Teaching Methods and Students' Academic Performance in Kinematical Motion: Graphical Interpretation and Conceptual Understanding

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ABSTRACT

The study investigated the differential effectiveness of teacher-centered , student-centered and teacher-student interactive instructions on students' academic performance in kinematical motion particularly in conceptual understanding and graphical interpretation. A sample of 112 first year physics undergraduate PHY110 students of MUCE was used for the study. The design adopted in the study was a Quasi- Experimental Design (non-randomized pre-test and post-test control group design). The instrument used in gathering data for the study was survey questionnaire and a combination of GIST and MCT. The internal reliability coefficient of the test was 0.74 using Kuder Richardson Formula-20 (KR-20). One way ANOVA test were used for statistical analysis. The one way ANOVA technique, $F(2, 93) = 0.316$, $p > 0.05$) and the Tukey HSD post-hoc results indicated no significant differences on the effectiveness of the three teaching methods. However, the mean scores results demonstrated that teacher-student interactive method group had relatively higher academic performance and was thus the most effective teaching method, followed by student-centered method while the teacher-centered approach was the least effective teaching method.

Keywords: *Kinematical, Teacher-centered, Student-centered, Teacher-student interactive, Teaching methodology and academic performance.*

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Highlights of this paper

- The study investigated the differential effectiveness of teacher-centered, student-centered and teacher-student interactive instructions on students' academic performance in kinematical motion particularly in conceptual understanding and graphical interpretation.
- The mean scores results demonstrated that teacher-student interactive method group had relatively higher academic performance and was thus the most effective teaching method, followed by student-centered method while the teacher-centered approach was the least effective teaching method.

ABBREVIATIONS AND ACRONYM

ANOVA: Analysis of Variance.

ECZ: Examination Council of Zambia.

GIST: Graphical Interpretation Skill Test.

KNEC: Kenya National Examination Council.

MCT: Motion Content Test.

MUCE: Mufulira College of Education.

PER: Physics Education Research.

PHY110: First year undergraduate physics introductory course.

TUG-K: Test of Understanding Graphs in Kinematics.

1. INTRODUCTION

1.1. Overview

This chapter describes the background of the study, statement of the problem, purpose of the study, objectives of the study, research question for guiding the study, research hypothesis, significance of the study, assumption of the study, scope of the study, limitations of the study and definitions of the research terms.

At both secondary school, college and university level, physics is taught under so many topics such as measurements and mechanics, just to mention a few. However, mechanics occupies an important space amongst other domains of general physics (Mesic, 2015). Carson and Rowlands (2005) consider mechanics as the entry point to scientific thinking whose understanding is essential for physics as a whole. According to Carson and Rowlands (2005) *kinematics* is a sub-domain of Mechanics which describes motion of points and bodies without considering mass of each or forces that cause motion. However, *motion* is the action of changing location or position whereas the study of motion without regard to the forces or energies that may be involved is called Kinematics. However, the importance of teaching and learning kinematics cannot be over emphasized as kinematics is one of the first topics taught in secondary schools, colleges and universities in introductory physics. It is mainly about the concepts of motion that include position, velocity, and acceleration and time. Kinematics endeavors to describe motion graphically and mathematically using equations. Using graphical analysis, one can visualize motion of an object. Graphs are frequently used because they offer a valuable alternative to verbal and algebraic descriptions of motion and avails students an opportunity of another way of manipulating the developing concepts.

Graphs are a summary of a functional relationship between variables. Therefore, it is important that teachers incorporate graphs to reinforce interpretational skills and develop a deeper understanding of physics concepts especially in kinematical motion. Furthermore, kinematics is a foundational topic of physics (www.spung.com), which anchors concepts which must be well taught and be mastered by students for good performance in subsequent physics topics.

1.2. Challenges Faced by Students

Research indicates that students have trouble with graph even when they understand the mathematical concepts (Hale, 2000). Researchers in both mathematics and science have closely examined some misconceptions underlying students difficulties in interpreting kinematics graphs. In this study the researcher discusses the common problems faced by students in interpreting kinematics graphs as cited by Hale (2000) discriminating between slope and height of a graph and relating one type of graph to another. Finally, the four important equations of uniformly accelerated linear motion are also discussed.

1.3. Discriminating between Slope and Height of Graph

It was observed that students have to a tendency to respond incorrectly by giving height of the graph at the point instead of the slope of the graph. Hale (2000) made similar observations and conceded that this kind of response is a simple mistake caused by misreading and not a misconception by the student. For example, Hale cites McDermott *et al.* (1987) who asked students to indicate which object had the greater velocity at time $t = 2s$ in Figure 1 Obviously, the majority of the students incorrectly chose object B.

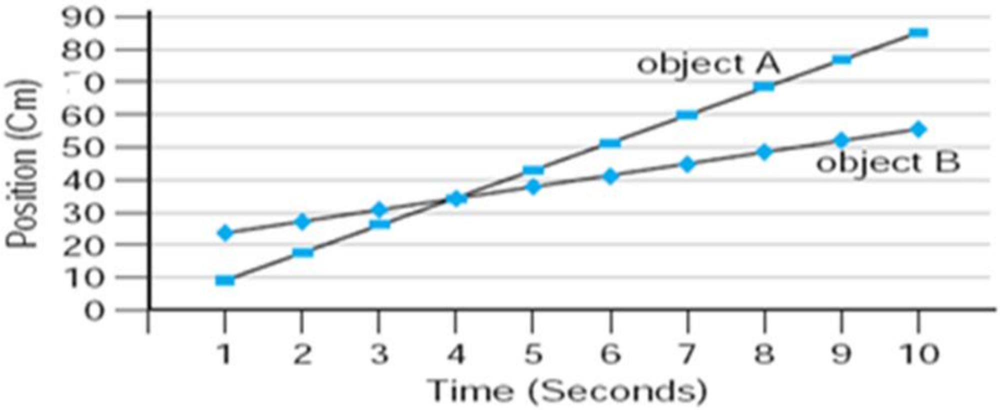

Figure-1. Position- versus- time graph.

Source: Hale (2000).

Such an error could be due to misreading either axis. The error is not an indication of students misconception. In a like manner, Carl, a college student who correctly read the axis but was misled by not only principles from his own experience but also visual qualities of the graph that supported his principles to respond incorrectly to a similar question. In this case Carl was asked to describe the distance between two cars after time $t = 5s$ as shown in Figure 2.

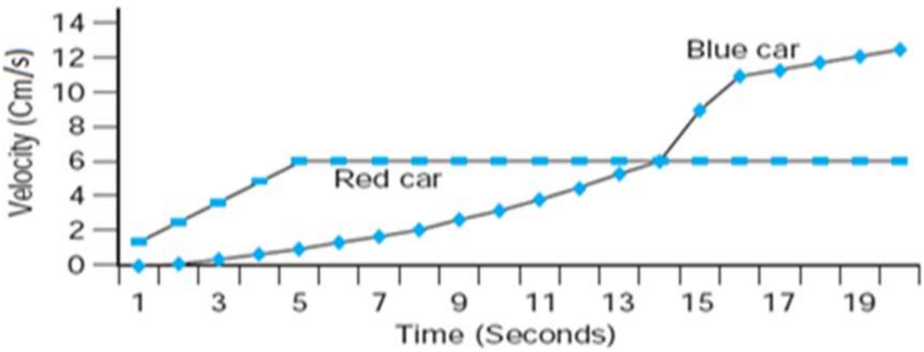

Figure-2. Velocity- versus- time graph.

Source: Hale (2000).

In quoting Monk (1994) on Carl's reasoning, Hale (2000) adopted the following principles:

- The *acceleration principle*: if the blue car is behind the red car and is accelerating very rapidly while the red car is not accelerating at all, then the blue car will get closer to the red car.
- The *speed principle*: if the red car is ahead of the blue car at time t_o and the red car is going faster than the blue car, then the red car will stay ahead of the blue car and will actually get farther ahead of the blue car.

Therefore, Hale concluded that students' difficulties are deeply rooted in their conceptions of kinematics variables such as acceleration and speed which are by and large influenced by personal experience.

In addition, Beichner (1994) observed a consistent set of student difficulties with graphs of position, velocity and acceleration versus time. The difficulties included misinterpreting graphs as pictures, slope/height confusion. Beinchner further observed the problems students face in finding the slopes of lines not passing through the origin and the inability to interpret the meaning of the area under various graph curves.

1.4. Relating One Type of Graph to Another

Experience has shown that students often mistake a position-time graph of a moving object to a velocity-time graph of that object. Further, research by Nemirovsk and Rubin (1992) and Brasell (1987) also indicate that students often expect the position graph of an object to be similar to the velocity graph of the same object.

In conclusion, it must be noted that students come to a either a physics or mathematics classroom with their own understandings of velocity, acceleration, and distance that are that are based on their experiences.

1.5. Equations of Motion

The following are the four equations of motion;

$$(1)\ v = u + at$$

$$(2)\ s = \left(\frac{v+u}{2}\right)t$$

$$(3)\ s = ut + \frac{1}{2}at^2$$

$$(4)\ v^2 = u^2 + 2as$$

These equations apply to uniformly accelerated linear motion of objects. The equation relate to distance covered (s) to the time taken(t) whereas u is the initial velocity and v is the final velocity. However, most text-books present these equations without showing where they originate from. Perhaps this is a reason why students have problems of choice when it comes to choose the equations which best suits the solution for a particular conceptualor numerical problem.

1.6. Performance

In a 2006 (www.researchgate.net) baseline survey conducted in Zambia indicated that many learners thought kinematics was an easy topic. This was contrary to the actual results in the examinations and the experience of the researcher who for thirteen years in teaching physics has seen kinematics as being troublesome to both secondary school, college and university students. In college examinations in France , students struggle to answer questions on kinematics (https:www.totalregistration). In Kenya, questions on kinematics have been poorly performed over the years. Sogoni (2017) attributed the poor performance in kinematics in Kenya to conventional teaching methods (teacher centered) that were being used by teachers. This assertion is similar to the assertion by Banda *et al.* (2014) in which he claims that the poor science results in Zambia are due to traditional methods (teacher centered) of teaching employed by teachers.

1.7. Teaching Methods

Tababal and Kahssay (2011) writes, " The purpose of teaching at any level is to bring a fundamental change in the learner. Such changes may be in the form of acquiring intellectual skills, solving problems and inculcation of desirable attitudes and values. Teachers adopt different approaches to help students to acquire Knowledge, skill and experience. Textbooks work example problems to illustrate concepts and principles, to demonstrate procedures, and to clarify points of likely confusion." These different approaches in this study are referred to as teaching methods. However, there are several teaching approaches but for the purpose of this research the researcher condensed them to the ones explained below. *Teacher- centered method* is sometimes referred to as traditional or conventional method. Under this instruction, the task of delivering materials in the teaching and learning process lies with the instructor (teacher or Lecturer). Students play a little role in preparing, analyzing and evaluating the materials. This approach is a teacher-centered in that the teacher dominates in the teaching and learning process. Research evidence suggests that students who are taught physics by traditional methods fail to learn essential physics concepts (Tababal and Kahssay, 2011). In line with this, Hake (1998) reported that traditional teaching approach is characterized by lectures requiring little or no active student involvement, labs with prescribed practical procedures and tests or examinations emphasizing quantitative algorithmically solving procedure. In this approach the main focus is to get students to perform well in promotion examinations rather than other motivation to learning such as innovations and skills to think (Zohrabi *et al.*, 2012). Furthermore, teachers or lecturers usually used particular textbooks which sometimes are largely knowledge oriented and just compare examination questions and solutions and answering examination questions though rote memorization is of more emphasis than acquisition of process skills and training. In this case students tend to be more competitive and selfish hence miss an opportunity to interact and innovate (Acat and Dönmez, 2009). Teachers or lecturers are more dominant sources of information, for instance, all questions posed by students, if any, are answered directly by teachers without students involvement. In terms of class activities, teachers control all learning experiences. However, other scholars argue that teacher-centered method is suitable for large class sizes, it takes shorter time to do class activities, learning materials can be well prepared, teachers may feel more confide (Nagaraju *et al.*, 2013). All in all, in teacher-centered method, the primary task of a teacher is to transfer knowledge to learners.

Research evidence has shown that *student-centered methods* are inspired by the sense of discovery learning and active learning (Tababal and Kahssay, 2011). This approach to teaching is more flexible and encourages learners to enhance their research and thinking skills and as such students assume responsibilities that increase interest in learning physics and subsequently promote conceptual reasoning. Therefore students' work is more important as it depicts the students learning process and quality of the learning product. However, the teaching and learning of physics using this approach links well with flexible learning, experiential learning, and self –directed learning (Acat and Dönmez, 2009).

The *teacher-student interactive method* is a blend of two teaching instructions: the teacher- centered and student-centered. Ganyaupfu (2013) recognizes the sentiments by Jacoby (1978), McDaniel *et al.* (1978) that subject information produced by the learners is remembered better than the same information presented to the learners by the lecturer. The method encourages the students self-search for relevant knowledge in contrast to lecturers' dominion over the dissemination of information to the learners. Perhaps, it is the reason why research evidence on teaching approaches maintains that this teaching method is effective in improving students' academic performance as observed by Damodharan and Rengarajan (1999).

However, this study endeavors to compare the effectiveness of teacher-centered, learner-centered and teacher-student interaction methods in the teaching of kinematical motion, in both graphical interpretation and conceptual understanding at Mufulira College of Education (MUCE).

Establishing a more effective teaching method in the teaching of kinematics could possibly offer a solution to poor performance in physics. As some research have indicated that poor academic performance in kinematics which in turn affect overall performance in physics is due to use of ineffective teaching methods such as teacher-centered method. Saga (2015) tells us that if the existing strategy of teaching is not yielding results, then, other teaching strategies should be adopted. In view of this, there is need for a paradigm shift to using methods that are appropriate, relevant and effective to the subject. Saribas (2009) is alive to the fact that when appropriate learning methods are used, the learners develop proper attitudes and skills during the learning process. Hence there is need to change from the conventional way of teaching kinematics to ones that are effective.

1.8. Statement of the Problem

Poor academic performance in kinematical motion in physics by the majority students at higher education level has mainly been cited to be a product of employment of ineffective teaching methods such as lecture methods by teachers or lecturers (Sogoni, 2017). Some teaching methods are not only contextually relevant to the subject matter and topic but also effective in imparting the necessary manipulative and interpretive skills as well as thinking and problem solving skills. In the teaching of science, physics in particular, strategies that involve critical thinking and generation of innovative minds need to be employed. Unfortunately, the teaching of physics in Zambia is mainly theoretical and talk and chalk, with less hands on activities and more less methods that directly engage the student in order to capacity build the ability to think and solve problems independently (Mwanza and Mvula, 2014). It must be noted that graphing is one of crucial ingredients to the understanding or description of kinematical motion which is a sub-topic of mechanics. So far there is research evidence showing that Zambia is moving towards learner centered conduction of science lessons in secondary schools but there is nothing on science lectures in colleges and universities the researcher came across. In particular, no studies have been done on effective teaching of kinematics at MUCE with regard to learner-centered, teacher-student interaction and teacher-centered method. In a quest to try and find a better a solution to the understanding of kinematics, the researcher decided to subject the undergraduate PHY110 students to the afore mentioned instructions with a hope to establish the most effective teaching method in the teaching of kinematics in physics at MUCE.

1.9. Purpose of the Study

The purpose of this study was to investigate which approach, student-centered , teacher-student interactive or learner-centered, was the most appropriate in teaching kinematical motion particularly concepts and graphical representation and interpretation to establish which approach produces higher student's performance as measured by individual test scores at the end of the instruction.

1.10. Research Objective

The primary objective of this study was to investigate whether there are significant differences in the effectiveness of learner-centered, teacher-student interactive and teacher-centered instructions on students' academic performance in kinematics.

1.11. Research Question

Are there any significant differences between the mean scores in kinematics test among learner groups treated with a learner-centered, teacher-student interactive and teacher-centered instructions respectively?

1.12. Hypothesis

Null Hypothesis (Ho)

1. *There are no significant differences between the effectiveness of learner- centered, teacher-student interactive and teacher-centered instructions on students' academic performance in kinematics.*

Research Hypothesis (H_1)

1. *There exist significant differences between the effectiveness of learner centered, teacher-student interaction and teacher centered instructions on students' academic performance in kinematics.*

1.13. Significance of the study

The results of this study will provide useful insights to the lecturers, teachers and the ministries of Higher and General Education respectively on the differential effectiveness of teaching methods on students' academic performance in kinematics. In addition, academicians and scholars will use the study as a source of information regarding the effective learning of kinematics. Finally, the study will add value to the literature on methods of enhancing learning of kinematics among college students.

1.14. Assumptions of the Study

The assumptions of the study were that:

i. The teaching period was the same in all the groups as the post test in kinematics was to be administered on the same day.
ii. Students were not familiar with learner-centered learning techniques such as cooperative learning and as such they needed to be inducted on what to do in this learning process.

1.15. Scope of the Study

The study was focused to investigate students' academic performance in kinematics when taught using student-centered, teacher-student interactive and teacher-centered method at MUCE. The study was restricted to MUCE first year undergraduate physics students. Student-centered was restricted to cooperative learning using jigsaw teaching technique, teacher-student interactive was restricted to research and discussion among students and teacher-centered was restricted to lecture method.

1.16. Limitation of the Study

The study lacked randomization on the subjects as the sample was picked from the available two first year degree science and mathematics classes from which three groups were randomly made by assigning subjects numbers 1,2 and 3 and finally putting all number 1s to experimental group for learner centered method and all number 2s to experimental group for teacher- student interaction method and number 3s to the control group subjected to traditional method in order to minimize biasness.

1.17. Theoretical Framework

The study is based on "The Reinforcement Theory". According to the theory, the behaviour of an organism can be shaped by rewarding or reinforcing the desired responses in a given environment. The educational implication of this theory is that through programmed instructions, a learner can be led through series of steps to desired level of performance. The teachers' choice of method of delivery of a lesson is central in the process of learning through quality teaching. Therefore, the method chosen must be relevant in the organization and delivery of the information in an appropriate environment, which in this case is the classroom and the school at large. Methods that favour students dominance in the teaching and learning process are said to be more effective as subject information produced by learners is remembered better than the same information presented to students by the lecturer (Ganyaupfu, 2013). Therefore, the students have a duty to create their own whereas the role of a teacher to reward by praising the students' effort and fill up the gap where it is not humanly possible for the student. In education, the performance in examinations by learners is a measure of the skills, knowledge, attitudes and other desirable values acquired by learning through teaching. This study however is focusing on the various teaching methods with a view of identifying the most effective method in the teaching of kinematics, a topic in physics using both the graphical and conceptual approach. Performance level is observable and measurable and a right teaching method can thus be an important ingredient to learners' outcomes.

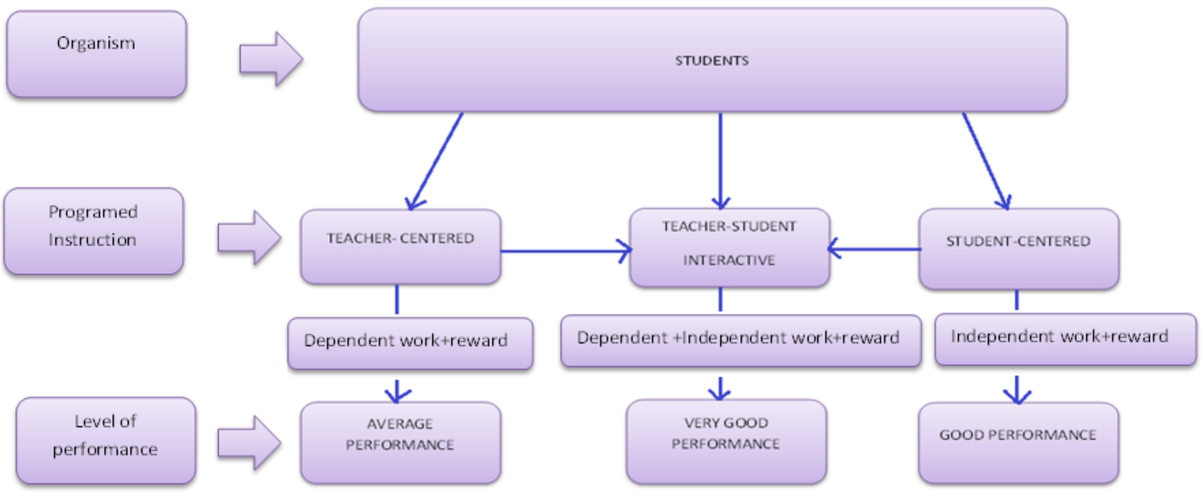

Figure-3. Theoretical framework.

1.18. Conceptual Framework

The competencies of a teacher in understanding and interpreting specific objectives enables the teacher to plan carefully for the teaching and learning processes, decide on suitable teaching strategies, select appropriate content, determine the depth of coverage of the content, select appropriate teaching and learning resources and determine the time required to cover a given topic. The learner's performance is seen as a reflection of the teachers' ability to change learners misconceptions into scientific facts. This task can only be realized if the teacher plans adequately before going to class to execute a lesson. The picking of teaching strategy that suits a particular topic is very important for effective delivery of a lesson. For example, physics is a practical subject that must be taught using methods that advocate for active, inquiry and experiential learning and just approaches that are systemic in nature: those that promote critical thinking and innovativeness.

Figure 4 shows the relationship between teaching methods and students' academic performance in kinematics in physics. The figure depicts that performance is a product of various interrelated and intertwining factors such as learning environment, professionalism and experience of the teacher, teacher/learner environment, student and teacher qualifications and teacher training content and methodologies. All these factors are interrelated and they are the ones that determine how good or poor a learner's performance will be.

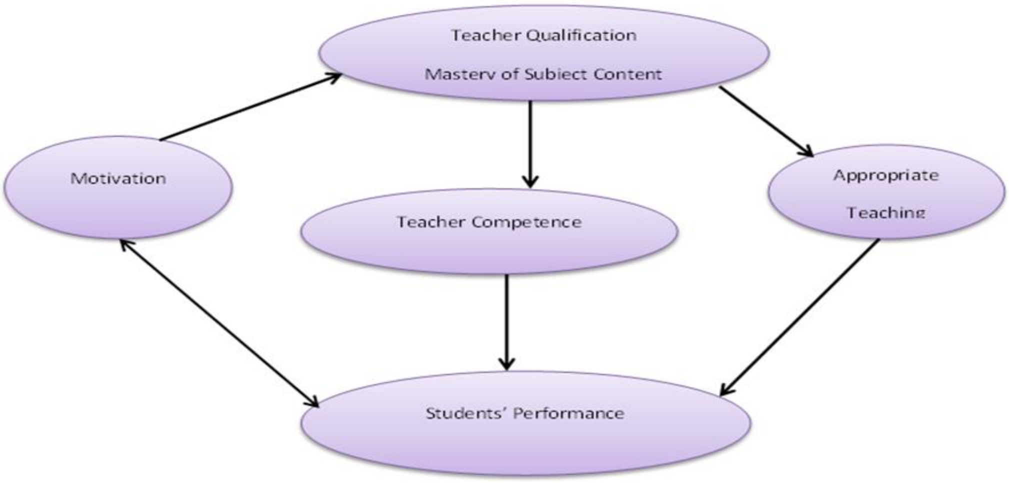

Figure-4. Conceptual framework.

1.19. Definitions of Technical Terms

The definitions of terms as used in this study were:

Assessment: Opinion or judgment of college physics teaching.

Competence: Ability of the physics teacher to teach the subject well.

Learner: first year degree student taking first year physics course (PHY110).

Learning: Relative permanent change in understanding physics concepts by a learner.

Performance: achievement in a physics test, a measure of skills development or a measure of.

Science Process Skills: skills involving investigative activities with emphasis on observing, recording, measurement and using numbers in kinematical physics.

Strategies: methods such as discovery instruction, lecture instruction , experimental instruction, role play instruction e.tc. used in teaching physics at college or secondary school level.

2. LITERATURE REVIEW

2.1. Introduction

This section provides the literature relevant to the methodology in kinematics instruction, students' academic performance, science process skills, and the knowledge gap.

Review of related studies reveal that research has been done to measure the success of leaner-centered strategy against conventional strategy regarding achievement across all levels from primary grades through college though least has been explored concerning teacher-students interactive method against the former two. The search found no study done in Mufulira that dealt with students' performance using students- centered and conventional learning with a focus on learner achievement in kinematics in physics and evidence on teacher-student interactive strategy. However, the common practice in teaching in Zambia is dominantly characterized by lecture method which in other words is a teacher-centered method. This approach is not so recommended for science which demands learner independent thinking, innovation and problem solving through enquiry. Based on this background the study sets out to investigate the effectiveness of learner -centered, teacher-student interactive and teacher centered method on academic performance of first year physics degree students in kinematics at MUCE, Copperbelt province in Zambia.

2.2. Academic Performance

Academic performance is the state of a students learning achievements at a particular time in a particular course or group of courses. It is measured by a grade obtained in a particular course or a set of courses depending on the design of the curriculum. However, for this performance to be realized in a classroom, the role of a teacher as an instructor is crucial. This is very important since teachers directed participation can range from complete control over what is learnt to minimal intervention. A teacher is the source of all knowledge that students can acquire in a classroom. A teacher can impact students learning in different regards based on the way he delivers the subject. Consequently, the way the teacher delivers the subject or methodology is directly related to learners Teachers' Method of Teaching (Selim and Shrigley, 1983). The strategies the teacher uses in a quest to impart knowledge to the learner is called methodology.

In this study the researcher reviews teacher-centered, teacher-student interactive and learner centered methods.

2.3. Teacher-Centered Methods

This method has more to do with teacher dominance in the dissemination of information. Students passively receive information from the teacher without creating an engagement level with the subject being taught (Boud and Feletti, 1999). This approach can be thought to be least practical, more theoretical and encourages memorization of concept Ganyaupfu (2013) It does not favour activity based learning to encourage students to learn real life problems based on applied knowledge. Since the lecturer controls the transmission and sharing of knowledge, the lecturer is bound to mislead the students to think the lecturer is the only fountain of knowledge and as such students make little effort to create their own knowledge. This results in students' loss of both interest and understanding of physics concepts. In order to realize some solutions to the shortfalls above , teaching must actively engage students as prime participants other than them being mere recipients of rules, definitions and rote memorization of procedural instructions (Zakaria *et al.*, 2010).

2.4. Student-Centered Method

According to Banda *et al.* (2014) student-centered approach to learning is a vehicle that takes us towards producing a learner that is analytical, innovative, creative and constructive in thought. In a quest to promote the concept of discovery learning, many scholars have of late widely adopted more student-centered biased methods to enhance active learning (Greitzer, 2002). Hesson and Shad (2007) observed that most teachers today apply the student-centered approach to promote interest, analytical research, critical thinking and subject pleasure among students. Student-centered instruction is therefore considered more effective as it does not confine the flow of knowledge from the lecturer to the student only but the other way round as well (Lindquist, 1995). The approach also motivates goal-orientated behaviour among students, hence the method is very effective in improving student achievement (Slavin, 1996).

2.5. Teacher-Student Interactive Method

This is a method that employs both teacher-centered and student-centered approaches. Researchers believe that this approach encourages students to do independent work than acquiring monopolistic knowledge from the teacher (Jacoby, 1978; McDaniel *et al.*, 1978). Therefore, students develop study skills, innovations, independent thinking and analytical skills as such the subject information produced by the learners is remembered better than the same information presented to the learners by the lecturer. As such, research evidence on teaching approaches maintains that this teaching method is effective in improving students' academic performance as claimed by Ganyaupfu in citing the claims of Damodharan and Rengarajan (1999).

Ganyaupfu (2013) did an experimental research using teacher-centered, student-centered and teacher-student interactive method in South Africa on an undergraduate cohort from the Department of Economic and Business Sciences, Kempton Park (Higher Education and Training) Campus and PC Training & Business College and the test results indicated that teacher-student interactive stratagem was more effective than student centered and teacher centered was the least.

However, no study was found concerning kinematical motion in which teacher-student interactive method was tested hence the need to conduct this study.

2.6. Teaching Methods in Kinematics Instruction

Banda *et al.* (2014) conducted an action research on the introduction of Lesson Study, a learner centered approach conducted in Central Province of Zambia on a biology lesson and discovered that in the province, teaching skills of science teachers were improved and students' pass rates in national examination increased in science compared with provinces which were not implementing the lesson study policy.

Furthermore, Tababal and Kahssay (2011) conducted an investigation using a quasi-experimental design on Ethopian grade nine (9) high school natural science students in Amhara National Regional State, to compare the effect of student-centered against teacher-centered method on 'Improving Students' Graphical Interpretation Skills and Conceptual Understanding of Kinematical Motion' and the post-test results showed that the student-centered method was more positively effective than the later.

Similarly, Sogoni (2017) did a quasi-experimental research to investigate how effective cooperative learning, a student -centered approach, in teaching and students achievements in kinematics in secondary schools in Sabatia Sub-County, Kenya and discovered that cooperative learning was more effective than conventional method in learner performance.

2.7. Knowledge Gap

Review of related studies has revealed that research has been done to measure the effectiveness learner-centered instruction, cooperative learning in particular , as an instructional strategy for achieving higher academic performance from primary schools to colleges and has compared to teacher-centered yielded better results. Besides, research on teacher-student interactive instruction, research and discussion in particular as a teaching instruction has in a various subject areas and across primary school grades to college level and have indicated supremacy over student-centered and teacher-centered respectively. However, there is no evidence of a study that compared the teacher-centered instruction, teacher-student interactive instruction and the student-centered instruction in in academic performance in kinematical motion: graphical interpretation and conceptual understanding . It is against this background the study set out to investigate the effectiveness of the afore mentioned teaching methods in students' academic performance in kinematical motion particularly graphical interpretation and conceptual understanding at Mufulira College of Education, Copperbelt Province in Zambia.

3. RESEARCH DESIGN AND METHODOLOGY

3.1. Introduction

This chapter describes research design, study location, study population, sampling techniques, research instruments, piloting of research instruments, reliability and validity of the research instruments, and data analysis procedures.

3.2. Design of the Study

The research design used was a *quasi-experimental design.* It is also called *non-equivalent control group design.* It was almost impossible to randomly sample subjects equivalently from a population of the first year degree physics class due to the subjects' different background variables.

According to Cohen *et al.* (2005) one of the most commonly used quasi-experimental designs in educational research can be represented as in Figure 5:

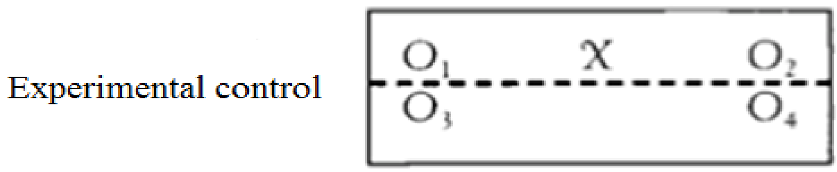

Figure-5. Non-equivalent control group design.

Source: Cohen *et al.* (2005).

The dashed line in Figure 5 indicates that the experimental and control groups have not been equated by randomization hence the term 'non-equivalent. However, this study had two experimental groups, student-centered and teacher-student interactive instruction group. The teacher-centered instruction group was the control group. Therefore, the modified design was as in Figure 6.

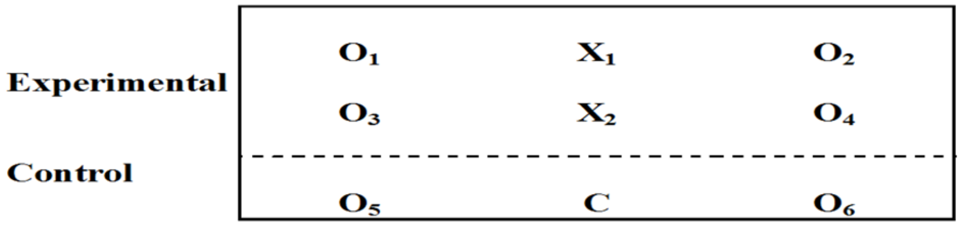

Figure-6. Research design depiction.

Key:

X_1– Cooperative learning using jigsaw approach.

X_2– Research and Discussion approach.

C– Teacher-centered approach.

O_1 – Pre-test/ initial Observation for X_1 group.

O_2 – Post-test/ final Observation for X_1 group.

O_3 – Pre-test/ initial Observation for X_2 group.

O_4 – Post-test/ final Observation for X_2 group.

O_5 – Pre-test/ initial Observation for C group.

O_6 – Post-test/ final Observation for C group.

In this study the independent variables were student-centered, teacher-student interactive and teacher-centered instruction. The dependent variables were students‟ graphical interpretation skills and conceptual understanding of kinematical motion which are presented through the students achievements in the pre-test and post-test results.

3.3. Study Location

This study was conducted in Mufulira, one of the mining towns in the Copperbelt Province of Zambia. However, the study was confined to Mufulira College of Education due to poor performance in physics specifically in kinematics, as observed by the researcher. Since the researcher is a lecturer in physics at this college, it was convenient in terms of cutting down the cost of research despite a compromise on the generalizability of the findings. Mufulira College of Education is the only public college situated along Mufulira-Kitwe road and about five kilometers (5km) from the central business area. It trains secondary school teachers at both diploma and degree level in Home Economics, Science, Mathematics, Physical Education , Music, Agriculture Science and Business studies.

3.4. Population of the Study

The target population of the study was first year Mufulira College of Education Degree physics students adopted from the Science and Mathematics program domains. The target population for this study consisted of hundred and twelve (N=112) students, all internal students or full time college students.

3.5. Sampling Technique and Sample Size

Borg and Gall (1979) suggest that causal-comparative and experimental methodologies require a sample size of no fewer than fifteen cases. Within the available population and with the consideration of attrition and mortality of respondents, it was within the justifiable limits of the study to follow the sampling frame outlined below.

3.5.1. Sampling Frame

This is the actual list of sampling units from which the sample is selected. It is a list of the study population. There were 112 first year degree physics (PHY110) students at Mufulira College of Education. The sample frame is presented as in Table 1.

Table-1. Sampling frame of physics students.

Groups (Methods)	Male	Female	Total
Teacher-Centered	20	11	31
Student-Centered	21	10	31
Teacher-Student interactive	20	11	31
Total			93

3.5.2. Sample Size

A sample is a smaller group obtained from the study population (Mugenda and Mugenda, 2003). The sample of 93 students, 33% (n=31) females and 67% (n=62) males, was purposely picked and divided into 3 equal groups. Group one (1) was the control group treated with teacher-centered method, group two (2) was an experimental group that was treated with teacher-student interaction method and group three (3) was also an experimental group treated with student-centered method. The remaining nineteen (19) were all males and were used in the piloting of the instrument only.

To guarantee fair representation in terms of sex in the group samples twenty one (21) sets of three (3) cards, on each card indicated a group number (either 1 or 2 or 3) were put in one box. 62 male subjects, each randomly drew a card from the box and was assigned to a group based on the card number. Similarly, eleven (11) sets of cards were put in the second box where 31 female subjects each drew a card and got assigned to the group according to the number reflecting on the card. That is to say, 33% (n=10) female and 67% (n=20) male proportion was fairly considered in each group. A summary of this is seen in Table 2.

Table-2. Sample size.

Groups (Methods)	Male	Female	Total
Teacher-Centered	20	11	31
Student-Centered	21	10	31
Teacher-Student interactive	20	11	31
Total			93

One physics lecturer was involved in this study during the teaching-learning process.

3.6. Instrument

Taking into account Wagner and Vaterlaus (2011) who says that proper concepts have to be learned but also misconceptions have to be unlearned, the pre-test and post-test items were to be constructed with the purpose of identifying student's concepts and misconceptions in kinematics at college level. Therefore, the tests were based on the following list of kinematics concepts:

1) Velocity as rate of change of displacement.
2) Velocity as vector in one dimension (i.e. direction of velocity).
3) Velocity as slope of the curve in a displacement-time graph.
4) Displacement as area under the curve in a velocity-time graph.
5) Acceleration as a rate of change of velocity.
6) Acceleration in one dimension (i.e. direction of the acceleration).
7) Change in velocity as area under the curve in an acceleration-time graph.

It is against the above background that two Graphical Interpretation Skills Test (GIST) and Motion content Test (MCT) were used to generate data for the study. The pre-test comprised eighty (8) GIST items and seven (7) MCT items while the post-test comprised seven (7) GIST items and eight (8) MCT items respectively. The tests were constructed picking some concepts from the general physics books and the Test of Understanding Graphs in Kinematics (TUG-K) (Beichner, 1994; Breithaupt, 2003; Mvula *et al.*, 2015) and administered as pre-test and post-test. The pre-test served as a base line survey to establish the initial knowledge level of the subjects in the three groups. The instruments were later given to four experienced lecturers of physics to obtain their views regarding appropriateness of objectives and language level.

3.6.1. Investigation of Background Variables and Pre-Test

All variables, except students' performance in pre-test and post-test were referred to as background variables. Since, the researcher was interested in observing the student-centered approach, teacher-centered approach and teacher-student interactive approach in terms of students achievement, there was need to make sure that these groups were statistically equivalent in terms of background variables. Therefore, a six (6) items questionnaire was constructed to check some students attitudes and attributes towards the learning of physics, and was administered in such a way that students' responded to questions by ticking in an appropriate box designated to tasks A, B, C, D, E, and F . Thereafter, a two by two (2x3) contingency table was constructed by combining responses of students with frequencies and ignoring observations with zero frequency. Since these background variables were categorical, chi squared (χ^2) test was used to check the equivalence of the three groups in terms of background variables.

3.6.2. Piloting

In order to ensure meaningful reliability and validity of the questionnaire a test must first be tried on subjects mostly on those that are not going to be part of the pre-test and post-test subjects. The act is called piloting. It involves editing the questionnaire on instructions that need simplifying to suit the subjects abilities to respond in line with the desired objectives of the study instrument. A pilot core purpose is to increase the reliability, validity and practicability of the questionnaire. Therefore, after construction, the instrument was tested on nineteen (19) first year degree physics students not included in the sample groups in order to check its reliability using the test scores.

3.6.3. Reliability

According to Sogoni (2017) reliability is the degree of consistency that the instrument demonstrates in the results obtained. It must therefore, be understood that reliability entails that the same candidates would score the same on a test if they sat for it repeatedly on different occasions. Kinematics pre-test and Kinematics post-test were pre-tested on the nineteen first year degree students who were not used in the actual study. Thereafter, some amendments on the language and questions that proved to be difficult and not testing kinematics concepts were done. Test-retest technique was used to assess the reliability of the instruments. The post-test was undertaken after two weeks from the first test to the same group of students. During the post-test the respondents were exposed to the amended tests. Therefore, for a test to be reliable it must have appropriate assessment method and language. Nevertheless, the two tests in this study were multiple choices based.

Reliability coefficient for multiple choice instruments is calculated using Kuder-Rechardson 20 (KR-20) formula. Tests having a KR-20 > 0.70 are generally considered to be reliable for group measurements. Therefore, the value of reliability in this case was calculated from the KR-20 formula using excel. The other important values calculated were difficulty index and discrimination index for pilot test as shown in Table 3.

Table-3. Statistical results from pilot test.

Name of statistics	Possible values	Desired value	Calculated value
KR-20	[0,1]	>0.70	0.74 (For groups)
Discrimination index	[-1,1]	>0.30	0.33 (Average)
Difficulty index	[0,1]	>0.30	0.61 (Average)

3.7. Treatment

Experimental groups were treated with student-centered (cooperative learning using jigsaw approach) and teacher-student interactive approach (research and discussion) respectively after administering a pre-test. On the other hand, the control group was treated with teacher-centered approach, specifically a more lecturer-driven lesson, textbook problems solved by the lecturer. The role of the student was to receive information from the lecturer. Thereafter, a post-test was administered to all the groups.

The collected data for the study were analyzed by using quantitative and descriptive statistical methods using statistical package software called SPSS 16. Specifically, Chi-square (χ^2) was adopted to investigate the difference between experimental and control groups in terms of their background variables. To investigate the difference among teaching method groups in terms of their pre-test and post-test achievement , one-way ANOVA (analysis of variance) test at an alpha level of 0.05 (α = 0.05) was used. In order to check whether there was any significant between the students' performance mean scores of the three teaching instructions in the post-test performance scores, the Tukey HSD post hoc test was applied.. In addition, descriptive statistics was also used to calculate the mean, variance and standard deviation.

4. DATA ANALYSIS AND RESULTS

The analysis and the results of this study were explained in three sections. The first section deals with investigation of background variables and pre-test results. The second section presents the achievement of post-test with its inferential and descriptive statistical analysis. The last section dealt with the findings of the study.

4.1. Analysis of Background Variables and Pre-Test

4.1.1. Sex

A chi-square (χ^2) test of independence was performed to determine whether participants sex contribution was significantly varying or not. As it is seen from Table 4 the test revealed that the three groups were not significantly different in terms of sex distribution, *i.e.* χ^2 (2, 85) = 0.075, p=0.963. Thus p > 0.05.

Table-4. Chi-square (χ^2) for sex distribution of participant students.

Name of statistics	Possible values	Desired value	Calculated value
KR-20	[0,1]	>0.70	0.74 (For groups)
Discrimination index	[-1,1]	>0.30	0.33 (Average)
Difficulty index	[0,1]	>0.30	0.61 (Average)

4.1.2. Age

A chi-square (χ^2) test for independence was performed to determine whether participants age distribution was significantly varying or not. Table 5 shows that, the three groups are not significantly different in age, *i.e.* χ^2 (6, 85) = 5.854, p=0.440. Thus p > 0.05.

Table-5. χ^2 For age distribution of participant students.

Age		Teaching method		
		Teacher centered	Teacher-Student interactive	Learner centered
14-16 Years	Observed	0	0	1
	Expected	.3	.4	.3
16-18 Years	Observed	10	10	5
	Expected	8.5	8.8	7.6
18-20 Years	Observed	19	19	20
	Expected	19.8	20.5	17.7
Above 20 Years	Observed	0	1	0
	Expected	.3	.4	.3

4.1.3.Students' Preparation

How students' feel in terms of the preparation on the topic of kinematics may affect their performance. Therefore, it is vital to check the experimental groups and control groups in terms of their feeling of how prepared they are. Table 6 summarized data on how students felt in terms of preparation for kinematics in physics.

Chi Square (χ^2) test was used to check the difference between the three groups in terms of feelings of preparation. The χ^2 test result showed that the three groups did not differ significantly on how well students felt prepared for kinematics in physics, *that is* χ^2 (6, 83) = 5.443, p=0.488. Thus p > 0.05.

Table-6. χ^2 For students' feelings in terms of preparation in kinematics in physics.

Students preparation		Teaching method		
		Teacher centered	Teacher-Student interactive	Learner centered
Very well	Observed	1	5	6
	Expected	3.9	4.3	3.8
Prepared	Observed	11	12	11
	Expected	11.1	12.3	10.7
Somewhat	Observed	3	3	3
	Expected	2.9	3.3	2.8
Unprepared	Observed	12	10	6
	Expected	9.1	10.1	8.8

4.1.4. Experience in Physics and Repeating Physics Subject in High School

Previous knowledge in physics may affect students' performance in kinematics. It is vital to check the previous physics taken by the students and repeating physics subject in both high school and college respectively. As we see from Table 7 only four (4) students repeated this subject at college level.

Chi Squared (χ^2) test was used by considering responses of students with non- zero frequency. Table 7 results showed that the three groups were not significantly different in previous experience with physics and repeating the subject in high school and college. That is to say. χ^2 (4, 78) = 5.138, p=0.273 and thus p > 0.05.

Table-7. χ^2 for students' physics background survey.

Physics experience		Teaching method		
		Teacher centered	Teacher-Student interactive	Learner centered
Ordinary level physics	Observed	17	19	20
	Expected	19.4	20.1	16.5
Advanced/College level physics	Observed	7	8	2
	Expected	5.9	6.1	5.0
Repeat physics at college	Observed	3	1	1
	Expected	1.7	1.8	1.5

4.1.5. Previous Mathematics Background

Student's mathematical background may affect their performance in kinematics in physics. From Table 8 we can see that there is no significant difference between the three groups in terms of previous mathematics class. The researcher used a chi-square (χ^2) test to analyze responses of students' school mathematics experience. The results showed that there is no significant difference between the three groups in terms of mathematics subject that they previously took at secondary school level , *i.e.*, (χ^2 (4,76) = 1.285,p=0.864 and thus $p > 0.05$).

Table-8. χ^2 for students mathematics background survey.

Mathematics experience		Teaching method		
		Teacher centered	Teacher-Student interactive	Learner centered
Ordinary level mathematics	Observed	16	19	17
	Expected	17.	18.5	15.7
Pure mathematics	Observed	8	6	4
	Expected	6.2	6.4	5.4
College mathematics	Observed	2	2	2
	Expected	2.1	2.1	1.8

4.1.6. Students' Study Time

Students were asked to respond to the question how much time outside of their class they expect to spend in studying physics subject. A significant difference in students' study time among the three groups could bring a significant difference in their achievement. Contrary the test results seen in Table 9 showed that the three groups were not significantly different in study time. That is to say, χ^2 (6, 76) = 5.242,p=0.491 and thus $p > 0.05$).

Table-9. χ^2 for students study time allotment for physics.

Students study time		Teaching method		
		Teacher centered	Teacher-Student interactive	Learner centered
2 Hours per week	Observed	2	4	5
	Expected	3.3	4.2	3.5
2-5 Hours per week	Observed	5	8	9
	Expected	6.7	8.4	6.9
6-10 Hours per week	Observed	8	11	4
	Expected	7.0	8.8	7.3
10-15 Hours per week	Observed	8	6	6
	Expected	6.1	7.6	6.3

4.1.7. Pre-Test: Background Knowledge of Kinematics in Physics

Participant students were tested on questions on one dimension kinematics topics. The questions were 15 multiple choice items drawn from physics text books and TUG-K. A test was used to check whether there is a significant difference among the three groups on students' knowledge level on kinematics or not. Table 10 showed that the three groups did not have statistically significant difference on their pre-test results based on descriptive statistics Table 10. Besides, one-way ANOVA test was used and yielded F(2, 85) = 0.130, p=0.878 and thus $p > 0.05$ with significant level of alpha (α) = 0.05 indicating that there was no statistically significant difference in the pre-test results between the groups as shown in Table 11. Above all, this saved as a baseline for the treatments.

Table-10. Summary of pre-test achievement according to treatment of student-centered, teacher- student interactive and traditional instruction.

Method	N	Mean	Std. deviation	Std. error	95% Confidence interval for mean		Minimum	Maximum
					Lower bound	Upper bound		
Teacher centered	29	7.52	2.613	0.485	6.52	8.51	3	14
Teacher-Student interactive	30	7.80	2.483	0.453	6.87	8.73	3	13
Learner centered	26	7.81	2,227	0.437	6.91	8.71	4	13
Total	85							

Table-11. ANOVA pre-test achievement according to treatment of student-centered, teacher-student interactive and teacher-centered instruction.

Pretest					
	Sum of squares	Df	Mean square	F	Sig
Between groups	1.567	2	0.784	0.130	0.878
Within groups	494.080	82	6.025		
Total	495.647	84			

4.2. Achievement of Post-Test

To assess the effectiveness of student-centered, teacher-students interactive and teacher-centered instruction on the teaching of one-dimensional kinematics, a pre-test and post-test was administered to all the three groups. Besides, the researcher also administered background information survey questionnaire. Here the groups' achievement difference in the post-test score and gain is examined. The research question was: Are there any significant differences between the mean scores in kinematics test among learner groups treated with a learner-centered, teacher-student interactive and teacher-centered instructions respectively? To answer this research question, students' achievement on conceptual understanding and graphical interpretation skills were measured at the end of the treatment using 15 questions given to all 93 students. The data was analyzed using one-way ANOVA test. Table 12 shows that there was no significant difference between teacher-centered instruction group and, teacher-student interactive and student-centered instruction groups, *i.e.* ($F(2, 93) = 0.316$, $p > 0.05$).

Table-12. ANOVA post-test achievement according to treatment of student-centered, teacher-student interactive and teacher-centered instruction.

Post test					
	Sum of squares	Df	Mean square	F	Sig
Between groups	1.957	2	0.978	0.316	0.730
Within groups	279.032	90	3.100		
Total	280.989	92			

Data were also analyzed using descriptive statistics to examine the means, standard deviations and standard errors as shown in Table 13.

Table-13. Descriptive statistics.

Post test						
Method	N	Mean	Std. deviation	Std. error	95% Confidence interval for mean	
					Lower bound	Upper bound
Teacher centered	31	9.48	1.947	0.350	8.77	10.20
Teacher-Student interactive	31	9.84	1.675	0.301	9.22	10.45
Learner centered	31	9.65	1.644	0.295	9.04	10.25
Total	93	9.66	1.748	0.181	9.30	10.02

According to Table 13 and basing on the teaching method applied, the estimated marginal mean estimates reveal that teacher-student interactive approach produced the high mean score (mean=9.84), followed by the student-centered approach (mean= 9.65) and the lowest mean score (mean=9.48) was recorded for the teacher-centered approach. The mean estimates for all the three teaching methods fall within the 95% confidence interval bands.

To detect which of the three teaching methods assessment mean scores differed significantly from one another; the Tukey HSD post hoc test was applied for the analysis Table 14. In light of the number of comparisons that were made, the Tukey post hoc approach was applied because of its power to control for alpha inflation.

Table-14. Tukey HSD post hoc tests.

(I)Teaching methods	(J)Teaching methods	Mean difference (I-J)	Std. error	Sig.	95% Confidence interval	
					Lower bound	Upper bound
Teacher centered	Teacher-Student interactive	-0.355	0.447	0.708	-1.42	0.71
	Learner centered	-0.161	0.447	0.931	-1.23	0.90
Teacher-Student interactive	Teacher centered	0.355	0.447	0.708	-0.71	1.42
	Learner centered	0.194	0.447	0.902	-0.87	1.26
Learner-Centered	Teacher centered	0.161	0.447	0.931	-0.90	1.23
	Teacher –Student interactive	-0.194	0.447	0.902	-1.26	0.87

The Tukey post hoc tests results indicated that student performance assessment scores of the teacher-centered approach differed significantly from student performance assessment scores of teacher-student interactive approaches. No significant differences existed between performance scores of student-centered and teacher-centered methods. Even though there was no significant performance scores difference between teacher-student interactive and learner-centered instruction, Table 14. indicates a bigger mean difference between the two methods than the difference between teacher-centered and student-centered instructions.

4.3. Average Normalized Gain

The normalized gain was introduced by Hake (1998) as a rough measure of the effectiveness of a course in promoting conceptual understanding of mechanics and has since become the standard measure for reporting scores on research based concept inventories. However, average normalized gain measures the tests relative score and it is therefore some sort of weighing function that compares the scores of students or groups of students. Hake define the average normalized gain (<g>) as:

$$< g >= \frac{< \text{post test}\% > - < \text{pre test}\% >}{100\% - < \text{pre test}\% >}$$

Where $< \text{gain} > = < \text{post test}\% > \; - < \text{pre test}\% >$ and brackets stand for group averages. In simple terms, normalized gain is described as “the amount students learned divided by the amount they could have learned.” In addition, it is important to note that Hake advocated for the use of normalized gain because of its strength to differentiate between teaching methods despite allowing a consistent analysis over diverse students’ populations with widely varying initial knowledge. Besides, instructors can use it to compare their students’ learning to those of other students at different kind of institutions.

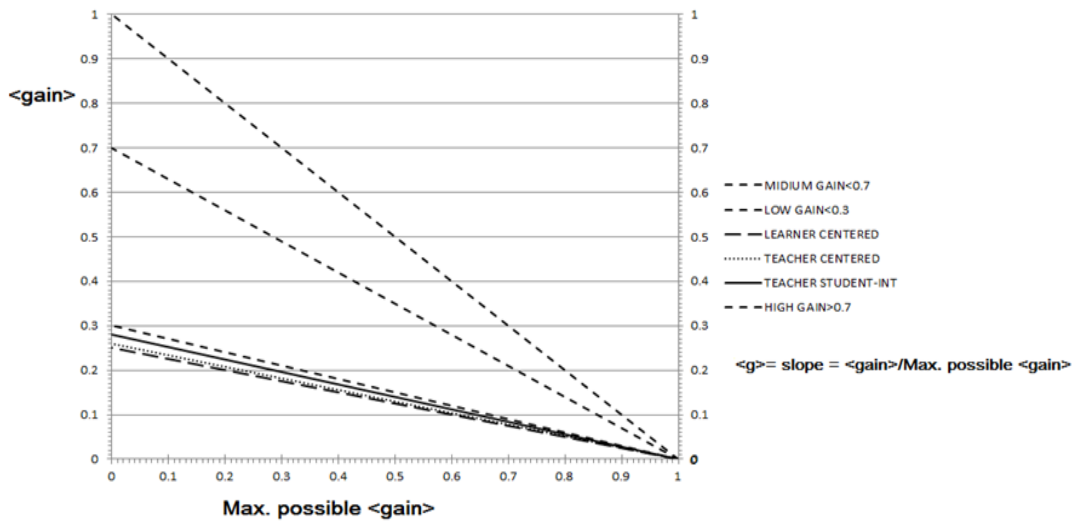

Figure-7. The <gain> versus maximum possible gain score for 93 students.

Hake divided average gain values in to high-g score (<g> > 0.7), medium-g score (0.7> <g> ≥ 0.3) and low-g score (<g> < 0.3). Figure 7 shows learner-centered instruction <gain>, teacher-centered instruction<gain> and teacher-student interactive instruction <gain> on Graphical Interpretation Skills and Conceptual Understanding of Kinematical Motion as 0.25, 0.26 and 0.28 respectively. Besides, Figure 7 further shows that the average normalized gain for learner-centered, is slightly lower than teacher-centered and teacher- student interactive instructions though all lie in the bottom part of low-g region. This implies that teacher-student interactive instruction despite scoring higher does not completely surpass the teacher-centered and learner-centered instructions. Table 15 shows that the summary result of the investigation and it is seen that students with teacher-student interactive instruction have a better gain than students with teacher-centered and learner-centered instruction.

Table-15. The difference between pre-test and post-test with in a group in terms of <gain>.

Group	Pre-test %	Post-test %	Gain
Learner-Centered	52.1	64.3	0.25
Teacher-Student interactive	52.0	65.6	0.28
Teacher-Centered	50.1	63.2	0.26

5. DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

This chapter provides the discussions on major findings, conclusions drawn from the findings, makes recommendations and brings out suggestions for further research.

5.1. Discussion

The comparative effectiveness of learner-centered , teacher- student interactive and teacher-centered instruction on students' academic performance in kinematical motion: graphical interpretation and conceptual understanding was examined.

First and foremost, the background survey to students in the experimental and control groups was administered to determine whether the groups differed with respect to the background variables or not. The chi-square (χ^2) test results showed that there was no significant difference in background variables between the three groups. Moreover, a pre-test was administered to students in the experimental and control groups to determine whether the groups differed with respect to the achievement in pre-test, and the one- way ANOVA test analysis of the results revealed that, no pre-existing difference between the three groups regarding students pre-test achievement existed, yielded $F(2, 85) = 0.130, p > 0.05$). The idea of determining similarities between the students in the experimental and control groups regarding background variables and pre-test scores were a good starting point as it was a baseline for the study before the treatments.

The result of the study indicated that teacher–student interactive instruction significantly surpassed teacher-centered instruction in terms of academic performance of students. However, this difference was less significant between students taught using learner-centered and students taught using teacher-centered. The normalized average gain analysis conducted showed the gain in academic performance of students in improving Graphical Interpretation Skills and Conceptual Understanding of kinematical Motion of $<g>=0.25$, $<g>=0.26$ and $<g>=0.28$ for learner-centered, teacher-centered and teacher-student interactive instruction respectively. In short teacher- student interactive instruction was the most effective method in this study. The one-way ANOVA test $F(2, 93) = 0.316, p > 0.05$) analysis showed no significant difference in the three groups' instructions in improving students‟ Graphical Interpretation Skills and Conceptual Understanding of kinematical Motion. Descriptive analysis of the students' post-test means for teacher-centered, learner-centered and teacher-student interactive instruction were 9.48 out of 15 questions, 9.65 out 15 questions and 9.84 out of 15 questions respectively. The mean scores were higher compared to pre-tests mean scores shown in table 4.7. implying that each teaching instruction recorded an improvement in academic performance. During the treatment period (three weeks), it was observed that, students in the experimental groups were actively participating than those in the control group. From this study, it can be deduced that teacher-student interactive instruction appears to be more promising for marked improvement over learner-centered instruction and teacher-centered instruction.

The finding of this study agrees with the findings of Ganyaupfu (2013) contrary to the findings of Banda *et al.* (2014), Tababal and Kahssay (2011) and Sogoni (2017) whose results favour learner- centered instructions. However, on the aspect of student-centered compared to teacher-centered instruction, this study agrees that student-centered instruction is better.

As if in keeping with the findings of Hake (1998) the study has shown that teacher-student interactive instruction agrees that interactive engagement strategies can increase the effective teaching of kinematics and consequently mechanics-course by far if compared to teacher dominant instruction.

Hake studied 62 introductory physics courses involving about 6500 students. In his survey, he used a pre and post-test to assess students' learning from these courses. From the data he acquired on various teaching methodologies he was able to compare the product of each methodology. Hake's findings support that active teaching methods (described as interactive engagement methods in his study) generally produce greater student learning and develop stronger problem solving skills than more teacher dominant methods. Furthermore, a study conducted by Ellis and Tuner (2002) on learner-centered approach to teach kinematics through graphical analysis supported this approach saying it was successful for increasing conceptual understanding of kinematics as well as increasing student interest in the study of physics which is in keeping with this study.

5.2. Conclusion

The main objective of this study was to investigate whether there are significant differences in the effectiveness of learner-centered, teacher-student interactive and teacher-centered instructions on students' academic performance in kinematics. The approaches employed were cooperative learning using jigsaw, research and discussion and lecture method respectively. It was found that students had better academic achievement in kinematics when taught using teacher-student interactive instruction, followed by learner centered instruction and teacher-centered instruction was the least despite recording a greater gain than learner-centered instruction. It was also found that teacher-student interactive and learner centered instructions were more effective in enhancing development of science process skills than teacher-centered instruction. Furthermore, the study revealed that teacher–student interactive and learner-centered instruction was more effective in enhancing attitude in kinematics than teacher-centered instruction. Finally, it was observed that approaches that are student biased such as cooperative learning method enhances interaction between resources and learners and may promote performance in physics and science in general. Overall, teacher-student interactive instruction through research and group discussion had to a large extent been successful in enhancing performance in kinematics among PHY110 students at Mufulira College of Education in Mufulira district of the Copperbelt province of Zambia. Since the number of participants is small and from one college out of the fourteen public colleges of education, there is a limitation about the generality of this study and as such the results are only generalized to PHY110 cohort of MUCE.

The findings also showed the achievement of the student-centered groups' academic performance was be better than that of the teacher-centered group. In other words, student-centered instruction is highly probable to cause significantly better understandings of scientific conception and elimination of alternative concepts than teacher centered instruction. In short, evidence from researchers in physics teaching and learning shows that teacher-centered instructional methods, largely lecture and problem solving, are not effective methods for promoting student learning in physics (Hake, 1998).

Owing to the fact that learning is a process that involves inquiry, formulation, reasoning and application of appropriate strategies to solve problems, teachers ought to understand that it becomes more effective if the students perform tasks in process of learning rather than just rote memorization of some information. An environment with a presentation from the lecturer coupled with a lecture does not enhance learners' participation nor build the required level of reasoning among students. Students' understanding of the main concepts grows more effectively when they are engaged in problem solving activities during and after class work.

5.3. Recommendations

The following recommendations were made:

1. Research and discussion to be used as a dominant instruction in teaching kinematics to enhance inquiry based learning among students.
2. Research and discussion to be used in learning of kinematics as it promotes objective debate among students that promote problem solving.
3. Cooperative learning using jigsaw to be used in learning in order to improve academic achievement in kinematics.
4. Cooperative learning using jigsaw to be used in learning in order to improve development of science process skills in kinematics.

5.4. Suggestions for Further Research

The study did not cover all matters related to teaching and learning kinematics in all colleges of education especially public colleges. There were other issues that came up in the study that require further investigation. These include:

1. Studies involving other techniques under learner centered instructions other than cooperative leaning using jigsaw technique.

2. Studies involving a larger sample and more colleges of education offering PHY110 or any similar undergraduate physics course to ascertain the consistence in the result in the whole country.
3. Studies involving other topics in physics other than kinematics.
4. Studies involving gender differences on performance in kinematics.
5. Studies using a different research designs.

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APPENDICES

Appendix 2 : Introductory Letter

MVULA ANDERSON KAMBANI
The Copperbelt University
School of Post Graduate
Kitwe, Zambia.
Dear Respondent,

RE: RESEARCH PROJECT

I am a student at The Copperbelt University pursuing a Master of Science Physics Education Degree in the School of Post Graduate Studies. I am carrying out an investigation on 'Teaching Methods and Students Academic Performance in Kinematical Motion: graphical Interpretation and conceptual understanding' at Mufulira College of Education. You have been selected as a respondent in this survey. The success of the research substantially depends on your cooperation. I hereby request you to respond to the questionnaire items as objectively as possible and to the best of your knowledge.

The questionnaire is designed for the purpose of this study only, therefore the responses will absolutely be confidential and anonymously given. No name will be required from you.

Thanking you in advance.
Yours Faithfully,
Mvula Anderson Kambani

Appendix 3: Questionnaire on background Variables

MUFULIRA COLLEGE OF EDUCATION

2019

QUESTIONNAIRE

Investigation of Background Variables and Pre-test

This questionnaire is for collecting information purely for academic purposes about the teaching of physics and students' academic performance in kinematics at a College of Education. The information collected will be confidential and only used for the intended purpose. Do not disclose your identity by writing your name or that of the school on this questionnaire.

This questionnaire is for academic purposes only.

Year of study:…………………………..

Duration: 5 minutes

Instructions

Indicate your appropriate choice by using a tick in the box, e.g (√).

A. **Sex:** Female ☐ Male ☐

B. Age:

☐ 14-16 years 16-18 years ☐ 18-20 years ☐ above 20 years

C. Students' Preparation

Very well ☐ prepared ☐ somewhat ☐ unprepared ☐

D. Previous experience in Physics and Repeating Physics Subject/Course:

☐ Ordinary level physics
☐ Advanced/college level physics
☐ Repeat Physics at ordinary level
☐ Repeat Physics at College level

E. Previous mathematics Background:

☐ Ordinary level physics
☐ Pure Mathematics
☐ College Mathematics

F. Students Study Time

☐ 2 hours per week

☐ 2-5 hours per week

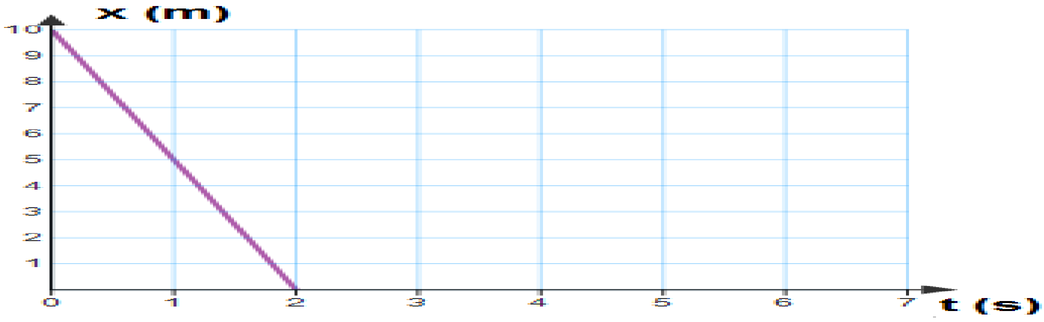
☐ 6-10 hours per week

☐ 10-15 hours per week

Appendix 4: Pre-test

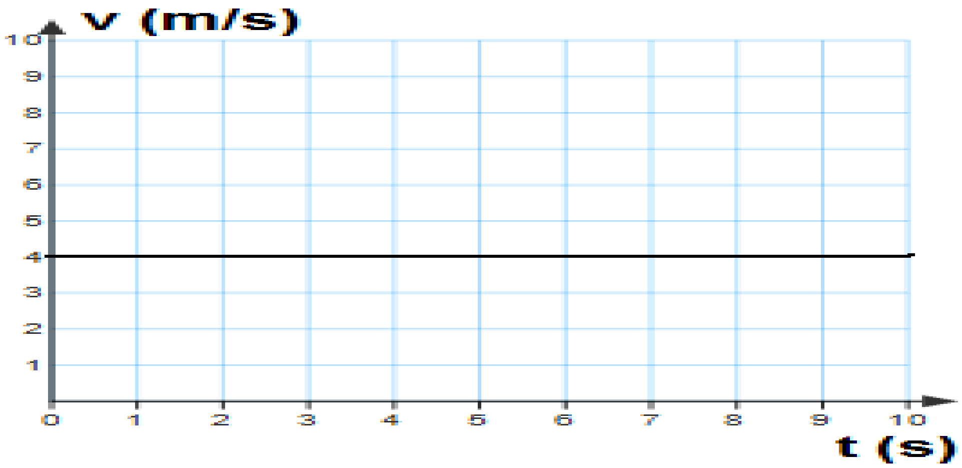
PRE-TEST: KINEMATICS
DURATION: 30 minutes
Instruction
Five possible answers have been given. Cross (X) the correct answer of your choice in the answer grid on page 6.

The following graph represents the position as a function of time of a moving object. Use this graph for questions 1 and 2.



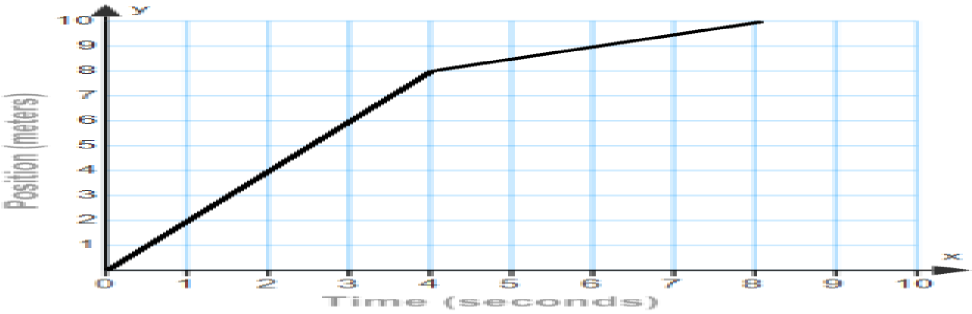
1. What is the position of the object after 1s?
   A. 5 m B. 4 m C. 3 m D. 6 m E. 10 m
2. What is the velocity of the object?
   A. 5 m/s B. -5 m/s C. 10 m/s D. -10 m/s E. 0 m/s

Use the graph below to answer question 3 and 4.



3. What is the velocity of the object at 5 s ?
   A. 1 m/s B. 2 m/s C. 3 m/s D. 4 m/s E. 5 m/s
4. The graph represents the relationship between velocity and time for an object moving in a straight line. What is the traveled distance of the object at 9 s?
   A. 10 m B. 24 m C. 36 m D. 48 m E. 56 m

The position vs. time graph of a moving object is shown to the right. Use this graph to answer questions 5 through 7.



5. What is the average speed from 0 s to 4 s?

   A. 0.5 m/s B. 1 m/s C. 2 m/s D. 3 m/s E. 4 m/s

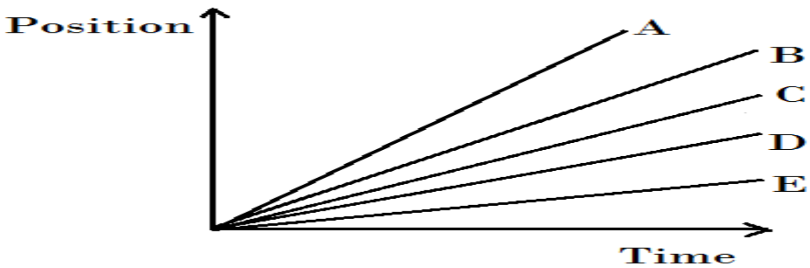
   What is the total displacement between 0 s to 4 s?

   A. 8 m B. 16 m C. 32 m D. 10 m E. 4 m

6. What is the object's position at 6 s?

   A. 2 m B. 1 m C. 3 m D. 7 m E. 9 m

7. For the objects shown in the graph, which is fastest?



8. For an object traveling at a constant velocity
   A. average velocity is greater than instantaneous velocity
   B. instantaneous velocity is greater than average velocity
   C. instantaneous velocity and average velocity are the same
   D. can't tell from the data given
   E. instantaneous velocity changes, but average velocity stays the same
9. Which has zero acceleration? An object
   A. at rest.
   B. moving at constant velocity.
   C. moving at a constant speed in a straight line.
   D. all of these.
   E. none of these.
10. As an object falls downward (neglecting air resistance), its
    A. velocity remains constant while acceleration increases
    B. velocity decreases while acceleration increases
    C. velocity increases and acceleration increases.
    D. velocity and acceleration remain constant
    E. velocity increases and acceleration remains constant.

11. Which one of the following equations calculates displacement?
    A. $dislacement = initial\ velocity + acceleration \times time$
    B. $displacement = average\ velocity\ \times time$
    C. $displacement = \frac{velocity}{time}$
    D. $displacement = \frac{final\ velocity + initial\ velocity}{2}$
    E. $displacement = velocity^2 \times time$
12. An object moving along a straight line at a constant speed has
    A. constant acceleration
    B. zero acceleration
    C. maximum deceleration
    D. maximum displacement
    E. constant deceleration
13. A car moving at a velocity 50m/s would avoid hitting a dog crossing at 200m in front if the driver stopped after 2s reaction time.
    A. False
    B. True
    C. May be
    D. yes, if the driver swayed the car
    E. None of the above
14. Uniform acceleration means
    A. object is at rest
    B. object is moving fast
    C. object is continuously changing speed
    D. Speed is constantly increasing
    E. speed is constantly decreasing

End of Test

Mufulira College of Education

2019

Pre-Test Answer Grid

1	A	B	C	D	E		**11**	A	B	C	D	E
2	A	B	C	D	E		**12**	A	B	C	D	E
3	A	B	C	D	E		**13**	A	B	C	D	E
4	A	B	C	D	E		**14**	A	B	C	D	E
5	A	B	C	D	E		**15**	A	B	C	D	E
6	A	B	C	D	E							
7	A	B	C	D	E							

8	A	B	C	D	E		
9	A	B	C	D	E		
10	A	B	C	D	E		

Appendix 5: Post-test

TEST 2: KINEMATICS

DURATION: 30Min

Instruction

Five possible answers have been given. Cross (X) the correct answer of your choice in the answer grid on page 4.

Appendix 6 : Post-test

1. The distance vs. time graph below shows data collected as a remote-controlled car moved across a level parking lot.

   According to the graph, which of the following conclusions about the car's motion is supported?

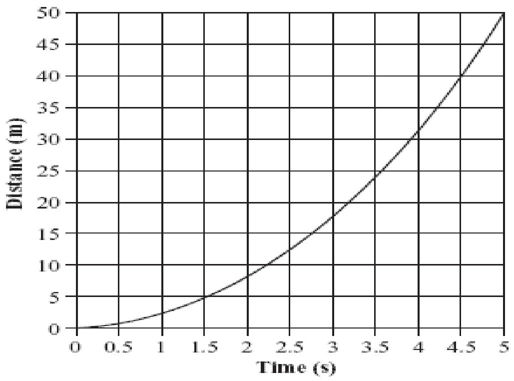
   A. The car is accelerating

   B. The car is stopping and starting

   C. The car is traveling at a constant velocity

   D. The car is moving through an obstacle course

   E. The car is retarding



2. What is the object's average velocity from t = 5 s to t = 7s?

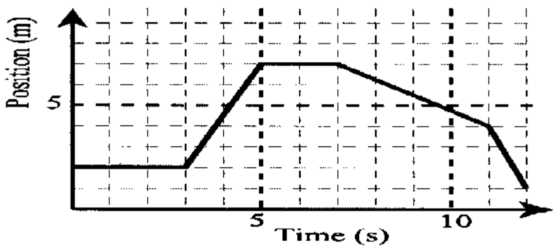
   A. 0.44 m/s

   B. 0.51 m/s

   C. 0.77 m/s

   D. 1.75 m/s

   E. 0.00 m/s



3. The graph below shows the velocity of a car over a period of six hours. What is the car's acceleration between hours 2 and 3?

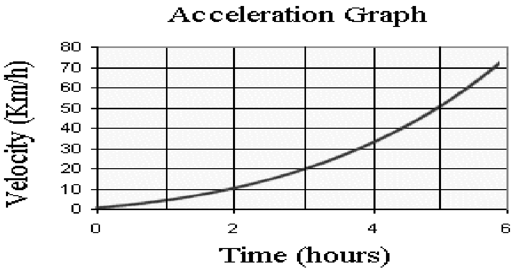
   A. 0 km/h²

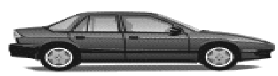
   B. ⁻10 km/h²

   C. 20 km/h²

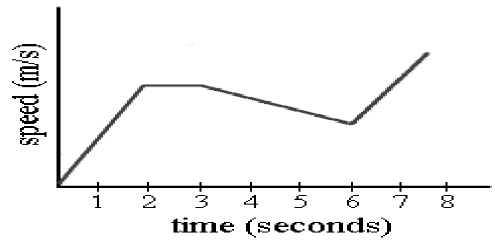
   D. 10 km/h²

   E. 5 km/h²



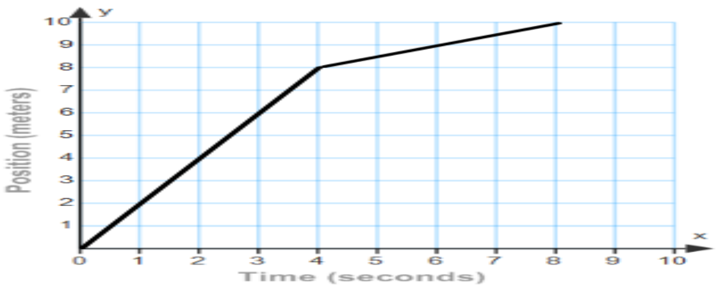


4. A graph of a car's motion is shown below. Which statement best describes the car's motion between 3 seconds and 6 seconds?



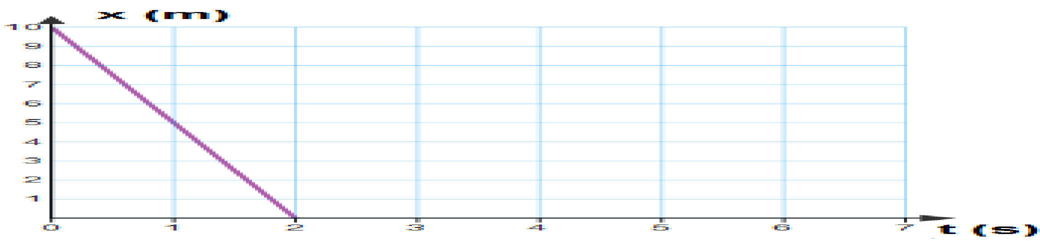
   A. The car is accelerating
   B. The car is decelerating
   C. The car has a constant velocity
   D. The car is stopped.
   E. The car is falling

5. What is the total displacement between 4 s s to 8 s?



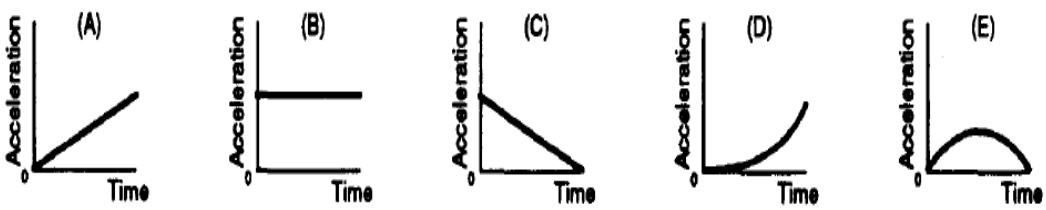
A. 8 m B. 16 m C. 32 m D. 10 m E. 2 m

6. What is the acceleration of the object?



A. 5 m/s B. -5 m/s C. 10 m/s D. -10 m/s E. 0 m/s

7. The acceleration- time graphs all have the same scale. Which graph best depicts a car with greatest change in velocity after some time?



8. An object is observed to have zero acceleration. Which of the following statements must be true?
   A. The object is losing speed.
   B. The object is moving with changing speed.
   C. There is no air resistance on the object.
   D. The object has a constant velocity.
   E. The object has zero time

9. A car driving down the freeway has a constant velocity. Which of the following statements must be true?

A. The car has zero acceleration.
B. The car is moving in a circular path.
C. There is no friction acting on the car.
D. The car is speeding up.
E. The car has constant acceleration

10. A ball starting from rest accelerates uniformly to 5.0 meters per second as it covers a displacement of 40 meters. How much time is required for the ball to cover the 40 meters?
A. 2.8 s B. 8.0 s C. 16 s D. 4.0 s E. 5.0 s

11. The speed of a car is decreased uniformly from 30 meters per second to 10 meters per second in 4.0 seconds. The magnitude of the car's acceleration is
A. 5.0 m/s^2 B. 10. m/s^2 C. 20. m/s^2 D. 40. m/s^2 E. 6.0 m/s^2

12. What is the average acceleration of a car that goes from rest to 60 m/s in 6 seconds.
A. 8 m/s^2 B. 13 m/s^2 C. 7.5 m/s^2 D. 10 m/s^2 E. None of the above

13. How long does it take to accelerate an object from rest to 10 m/s if the acceleration was 2 m/s^2?
A. 10 seconds B. 5 seconds C. 15 seconds D. 2 seconds E. 20 seconds

14. A sports car accelerates uniformly from an initial velocity of 10m/s to a final velocity 20m/s in time 2s. What is the acceleration of a sports car?
A. 20m/s^2 B.10m/s^2 C. 40m/s^2 D. 5m/s^2 E. 200m/s^2

15. A car moving at a velocity 50m/s would avoid hitting a dog crossing at 200m in front if the driver stopped after 2s reaction time.
A. False B. True C. May be D. yes, if the driver swayed the car E. None of the above

End of Test

Mufulira Coll Ege of Education

2019

Post-Test Answer Grid

GROUP NO.:……………. **NAME:………………………….**

1	A	B	C	D	E		**11**	A	B	C	D	E
2	A	B	C	D	E		**12**	A	B	C	D	E
3	A	B	C	D	E		**13**	A	B	C	D	E
4	A	B	C	D	E		**14**	A	B	C	D	E
5	A	B	C	D	E		**15**	A	B	C	D	E
6	A	B	C	D	E							
7	A	B	C	D	E							
8	A	B	C	D	E							
9	A	B	C	D	E							
10	A	B	C	D	E							

Appendix 7: Pre-Test Marking Scheme

1	A	B	C	D	E		**11**	A	B	C	D	E
2	A	B	C	D	E		**12**	A	B	C	D	E
3	A	B	C	D	E		**13**	A	B	C	D	E
4	A	B	C	D	E		**14**	A	B	C	D	E
5	A	B	C	D	E		**15**	A	B	C	D	E
6	A	B	C	D	E							
7	A	B	C	D	E							
8	A	B	C	D	E							
9	A	B	C	D	E							
10	A	B	C	D	E							

Total Marks: 15

Appendix 8: Post –Test Marking Scheme

1	A	B	C	D	E		**11**	A	B	C	D	E
2	A	B	C	D	E		**12**	A	B	C	D	E
3	A	B	C	D	E		**13**	A	B	C	D	E
4	A	B	C	D	E		**14**	A	B	C	D	E
5	A	B	C	D	E		**15**	A	B	C	D	E
6	A	B	C	D	E							
7	A	B	C	D	E							
8	A	B	C	D	E							
9	A	B	C	D	E							
10	A	B	C	D	E							

Total Marks: 15

Appendix 9: Research Budget

The budget for the materials and services to wards the research studies.

The figures are estimated based on the current prices.

Item	**Price / Cost (K)**
Writing Materials	160.00
Typing Services	100.00
Traveling Expenses	1000.00
Photocopy	50.00
Binding	100.00
Other Expenses	600.00
Total.	**2,010.00**

Appendix 10: Research Time

Data Collection, Analysis & Thesis writing	January - April 2019

1. Monk, S, 1994. "How students and scientists change their minds." MAA invited address at the Joint Mathematics Meetings, Cincinnati, Ohio, January, 1994.

2. Wagner, C. and Vaterlaus, A, 2011. A Model of concept learning in physics. Conference proceedings, Frontiers of Fundamental Physics FFP12. http://www.fisica.uniud.it/ffp12/proceedings.html.