Indeed, the subject does not perceive an experience as novel until it generates a perturbation relative to some expected result. Only at that point the experience may lead to an accommodation and thus to a novel conceptual structure that re-establishes a relative equilibrium. In this context, it is necessary to emphasize the most frequent source of perturbations for the developing cognitive subject is the interaction with others* (von Glasersfeld, 1989. p. 54).

Constructivism in Educational Practices

The influence of constructivism in education today can be seen in a variety of published curricula as well as instructional practices. Social constructivist applications are commonly found in schools through the widespread use of cooperative and collaborative teaching strategies such as: Teams-Games-Tournament, Student Teams Achievement Division, Jigsaw, Numbered Heads Together, and Peer-Peer Tutoring (Slavin, 1980; 1990). In each of these, the emphasis is on having students working together while sharing ideas and challenging each other's perspectives. The emphasis on "significant others" has led some educators to question the usefulness of homogeneous ability grouping (Carter & Jones, 1994). Grouping by ability has come under fire as a traditional strategy that fails to build on the strengths of diverse student abilities and perspectives. As a result, teachers are increasingly using older student tutors, adult tutors, and more advanced students in instruction. One of the most obvious places that the impact of social constructivist theories can be seen is in the design and organization of classrooms. Teachers today must recognize the power of peer-peer interactions and the greater classroom community in learning. Using a collaborative group structure, teachers encourage interdependency among group members, assisting students to work together in small groups so that all participate in sharing data and in developing group reports (National Research Council, 1996). This statement reflects the constructivist values of small group work, cooperative development of ideas, and the role of written and spoken language in learning.

Brooks and Brooks (1993) summarize a large segment of the literature on descriptions of ‗constructivist teachers'. They conceive a constructivist teacher as someone who will:

1. encourage and accept student autonomy and initiative;
2. use a wide variety of materials, including raw data, primary sources, and interactive materials and encourage students to use them;
3. inquire about students' understandings of concepts before sharing his/her own understanding of those concepts;
4. encourage students to engage in dialogue with the teacher and with one another;

5. encourage students' inquiry by asking thoughtful, open-ended questions and encourage students to ask questions to each other and seek elaboration of students' initial responses;
6. engage students in experiences that show contradictions to initial understandings and then encourage discussion;
7. provide time for students to construct relationships and create metaphors;
8. assess students' understanding through application and performance of open-structured tasks.

Hence, from a constructivist perspective, the primary responsibility of the teacher is to create and maintain a collaborative problem-solving environment, where students are allowed to construct their own knowledge, and the teacher acts as a facilitator and guide (Brooks & Brooks, 1993).

Naive Theory View

This view contends that as students gain knowledge about the world (either through formal schooling or informally) means they build —naive theories" about how the physical world works, and that often these naive theories contain misconceptions that contradict scientific concepts (Clement, 1982; McDermott, 1984; Posner, Strike, Hewson, & Gertzog, 1982). Hence, students do not come to class as —blank slates" upon which instructors can write appropriate scientific concepts (Bransford, Brown, & Cocking , 1999). For example, children observe leaves fluttering down from tree branches and rocks thrown from a bridge onto a stream below, and from these and multiple similar observations construct the notion that heavy objects fall faster than light objects.

Misconceptions are viewed as stable entities that are used to reason about similar but varied contexts (Docktor & Mestre, 2014). They continue to explain that misconceptions have three qualities:

a. They interfere with scientific conceptions that teachers attempt to teach in science classes.
b. They are deeply seated due to the time and effort that students spent constructing them, and they make sense to the student since they do explain many observations (it is difficult to ―shut off" air resistance and observe a leaf and a rock falling at the same rate, thereby allowing direct verification of the physicist‘s view that all objects fall at the same rate).
c. They are resistant to change.

Some researchers make distinctions between ―weak" and ―strong" restructuring of misconceptions. For example, young children‘s eventual conception of the meaning of ―alive" is considered strong restructuring (Carey, 1999); prior to correctly conceptualizing ―alive," children believe that to be alive means being active (people and animals are alive by this criterion, but not lichen), or being real or seen; Carey conveys an incident whereby her 4-year-old daughter once proclaimed that it is funny that statues are dead even though you can see them, but Grandpa‘s dead because we cannot see him anymore (Carey, 1999). Other distinctions include intentional versus non-intentional conceptual change, where the former is ―…*characterized by goal-directed and conscious* *initiation and regulation of cognitive, metacognitive, and motivational processes to bring about a change in knowledge*” (Sinatra & Pintrich, 2003).

In the misconceptions view, it is generally accepted that some degree of dissatisfaction is needed for someone to replace a misconception with a more scientifically appropriate form. As Carey argues, ―Without doubt, the process of disequilibration is an important part of the process of conceptual change” (Carey, 1999). Hammering on this point, children restructure their naïve theory structures by increasing their knowledge in a specific domain. As children are exposed to new experiences and instruction, they gradually replace their theory-like conceptual structures with scientifically correct conceptual structures (Özdemir & Clark, 2007). These restructurings result from the child‘s increased knowledge of a domain, social interactions, and a variety of disequilibrating influences, partially resulting from the development of the logical structures of the child (Özdemir & Clark, 2007). According to Carey, concepts and beliefs are the two primary components of intuitive knowledge. Beliefs are the relational pieces that connect concepts. For example, ―people are animals” refers to two different concepts, people and animals (Carey, 1999). She argues that while changes in relations between the concepts are relatively easy, changes in the concepts are thorny processes because intuitive theories constrain the concepts in which beliefs are formed. Therefore, naïve concepts change is a gradual process that occurs at the level of individual concepts.

Hatano and Inagaki (1996) focus on naïve theories of children within biological concepts. Their view is consistent with that of Carey (1999), that young children, before being taught in school, possess a fairly well-developed body of biological knowledge that enables them to make consistent predictions and explanations regarding biological phenomena. Naïve knowledge is constructed through daily experiences at early ages and formal physics is constructed from naïve physics through the restructuring of it (Hatano & Inagaki, 1996).

Conceptual Change Theory

Concepts are like mental representations which, in their simplest forms, can be expressed by a single word, such as ―plant" or ―animal", "alive" or ―dead", ―table" or ―chair", ―apple" or ―orange" (Carey, 2000). Concepts may also represent a set of ideas that can be described with a few words. Through the use of language, individual concepts can be connected to build more complex representational structures, such as ―babies crawl" or ―birds fly". At other times, two concepts can be combined to form a third representational structure. An example of the latter could be ―density", which is the ―matter" per ―volume". Thus a concept stands alone but is a product of two other concepts. Through the use of language, we can thus create new concepts that can stand by themselves. More complex concepts can describe a whole idea, such as ―the Theory of Natural Selection". Similarly, through the use of mathematics, we can build somewhat more abstract theories that end up representing one idea, like for example ―the Big Bang Model of the Universe". In other words, within a particular representational structure, concepts help us to make deductions and explain even more complex ideas. Concepts can thus act as building blocks of more complex or even abstract representations (Zirbel, 2005a).

The process of correcting learner misconceptions depends on not only the delivery of new knowledge but also the gradual integration of new concepts related to learners‘

existing conceptual structures (Vosniadou, 2002). New instructional strategies must be developed to assist learners in actively constructing and adapting their knowledge (De Jong & Van Joolingen, 1998). Almost three decades ago Posner and co-workers formulated a theory of conceptual change with four components that needed to be present for an individual to abandon a misconception in favour of a scientific concept:

1. Dissatisfaction with a current concept (The learners must first realise that there are some inconsistencies and that their way of thinking does not solve the problem at hand),
2. Intelligibility of the new concept (The concept should not only make sense, but, the learners should also be able to regurgitate the argument and ideally be able to explain that concept to other classmates),
3. Initial plausibility of the new concept (The new concept must make ―more" sense than the old concept. It must have the capacity to solve the problem better. The learners should be able to decide on their own how this new concept fits into their ways of thinking and recall situations where this concept could be applied), and
4. Usefulness of the new concept in reasoning and making predictions about phenomena thus fruitfulness (The new concept should do more than merely solve the problem at hand; it should also open up new areas of inquiry).

Strike and Posner (1992) have since revised their initial views somewhat to include issues related to the learner's ―conceptual ecology" as well as developmental and interactionist considerations.

The conceptual change learning environment may incorporate these four conditions by, at first, creating scenarios of conceptual conflict that guide learners to discover their dissatisfaction with existing concepts. Moreover, learning environment needs to manifest plausible and fruitful concept features and implement an effective instructional strategy for learners to comprehend new concepts (Zirbel, 2005b). The conceptual change theory is a combination of two theories: one from the history and sociology of science (Kuhn, 1970) and one from developmental psychology (Piaget, 1977a). The process of doing science that Kuhn typified as assimilation of scientific results within a paradigm is similar to the way that Piaget described how individuals acquire knowledge. Kuhn's paradigm shift caused by the scientific revolution can then be compared to the accommodation of new knowledge in an individual that leads to a change of that individual's conceptual framework. One of the common instructional strategies to foster conceptual change is to confront students with discrepant events that contradict their existing conceptions. This is intended to invoke a disequilibration (Piaget, 1977b) or conceptual conflict that induces students to reflect on their conceptions as they try to resolve the conflict. Following that, the students have to undergo the process of accepting, using and integrating the new concepts into their lives and even applying them to new conditions.

Chen, Pan, Sung & Chang (2013) in their study identified three key elements for constructing a conceptual change learning environment according to the four conceptual change theory conditions:

1. an appropriate learning environment to manifest plausible and fruitful concept features,

2. an effective instructional strategy that assists learners to comprehend conceptual implications, and
3. construction of conceptual conflict scenarios for the adaptation and reconstruction of existing knowledge structures

Zirbel (2005b) suggests that to form new concepts or change old inadequate ones, students have to be led through several processes. First, they have to consciously notice and understand what the problem is; second, they have to assimilate more information and try to fit it into already existing neural networks; third, they have to critically think through all the argumentation in their own words and reorganise what exist already – they have to accommodate the knowledge and evaluate against their prior beliefs; and finally, they have to work towards obtaining fluency in the newly acquired and understood concept so that concept itself becomes a mere building block for future and more advanced concepts. The claim here is that during the process of conceptual change what happens in the students' mind is a reorganisation of their thoughts, the creation of new neural networks, and the rewiring of old ones. This process is difficult to provoke and requires that students work hard. A good instructor can help with the process of conceptual change but cannot do it for the student (Zirbel, 2005b).

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. For that reason, it is valuable to learn how science, especially physics and technology, can be designed to be more interesting for pupils (Reeve, 2002).

Science has been regarded as the bedrock of modern day technology. Countries all over the world especially the developing ones like Ghana are making a lot of efforts to develop technologically and scientifically. 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). However, many teachers in Senior High Schools (SHS) in Ghana do not use audio-visual aids when teaching physics which goes contrary to teaching as the systematic presentation of facts, ideas, skills and techniques to students thus 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 audio-visual aids to complement the traditional lecture method while others perceive the use of it as waste of time. Since most students consider Physics as an abstract subject, the use of audio-visual resources should be a requirement for every physics teacher if the aim of the teacher is to guide the student 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 and stress 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.

Organisation of the Senior High School Physics Syllabus in Ghana

Education in Ghana is centrally administered under the purview of the Ministry of Education. The Ministry has various units responsible for education in Ghana. Ghana Education Service (GES) administers pre university education (Ghana Education Service [GES], 2009). The West African Examinations Council (WAEC), a consortium of five Anglophone West African Countries (Ghana, Nigeria, Sierra Leone, Gambia and Liberia) is responsible for developing, administering and grading school-leaving examinations up to the secondary level (GhanaWeb, 2009).

In Ghana, the sciences taught in SHS are Biology, Chemistry, Physics, and Integrated Science. Syllabus in these subjects build upon the foundation laid in the Junior High School Integrated Science at the Basic level and SHS Integrated Science. The topics in the subjects have been selected to enable the students acquire the relevant knowledge, skills and attitudes needed for tertiary level education, other institutions, apprenticeship and for life. The syllabus embodies a wide range of activities such as projects, experiments, demonstrations and scientific inquiry skills designed to bring out the resourcefulness and ingenuity of the physics student (Curriculum Research and Development Division [CRDD], 2008). All these objectives are achieved by the teacher through giving innovative and appropriate instructions to the physics students. The Physics syllabus has been structured to cover three years of SHS programme. Each year's work consists of a number of sections with each section comprising a number of units. There are six main sections as shown in Table 1.

Table 1

Organisation of the Physics Syllabus

Sections	Components
1. Motion, Forces and Energy	Different types of motion, effects of force on motion and nature of energy are to be discussed
2. Thermal Physics	In this section, heat and temperature are to be discussed. The study of temperature, its measurement and the effect of temperature changes are to be discussed.
3. Waves	The general characteristics of wave motion including that of light and sound waves are to be discussed in this section
4. Electric and Magnetic Fields	Special emphasis is given to the study of magnets since magnets play a major role in instrumentation and machinery.

5. Atomic and Nuclear Physics	The characteristics of the atom and that of the nucleus are to be discussed in this section. The concept of photoelectric effect and its applications, the x-rays and the peaceful uses of nuclear energy are to be discussed in this section.
6. Electronics	In this section, another dimension of electronics is to be treated to include the characteristics and applications of semi-conductor diode and transistors in **voltage stabilisation, amplification** of signals and **electronic switching.**

(Curriculum Research and Development Division [CRDD], 2008).

At the end of the school year, students write a national examination, the West African Senior Secondary Certificate Examination (WASSCE) formally called Senior Secondary School Certificate Examination (SSSCE). The performance of students in the examination is used for selection into tertiary institutions.

Rationale for Teaching Physics

Physics, as a discipline, deals with the nature of matter and energy, their interactions and measurements. The study of Physics has had, and continues to have, a big impact on the world community (Curriculum Research and Development Division [CRDD], 2008). The ideas, skills and attitudes derived from the study of the physics are being widely applied in various scientific and technological developments. As an example, development in renewable energy is serving the world profoundly and it is hoped that it will become more available in Ghana to complement other sources for meeting the energy needs of the country. The specific example of renewable energy is solar, that transforms in appropriate forms such as electrical energy for operating simple equipment, and machinery, and for domestic use. The principles and applications of physics cut across the various spectrums of everyday life activities like walking, lifting objects, seeing and taking photographs (Curriculum Research and Development Division [CRDD], 2008).

Implications for Physics Teachers

Physics Education Research has highlighted the need for teaching to be student-centred, explicitly recognising the knowledge state of the students and the activities that will transform them to the desired state (Knight, 2004). However, there is no single solution to this problem. Research does provide general guidance to teachers on teaching and learning methods that are *likely* to be effective. Knight (2004) identified five lessons for teachers for successful Physics teaching;

Lesson 1: Keep students actively engaged and provide rapid feedback.

- Active engagement is the essence of the constructivist approach because students must build their mental models rather than receive them from the teacher.
- Ask students to predict the outcome of an experiment – they discover if their predictions are right or wrong.
- Provide rapid feedback on their predictions to help students confront their misconceptions and resolve the conflict. The common theme is that students are engaged in *doing* or *talking about* physics rather than *listening* to physics.

Lesson 2: Focus on phenomena rather than abstractions

- The goal of physics is to understand physical phenomena.
- Work inductively, from the concrete to the abstract. This keeps theory grounded in reality rather than becoming ‗just maths‘

- Ask questions _howdo we know…? / Why?‘
- Ask students to explain the outcome of an experiment by using qualitative reasoning but no equations. Research has shown that problem-solving ability increases when instruction is shifted away from derivations and theory and towards building a coherent knowledge structure.

Lesson 3: Deal explicitly with students' alternative conceptions.

- Confront student misconceptions directly.
- Prediction and reality – explore the fact that many of their predictions may be wrong.

Students‘ alternative conceptions are highly resistant to change, and one example of a conflict is unlikely to have much effect. Students‘ misconceptions need to be challenged but the students‘ feelings also need to be taken into consideration. Explaining to the students that they are not alone when it comes to holding misconceptions in physics, even very bright people can have misconceptions. Secondly, the concepts of physics are difficult and are not obvious. Even Newton struggled with his laws for several years.

Lesson 4: Teach and use explicit problem solving skills and strategies.

- One way is to ask students for significant qualitative reasoning and explanations.
- Activities that promote learning the logical connections between ideas rather than memorisation of formulas.

- Teach students the specific skills to solve complex problems (i.e. interpretation skills, graphical skills, reasoning skills).

Lesson 5: Homework & Examination questions

- Assign homework as well as examination motion problems that go beyond symbol manipulation to engage students in the qualitative and conceptual analysis of the physical phenomena.
- Balance qualitative and quantitative reasoning.
- Emphasise reasoning, de-emphasise formulas and equations.
- Deal directly with phenomena and observations.

These Five Lessons are simply guidelines that physics teachers can take on board and adapt to suit their needs (Knight, 2004 pg. 12).

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).

Examples of alternative conceptions are

- Motion of an object implies force acting on the object.
- Electric current is ―used up" in a circuit.
- Big/heavy things sink, small/light things float.
- Greater mass implies a greater force.
- Heavier objects fall faster.

(Johnston, 2010)

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; Van Heuvelen, 1991; McDermott, 1993). 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.

Van Heuvelen (1991a) explained that many studies in physics education revealed that simple instruction failed to achieve the objectives. He explained that the students leave their courses with about the same status as those students entering the course. Meaning students have ideas described as ―misconceptions" about the course even if they are taught theoretically. Some researchers describe students' misconceptions as rather fixed, theory-like conceptions while others see them as alternative ways of seeing things that are appropriate in different contexts.

Research on Physics Education has repeatedly shown that students lack an appropriate understanding of fundamental Physics concepts, even students who can successfully solve traditional physics problems (Kim & Pak, 2002). Given the results of research on students' understanding of acceleration (Trowbridge & McDermott, 1981), special relativity (Scherr, Shaffer, & Vokos, 2001), electromagnetic waves (Ambrose, Heron, Vokos, & McDermott, 1999), it is no surprise that step-by-step-like instruction of uncertainty leaves students with, at best, the ability to successfully calculate the average and standard deviation, but with little conceptual understanding of why, when, and how to use these constructs. One way toward a solution of this problem is to create experiences that require students to build a conceptual understanding of measurement before or perhaps along with their calculation ability (Allie, Buffler, Campbell, Lubben, Evangelinos, Psillos &Valassiades, 2003).

A typical analysis of such problem is that, 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. For the past 30 years, Lillian C. McDermott and the Physics Education Group at the University of Washington have been leaders in carrying out this research (McDermott, 1984). McDermott and other Physics Education researchers have documented that even after studying Physics; student understanding of fundamental concepts is often weak.

Since the 1970‘s a great amount of educational research has focused on the ideas students have in relation to scientific concepts (Driver, 1989; Hestenes, Wells, & Swackhamer, 1992; McDermott, 1984; Halloun & Hestenes 1985; Bayraktar, 2009). These ideas have been described as ―misconceptions”, ―alternative conceptions” or ―common-sense beliefs”. Some researchers describe students‘ misconceptions as rather fixed, theory-like conceptions while others see them as alternative ways of seeing things that are appropriate in different contexts.

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

1. Students believe that heavier objects fall faster than lighter ones (Bayraktar, 2009; Hestenes et al. 1992; McDermott, 1984).

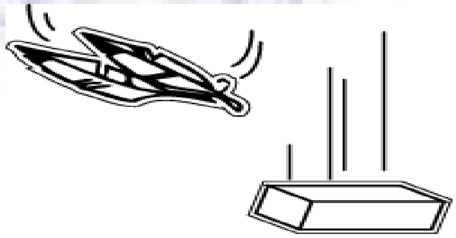


Figure 6: Comparison of heavier and lighter objects

2. 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 (Bayraktar, 2009).

Figure 7: Force (big and small objects)

3. 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 (Bayraktar, 2009; Hestenes, Wells & Swackhamer, 1992), some students also believe in a circular impetus. Hestenes, Wells & Swackhamer (1992) explain it by a ―training metaphor”. The students think that the objects tend to do what they have been trained to do.

Figure 8: Impetus

4. 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 (Bayraktar, 2009; McDermott, 1984) which is the opposite.

Figure 9: Direction of force and motion

5. Students cannot discriminate between position and velocity and between velocity and acceleration (Hestenes, Wells & Swackhamer, 1992; McDermott, 1984).

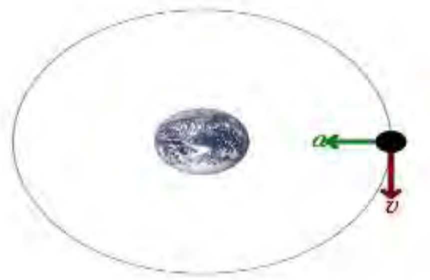


Figure 10: Position, Velocity (v) and Acceleration (a)

Again ongoing research by Paul Steif of Carnegie Mellon University and others suggests that students make a range of typical errors including; the inclusion of internal forces, inadequate distinction between force and moment, couples seen as equivalent to a force, direction of force at connections set by the direction of the connecter, and assumption that the force direction is influenced by the presence of an applied load (Steif & Hansen, 2006). The use of both force and moment equilibrium concepts on free-bodies are basic to all Mechanics problems. An initial step in Mechanics design analysis is to conceptually isolate bodies (i.e. whole structures, or elements of multi-part structures) from their physical environment and to mathematically analyse how forces and moments affect each individual body (Dwight & Carew, 2006). Force and motion concepts are encountered frequently in everyday experiences which people try to rationalize their experiences based upon their prior knowledge, even without formal instruction. Regardless of the level in which force and motion concepts are taught, most students have similar preconceptions about motion and forces' (Camp & Clement, 1994; Champagne, Klopfer & Anderson, 1980; Clement, 1982; Halloun & Hestenes, 1985; McDermott, 1984; McDermott, 2001; Singh, 2007). For example, contrary to the Newtonian view, a majority of students believe that motion implies force and an object moving at a constant velocity must have net force acting on it. This is an over-generalization of the everyday observation that if an object is at rest, a force is required to set it in motion. Due to the presence of frictional forces in everyday life, such preconceptions are reinforced further. For example, in order to make a car or a box move at a constant velocity on a horizontal surface one needs to apply a force to counteract the frictional forces. These observations are often interpreted to mean that there is a net force required to keep an object in motion.

Research has shown that these preconceptions are very robust, interfere with learning, and are extremely difficult to change without proper intervention (Arons, 1990; Camp & Clement, 1994; Champagne, Klopfer, & Anderson, 1980; McDermott, 1991; McDermott, 1993). 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 (Antwi, 2013). 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; Mazur 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 leaders should understand their roles clearly. Peer leaders 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, according to 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. The *Peer Instruction* process is described as follows:

1. Question posed
2. Students given time to think
3. Students record or report individual answers
4. Neighbouring students discuss their answers
5. Students record or report revised answers
6. Feedback to teacher: Tally of answers
7. Explanation of the correct answer (Mazur, 1997, page 10)

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 and Mazur (2001), 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 student conversations can provide unexpected insights into student 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 research outputs have concerned the 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). The Physics Education Group at the University of Washington has been leaders in carrying out this type of study in USA using peer teaching (Redish & Steinberg, 1999). Recently in Ghana, Antwi (2013) who focused on the use of interactive teaching method based on the fundamental block of Mazur‘s peer teaching to address students alternate conception in Mechanics obtained good results.

Concept Tests: the cornerstone of teaching with Peer Instruction

What makes a good Concept Test?

Appropriate Concept Tests are essential for success (Mazur, 1997). Mazur continued that Concept Tests should be designed to expose students‘ difficulties with the material, and to give students a chance to explore important concepts; they should not primarily test cleverness or memory. For this reason, incorrect answer choices must be plausible, and, when possible, based on typical student misunderstandings. While there are no hard-and-fast rules in writing good Concept Test, questions which constitute a concept test satisfy a number of basic criteria:

- Focus on a single important concept, ideally corresponding to a common student difficulty
- Require thought, not just plugging numbers into equations
- Provide plausible incorrect answers
- Be unambiguously worded
- Be neither too easy nor too difficult (Crouch, Watkins, Fagen, & Mazur, 2007)

All these criteria directly affect feedback to the instructor. If more than one concept is involved in the question, it is difficulty for the instructor to interpret the results and correctly gauge understanding. If students can arrive at the answer by simply plugging numbers into equations, the answer does not necessarily reflect real understanding (Crouch, Watkins, Fagen, & Mazur, 2007).

Summary

From the literature, the study is focused on how to understand and analyse the students' construction of concepts along a teaching sequence in mechanics. This starts from the students' previous knowledge or pre-conceptions through to conceptual change during teaching to the construction of new concepts after teaching. Conceptual understanding requires both knowledge of and the ability to use scientific concepts to develop mental models about the way the world operates in accordance with a current scientific theory (Girard & Wong, 2002). It is important to ensure the mastery of science concepts among students (National Assessment of Educational Progress, 2005). Furthermore, it develops a student‘s ability to apply facts and events learned from science instruction and from personal experiences with the natural environment, to use scientific concepts, principles, laws, and theories that scientists use to explain and predict observations from the natural world. Another important idea is that teaching science based on the methods advocated by current reforms is fundamentally different from how most teachers learned science themselves (American Association for the Advancement of Science, 1998); yet research indicates that teachers, unfortunately, tend to teach the way they have been taught (McDermott, 1990). The above arguments suggest that preparation of physics teachers should be a purposeful intellectual endeavour that needs to be carried out by professionals who possess strong expertise in the content area, can apply it to learning of physics and simultaneously have skills and experience in implementing the reformed way of teaching in a classroom. In addition to knowing the right method of teaching (by including hands-on activities), the concepts as well as laws of Mechanics and the methods of scientific inquiry, teachers should be able to create learning environments in which students can master the concepts and the processes of Mechanics.

CHAPTER THREE

METHODOLOGY

Overview

This chapter deals with the research methodology employed in the study. It discusses the research design adopted for the study, population covered by the study and sample and sampling procedures used in the study. The data collecting instruments, validity and reliability of research instruments used in the study and how the data collected were analysed in the study have also been discussed in this chapter.

Research Design

Quasi experimental research design was adopted for this study. This is to buttress the point that often times students‘ performance in a reformed course is compared to other sections of a similar course taught traditionally, or to past years in which the course was taught differently. Comparisons are typically made between courses within a single institution, but occasionally researchers make cross-institutional comparisons (Hake, 1998). Quasi experimental design was used because intact classes were used instead of randomly composed samples (Oladajo, Olosunde, Ojebisi, & Isola, 2011; Osokoya, 2007; Owusu, Monney, Appiah, & Wilmot, 2010). Indeed, conducting a legitimate experiment without the participants being aware of it is possible with intact groups, but not with random assignment of subjects to groups. Thus allowing a higher degree of external validity (Dimitrov & Rumrill, 2003)

Quasi experiment design was chosen due to the fact that, 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 3.1.

O_1 X_1 O_2	Experimental group
O_3 X_2 O_4	Control group

Figure 11: 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)

Population

A population is defined as all elements (individuals, objects and events) that meet the sample criteria for inclusion in a study (Burns & Grove, 1993). Also, population used in research refers to all the members of a particular group. It is the group of interest to the researcher, the group to whom the researcher would like to generalise the results of a study (Fraenkel & Wallen, 2009). The population for this study encompasses all Senior High Schools in the Central Region of Ghana since the problem understudy applies to all of them. The target population is the actual population to whom the researcher would like to generalise (Fraenkel & Wallen, 2009). This also comprises all form two Senior High School students in the Central region of Ghana. The accessible population is the population to whom the researcher is entitled to generalize. This comprises form two Senior High Schools science students selected from two schools in the Central Region due to proximity of the researcher to the two schools.

Sample and sampling technique

The term ‗sampling', as used in a research, refers to the process of selecting the individuals who will participate (e.g., be observed or questioned) in a research study. A sample is any part of a population of individuals on whom information is obtained (Fraenkel & Wallen, 2009). Form two science students from two senior high schools in the Central Region were purposely selected for this study. Purposive sampling is the form of non-probability sampling in which units to be observed are selected on the basis of the researcher‘s judgements about which one will be the most useful or representative

(Fraenkel & Wallen, 2009). These two schools were selected due to equal qualities they both have. Equal qualities in terms of numbers and passes in WAEC results and are also found in the capital cities of the two municipalities. The two schools were also selected based on the following assumptions that all the schools selected

- 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 concepts in Physics required of form 1 students.
- 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 random sampling was then used to select one science class from each of the two schools participating in the research. A simple random sample is one in which each and every member of the population has an equal and independent chance of being selected (Fraenkel & Wallen, 2009). Three pieces of cards written on them, _selected‘, _not selected‘ and _not selected‘ were folded and put in a small container. The class prefect of each of the three classes was called to pick one of the cards. The class of the prefect who chose the card with _selected‘ on it was chosen for the study. This was done in the two schools.

Sample size

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 students were second year science students from two purposefully selected co-educational senior high schools of which they are all schools. The two selected schools were designated experimental and control group. The two schools 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.

Instrumentation

Given the purpose of the study, data were to be collected to evaluate students learning outcomes and students' opinions on the use of peer instruction in teaching. Instruments used for data collection were the Force Concept Inventory (FCI), Mechanics Baseline Test (MBT), questionnaire and interview.

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 standardised 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

Avoke (2005) narrated that questionnaire is the instrument used to collect data for decision making in research. Creswell (2008) further described questionnaire as, a form used in survey design that participants in a study complete and return. It is a mechanism by which information is gathered by a researcher, asking forms of questions to respondents on a topic being researched.

On the questionnaire, the students‘ opinions and attitudes towards Physics teaching and learning were assessed to determine any attitudinal changes due to the new instructional approach. The questionnaire on students‘ attitudinal change was categorised into *Pre* and *Post*. *Pre* refers to students‘ attitude towards physics teaching before the instructional approach, and *Post* was their attitude towards physics teaching after the instructional approach. The Students' Attitudes Questionnaire (SAQ) used for this study was adapted from Martin-Dunlop and Frazer (2007) and modified to suit the study. The questionnaire was categorised into two parts:

1. The first part of the SAQ solicited students' personal information on age and gender. Students were not to include their names and identity numbers, to free their minds from fear of being victimised.
2. The second part sought students' opinions about the type of instructional methods, learning environments and activities used in the teaching and learning of Physics. It consisted of seven (7) questions on students' attitude towards the teaching and learning of Mechanics, and required the students to rate their responses using a five-point Likert scale ranging from strongly - disagree SD (1), disagree - D (2), not sure - NS (3), agree -A (4) and strongly agree - SA (5)

Interview

An interview is one instrument used to collect vital information about the students. When answers to a set of questions are solicited in person, the research is called an interview (Fraenkel & Wallen, 2009). According to these authors, interviews are conducted orally, and the answers to the questions are recorded by the researcher (or someone who has been trained). An interview was organised for ten students, five from each group were picked randomly to answer questions in soliciting information concerning their attitude and performance in the study of Mechanics. The Students' Attitudes Questionnaire (SAQ) developed by Martin-Dunlop and Frazer (2007) were modified into interview questions. This time students were not given option in a form of a five-point Likert scale.

But rather the questions were modified into open-ended questions. It was also made up of seven (7) questions on students‘ attitude towards the teaching and learning of Mechanics.

Data Collection Procedure

Force Concept Inventory (FCI)

Students were made to answer 30 multiple choice questions of the force concept inventory (FCI) as a pre-test, the first day they met the researcher. Both the experimental and control group had the pre-test on the same day. The experimental group had their pre-test of the FCI in the morning because of researcher‘s proximity to the school and later the control group had their pre-test in the afternoon because the school is not close to the researcher. In both cases the researcher was helped by a resource person in the various schools. The researcher with the resource persons made sure students followed all the instruction written in front of the question sheets. This was a revised version of the FCI by Halloun, Hake and Mosca, (1995). Students used 30 minutes for the answering of the questions. The instructors collected the sheets after the 30 minutes. The students were not supposed to leave any question unanswered. They should avoid guessing and answer according to how they understand the option to be the right answer. After the pre-test, the instructors briefed the students of the new approach they were going to use to teach the students. Instructors marked the sheets later and recorded marks as pre-test scores.

Teaching started the same week after students have finished with the pre-test. The researcher taught the experimental group with peer instruction since he was conversant with peer teaching whiles a resource person who is a physics teacher taught the control group with tradition lecture method. The researcher discussed how the Mechanics content will be taught with the resource person who will be teaching the control group prior to the intervention. The Mechanics content was grouped into three topics; Forces, Motion and Energy/Work. Each topic was treated within a week. The instructors had a three-week consecutive lesson with the students, both the control and experimental group. After the last week of teaching, students were again given the FCI to answer as post-test likewise the MBT, on two different days. Students answered the post FCI first before answering the MBT the following day. The instructors made sure the students stick to the recommended rules of taking 30 minutes in answering the questions in FCI. The question sheets were collected from students after the 30 minutes. The instructors marked the sheets and recorded the scores as Post FCI.

Mechanics Baseline Test (MBT)

The students in both groups were made to answer the MBT the following day at the same time of meeting after the end of the last lesson. The students were given 45 minutes to answer the MBT after which the sheets were collected, marked and recorded. Also, the means and standard deviations of the pre- and post-FCI and MBT were used to determine whether the peer instruction has had significant impact on students‘ conceptual understanding and insightful problem solving skills in mechanics. [Procedure was adopted from (Antwi, Hanson, Sam, Savelsbergh, & Eijkelhof, 2011)].

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.

Interview

The researcher‘s first interaction with the students in the two groups found out that most of the students‘ participation during physics lessons was not encouraging enough;

students showed a very minimal effort to class discussion during lessons and most had very low marks in their previous class exercises. With that in mind an open interview was scheduled for students to answer concerning their class participation and attitude towards the teaching and learning of Mechanics. Again the interview questions were also administered by the researcher with the experimental group and a resource person (physics teacher) with the control group which was based on the probable causes of poor performance towards the study of Mechanics. The same questions were used in both cases. Students were interviewed in a friendly manner before and after the interventions to enable them respond freely to the interview questions. The interview was organised right after the first lesson with the students in both groups (control and experimental) and another was organised at the end of the last lesson with the students. In all, the researcher selected ten (10) students from the chosen science classes, five from each group.

Procedure of Peer Instruction

In order to understand peer instruction as a teaching strategy, a typical classroom process in which peer instruction is used is discussed in detail. One topic is taken to show the process of peer instruction but was applied in all the selected topics (Forces, Motion and Energy/Work) taught under Mechanics with the experimental group. One topic was chosen based on these assumptions that

- Students have revised on the topic before coming to class.

- Students already had some experience with peer instruction, meaning there was no room for starting problem implying that students are now familiar with peer instruction.
- Students had many conceptual difficulties on the topic which needed to be addressed.

Based upon these, the third meeting was selected for an in depth analysis of the classroom process. In this meeting the following topics were covered:

- Newton's first law of motion.
- Definitions of Force and Mass
- Newton's second law of motion.
- Newton's third law of motion.

The meeting started at 6:40 am, supposedly first and second period, with concept quiz questions on Newton's laws of motion, which were used to test students' understanding on their preparatory reading of the laws. Students present were 30 and the researcher as the teacher.

Concept quiz

Each new topic was introduced by giving a concept quiz to assess the knowledge gained from the reading assignment, so as to motivate students to come prepared all the time. The aim of the design for these questions was that a well prepared student could perform well. Some of the questions were selected from Mazur (1997) shown in Figure 3.2.

(1) Which of these laws is not one of Newton‘s laws?

a. Action is reaction
b. F=ma
c. All objects fall with equal acceleration
d. object at rest stays at rest.

(2) The law of inertia

a. is not covered in the reading assignment
b. expresses the tendency of bodies to maintain their state of motion
c. is Newton‘s third law.

(3) ―Impulse” is

a. not covered in the reading assignment
b. another name for force
c. another name for acceleration

Figure 12: Pre-class reading assignments

These questions were used to detect whether or not students did pre-class reading before coming to class. For statistical analysis, students were asked to raise their hands corresponding to the answer they choose during the discussion of the questions. Correct answers were given and discussed with the students. This procedure lasted for ten minutes before the actual lesson for the day began. Students were then asked to join their group which was designated to them on the first meeting with them on peer instruction. Students were in six groups labelled *A, B, C, D, E,* and *F,* each with five members. Each group appointed one member to give their final explanation to each concept test.

Newton's first law of motion

Newton‘s first law of motion was the first topic in the third lesson after the discussion of the concept quiz questions with students. A brief discussion was made with reference to question one and Newton‘s first law of motion was introduced by projecting the definition of the law on the screen. After this, the law was related to practical examples such as the reaction of passengers when a car suddenly stops or moves in a form of animation projected on the screen.

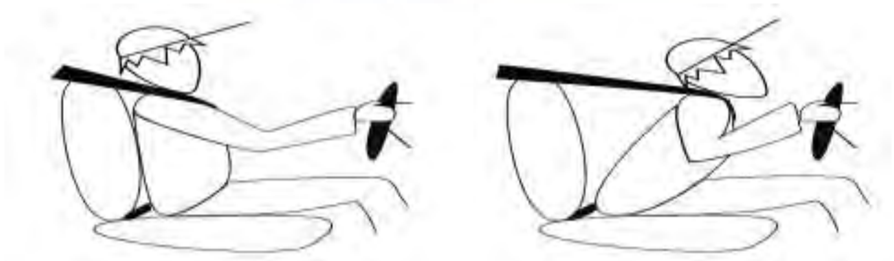


Figure 13: Newton's first law

After, the law of inertia was also discussed with the help of animation which was projected on the screen to solicit more practical understanding of the law.

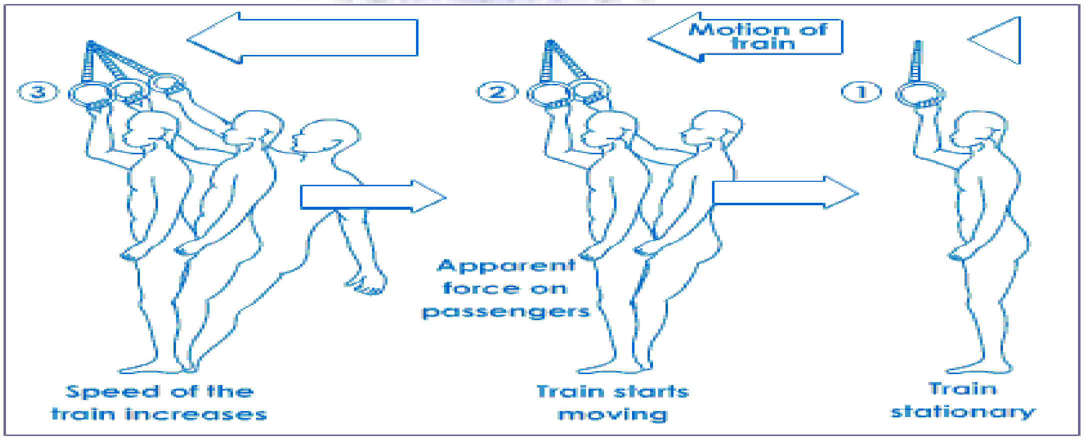


Figure 14: Law of inertia

In establishing the relationship between forces and acceleration, concept test question was posed to students to answer.

A car rounds a curve while maintaining a constant speed.

Is there a net force on the car as it rounds the curve?
1. No—its speed is constant.
2. Yes.
3. It depends on the sharpness of the curve and the speed of the car.

Answer 2: This is because; acceleration is a change in the speed and/or direction of an object. Thus, because its direction has changed, the car has accelerated and a force has been exerted on it.

Figure 15: Concept Test on Newton's first law

After the question was posed, students were given three minutes to answer and record whiles in their various groups but individually. After the one minute students were given another two minutes to discuss the question as a group and convince their colleagues on the choice of answers picked to bring out the correct answer. During this time, the researcher went around to listen to the students as they discussed the question. Next, students recorded the answer which resulted from the discussions and given to one member of the group to present their final answer. For statistical analysis, answers given by the individual groups were recorded.

- Group *'B'* chose the option **1**, representing *16.7%*
- Groups *'A' 'C' 'D' 'F'* chose the option **2**, representing *66.6%*
- Group *'E'* chose the option **3**, representing *16.7%*

From the statistics most of the groups selected the correct answer meaning that most of the students understood the concept under the Newton‘s first law. One member of each of the two groups was picked by the group members to give explanation to their choice of answers. The group members laid down their reasons for the choice of answers which was then discussed with the rest of the class to solicit more understanding.

Students were then asked to reflect on their answers and compare them to the correct answer as well as the explanation. After sometime, students were again asked if they understood the concept and asked questions if there was any problem. All the students agreed they had grasped the concept and that they understand the Newton‘s first law.

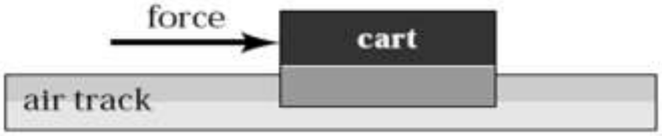
Force and Mass and Newton’s Second Law of motion

Next, the concepts of force and mass, and also Newton‘s second law were explained to the students. The second law was defined for students as well as the relationship between force, mass, speed and acceleration from the formula ‗***F=ma***‘. The types of force were also discussed to give more understanding on force. For a clear understanding, a concept test on force was given to students to answer as shown in Figure 3.6.

The process of peer instruction was repeated; where students were given time to choose the correct answer, discuss the question as a group and select the best answer that fits the question. Later, students were asked to produce their answers as a group. Students‘ answers were recorded for statistical analysis.

- Groups *‘B’, ‘D’* and *‘E’* chose option **2**, representing *50%*
- Group *‘A’* chose option **3**, representing *16.7%*
- Groups *‘C’* and *‘F’* chose option **4**, representing *33.3%*

A constant force is exerted on a cart that is initially at rest on an air track. Friction between the cart and the track is negligible. The force acts for a short time interval and gives the cart a certain final speed.



To reach the same final speed with a force that is only half as big, the force must be exerted on the cart for a time interval________________ that for the stronger force.

1. four times as long as
2. twice as long as
3. equal to
4. half as long as
5. a quarter of

Answer: 2.The final speed is proportional to the acceleration of the cart and the time over which it acts.

Figure 16: Concept Test on Force/Newton‘s Second Law

From the analysis, 50% of the groups representing half of the class chose the correct answer. One member of each of the groups was picked by the group members to give explanation to their choice of answers. Each group gave their reason for the choice of answer and later the right answer was discussed with the rest of the class. Students were then asked to reflect on their answers and compare them to the correct answer as well as the explanation given. After, students were given the opportunity to ask questions if they were not convinced of the answer for more explanations. The class had no problem and agreed that, force, mass and acceleration and their relation to Newton‘s second Law of motion was understood. To be convinced that students understand the second law, another concept test was given to the students to answer. This is shown in Figure 3.7.

A constant force is exerted for a short time interval on a cart that is initially at rest on an air track. This force gives the cart a certain final speed.

The same force is exerted for the same length of time on another cart, also initially at rest, which has twice the mass of the first one. The final speed of the heavier cart is___________________ that of the lighter cart

1. One-fourth
2. Four times
3. Half
4. Double
5. the same as

Answer: 3.The final speed is proportional to both the force on the cart and the time over which it acts, and inversely proportional to the mass of the cart.

Figure 17: Concept Test on Force/Newton's Second Law

Students were given time through the peer instruction processes to provide their answers as a group. Students' answers were recorded for statistical analysis. From the analysis, all the groups selected the option 3 as their answer. This means that 100% was recorded for the second concept test on Newton's second law.

Newton's Third Law

With 100% recorded in the second concept test on the second law, the lesson continued with the introduction of Newton's third law of motion. The law was projected on the screen with practical examples for more understanding of the law. It was emphasised that to every action there is an equal and opposite reaction. This was further explained with a person standing in an elevator. The normal force exerted by the elevator floor on the person is equal and opposite to the weight of the person when the elevator is at rest. When the elevator is accelerating, these two forces are no longer equal because the difference is now being responsible for accelerating the person. This is seen in Figure 3.8.

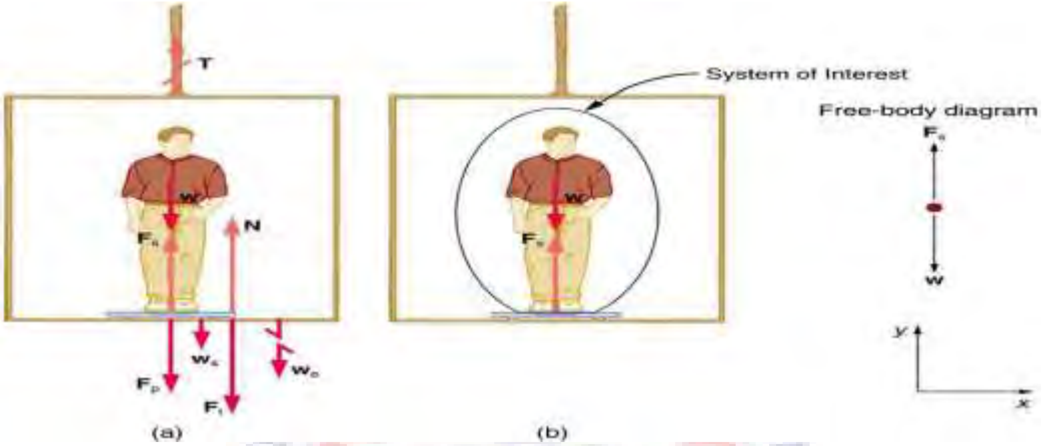


Figure 18: Man in an elevator

It was realised that some of the students had some difficulties in identifying and understanding Newton's third law of motion from real life situation. This was backed by another example; when two people pull on opposite ends of a rope in a tug of war Figure 3.9.

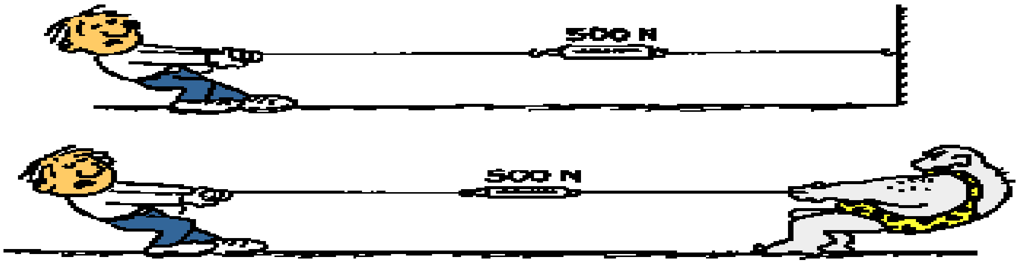


Figure 19: Tug-of-War

This lesson demonstration was quickly followed with a concept test to really test students understanding of the third law.

A person pulls a box across the floor. Which of the following is the correct analysis of the situation?

1. The box moves forward because the person pulls forward slightly harder on the box than the box pulls backward on the person.
2. Because action always equals reaction, the person cannot pull the box- the box pulls backward just as hard as the person pulls forward, so there is no motion.
3. The person gets the box to move by giving it a tug during which the force on the box is momentarily greater than the force exerted by the box on the person.
4. The person's force on the box is as strong as the force of the box on the person, but the frictional force on the person is forward and large while the backward frictional force on the box is small.
5. The person can pull the box forward only if he or she weighs more than the box.

Answer: 4.The force exerted by the person on the box is equal to that exerted by the box on the person. The person moves forward because of a forward frictional force exerted by the floor. The frictional force exerted by the floor on the box is much smaller.

Figure 20: Concept Test on Newton's Third Law

A peer instruction process was repeated for the students to bring the correct answer out. This lasted for 7 minutes. In spite of the conceptual difficulty of this concept test question, it was surprising all the groups except one did not get the correct answer. Group _A' could not give the correct answer, but upon explanation of the question, students quickly grasped the concept. Students were then again instructed to reflect on what has been taught and the concept tests given on the various topics by discussing in groups with their peers to get more understanding of the concepts. Students were given 5 minutes after which they were asked to pose questions on all that they had learnt for that particular lesson. The lesson ended with the researcher going through the salient points with the students for more understanding of the concepts. Although in groups, students gave one particular answer, some members of the groups individually had answers which may be correct or wrong.

The students also had a strong incentive to participate because the midterm and final examination include a significant number of Concept Test-like questions. Learning from reading is a skill well worth developing, particularly because after college, a great deal of ongoing learning takes place through reading.

Data Analysis

Creswell (2008) expressed that, data analysis consists of ―taking the data apart to determine individuals response and putting them together and to summarise it" (p.231). Creswell stated that, analysing and investigating data refers to taking up the response from respondents and drawing final conclusions about it, where conclusions could be clearly seen and explained to any reader, how the conclusions were arrived in words, to provide answers that benefit each research questions raised.

To assess gains in the conceptual understanding of mechanics, we used the force concept inventory (FCI) both as a pre-test and as a post-test. Students had 30 minutes to answer the questions in each case. It has been argued that in order to assess the quality of instruction, the difference between pre- and post-test score is not a good measure, because it will lead to a ceiling effect in initially more proficient students. In an attempt to compensate for this, Hake (1998) proposed a gain score as follows:

$$\langle g \rangle = \frac{(\mathrm{FCIpost} - \mathrm{FCIpre})}{(100 - \mathrm{FCIpre})}$$

Figure 21: Hake's Gain formula

This reflects the actual improvement divided by the initial room left for improvement. Of course, the downside of this metric is that for a high pre-test score (small denominator) it becomes very sensitive to small random differences, but for an assessment at the classroom level, this disadvantage was considered acceptable against the advantage that the Hake gain score allows one to compare results across classes of different ability ranges.

The mechanics baseline test (MBT) was used to assess quantitative problem solving skills. This test was taken only as a post-test because it emphasizes concepts that cannot be grasped without formal knowledge about Mechanics. A correlational analysis was made between the MBT scores and the post-FCI scores to check whether the improvement of students‘ quantitative problem skills correlate with their improvement in the post-FCI scores.

SPSS version 16.0 was used to analyse data from questionnaire to determine any change in attitudes towards the teaching and learning of Mechanics in the form two Science classes. Descriptive summaries were made from the results obtained to establish conceptual change and learning behaviour of students.

The interview was analysed carefully and general conclusions were drawn from the answers given by the majority of the students.

Validity and Reliability

Validity refers to the appropriateness, meaningfulness and usefulness of the inferences researchers make based specifically on the data they collect, while reliability refers to the consistency of scores or answers from one administration of an instrument to another and from one set of items to another (Fraenkel & Wallen, 2009).

For validity of the FCI and MBT, the developers, Hestenes, Wells and Swackhamer (1992) made them available for critiques by physics professors and physics graduate students. FCI and MBT have been used on students over the years which many lecturers and teachers from universities and even senior high schools have also tested for its validity. Reliability of the FCI and MBT indicates that the instrument results are reproducible for a given group of subjects each case, results produced are similar. Thus, the FCI and MBT became standardised tests used all over the world.

In order to achieve the validity of the questionnaire, it was given to the research supervisors for their comments and corrections. The necessary and constructive corrections and suggestions made were taken into consideration. In determining the reliability of the instrument for this study on students‘ attitude towards Physics teaching and learning, as adapted from Martin-Dunlop and Fraser (2007), a pilot test was done with the form two students in a Senior High School. Cronbach alpha value was found to be 0.76, using the SPSS. This suggests that the instrument used in this study was reliable.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSION

Overview

This chapter discusses the details of the study. It presents data analysis and discussion of the results obtained from the study.

Analysis of Data

In this section, we will look at students‛ overall learning results in pre- and post-FCI and MBT, questionnaires and interview scores.

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 indicated in chapter three, 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 2

Hake Gain <g> for Control group and Experimental group

	N	**Mean % Pre-FCI (SD)**	**Mean % Post-FCI (SD)**	**Hake 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 2 shows the Hake 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 0.68, i.e. $0.36 < \langle g \rangle < 0.68$ (Hake, 1988). In comparison, the Hake 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 Hake gain interval. The Hake gain for the experimental group was 0.45 which falls in the medium Hake 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, an independent-sample t-Test was used to analyse the percentage scores between the control and experimental group in the post-FCI test and the MBT.

Table 3

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 3 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 was reflected in the average mean score by the two groups. The mean values for the control and experimental groups in the pre-FCI test were 17.8381 and 18.0181 respectively. 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, the mean values for the control and experimental groups in the post-FCI test were 23.8743 and 54.3243 respectively. The mean values in the MBT test also prove that students who were exposed to peer instruction (experimental group) performed better than students who experienced traditional lecture method approach (control group). This means that peer instruction technique was able to give more understanding of materials taught in the classroom. 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 is recommended as a FCI companion 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 emphasises 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.

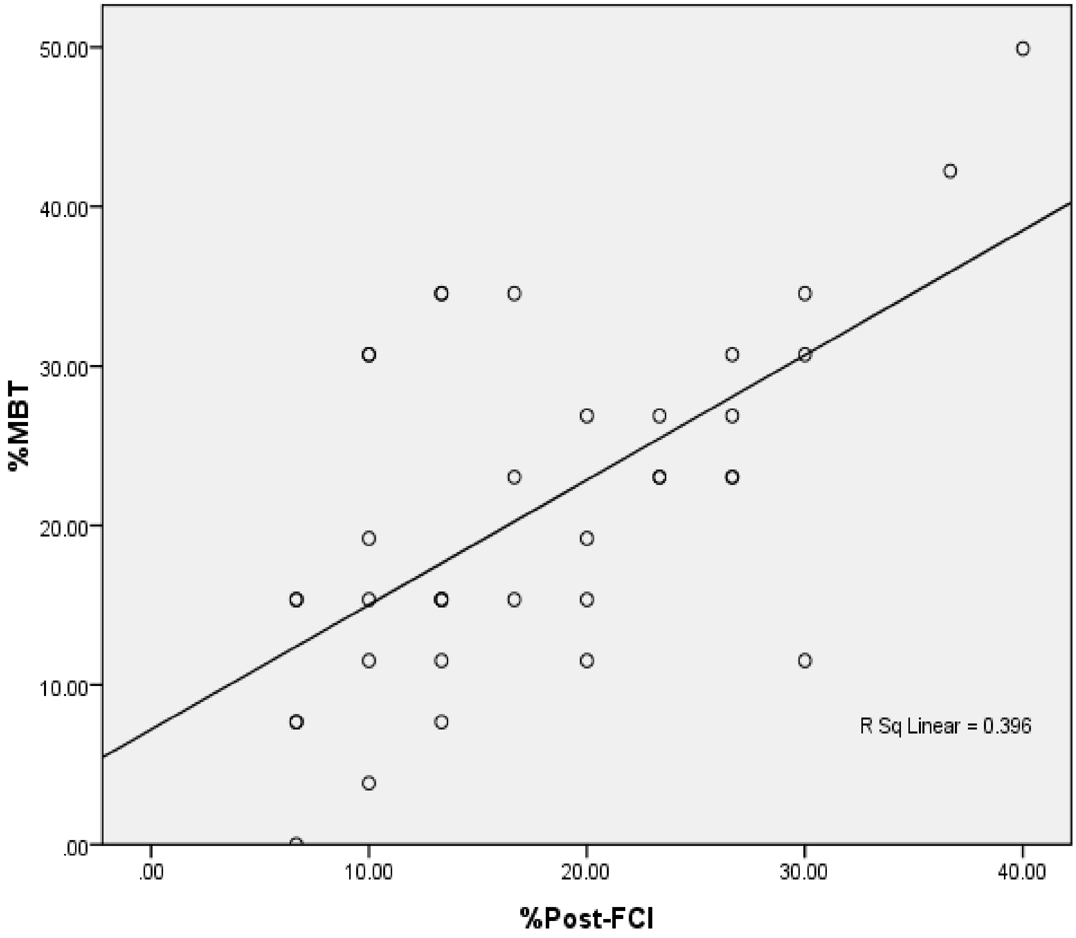


Figure 22: A scatter-plot of %MBT against %Post-FCI (Control)

Figure 22 shows a scatter-plot of MBT against post-FCI of the control group. MBT is designed to measure more quantitative aspects of students understanding than the FCI. This means that if one is able to pass the FCI that one is assured to pass in the MBT. It is given only as a post test. From the graph the resulting R2 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.

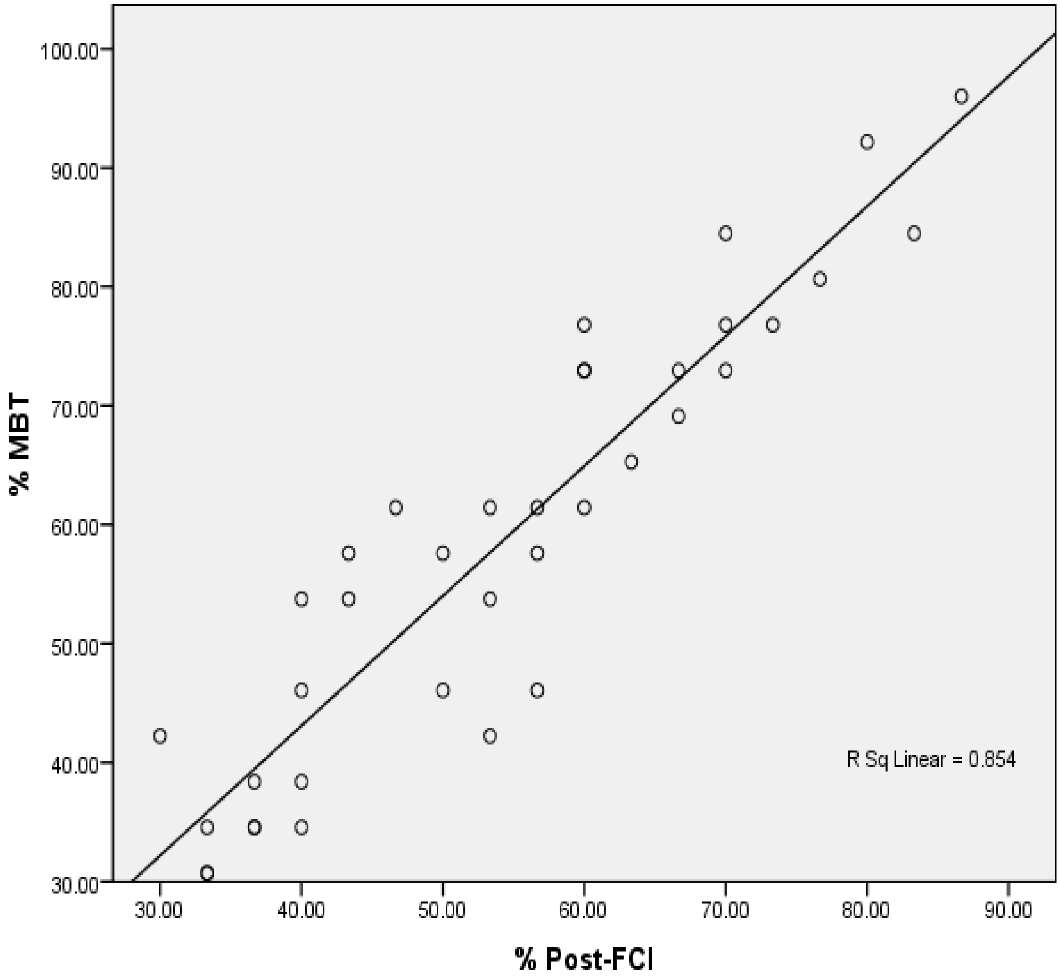


Figure 23: A scatter-plot of %MBT against %Post FCI (Experimental)

Figure 23 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. This is in line with Hake (1998), that the MBT requires conceptual understanding in addition to some mathematical skills and critical thinking.

This indicates that the more students have conceptual understanding; there is the tendency to improve in their quantitative problem skills.

Analysis of data with respect to the Research Question Three

RQ 3: What is the level of conceptual understanding in the teaching and learning of Mechanics of male students compared to their female counterparts in the senior high schools in the Central region?

Results from research question two showed that the use of peer instruction improved students' conceptual understanding in the study of Mechanics, but research question three sought to investigate into the level of conceptual understanding of male students compared to their female counterparts. An independent-sample t-Test was used to analyse if there was difference in the conceptual understanding of Mechanics between the male students and their female counterparts.

Table 4

Performance of Male and Female Students

	Gender of Students	N	Mean	Std. Deviation	Std. Error Mean	Sig. (2-tailed)
Pre-FCI	Male	51	21.04	1.78	1.24	
	Female	23	11.01	0.74	.82	.001
Post-FCI	Male	51	43.07	3.75	2.96	
	Female	23	30.29	2.42	2.53	.000
MBT	Male	51	45.25	3.40	3.58	
	Female	23	28.21	1.23	3.25	.000

*Significant at 0.05, $p<0.05$

Table 4 shows the mean percentage scores of both male and female students in the pre- and post-FCI scores and the MBT scores. The male students are dominating in the pre- and post-FCI and the MBT. In the pre- and post-FCI, the means for the male and female students are 21.04 (SD = 1.78), 11.01(0.74) for pre-FCI and 43.07 (SD = 3.75), 30.29 (SD = 2.42) respectively. This means that the male students performed better in all the tests as compared to their female counterpart. This also goes to confirm that once the male students showed a greater value of the mean in FCI, signifying better understanding of the concepts, they would also perform better in the conceptually based quantitative problems of MBT. This result is reflected in the MBT where the means were 45.25 (SD = 3.40) for the male students and 28.21 (SD = 1.23) for their female counterparts.

Testing of hypothesis with respect to Research Question Three

It was hypothesised that:

H_o2: There is no significant difference between the levels of conceptual understanding in the teaching and learning of Mechanics of male students compared to their female counterparts in the senior high schools in the Central region.

To determine whether there was a statistically significant difference in the level of conceptual understanding in Mechanics of the male students compared to their female counterparts, an independent-sample t-Test was used to analyse the mean scores (Table 4).The analysis presented in Table 4 shows the difference in the level of conceptual understanding in students. The level of significance (thus the p-value) in the pre-FCI, post-FCI and MBT scores showed 0.001, 0.000 and 0.000 (2-tailed) respectively. This means that there is difference in the level of understanding concepts in Mechanics between the male and female students. The male students in the physics classroom had more understanding of concepts in the study of Mechanics than their female counterpart, when the means were compared in Table 4. Also, the male students performed better in the conceptually based quantitative problems of MBT than their female counterpart, because the more you have better qualitative understanding in the Mechanics the more you improve in the quantitative problem skills. Therefore, it was concluded that there was a statistically significant difference in the level of conceptual understanding in the study of Mechanics of male students compared to their female counterparts in the senior high schools in the Central region. The second null hypothesis (H_o2) was thus rejected in this case.

Analysis of data with respect to the Research Question Four

RQ 4: 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 was 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 impression about 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 impression 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 5

Pre- and Post-responses on Students' Attitude

		Pre/Post	N	Mean	Sig.	Std. deviation
Students' attitude	Control	Pre	37	2.08		
	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 5, 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, an independent sample t-Test analysis was used in both cases. From Table 5, 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 ($p\text{-value} < 0.05$). 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.

Analysis of the Interview

Interviews were organised for students to find out reasons to their performance and attitude towards physics lessons. Some of the reasons which arose from the interviews with students before the intervention were as follows:

- Students admitted that they lacked the necessary skills to approach Mechanics questions and that they solved questions through memorization of formulas and equations. This in their own context suggests that if the questions are framed to demand critical thinking they will not be able to break the question down step by step.
- Students complained that most of the physics lessons were taught theoretically. Thus students admitted they were always imagining what they were being taught in the abstract form making it difficult for students to relate it to the physical world.
- Students claimed that they were not given enough class exercises and assignments regularly making it difficult for them to answer questions during their terminal exams leading to their failure in the subject.

- Teaching and learning materials like charts, physical materials (experimental apparatus) and diagrams were not used during physics lessons. Cushen (1996) indicates that teaching and learning resources are materials which will increase pupils‘ interest and enrich their comprehension of concept.

After the intervention the same students were interviewed again to find out if there has been change in their attitude towards the teaching and learning of Mechanics. Students in the experimental group (i.e. students who were exposed to peer instruction) gave a more positive response to the questions being asked than the students in the control group (i.e. students who experienced the traditional lecture method). Responses which arouse from the experimental group were that

- Students again indicated that the use of the concept tests in the peer instruction gave them proper explanation to what is being taught than the pre-conception they had on the same topic.
- Students also made it clear that the use of diagrams and animations helped them to relate the concepts in Mechanics to real life situations. This made them become more interested in the study of Mechanics because it was easier to understand what was being taught.
- Students admitted that the interaction with their fellow mates in the form of peer instruction when the questions were asked gave them the confidence to ask any question to solicit more understanding compared to asking the teacher.
- Finally students admitted that peer instruction had wiped misconceptions they had to its minimum and the teaching strategy has actually improved the conceptual understanding in Mechanics likewise their academic performance.

Although students in the experimental group gave more positive answers, students in the control group were still with the view that Mechanics was difficult to learn. Students also indicated that imagination of the concepts in the abstract form was still the order for the day which made it difficult to understand the concepts in Mechanics.

Discussion of Results

The study was to use peer instruction as an effective instructional teaching approach to enhance students‘ conceptual understanding and academic performance in Mechanics. It yielded some information about the effect of peer instruction on students‘ academic performance at the senior high school level. In the earlier part of this chapter, findings were mainly presented and analysed on the specific research questions with only brief comments on them. In this part however, the findings have been discussed in detail under the research questions set to guide the study.

Findings with respect to research question one was positive in that the performance of the group exposed to peer instruction (experimental group) was better in the post-FCI and MBT than it was in those who received traditional lecture method (control group). Reviewing from Table 2, it was realised that the difference in pre- and post-FCI scores in the experimental group was statistically significant compared to the control group. The average normalised gains (Hake Gain) calculation with the control group (0.07) fell below Hake‘s low-g of (0.3) whiles that of the experimental group (0.45) fell within Hake‘s medium-g. This means that the use of peer instruction impacted significantly on students‘ academic performance. The findings of this study does not support the research hypothesis that there is no significant difference in academic performance of senior high school students in the central region using peer instruction in the study Mechanics. This is because; the p-value gave significance at 0.000 which meant that the research hypothesis was overruled. The findings are in line with what Ezeugwu (2007) stated that teachers instructional method can greatly influence students achievement of acquisition skills. The results were also in line with Crouch and colleagues on what they discussed in their work when they used peer instruction as an interventional tool to improve students‘ performance at Harvard University (Fagen, Crouch, Yang, & Mazur, 2000). Peer Instruction has been extensively used at Harvard University, and its success at increasing student understanding in physics courses has been documented extensively (Mazur & Crouch, 2001). Mazur and Crouch (2001) continued to support the claim that ―informal conversation with many other institutions suggests that peer instruction has been very successful at a wide range of schools, from community colleges to large state universities to elite private colleges". Based on the strength of the findings of the study a strong case can be made in favour of incorporating peer instruction in the study of Mechanics and Physics in general at the Senior High School level.

With respect research question two, the results indicated that there was a positive relationship between students‘ conceptual understanding and their quantitative problem solving skills. The MBT is recommended as a FCI companion because it is used in assessing quantitative problem solving skills among students (Antwi, Hanson, Sam, Savelsbergh, & Eijkelhof, 2011). A scatter-plot graph of MBT against post-FCI was drawn to see the relationship between the two for both control and experimental group. From Figures 22 and 23, it is seen that if students are able to perform well in the FCI, there is high probability of the students performing well in the MBT. This is in line with Hake, that the MBT requires conceptual understanding in addition to some mathematical skills and critical thinking. This indicates that the more students have conceptual understanding; there is the tendency to improve in their quantitative problem skills. In support of research question two, Antwi, Hanson, Sam, Savelsbergh, & Eijkelhof (2011) showed the relationship of %MBT against %Post-FCI in their study. As the %Post-FCI increases, %MBT also increases. This suggested that as one improves in a more qualitative-problem of FCI, there is the likelihood for the person to improve as well in the more quantitative problem-solving MBT (Antwi, Hanson, Sam, Savelsbergh, & Eijkelhof, 2011). His 1991 students showed improved performance, suggesting improved conceptual understanding led to improve problem-solving skills through the use of peer instruction (Mazur, 1997).

Results acquired from research question three rejected the null hypothesis that there is no significant difference between the levels of conceptual understanding in the study of Mechanics of male students compared to their female counterparts in the senior high schools in the Central region. The male participants improved significantly in their level of conceptual understanding compared to the female participants. The p-value gave 0.000 for all the three tests which meant that there was a significant difference between the levels of conceptual understanding in the study of Mechanics of male students compared to their female counterparts therefore the second hypothesis ($\boldsymbol{H_o2}$) was rejected.

The findings of the study do not agrees with Whitten, Foster and Duncombe (2003) who asserted that research on retention of female students in the physical sciences suggests that interactive teaching methods, a non-competitive atmosphere, and a conceptual emphasis should all make a course more welcoming to female students. They found out in their study that male students outperformed female students on the Force Concept Inventory post-test when the course was taught traditionally, and also performed well when the course was taught with peer instruction. Furthermore, in the traditionally taught course there were many female students who scored below 60% on the Force Concept Inventory post-test and relatively few who scored above 85%; in the interactive course, there were no female students (and only a couple of male students) who scored below 60% and nearly the same percentage of female students as male who scored above 85% (Whitten, Foster, & Duncombe, 2003). The results in the research question three are similar to a report by Lorenzo, Crouch, and Mazur when in their study at Harvard University saw that effect of pedagogy on the gender distribution of final grades brought difference. In all the three graphs showed in their study, the percentage of males receiving the highest grade of an A is consistently higher than the percentage of females in traditional taught course; however, this gap reduces as Peer instruction was used (Crouch, Watkins, Fagen, & Mazur, 2007).

Finally, results with respect to research question four indicated that the use of peer instruction impacted positively on the students‘ attitudes towards the teaching and learning of Mechanics. Philip Sadler has established that students often require a period of adjustment to new methods of instruction before their learning improves. In the same fashion, when learning a new way to grip a tennis racquet, a tennis player is likely to play worse at first, and improve only after becoming comfortable with the new (and presumably better) grip (Sadler, 1998). This makes students find it difficult to adjust to new method of teaching but get more involved when the effect of the new teaching method impacts positively on them. In assessing students‘ attitude towards the study of Mechanics before the two interventions (Peer Instruction and traditional method of teaching) students had a negative attitude towards the teaching and learning of Mechanics. The mean scores before the interventions in both control and experimental group showed almost the same, 2.08 and 2.07 respectively. The post-intervention results brought difference in students‘ attitudes. There was statistically significant difference in their attitudes towards the study of Mechanics after they were exposed to the two different interventions with significance (p-value) of 0.000. In the control group, the difference was not felt because the traditionally taught course could not impact well on students‘ attitudes towards the study of Mechanics. Student attitudes to a course taught with peer instruction, as measured by student evaluations and by our interactions with students, have differed (Crouch, Watkins, Fagen & Mazur, 2007). In introducing peer instruction in teaching of Mechanics, written comments on evaluations indicated that the majority of the students‘ attitude changed positively and appreciated the peer instruction approach to the course learning. These findings are in line with the research conducted by Mazur (1997) where he stressed that most of his students showed positive attitudes after they were exposed to peer instruction in Physics taught courses.

CHAPTER FIVE

SUMMARYOF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

Overview

This chapter focuses on the summary of the study, conclusion and recommendations based on the findings of the study.

Summary of Findings

This research was primarily designed to find out the impact of two different methods of teaching (peer instruction and traditional lecture method) to enhance students‘ conceptual understanding in Mechanics among Senior High School students in the Central region of Ghana. From the study it was found out that the academic performance of students who were exposed to peer instruction method of teaching improved significantly compared to students who were exposed to traditional lecture method of teaching. This can be associated to the fact that, students were allowed to discuss among themselves concepts being taught.

Students‘ problem solving skills were determined through the analysis of MBT scores and the post-FCI scores. The graphs showed that students‘ quantitative problem skills were increased because after the introduction of peer instruction students post-FCI scores increased as well as the MBT unlike the students who were exposed to the traditional lecture method. This indicates that the MBT requires conceptual understanding in addition to some mathematical skills and critical thinking. This indicates that the more students have conceptual understanding; there is the tendency to improve in their quantitative problem skills.

Again, it was found out that the male students had a good conceptual understanding of physics before and after intervention although they all performed better in the post-intervention test. The p-value of significance 0.000 proves that there was statistically significant difference between the level of conceptual understanding between male students and their female counterparts in the study of Mechanics.

Student‘s attitude towards the study of Mechanics was also addressed. After the implementation of Peer Instruction, it was found that students attitude was changed not like before the intervention when they felt learning Mechanics was difficult. In the control group, there was no significant difference in their attitude in teaching and learning of Mechanics when traditional method of teaching was used on them. Thus, the students‘ interests and attitudes towards the teaching and learning of Physics, and their learning environment significantly improved after their exposure to peer instruction teaching strategy than the traditional teaching strategy.

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 most 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, it is recommended that;

- 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. These were the various combination of peer instruction. Through that the academic performance of students were increased in this study. 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 and improve students‘ academic performance.
- From this study it was concluded that the use of Peer Instruction increased the conceptual understanding and problem solving skills 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.

- Although the male students performed better than the female students in this study, there was still an improvement in the performance of the female students. It is therefore recommended methodologies in teaching should be varied to cater for especially female students.
- Teachers are also advised to use varied methods of teaching that would satisfy individual ability and also make provisions for regular class exercises, project/group work, educational trips and other practical activities to make the study of Physics more real, interesting and meaningful to students. Through that students could have positive attitudes towards the learning of Mechanics and Physics in general.

Recommendations for Further Research

Reflecting on the findings of this study, the following recommendations are made for further research with respect to the use of Peer Instruction in Physics teaching:

- The sample size was quite small due to the focus of this study. It would be worthwhile to also investigate how to deal with a large setting when using peer instruction to provide a basis for more generalisations of the conclusions drawn from the findings of the study about the effectiveness of peer instructional packages in the teaching and learning of Mechanics as well as Physics in general.
- Future study should not limit to short period but should conduct peer instruction process for more than eight weeks to see the long term impacts of the use of peer

instruction in the teaching and learning of Mechanics as well as Physics in general.

- Finally, though the use of peer instruction was studied in Mechanics and had a good learning effect on students, it would be important to explore effective ways of applying this approach to different disciplines.

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APPENDIX 1

STUDENTS’ ATTITUDE QUESTIONNAIRE (SAQ)

FORMAT

This questionnaire is aimed at soliciting your views and opinions on how Mechanics teaching and learning is done in our 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.					

APPENDIX 2

Interview Sample

Interview guidelines:

1. What new things have you gained from some of the lessons?
2. How did you participate in the interactive activities?
3. What is your opinion about the activities in the lessons? Difficult or not?
4. How could your learning be supported?
5. Given the list of interactive engagement approaches/activities,
   - i. Which one do you like best and why?
   - ii. Which one do you like the least and why

APPENDIX 3

Concept Test Sample

1. A constant force is exerted on a cart that is initially at rest on an air track. Friction between the cart and the track is negligible. The force acts for a short time interval and gives the cart a certain final speed.

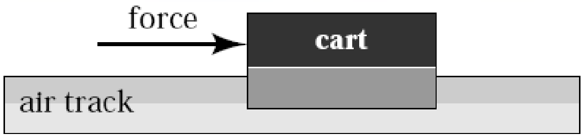
To reach the same final speed with a force that is only half as big, the force must be exerted on the cart for a time interval

1. four times as long as 2. twice as long as 3. equal to

4. half as long as 5. a quarter of

that for the stronger force.

2. A constant force is exerted for a short time interval on a cart that is initially at rest on an air track. This force gives the cart a certain final speed. The same force is exerted for the same length of time on another cart, also initially at rest, that has twice the mass of the first one. The final speed of the heavier cart is



1. one-fourth

2. four times

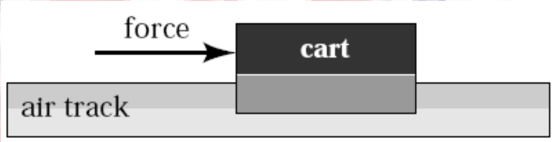
3. Half

4. Double

5. the same as

that of the lighter cart.

3. A constant force is exerted for a short time interval on a cart that is initially at rest on an air track. This force gives the cart a certain final speed. Suppose we repeat the experiment but, instead of starting from rest, the cart is already moving with constant speed in the direction of the force at the moment we begin to apply the force. After we exert the same constant force for the same short time interval, the increase in the cart's speed



1. is equal to two times its initial speed.
2. is equal to the square of its initial speed.
3. is equal to four times its initial speed.
4. is the same as when it started from rest.
5. cannot be determined from the information provided.

4. Consider a person standing in an elevator that is accelerating upward. The upward normal force N exerted by the elevator floor on the person is

1. larger than

2. identical to

3. smaller than

the downward weight *W* of the person.

5. A person pulls a box across the floor. Which is the correct analysis of the situation?

   1. The box moves forward because the person pulls forward slightly harder on the box than the box pulls backward on the person.

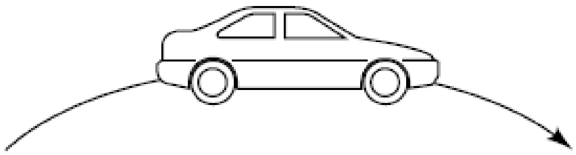
   2. Because action always equals reaction, the person cannot pull the box- the box pulls backward just as hard as the person pulls forward, so there is no motion.

   3. The person gets the box to move by giving it a tug during which the force on the box is momentarily greater than the force exerted by the box on the person.

   4. The person's force on the box is as strong as the force of the box on the person, but the frictional force on the person is forward and large while the backward frictional force on the box is small.

   5. The person can pull the box forward only if he or she weighs more than the box

6. A car rounds a curve while maintaining a constant speed. Is there a net force on the car as it rounds the curve?



   1. No—its speed is constant.

   2. Yes.

   3. It depends on the sharpness of the curve and the speed of

      the car.

7. In the 17th century, Otto von Güricke, a physicist in Magdeburg, fitted two hollow bronze hemispheres together and removed the air from the resulting sphere with a pump. Two eight-horse teams could not pull the halves apart even though the hemispheres fell apart when air was readmitted. Suppose von Güricke had tied both teams of horses to one side and bolted the other side to a heavy tree trunk. In this case, the tension on the hemispheres would be

   1. twice 2. exactly the same as 3. half

   what it was before.

8. You are pushing a wooden crate across the floor at constant speed. You decide to turn the crate on end, reducing by half the surface area in contact with the floor. In the new orientation, to push the same crate across the same floor with the same speed, the force that you apply must be about

   1. four times as great

   2. twice as great

   3. equally great

   4. half as great

   5. one-fourth as great

   as the force required before you changed the crate‘s orientation.

9. An object is held in place by friction on an inclined surface. The angle of inclination is increased until the object starts moving. If the surface is kept at this angle, the object

1. slows down
2. moves at uniform speed
3. speeds up
4. none of the above

10. You are a passenger in a car and not wearing your seat belt. Without increasing or decreasing its speed, the car makes a sharp left turn, and you find yourself colliding with the right-hand door. Which is the correct analysis of the situation?

    1. Before and after the collision, there is a rightward force pushing you into the door.

    2. Starting at the time of collision, the door exerts a leftward force on you.

    3. both of the above

    4. neither of the above

11. Consider a horse pulling a buggy. Is the following statement true?

    The weight of the horse and the normal force exerted by the ground on the horse constitute an interaction pair that are always equal and opposite according to Newton‘s third law.

    1. yes

    2. no

12. Consider a car at rest. We can conclude that the downward gravitational pull of Earth on the car and the upward contact force of Earth on it are equal and opposite because

1. the two forces form an interaction pair.

2. the net force on the car is zero.

3. neither of the above

APPENDIX 4

Force concept Inventory (FCI) and Mechanics Baseline Test (MBT)

This was a revised version of the FCI and MBT by I. Halloun, R. R. Hake, and E. P. Mosca, which is available as a pdf file at the site of authorized educators, (http://www.modelling.asu.edu/R&E/researchhtml).