May 2014

Development of Supplementary Material to Enhance the Graph Interpretation Skills of Students

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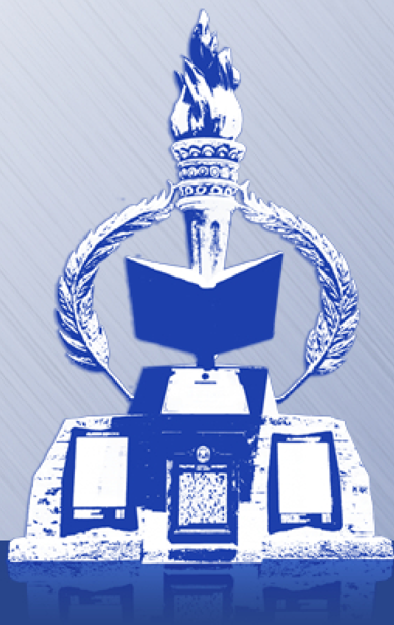

DEVELOPMENT OF SUPPLEMENTARY MATERIAL TO ENHANCE THE GRAPH INTERPRETATION SKILLS OF STUDENTS

A Thesis Presented to the Faculty of
College of Graduate Studies and
Teacher Education Research
Taft Avenue, Manila

In Partial Fulfillment of the Requirements for the Degree
Master of Arts in Science Education
with Specialization in Physics

JOANNA MARIE A. DE BORJA
May 2014

APPROVAL SHEET

In partial fulfillment of the requirements for the degree of Master of Arts in Science Education with specialization in Physics, this thesis entitled **"DEVELOPMENT OF SUPPLEMENTARY MATERIAL TO ENHANCE THE GRAPH INTERPRETATION SKILLS OF STUDENTS"** prepared by **MS. JOANNA MARIE AGUILAR-DE BORJA**, is hereby recommended for approval and acceptance.

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ACKNOWLEDGEMENT

I would like to express my sincerest thanks and appreciation to the following people:

DR. VIOLETA N. ARCIAGA and **PROF. ABEL F. OLE** for their brilliant and excellent ideas, countless support and encouragement, and the untiring effort especially in making this study;

DR. VIRGIL DUAD for his invaluable suggestions and effort in doing the statistical analyses of data;

DR. ZENAIDA REYES, DR. EDEN EVAGELISTA, DR. ANTRIMAN ORLEANS, and **PROF. DONNA MARIE DE MESA**, my panelists, for their brilliant comments and suggestions to improve this research study;

COLEGIO DE SAN JUAN DE LETRAN CALAMBA HS FACULTY especially Math and Science Cluster for all the help and support;

PROF. SIMPLICIO ALBA, Letran Calamba BED Principal and **MS. ARACELI GECALE**, Math and Science Cluster Chair, for being considerate enough during the conduct of the study;

To my family, **MOMMY, TATAY,** and **MGA KAPATID**, for being always there for me through thick and thin;

To my husband, **MC ANTHONY R. DE BORJA**, for all the support, understanding, trust, love, and care… I love you;

To my two little angels and wind beneath my wings, **MARCO ANTONIO** and **TONEE MARIE**, you will always be my source of inspiration and strength, and for giving meaning to my life, I love you both always…

And above all, to our **OMNIPOTENT GOD**, for the gift of life – blessings, talent, intelligence, courage, friends, family, and everything that exists in this world. Thank you so much Lord!

THAT IN ALL THINGS, GOD MAY BE GLORIFIED!

JOANNA MARIE A. DE BORJA

ABSTRACT

Name	:	Joanna Marie Aguilar de Borja
Title	:	Development of Supplementary Material to Enhance the Graph Interpretation Skills of Students
Key Concepts	:	Supplementary Material, Kinematics Graphs, Graph Interpretation Skills, TUG-K
Degree	:	Master of Arts in Science Education
Specialization	:	Physics
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The main objective of this study is to develop a supplementary material to enhance the graph interpretation skills of students. It attempted to answer the following questions: (1) What are the common difficulties of students in interpreting kinematics graphs? (2) What is the acceptability rating of experts as regards the supplementary material? (3) Is there a significant difference between the pretest and posttest scores of the control group and of the experimental group; and (4) Is there a significant difference between the change scores of the control and experimental groups?

The selected fourth year students of Colegio de San Juan de Letran Calamba for AY 2013-2014 were the respondents in identifying the difficulties of students with kinematics graph that served as the basis of developing a supplementary material. The supplementary material was validated by four physics experts and then revisions were made based on the suggestions of the said experts. Lastly, quasi-experimental design specifically the non-equivalent pretest-posttest control group design was used in validating the effectiveness of the supplementary material.

Two instruments were used: Test of Understanding Graphs – Kinematics by Dr. Beichner (1994) and Expert's Evaluation Instrument.

After the tabulation and interpretation of the data, the salient findings were obtained: (1) The results revealed that majority of the students performed "Low" on the TUG-K. In the determination of the difficulties of the students in interpreting kinematics graphs using the seven objectives listed by Beichner in his study, results showed that the most difficult objective was “Select textual description” given a kinematics graph. (2) Based on experts’ assessment, the developed supplementary material on graphical analysis of motion is “Acceptable”. (3) Findings showed that there is a significant difference between the pretest (2.72) and posttest (14.48) scores of the control group. (4) The data obtained also revealed that there is a significant difference between the pretest (2.70) and posttest (18.00) scores of the experimental group. (5) Results revealed that during the posttest the experimental group with a mean score of 18.00 (High) performed better than the control group with a mean score 14.48 (Average) in terms of level of graph interpretation skills in kinematics. The computed *t* value which is 3.13 exceeded the critical value of 2.021 (df = 40) with 95% level of confidence as well as the p-level obtained a value of 0.001 which states that it is “Highly Significant”. As a result, it is therefore concluded that there is a significant difference between the performance of the students with or without the supplementary material.

DEDICATION

To my husband, ***Mc Anthony,***

my son, ***Marco Antonio***

and

my daughter, ***Tonee Marie***.

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CHAPTER I

THE PROBLEM AND ITS BACKROUND

Introduction

Kinematics is often the first topic discussed in Physics. Most of the ideas in kinematics such as position, velocity, and acceleration are incorporated into almost all branches of Physics. If there is no solid understanding of kinematics, students would lack the foundation necessary to succeed in the following lessons as physical concepts become more abstract and complicated. Because of the fundamental nature of kinematics in the whole of Physics, any improvement in student understanding of these concepts enhances the possibility of comprehension of Physics that the students would encounter throughout the year (Archambault et al, 2008).

On the other hand, Physics teachers are always challenged on how to build the best foundation for the students to learn which would help them cope with the mathematical aspects of studying Physics. One of the methods used by Physics teachers to answer this challenge is the use of graphs. The ability to use graphs could be an essential step toward the mastery of problem solving as mentioned by Mamaril (2004).

A graph is a diagram showing the relation between two variable quantities. It helps to represent Physics formulas which are abstract forms of the existing relationship between physical quantities. In Physics, particularly in kinematics, the use of graphs can be very useful in enhancing the conceptual understanding of the students. Graphical analysis is an approach in learning kinematics that uses slope and area under the graph to solve for unknown quantities related to the motion of an object (Ellis and Turner, 2002). This could help students improve their problem solving abilities in Physics.

In 1987, McDermott conducted a study that probed the students' understanding of the concepts of position, velocity, and acceleration in one dimension. Other researchers conducted similar studies on the same area including the work of Beichner. His study revealed the problems encountered by the students in their interpretation of kinematics graph that led him to propose a model for creating a multiple-choice type of test that - can be used as a diagnostic tool, as well as formative and summative evaluation of instruction n graphical analysis of motion. According to Beichner (1994), graphs summarize large amounts of information while still allowing details to be resolved. The ability to comfortably work with graphs is a basic skill that must be developed by anyone involved in the study of science particularly in Physics. Line graph construction and interpretation are very important because they are an integral part of experimentation - the heart of science. The ability to use graphs may be an important step toward expertise in problem solving since "the central difference between expert and novice solvers in scientific domain is that novice solvers have much less ability to construct or use scientific representations. Perhaps the most compelling reason for studying students' ability to interpret kinematics graphs is its widespread use as a teaching tool. Since graphs are such efficient packages of data, they are used almost as a language by Physics teachers.

With this, Beichner (1994) developed the *Test of Understanding Graphs in Kinematics* (TUG-K). It is an instrument designed to disclose student difficulties with position, velocity, and acceleration versus time graphs. Beichner (1994) generously shared this instrument as a research tool for others who are interested in working with the same topic. The findings of Beichner (1996) in his study of graph interpretation motivated the author of this thesis to conduct a similar study and test the understanding of kinematics graphs of the students of Colegio de San Juan de Letran Calamba. In addition, Beichner (1994) mentioned that whether the instruction was exemplary or ordinary, the students were not able to fluently interpret kinematics graphs. Therefore, the researcher believed that a supplementary material should be given to students to increase their level of understanding of kinematics graph.

Conceptual/Theoretical Framework

According to Mayer (2001) in his "*Cognitive Theory of Multimedia Learning*", students construct knowledge based on cognitive processes during learning. Learners are regarded as sense makers, and that they construct meaning from information, experience, and some mental models or representations of knowledge. The cognitive theory of multimedia learning (CTML) is based on three cognitive science principles of learning; the human information processing system includes dual channels for visual/pictorial and auditory/verbal processing (i.e., dual-channels assumption); each channel has limited capacity for processing (i.e., limited capacity assumption); and active learning entails carrying out a coordinated set of cognitive processes during learning (i.e., active processing assumption). In addition, multimedia learning can be delivered using any medium, including paper (i.e., book-based communications) or computers (i.e., computer-based communications). Words can include printed words or spoken words; pictures can include static graphics – such as illustrations or photos or dynamic graphics – such as animations or video clips. For a meaningful learning to occur in a multimedia environment, the learner must engage in five cognitive processes: (1) selecting relevant words for processing in verbal working memory, (2) selecting relevant images for processing in visual working memory, (3) organizing selected words into a verbal model, (4) organizing selected images into a pictorial model, and (5) integrating the verbal and pictorial representations with each other and with prior knowledge. Although processes were presented as a list, they do not necessarily occur in linear order, so a learner might move from process to process in many different ways. Successful multimedia learning requires that the learner coordinated and monitor these five processes.

In the study conducted by Sadaghiani (2012) which adopted the use of Multimedia Learning Modules (MLM) for teaching mechanics found out that the students in the multimedia group outperformed the students who did not experience the MLMs in a final course examination and across identical discussion questions. According to Sadaghiani (2012), multimedia learning modules present essential content of one lecture using various media (e.g., text, narration, flash animations).

Redish (2003) believed that multiple representations (visual and verbal) may help students make better use of their working memory. According to him, different representations associate more naturally with different features of the data/situation that is being described. Furthermore, he stated that multiple representations can be effective in building links between different aspects of the situation. The most common representations used in Physics are words, equations, table of numbers, graphs, and specialized diagrams. Each representation takes some time and effort to learn. If students haven't learned yet how to read a representation, that is, if their knowledge of that representation hasn't be compiled into an easily processed chunk, the translation of the representation can take up too much working memory to allow the students to make effective use of the representation. Some may have mastered one or more of these representations through experiences they had before coming to the class. Some may have a learning style that favors a verbal or a visual representation. As stated by Redish, the student needs to familiarize the representation, otherwise, it could add to the "cognitive load which could make understanding increasingly more difficult."

The level of understanding and difficulties of students in learning kinematics graphs were determined based on the study conducted by Beichner (1994). In the study, it was found that several students' difficulties with kinematics graphs were graph as picture errors, slope/height confusion, variable confusion, nonorigin slope errors, area ignorance, and area/slope/height confusion.

On the other hand, Beichner (1996) mentioned that Physics teachers often report that their students cannot use graphs to represent physical reality. The types of problems Physics students have in this area have been carefully examined and categorized. Several of these studies have demonstrated that students entering introductory Physics classes understand the basic construction of graphs, but have difficulty applying those skills to the tasks encountered in the Physics laboratory. The most common errors students make when working with these kinds of graphs are (1) thinking that the graph is a literal picture of the situation and (2) confusing the meaning of the slope of a line and the height of a point on the line (Beichner, 1994).

In general, Beichner (1994) stated that students tend to find slopes more difficult than individual data points. Students also have a hard time separating the meanings of position, velocity, and acceleration versus time graphs. Regardless of the type of errors students make, it is generally agreed that an important component of understanding the connection between reality and the relevant graphs is the ability to translate back and forth in both directions. Recognizing the importance of graphing skills and the recent interest in students' interpretation of kinematics graphs leads to the need for assessment of those skills. He also mentioned that students who could correctly translate from one kinematics graph to another also had the best overall understanding of kinematics graphs. This might mean that "graph as-picture" errors are the most critical to address. If students viewed graphs as photographs of the situation, they would see no reason for the appearance of a graph to change, even though the ordinate variable changed. Table 1 illustrates the difficulties of the students when it comes to kinematics graph.

Table 1. Student Difficulties with Kinematics Graphs

Graph as Picture Errors
The graph is considered to be like a photograph of the situation. It is not seen to be an abstract mathematical representation, but rather a concrete duplication of the motion event.
Slope/Height Confusion
Students often read values off the axes and directly assign them to the slope.
Variable Confusion
Students do not distinguish between distance, velocity, and acceleration. They often believe that graphs of these variables should be identical and appear to readily switch axis labels from one variable to another without recognizing that the graphed line should also change.
Nonorigin Slope Errors
Students successfully find the slope of lines which pass through the origin. However, they have difficulty determining the slope of a line (or the appropriate tangent line) if it does not go through zero.
Area Ignorance
Students do not recognize the meaning of areas under kinematics graph curves.
Area/Slope/Height Confusion
Students often perform slope calculations or inappropriately use axis values when area calculations are required.

*Source: Beichner, Robert J. (1994) "Testing Student Interpretation of Kinematics Graph"

Based on the findings of Beichner (1994), students are having hard time in interpreting kinematics graphs even if the instruction was exemplary or ordinary. With this, the researcher thought of developing a supplementary material that would enhance the interpretation skills of students with kinematics graphs. As mentioned above in the "Cognitive Theory of Multimedia Learning" of Mayer (2001), learners construct meaning from information, experience, and some mental models or representations of knowledge. It could be delivered using any medium, including paper (i.e., book-based communications) or computers (i.e., computer-based communications). The developed supplementary material is equipped with multiple representations such as texts, pictures, diagrams, and simulations that would guide students in understanding kinematics graphs.

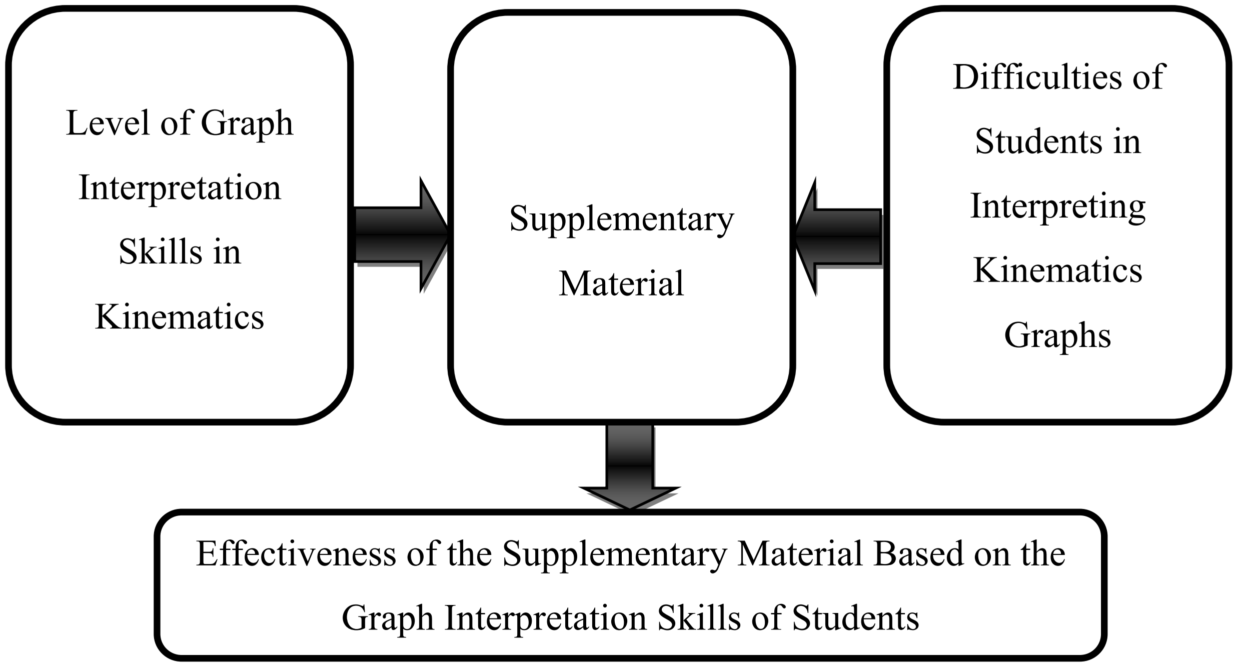

Figure 1. Paradigm of the Study

Figure 1 presents the paradigm of the study. The researcher identified the level and difficulties of the students in interpreting kinematics graphs. The results served as the bases of developing a supplementary material. The material's effectiveness was tested based on the graph interpretation skills of students.

Statement of the Problem

The study generally aimed to develop a supplementary material to enhance the graph interpretation skills of the students. Specifically, it would attempt to answer the following questions to serve as bases for the development of the supplementary material:

1. What are the common difficulties of students in interpreting kinematics graphs?
2. What is the acceptability rating of experts as regards the supplementary material?
3. Is there a significant difference between the pretest and posttest scores of the

   3.1. control group; and

   3.2. experimental group?
4. Is there a significant difference between the change scores of the control and experimental groups?

Significance of the Study

Students. This study would identify common difficulties of students in interpreting graphs and find ways to solve such problems. The developed supplementary material would help the students enhance their graph interpretation skills in kinematics and would further develop their analysis in solving problems in physics.

Teachers. The study would help science educators in offering quality education for the effective delivery of science instruction. This study would make the teachers aware of the importance of using graphs in enhancing students' understanding of Physics concepts particularly in kinematics. Furthermore, the developed supplementary material would help teachers in teaching kinematics graphs.

Curriculum Planners. This study would help curriculum planners on how to develop physics teaching materials using graphs to enhance students' conceptual understanding.

Other Researchers. Researchers could also use the results as bases for future investigations on other activities, as well as their applications in other Science or Mathematics subjects. Moreover, the results gathered from this study would give baseline data to develop their own supplementary material aligned to the needs of the learners.

Scope and Delimitations of the Study

The study focused on the level of graphical interpretation skills in kinematics as well as the difficulties in interpreting kinematics graphs of students using the TUG-K. Based on the results of the said test, the researcher developed a supplementary material to enhance the graph interpretation skills of the students. A teacher's guide was also developed; however, it was not evaluated by the experts since the study only focused on the effects of the supplementary material. The teacher's guide was only designed to help teachers on how to implement the supplementary material to the students.

In addition, the topics free fall and projectile motion were not included in the study even if these topics are part of Kinematics. Thus, in the Test of Understanding Graph – Kinematics (TUG-K) these topics were not included and at the same time discussions of these topics in the graphical analysis were not included in the textbook used as a reference material in Colegio de San Juan de Letran Calamba.

Lastly, quasi-experimental design specifically the non-equivalent pretest-posttest control group design was used in validating the effectiveness of the supplementary material. Conversely, this design has its own limitations. According to Price and Oswald (2008), a quasi-experiment is a study that includes a manipulated independent variable but lacks important controls (e.g., random assignment), or a study that lacks a manipulated independent variable but includes important controls. So a quasi-experiment has some features of a well conducted experiment but not others. In addition, it was also mentioned that the problem with this approach is that there might be differences between the two groups of students other than the style of teaching to which they were exposed. It is possible that differences in the dependent variable could have been caused by these differences rather than differences in teaching style.

Definition of Terms

To provide a better understanding of the study, the following terms are defined:

*Difficulty Index (d).*It is the proportion of the individuals who got the wrong answer to the individuals who responded to the item.

Kinematics Graphs. Graphs of motion which may be position vs. time, velocity vs. time, or acceleration vs. time.

Mental Models. These are patterns used by a learner to construct knowledge that involves perception of symbols, graphs, diagrams, etc.

*Quarterly Average (Q).*This is the average of the first quarter (Q_1) and second quarter (Q_2) of the respondents in Basic Physics.

Student Difficulties. It refers to both Mathematics and Physics related factors that hinder student's correct interpretation of kinematics graphs.

TUG-K. Test of Understanding Graphs – Kinematics was developed by Dr. Beichner (1994) to identify the level and difficulties of students in understanding kinematics graphs.

CHAPTER II

REVIEW OF RELATED LITERATURE

This chapter presents relevant information and theories from related studies and related literature from foreign and local researches. It is subdivided into two headings namely: understanding graphs and supplementary material.

Understanding Graphs

According to McDermott (1987), students are often unable to relate the concepts and formal representations of physics to one another and to the real world. The inability to interpret equations, diagrams, and graphs underlies many conceptual and reasoning difficulties.

Mokros and Tinker (1987) noted that graphs allow scientists to use their powerful visual pattern recognition facilities to see trends and spot subtle differences in shape. In fact, it has been argued that there is no other statistical tool as powerful for facilitating pattern recognition in complex data. Graphs summarize large amounts of information while still allowing details to be resolved. The ability to use graphs may be an important step toward expertise in problem solving since "the central difference between expert and novice solvers in a scientific domain is that novice solvers have much less ability to construct or use scientific representations". Perhaps the most compelling reason for studying students' ability to interpret kinematics graphs is their widespread use as a teaching tool. Since graphs are such efficient packages of data, they are used almost as a language by Physics teachers.

On the other hand, the researcher found out that students have difficulties when it comes to understanding graphs in kinematics. According to Mayer (2001), students construct knowledge based on cognitive processes during learning. Learners are regarded as sense makers, and that they construct meaning from information, experience, and some mental models or representations of knowledge. In the cognitive study of physics, Redish (2003) developed principles based on the assumption of the literacy of human mind to form patterns. His "construction principle" described people's tendency to organize their experiences and observations into patterns or mental models. When applied to classroom setting, Reddish stressed that the goal of physics teaching is to have student build the proper mental models for doing physics. This cognitive skill, however, could not be realized in the absence of objects and events that are the content of thought (Matthewson, 1999).

The papers of Leinhard, Zaslavsky, and Stern (1990) described theories related to the tendency of learning of functions and graphing in high school mathematics. The researchers considered that these theories were fundamental links between graphs and the functions that they represent. Graph interpretation is colored by the viewpoint from which it was taught or learned. The result is that students often have difficulty translating their mathematical prowess to scientific graphs, even though graphs were constantly used in science and social studies courses. The authors found several factors as hindrances to students' learning of graphical information. These include: (1) when a graph has features that can be seen as pictorial representation of some aspect of the situation, the students can be distracted; and (2) when information is presented in a new subject, students become overwhelmed making abstraction of the data representation more difficult. In addition, the author claimed some of the difficulties faced by a learner in understanding graphical information. These difficulties are due to the students' not viewing graph as an abstract representation of the system under study. As consequences, students give more meaning to the graph's scale than what is mathematically warranted; do not comprehend the significance of the slope for a situation; and view a graph as a scene of an event.

Svec (1999) observed that many teachers consider the use of graphs in developing an understanding of many topics in physics, especially the topic about motion. Furthermore, he observed that the use of graphs help physics students learn kinematics concepts.

Murphy (1997) is convinced that the ability of the students to interpret line graphs depends on their cognitive level and in gaining certain specific mental structures. Murphy was not sure if instruction that helps students gain ability in graphical interpretation would also help build "the corresponding mental structures and facilitate a transition from concrete operational reasoning".

Beichner (1994) conducted a research about testing student interpretation of kinematics graphs. He developed the Test of Understanding Graphs in Kinematics (TUG-K) that was intended to serve two purposes. First, the results of the study aimed at uncovering student problems with interpreting kinematics graphs will be reported. This kind of knowledge can be very helpful before, during, and after instruction. Physics teachers tend to use graphs as a sort of second language, assuming their students can extract most of their rich information content. These results indicate that this is often an incorrect assumption. The secondary purpose of this article is to propose a model for creating research oriented multiple choice tests which can be used as diagnostic tools and for formative and summative evaluation of instruction.

Data from 895 students at the high school and college level was collected and analyzed. The test mean score of 40% is quite low considering that the test was taken following instruction in kinematics. The case could even be made that this instruction might be better than the norm since the teachers who administered the test to their students were volunteers (mostly contacted via electronic mail). This might lead to a bias in the student population since it is possible that only good teachers would “risk” giving an outsider the opportunity to closely examine what their students were learning. It can certainly be said that the teachers who volunteered were interested in improving instruction. But the results are clear, whether the instruction was exemplary or ordinary, the students were not able to fluently interpret kinematics graphs.

Moreover, Beichner (1996) also conducted a study about video motion analysis software that was used by 368 introductory Physics students in a variety of instructional settings. These high school and college students experienced graduated variations in their use of a video analysis software package. Post-instruction assessment of their ability to interpret kinematics graphs clearly establishes that all performed better than students taught via traditional instruction. The data indicate that the greater the integration of video analysis into the kinematics curriculum, the larger the educational impact. Hands-on involvement appeared to play a critical role. Limiting student experience with the video analysis technique to a single teacher-led demonstration resulted in no improvement in performance relative to traditional instruction. Offering more extensive demonstrations and carrying them out over an extended period of time proved somewhat effective. The greatest impact came from a combination of demonstrations with hands-on labs. The curricular modifications employed in the different classrooms and the methods used to evaluate them are discussed.

According to the action research conducted by Archambault, et.al (2008), kinematics concepts in physics have been modeled algebraically, graphically and with motion maps. However, the investigators have noticed that despite the many representations available to them, students show a strong preference for solving kinematic problems algebraically. Students were required to solve kinematics problems exclusively utilizing graphical representations prior to being introduced to methods of algebraic solutions. Results indicate that students who received the treatment chose graphical methods for solving kinematics problems more frequently, and demonstrated stronger gains in understanding kinematics concepts overall than those students who did not receive the treatment. This study attempted to improve conceptual understanding of kinematics concepts by having students solve problems with graphical representations prior to acquiring the ability to solve similar problems algebraically. By spatially exploring these problems before abstracting the concepts to an algebraic level, we emphasized the conceptual understanding with the students. We hoped that this method of teaching kinematics would be successful in creating a deeper understanding of the concepts of kinematics than the modeling program has done.

Cadorna, et.al (2012) conducted a research on the skills in interpreting kinematics graph among the engineering students in the University of Northern Philippines, Tamag, Vigan City. The students had finished the general physics courses. Kinematics graphs were focused on position-time (x-t), velocity-time (v-t), and acceleration-time (a-t) graphs. This study made use of the exploratory type of research. The students completed a written instrument, the Test of Understanding Graphs-Kinematics (TUG-K), adopted from Beichner (1996). The influence of students' personal variables and mathematics grades on graphical interpretation skills were likewise looked into in the study. Findings show that, generally, the engineering students under study only had an average skill in interpreting kinematics graph. They were found to have a moderate skill in interpreting v-t graphs and a-t graphs but high skills in interpreting x-t graphs. Moreover, they were skillful in finding the velocity given the x-t graph but not skillful in finding the acceleration and distance, given the v-t graph. Likewise, they were not skillful in finding the change in velocity, given the a-t graph; in identifying corresponding kinematics graph and text explanation of a graph, given the kinematics graph, and in identifying the corresponding graph, given the text explanation of the graph.

Furthermore, the researchers recommended that students should learn how to use graphs as early as their high school years so as to facilitate their understanding and use at the college level. Physics teachers should use graphs more frequently in their Physics classes to reinforce students' understanding of Physics concepts. The results of this study should be used to improve instructional materials such as textbooks and workbooks. It can also be used to improve instructional techniques particularly in improving the mathematics concepts of slope and area under a graph and the physics concepts of time, position, velocity, and acceleration.

In the research conducted by Cadorna, et.al (2013), they analyzed the spatial ability and understanding of graphs in kinematics of college students. Spatial ability was measured along developments, rotation, and visualization. On the other hand, students' understanding of graphs in kinematics was focused on topics related to the interpretation of a slope of a line and area under a curve or a line. The descriptive research design was employed in the study. The 203 students who were enrolled in Physics I completed the Purdue Spatial Visualization Test and the Test of Understanding of Graphs in Kinematics (TUG-K). The latter probed the students' understanding of graphs in kinematics.

Findings reveal that the students do not possess the ability to think and to draw conclusions about those objects from limited information. They do not possess the capacity to keep track of objects or locations in space even after a rotation or movement to a new location. Moreover, the students do not fully understand kinematics graph. They do not have adequate knowledge in understanding the slope and area under a curve or a line in a kinematics graph The students are confused when to use the area and when to use the slope when referring to kinematics graph, i.e., they tend to calculate the area instead of the slope of a graph. In addition, they cannot discriminate between slopes. Lastly, spatial ability along rotations and views, and sex predict the students' overall understanding of graphs in kinematics.

Bahjati (2012) conducted a study to find out if instruction in construction and extraction of graph affect the performance of the students in physics. It sought to determine if there are significant differences among the treatment groups at the start and at the end of the experiment in terms of scores in the achievement test and scores in the graphing skills test. The study utilized the pretest-posttest matched group design. Three research-made instruments were used. The pretest scores result in the achievement test show comparison of the three groups using ANOVA. The study revealed that the instruction in construction and extraction of graph that increase the performance of the students in the achievement test and graphing skills test. Traditional Teaching Approach with instruction in construction and extraction of graph significantly enhanced the achievement of students in Physics. Among the recommendation is instruction in construction and extraction of graph should be used to help and encourage students to enhance the performance of the student in their performance in physics. Future researcher may focus on the use of facilitating teaching approach with instruction on construction and extraction of graph or on other related strategies that may generate more high level graphing skills and enhancement of student achievement in physics. Lastly, a training program should be conducted to make teachers and students integrate construction and extraction of graph.

Bose (1999) conducted a study to find out the effectiveness of the graphical method in teaching mathematics to the second year students of the Abra State Institute of Sciences and Technology, Lagangilang, Abra during the School Year 1998-1999. The study utilized the quasi-experimental design, specifically, the non-equivalent pretest-posttest control group design since randomization process in selecting and assigning samples to the experimental group and control group was not possible. Two intact classes were used: one group served as the experimental class subjected to the experimental variable, graphical method of instruction and the other, the control group underwent the traditional method of instruction. The study used a mathematics achievement test of 40 items which was developed by the researcher. He concluded that there is a significant difference between the performance of the experimental group and control group. The difference was due to the experimental treatment the graphical method in teaching mathematics. He suggested that the graphical method of instruction could aid the students from the instructional point of view to acquire better understanding of the basic concept of points, lines, planes, negative and positive slope, and graphing. The graphical method could aid the students without sufficient skills in performing algebraic operations in solving problems.

Supplementary Material

According to The Global Source for Summaries and Review (2010), a supplementary material are substantial additional work which appends, incorporate, are appended to or is incorporated into the original material but which has some capacity to entertain or inform independently of the original material. Another definition said that supplementary material is a part of a work, physically separate from the basic bibliographic unit and frequently in a different medium. In addition, supplementary material is substantial additional work which is incorporated into or related to the original material but which has some function or capacity to entertain or inform independently, physically separate from the basic bibliographic unit and frequently in a different medium.

The characteristics of supplementary materials are:

- Related to, intended to or incorporate into the original material;
- Has capacity to inform or to entertain independently from original material;
- Physically separate from the basic bibliography unit; and
- Frequently in a different medium.

According to UNESCO (2014) the school may have acquired a variety of supplementary learning materials that students can use to reinforce their learning. The most common among these materials are books, newspapers, magazines and other reading materials that supplement the textbooks. Students can borrow various charts, kits, models and equipment or instruments for science, sports, music and arts, for schools that are equipped with audio-video equipment and computers, the range of supplementary learning materials can also include audiotapes and videotapes, CD-ROMs and dVds, access to computers and access to the internet.

Davanellos (n.d.) also mentioned that supplementary materials are materials which do not exist in the book/s which we are currently using with a group of learners. They are 'free-standing' and they are here to make the teacher's life easier and the learner's a bit more interesting. Supplementary materials may be of various types. A song, an authentic film, a cut-out from a magazine or newspaper, a poem, a game, a project etc. may become 'extra' tools in the hands of the trained teacher who wishes to teach effectively and professionally.

According to Kitao (1997), since the end of 1970s, there has been a movement to make learners rather than teachers the center of language learning. According to this approach to teaching, learners are more important than teachers, materials, curriculum, methods, or evaluation. As a matter of fact, curriculum, materials, teaching methods, and evaluation should all be designed for learners and their needs. It is the teacher's responsibility to check to see whether all of the elements of the learning process are working well for learners and to adapt them if they are not. In other words, learners should be the center of instruction and learning. The curriculum is a statement of the goals of learning, the methods of learning, etc. The role of teachers is to help learners to learn. Teachers have to follow the curriculum and provide, make, or choose materials. They may adapt, supplement, and elaborate on those materials and also monitor the progress and needs of the students and finally evaluate students.

From a study conducted by Ismak Nairobi (n.d) in his thesis found how schools are effective using supplementary material. Some of the highlights of his finding on the effect according to teachers and students are students are better equipped to meet the demands of higher education and the business world as well as their current educational challenges with increased technological skills. Teachers on the other hand seem to be more comfortable using supplementary materials.

Anir (1996) in his thesis compared the achievement and attitude toward Science and Technology III of students taught using the teaching resource package with those students taught without the teaching resource package. He also examined whether pre-test, mental ability, and average grade in chemistry are correlated to students achievement and attitude toward chemistry. The study found out that the teaching resource package was an effective supplementary instructional material for teaching selected topics in Chemistry. Findings showed that there is a significant difference in the achievement between the students taught using the teaching resource package and of those students taught without using the teaching resource package. Students exposed to the teaching resource package performed better than the students who were not exposed to the teaching resource package. Findings also showed that there is a significant difference in the attitude toward chemistry between students taught with the teaching resource package. Furthermore, intellective factors such as pretest, mental ability, and average grade in chemistry were significantly correlated with students' achievement in chemistry. Based on the conclusion, it can be deduced that the teaching resource package is an effective supplementary instructional material for teaching selected topics in chemistry.

In the study conducted by McKee, et al (2010) which examined the influence of an online learning course on student exam results. The study design was a cross-sectional survey. The online learning course was supplementary material for a first year biological sciences module in a four year nursing degree programme. Students' access to the course was monitored automatically throughout the academic year. Student exam results and profile were collated from the School database. The data was analyzed using SPSS version 16.195 students participated in the study of which 95% were female and 36% mature students. The sample consisted of students from two strands of the degree: General Nursing (84%) and Intellectual Disability (ID) nursing (16%). There was a significant difference in the exam results of General and ID nursing students. There was a significant difference in the usage of the online course depending on mode of entry to the degree programme with mature students making greater use of the online learning course. Spearman's correlation identified a very significant relationship between exam results and usage of the online course ($n = 185$, $r = 0.288$, $p = 0.0001$ (one tailed)). This indicated that usage of the online course accounted for 8% of the variability in exam results.

Similarly, in the study conducted by Shu-Mei Chwo (2010) which investigates if supplementary materials can be adopted to enhance college EFL learners' listening and speaking strategy use. Four sophomore non-English major classes were randomly chosen for this study. Two of them served as experimental groups (EG), and the other two control groups (CG). Recycling vocabulary, read-aloud, and oral presentation materials were used with EG to supplement the regular textbook. Data were collected via three instruments: (1) pre and post

Chinese versions of Oxford's Strategy Inventory for Language Learning (Yang, 1992), (2) pre and post tests from both groups, and (3) quizzes from EG. T-test was used to analyze the data. The findings indicate the effectiveness of adopting supplementary materials to enhance strategy use as well as learning outcomes. It is then suggested that in order to expand students' learning capacity, more and diverse materials should be used to supplement the existing textbook in the listening and speaking course.

The essence that the literature presented has shown that making use of graphs as representation, if used appropriately, could help promote and enhance the conceptual understanding of kinematics among physics students. Being basic in the understanding of physics, the researcher presented by different authors pointed toward one direction – to exploit the use of graphs in developing and improving the skills of students in problem solving, and much more, in their conceptual understanding.

On the other hand, scores of researches have been undertaken to evaluate the effectiveness of supplementary material. These studies unanimously conclude that the use of supplementary have shown better results than the traditional lecture method. That is, supplementary material helped learners reduce their learning difficulties. Therefore, the researcher believed that a supplementary material is needed to enhance the graph interpretation skills of students.

CHAPTER III

METHODOLOGY

This chapter presents the research design, respondents, instrumentation, and research procedure for data gathering and tools for data analyses.

Research Design

According to Richey & Klein (2005), there are two categories of developmental research, referred to as Type 1 and Type 2. They vary in terms of the extent to which the conclusions resulting from the research are generalizable or contextually specific. Type 1 developmental studies focus upon a given instructional product, program, process, or tool. They reflect an interest in identifying either general development principles or situation-specific recommendations. Typically Type 1 studies address not only product design and development, but evaluation as well. At times they may validate a particular design or development technique or tool. Type 2 studies, on the other hand, focus upon a given design, development, or evaluation model or process. They may involve constructing and validating unique design models and processes, as well as identifying those conditions that facilitate their successful use.

In this study, Type 1 developmental research was used. According to Richey and Klein (2005), developmental studies often are structured in phases. For example, comprehensive Type 1 studies may have an analysis phase, design phase, a development phase, and a try-out and evaluation phase. Another organization of a Type 1 study would include phases directed toward first analysis, then prototype development and testing, and finally prototype revision and retesting.

Participants

The samples were gathered using a purposive sampling design for the identification of student's level and difficulties in interpreting kinematics graph. The participants were the two sections of 4th Year Basic Education Curriculum (BEC) of Colegio de San Juan Letran Calamba (IV-Feynman and IV-Pascal) for the Academic Year 2013-2014 handled by the researcher. There were 47 students from both sections. However due to uncontrollable reasons, there were only a total of 38 participants from IV-Feynman and 40 respondents from IV-Pascal.

The two sections of 3rd Year Special Science Curriculum (SSC), AY 2013-2014 were the participants for the quasi-experimental design to test if there is a significant difference in the performance of the students with or without the supplementary material. The SSC students received more advanced subjects in Science and Technology and Mathematics. These students were assumed to demonstrate same levels of intellectual abilities. They were homogeneously grouped by virtue of their academic grades and class performances, results of their entrance exam at Colegio de San Juan de Letran Calamba upon admission in High School.

Both of the two sections were composed of 26 students. However due to International Robotics Olympiad trainings and excused absences of some students, there were only 20 respondents from the control and 25 respondents from experimental. Using simple random sampling specifically fish-bowl technique to identify which group was the control or experimental group, the two sections were drawn.

Experts

Purposive sampling design was used for the selection of four Physics experts who validated the content of the material. Table 2 shows the qualifications of the experts who validated the developed supplementary material. All of the experts are male. Though they have different years of teaching experiences, all of them are teaching Physics. Lastly, the four physics experts have different working environment.

Table 2. Expert's Qualifications

EXPERT	GENDER	HIGHEST EDUCATIONAL ATTAINMENT	POSITION	SCHOOL	YEARS IN SERVICE	SUBJECTS TAUGHT
A	Male	PhD in Educational Management DLSU Manila	Faculty & Former Dean (College of Engineering)	Letran Calamba	33	Mechanics I and II
B	Male	MS Applied Physics UST Manila	Faculty	FEU-Manila	6	Physics
C	Male	PhD in Physics (with units) UP Diliman	Faculty	ADMU	7	Physics
D	Male	MST Physics DLSU Manila	Faculty	PNU-Manila	8	Physics

Research Instrument

1. *The Test of Understanding Graph – Kinematics (TUG-K)*

The TUG-K latest version 3.2 (2010) is a form of diagnostic tool that was aimed at finding student problems with interpreting kinematics graphs. The test was formulated and validated by Robert J. Beichner, a distinguished Physics Professor from the North Carolina State University, Raleigh, North Carolina, USA. It was constructed based from seven specific learning objectives that are related to an understanding of kinematics graphs. The items were written for each objective, producing a 26-item multiple-choice type of questions. It has a reliability of 0.78.

This also served as the pretest and posttest to validate the supplementary material. The said test was adapted and the researcher asked for the permission to use the said material.

The test was used as the pretest and posttest of 3rd year SSC students of Colegio de San Juan de Letran Calamba to test the effectiveness of the supplementary material.

2. Evaluation Instrument

The evaluation instrument was in the form of a questionnaire which used Likert-type scale to assess the acceptability and validity of the supplementary material using the following criteria: objective, content, language, and layout. The evaluation instrument prepared by Parocha(2013), was adopted, however there were some revisions. The revisions were based on the “Cognitive Theory of Multimedia Learning” of Mayer (2001) and multiple representations of Redish (2003) which served as the bases of this study. The experts were also free to give their comments and suggestions.

As shown in Appendix E, Physics experts were asked to check the box that corresponded to their assessment on the supplementary material. Each criterion was measured on a five-point Likert-type scale and was used in each item using the following rating:

5 – Strongly Agree;

4 – Agree;

3 – Uncertain;

2 – Disagree; and

1 – Strongly Disagree.

The instrument was submitted to the advisers for suggestions and recommendations.

Research Procedure

Presented in Figure 2 is the flow chart of the study. This would show how the study was conducted.

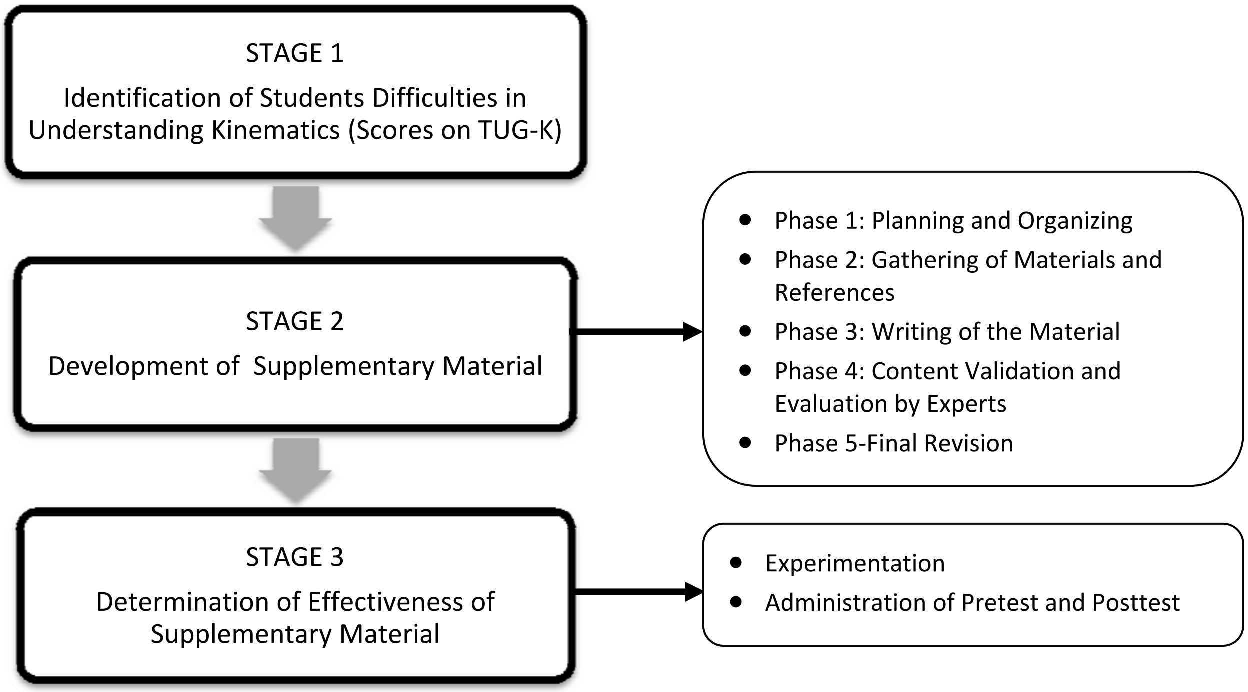

Figure 2. Flow Chart of the Study

Stage 1: Identification of Students Difficulties in Kinematics Graphs (Scores on TUG-K)

The Test on Understanding Graphs – Kinematics (TUG-K) was administered to the 4th year BEC (Basic Education Curriculum) students of Colegio de San Juan de Letran Calamba for AY 2013-2014. Letter of consent was given to the students to be given to their parents/guardians asking for permission to allow them to take the said test. The reply slips were collected by the class advisers.

In order to interpret the scores of the students on the TUG-K, Table 3 shows the range of scores with its corresponding remark.

Table 3. Interpretation of Scores in the TUG-K

Range	Remark
18 – 26	High
9 – 17	Average
0 – 8	Low

Furthermore, in order to identify the difficulties of students in understanding kinematics graphs, the researcher used the data suggested by Beichner (1994) as shown in Table 4. In every item distribution, the scores of students were counted and tabulated. The difficulty index was then computed to identify the items and objectives that were difficult to the students. The results served as the bases of developing the supplementary material.

Table 4. Objectives of the Test of Understanding Graphs-Kinematics

OBJECTIVE		ITEM DISTRIBUTION
Given	The student will	
Position-time graph	Determine velocity	5, 13, 17
Velocity-time graph	Determine acceleration	2, 6, 7, 22, 26
Velocity-time graph	Determine displacement	4, 18, 20, 23
Acceleration-time graph	Determine change in velocity	1, 10, 16
A kinematics graph	Select Another correspond graph	11, 14, 15
A kinematics graph	Select textual description	3, 8, 21, 24, 25
Textual motion description	Select corresponding graph	9, 12, 19

*Source: Beichner, Robert J. (1994) "Testing Student Interpretation of Kinematics Graph"

Stage 2: Development of the Supplementary Material

The development of the supplementary material went through five phases.

Phase 1 – Planning and Organization

The researcher identified the specific topics and skills to be developed in the said material based on the results of the TUG-K (Test of Understanding Graph – Kinematics) developed by Beichner (1994) of the two sections of 4^{th} Year BEC students of Colegio de San Juan de Letran Calamba. Sequencing of the lessons was based on how those lessons were normally sequenced in textbooks and other references.

Table 5 shows the table of specifications for the supplementary material. The table of specifications includes the difficulties of the students in interpreting kinematics graphs based on the seven objectives listed by Beichner, learning activities, and the theory/concepts involved in each activity.

Table 5. Table of Specification

DIFFICULTIES	OBJECTIVE	LEARNING ACTIVITY	THEORY/ CONCEPT
Position-time graph	Determine velocity	• Recall the concept of distance and displacement • Answer Me First! • Graph the Position-Time Data • Discussion of Cases for the Position-Time Graph • Exercises	Cognitive Theory of Multimedia Learning Multiple Representation Cognitive Theory of Multimedia Learning/Multiple Representation Multiple Representation
Velocity-time graph	Determine acceleration	• Recall the concept of speed and velocity • Do these on your own! • Check your understanding	Cognitive Theory of Multimedia Learning Multiple Representation Multiple Representation
Velocity-time graph	Determine displacement	• Guided examples • Exercises	Multiple Representation Multiple Representation
Acceleration-time graph	Determine change in velocity	• Five cases • Check your understanding • Exercises	Cognitive Theory of Multimedia Learning/Multiple Representation Multiple Representation Multiple Representation
A kinematics graph	Select Another correspond graph	• Graph Matching • Summary of Graphs	Multiple Representations/ Cognitive Theory of Multimedia Learning
A kinematics graph	Select textual description	• More Examples	Multiple Representations/ Cognitive Theory of Multimedia Learning
Textual motion description	Select corresponding graph	• Simulations of x-t, v-t, and a-t graphs • Motion Simulation: The Moving Man • Story-telling	Cognitive Theory of Multimedia Learning Cognitive Theory of Multimedia Learning Cognitive Theory of Multimedia Learning

As gleaned from Table 5, each difficulty in interpreting kinematics graph has learning activities that would help the learners enhance their graph interpretation skills. The supplementary material is equipped with multiple representations such as texts, pictures, diagrams, and simulations that would develop active cognitive processing by which learners construct meaningful learning outcomes from words and pictures.

Phase 2 – Gathering of Materials and References

Materials and references gathered were from the researcher's personal books, articles from periodicals, internet sources and some resources from the library. The researcher adapted simulations and computer-based activities with appropriate acknowledgement of the developers.

Phase 3 – Writing of the Material

The supplementary material's outline has three parts namely:

(1) the statement objectives;

(2) the lesson proper containing detailed discussions, simulations, and computer-based activities; and

(3) the drills for evaluative purposes, answers would be found at the back of the material so that the students could check how much he or she has progressed in the said material.

Phase 4 – Content Validation and Evaluation by Experts

Validation and evaluation instruments were prepared after the initial copy of the supplementary material was completed. The researcher asked four Physics experts to evaluate the supplementary material. The supplementary material, together with the validation form was given to the four Physics experts for validation. The validity was determined based on the responses of the experts in terms of objectives, content, layout, and language. The experts determined the content validity and applicability of the developed material with respect to the difficulties of the students in understanding kinematics graphs. Initial revisions were done after the content validation. The results of content validation by the four Physics experts were tallied, tabulated, and interpreted using the mean.

Phase 5 – Final Revision

The supplementary material was revised based on the content validation of the four Physics experts. Suggestions of the experts from the faculty of Philippine Normal University – Manila were also considered in the final revision of the supplementary material. Their validation covered

Objectives – active cognitive processing

Content – principles, simulations, computer-based activities, and calculations

Layout – outline and general appearance

Language – correctness of spelling, grammar, and logical sequency

Supplementary Material: Teachers Guide

Per suggestions of the PNU experts/Physics faculty, Teachers Guide was developed. The Teachers Guide includes the following: Learning Content, Preface, and every chapter contains – Overview, Summary of Topics, Learning Outcomes, Materials, Skills, Values Integration, Lesson Development, and Answer Key. The said teachers guide was reviewed by the advisers.

Stage 3: Determination of Effectiveness of Supplementary Material

The effectiveness of the supplementary material was tested to the two sections of 3rd Year SSC (Special Science Curriculum) of Colegio de San Juan de Letran Calamba for the AY 2013 –

2014 using quasi-experimental design, specifically, the non-equivalent pretest-posttest control group design since randomization process in selecting and assigning samples to the experimental group and control group were not possible. According to Harris, et. al (2006), quasi-experimental studies encompass a broad range of nonrandomized intervention studies. These designs are frequently used when it is not logistically feasible or ethical to conduct a randomized controlled trial. In addition, the pre-post with non-randomized control design mimics a simple experimental design. Like the experimental design, there is at least one group which receives the intervention (intervention group) and one group which does not (control group).

According to Safety Science Monitor (n.d.), by adding a non-randomized control group to the simple before-and-after design, it automatically reduces some of the threats to internal validity. In particular, interference by external circumstances (i.e., history effects) is reduced, because they would often apply to both the control group and the intervention group. It therefore allows a separation of the effect of the intervention from that of other circumstances.

The two sections were handled by other Physics teacher and the researcher was the one who discussed the Graphical Analysis of Motion. Both groups received the same teaching strategy for the said topic; however, the experimental group used the supplementary material after the discussion of the Graphical Analysis of Motion.

Table 6 shows the profile of both control and experimental groups. The control group consists of 9 males and 16 females while the experimental group consists of 5 males and 15 females. Majority of both control (88%) and experimental (75%) groups belong to age 15 with a minimum age of 14.5 and maximum age of 15. Comparing the overall ages mean of two groups, they are relatively of the same age with values 14.64 and 14.75 respectively.

Table 6. Profile of Subjects

Variable	Level	Control						Experimental					
		f	%	Min	Max	Mean	SD	f	%	Min	Max	Mean	SD
Sex	*Male*	9	36.0	—	—	—	—	5	25.0	—	—	—	—
	Female	16	64.0	—	—	—	—	15	75.0	—	—	—	—
	All Sexes	25	100.0	—	—	—	—	20	100.0	—	—	—	—
Age	*14*	3	12.0	14.00	14.00	14.00	0.000	2	10.0	14.00	14.00	14.00	0.000
	15	22	88.0	14.50	15.00	14.73	0.255	15	75.0	14.50	15.00	14.70	0.254
	16	0	0.0	0.00	0.00	0.00	0.000	3	15.0	15.50	15.50	15.50	0.000
	All Ages	25	100.0	14.00	15.00	14.64	0.339	20	100.0	14.00	15.50	14.75	0.444
Q_1	*Outstanding*	1	4.0	96.38	96.38	96.38	0.000	0	0.0	0.00	0.00	0.00	0.000
	Excellent	9	36.0	90.76	94.38	92.87	1.372	9	45.0	90.62	94.38	92.63	1.463
	Very Good	12	48.0	85.51	90.12	88.10	1.620	9	45.0	86.67	90.01	88.15	1.197
	Good	3	12.0	84.19	84.48	84.31	0.150	2	10.0	83.02	84.74	83.88	1.216
	All Levels	25	100.0	84.19	96.38	89.70	3.516	20	100.0	83.02	94.38	89.74	3.219
Q_2	*Outstanding*	1	4.0	95.55	95.55	95.55	0.000	0	0.0	0.00	0.00	0.00	0.000
	Excellent	9	36.0	91.18	95.15	93.14	1.539	10	50.0	90.58	94.13	92.00	1.244
	Very Good	9	36.0	86.00	89.53	87.58	1.303	7	35.0	86.05	89.48	88.39	1.280
	Good	5	20.0	80.80	84.13	82.90	1.412	3	15.0	81.33	85.35	83.71	2.110
	Fair	1	4.0	80.30	80.30	80.30	0.000	0	0.0	0.00	0.00	0.00	0.000
	All Levels	25	100.0	80.30	95.55	88.67	4.631	20	100.0	81.33	94.13	89.49	3.280
Q	*Outstanding*	1	4.0	95.97	95.97	95.97	0.000	0	0.0	0.00	0.00	0.00	0.000
	Excellent	9	36.0	90.97	94.77	92.80	1.445	8	40.0	90.94	94.17	92.39	1.177
	Very Good	10	40.0	86.37	88.73	87.88	0.757	11	55.0	86.01	90.36	88.28	1.644
	Good	5	20.0	83.29	84.82	83.92	0.564	1	5.0	82.18	82.18	82.18	0.000
	All Levels	25	100.0	83.29	95.97	89.18	3.780	20	100.0	82.18	94.17	89.62	3.020

Table 7. Interpretation of Grades

Range	Level
96 – 100	Outstanding
91 – 95	Excellent
86 – 90	Very Good
81 – 85	Good
75 – 80	Fair
70- 74	Poor

The interpretation of grades of the students during 1st quarter (Q_1), 2nd quarter (Q_2), and finally average (Q) of both Q_1 and Q_2 in Basic Physics, was based on the data suggested by Mirabueno (2014) as listed in Table 7. As illustrated in Table 5 during the 1st Quarter, 48% of the control group belongs to the range of 86% to 90% which is verbally interpreted as “Very Good”. During the 2nd quarter, respondents in the control group are in the levels “Very Good” (36%) and “Excellent” (36%). On the contrary during the 1st quarter grading period, most of the respondents from the experimental group are in both “Excellent” (45%) and “Very Good” (45%) levels. In addition, during the second quarter, 50% of the respondents from experimental group is considered “Excellent” in the grade level. Comparing the mean in all levels of the two groups, the control group has a mean grade of 89.70%, standard deviation of 3.516 while the experimental group has a mean grade of 89.74%, standard deviation of 3.219. Therefore, during the first quarter both groups performed at the same level which is verbally interpreted as “Very Good”. During the second quarter however, the control group yields a mean grade of 88.67% and the experimental group yields a mean grade of 89.49%. Thus, both groups at this quarter are in the “Very Good” level.

Figure 3. Bar Graph of Grade Level of Both Groups

Figure 3 and Table 6 illustrate the average grades (Q) of both groups during the 1st and 2nd quarters in Basic Physics. Majority of the respondents in the control group belongs to the "Very Good" (40%) and "Excellent" (36%) levels while 55% of the respondents from the experimental group belongs to the "Very Good" level and 40% to the "Excellent" level. Conversely, 20% of the respondents from the control group is in the "Good" level whereas only 5% of the respondents from the experimental group is in this level. Thus, these data tell that both of the grades of control and experimental group are in the "Very Good" level with mean grades of 89.18% and 89.62% correspondingly.

To further compare the two groups, t test for independent means for the average grades in Basic Physics and scores on pretest were computed to statistically determine the significant difference of the two.

Table 8. Difference Between the Pretest Scores on TUG-K

	Control Group	Experimental Group	Mean Difference	df	t
Total Number	25	20	0.02	43	**0.05**
Mean	2.72	2.70			

Based on the data on Table 8, control group with 25 respondents got a mean score of 2.72 while the experimental group with 20 respondents got a mean score of 2.70. The mean difference of the group is 0.02. Comparing these results yielded a t value of 0.05 which did not exceed the tabulated value of 2.021 for the degrees of freedom of 40. This indicates that there is no significant difference between the pretest scores of control and experimental groups.

Table 9. Difference Between the Average Grades in Basic Physics

	Control Group	Experimental Group	Mean Difference	df	t
Total Number	25	20	0.44	43	**0.42**
Mean	89.18%	89.62%			

On the other hand, Table 9 shows the difference between the average grades of both groups in Basic Physics. The control group with 25 respondents got a mean percentage grade of 89.18% while the experimental group with 20 respondents got a mean percentage grade of 89.62%. The mean difference of the group is 0.44. The t value yielded 0.42 which did not exceed the tabulated value of 2.021 for the degrees of freedom of 40. This indicates that there is no significant difference between the average grades of control and experimental groups.

These results indicate that there are equal performances between the control and experimental groups in terms of pretest results and average grades in Basic Physics.

Schedule of Activities

Table 10 shows the different activities conducted for both the control and experimental groups. The researcher asked for the schedule of the Basic Physics, Robotics, and Chemistry teachers to conduct the said study as approved by the Math, Science, and Technology Chair of the said school. The researcher was the one who discussed the graphical analysis of motion to both control and experimental groups. On the other hand, the researcher also gave letter of consent to the parents of the students to allow them to be part of this study. The advisers of the two classes were asked to collect the reply slips of their advisory class.

Majority or 84% of the participants returned the reply slips. However, 16% of the participants were not able to return the reply slips due to the nature of work of their parents. All of the reply slips returned from the students indicate that the parents/guardians of the participants allowed their children to be part of the study.

Table 10. Schedule of Activities

CONTROL GROUP		EXPERIMENTAL GROUP	
DATE/TIME	LEARNING TASK	DATE/TIME	LEARNING TASK
11-26-2013 7:00-7:30	Orientation and Giving of Letter of Consent to Parents	11-26-2013 7:00-7:30	Orientation and Giving of Letter of Consent to Parents
11-28-2013 7:00-7:30	Collection of Reply Slips c/o Adviser	11-28-2013 7:00-7:30	Collection of Reply Slips c/o Adviser
11-29-2013 1:00-2:00	Administration of Pretest	11-29-2013 10:20-11:20	Administration of Pretest
12-2-2013 4:00-5:00	Discussion of Position-Time Graph and Velocity-Time Graph	12-2-2013 1:00-2:00	Discussion of Position-Time Graph and Velocity-Time Graph
12-3-2013 5:00-6:00	Discussion of Acceleration-Time Graph and Combination of *x-t, v-t*, and *a-t* Graphs	12-3-2013 4:00-5:00	Discussion of Acceleration-Time Graph and Combination of *x-t, v-t*, and *a-t* Graphs
12-4-2013 8:00-9:00	Continuation of *x-t, v-t*, and *a-t* Graphs	12-4-2013 4:00-5:00	Continuation of *x-t, v-t*, and *a-t* Graphs
12-4-2013 5:00-6:00	Administration of Posttest	12-5-2013 9:00-10:00	Administration of Supplementary Material
	Simulations in the internet were also given to them for additional information.	12-5-2013 1:00-2:00	Continuation of activities on the supplementary material Entertain questions regarding the simulations in the internet
		12-6-2013 10:20-11:20	Administration of Posttest

Experimentation (Control and Experimental Groups)

Three days were allotted in the discussion of the graphical analysis of motion for both control and experimental groups. Using PowerPoint presentation, the researcher recalled the concept of position, velocity, acceleration, and time. After which, the three types of graphs (position-time, velocity-time, and acceleration-time graphs) were discussed using PowerPoint presentation. Both groups received the same teaching strategy as well as drills and exercises to enrich their understanding of graphs.

On the other hand, the developed supplementary material was given to the experimental group to read and answer the exercises in the said material. Due to limited time, the researcher allowed the respondents to bring the material at home for further reading. With an aid of LCD projector, the researcher was the one who showed the simulations to the respondents.

Administration of Pretest and Posttest

The letter of consent was given to the two groups through their class advisers. The researcher oriented the respondents regarding the conduct of study. The advisers of the two classes were asked to collect the reply slips of the students. The control and experimental groups were given the pretest using the TUG-K on November 28, 2013.

After three days, the control group was given the posttest using the same test while the posttest was administered to the experimental group after five days. Two days were given to the experimental group to read the material and answer the exercises.

The simulations and sites in the supplementary material were also given to the control group after the posttest was given to them.

Data Analyses

Individual answers to the TUG-K were analyzed based on the specific objectives listed by Beichner (1994) from which the items were constructed (Table 3). The difficulty index was also computed. Difficulty index (d) in this study is defined as the proportion of the respondents who answered the item incorrectly to the number of respondents who answered the item.Table8 shows the interpretation of difficulty index (d).The data suggested by Gronlund (1990) in his book was used in the interpretation of difficulty index.

Table 11. Interpretation of Difficulty Index (d)

Range	Remark
$0.800 < d \leq 1.000$	Very Difficult
$0.700 < d \leq 0.800$	Difficult
$0.600 < d \leq 0.700$	Moderately Difficult
$0.400 < d \leq 0.600$	Slightly Difficult
$0.300 < d \leq 0.400$	Slightly Easy
$0.200 < d \leq 0.300$	Easy
$0.000 < d < 0.200$	Very Easy

In the interpretation of expert's rating, the researcher used the interpretation suggested by by Corpuz (2001) in his study. The rating scale has the following interpretations range:

Table 12. Interpretation of Expert's Rating

Range	Interpretation
4.50 to 5.00	Very Much Acceptable
3.50 to 4.49	Acceptable
2.50 to 3.49	Moderately Acceptable
1.50 to 2.49	Need Revision
1.00 to 1.49	Unacceptable

To test if there is a significant difference between the pretest and posttest scores of the control group and at the same time the experimental group, the researcher used the two-way analysis of variance (ANOVA) without repetition. Bluman (2012) mentioned that the two-way ANOVA is an extension of the one-way analysis of variance; it involves two independent variables. The independent variables are called factors. In doing a study that involves a two-way

ANOVA, the researcher was able to test the effects of two independent variables or factors on one dependent variable. In addition, he mentioned that the interaction effect of the two variables could be tested.

To test if there is a significant difference between the change scores of control and experimental groups, the researcher used t-test for independent means since there are no significant differences between the results of pretest and average grades in Basic Physics. According to San Jose State University (2013), the independent-samples t test compares the average values of a characteristic measured on a continuous scale between two subgroups of a categorical variable.

In addition to further accept or reject the hypotheses stated, interpretation of p-value was utilized. Table 11 illustrates the interpretation of p-level as suggested in the study conducted by Palomares (2013). According to StatsDirect Limited (2014), the p-value or the calculated probability is the estimated probability of rejecting the null hypothesis (H_0) of a study question when that hypothesis is true.

Inferential statistical treatments were considered significant at 0.05 level of significance.

Table 13. Interpretation of p-Level

Range	Remark
$p \geq 0.050$	Not Significant
$0.010 \leq p < 0.050$	Significant
$0.001 \leq p < 0.010$	Highly Significant
$p < 0.001$	Extremely Significant

CHAPTER IV

PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

This chapter includes the different tables and diagrams which present the data of the findings on this study with respective interpretations. The questions enumerated in the statement of the problem were answered in this chapter. The data were analyzed and interpreted, so that conclusions and recommendations could be drawn from the study

Problem #1: *What are the common difficulties of students in interpreting kinematics graphs?*

The level of graph interpretation skills of the students were identified using the data in Table 3.

Table 14. Graph Interpretation Skills

Category	f	%	Min	Max	Mean	SD
Average	16	20.5	9.00	14.00	11.88	1.821
Low	62	79.5	1.00	8.00	4.06	1.658
All Categories	78	100.0	1.00	14.00	5.67	3.592

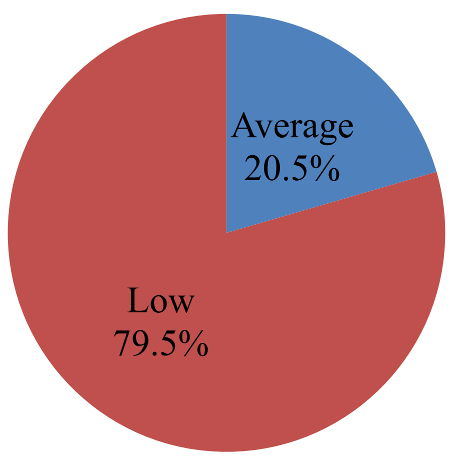

Figure 4. Pie Graph of Performance on TUG-K

Table 14 and Figure 4 represent the performance of the respondents (IV-Feynman and IV-Pascal) on the TUG-K. The total number of respondents is 78. Out of 78 respondents, 62 or 79.5% of the respondents with a mean of 11.88 and standard deviation equal to 1.821 are in the range of 0 to 8 which is verbally interpreted as "Low" as stated in Table 2. Meanwhile, 20.5% of the respondents are considered "Average" in their performance in TUG-K. In addition, the overall value of mean is 5.67 which is also verbally interpreted as "Low". This indicates that the students have poor graph interpretation skills in kinematics.

In the study conducted by Beichner (1996), the data from 895 students at the high school and college level were collected and analyzed after answering the TUG-K. The test mean score of 40% is quite low considering that the test was taken following instruction in kinematics. According to Beichner, the results were clear, whether the instruction was exemplary or ordinary, the students were not able to fluently interpret kinematics graphs.

Based on the objectives listed by Beichner in Table 4, the researcher identified the difficulties of students on TUG-K.

Table 15. Difficulty Indices: Position-Time Graph – Determine Velocity

Item	Index	SD	Rank	Remark
5	0.821	0.386	2	Very Difficult
13	0.705	0.459	3	Difficult
17	0.833	0.375	1	Very Difficult
All Items	0.786	0.755	—	Difficult

Table 13 shows the difficulties of the students when it comes to determining the velocity given position-time graph. Based on the interpretation of difficulty index in Table 8, item number 17 has a difficulty index of 0.833 making it the most difficult item in this objective with a remark of "Very Difficult". Item 5 with index of 0.821 is also considered very difficult.

However, item number 13 is interpreted as difficult. This indicates that students have slope/height confusion as listed in Table 1. Students often read values off the axes and directly assign them to the slope. In addition, students successfully find the slope of lines which pass through the origin. However, they have difficulty determining the slope of a line (or the appropriate tangent line) if it does not go through zero.

Table 16. Difficulty Indices: Velocity-Time Graph – Determine Acceleration

Item	Index	SD	Rank	Remark
2	0.833	0.375	2	Very Difficult
6	0.641	0.483	5	Moderately Difficult
7	0.859	0.350	1	Very Difficult
22	0.795	0.406	3.5	Difficult
26	0.795	0.406	3.5	Difficult
All Items	0.785	0.923	—	Difficult

Table 16 illustrates the two items (2 and 7) as "Very Difficult". Item numbers 22 and 26 have the same difficulty index of 0.795 interpreted as "Difficult". However, item number 6 is considered as "Moderate Difficult". This result also proved the students' inadequate understanding of the concept of slope as discussed in Table 14. As mentioned by Cardona, etal (2013), students need to know how to apply the skill in getting the slope of a line to successfully answer the problem, like in getting the acceleration for the velocity-time graph and velocity for the position-time graph.

Table 17. Difficulty Indices: Velocity-Time Graph – Determine Displacement

Item	Index	SD	Rank	Remark
4	0.885	0.322	1	Very Difficult
18	0.718	0.453	3	Difficult
20	0.628	0.486	4	Moderately Difficult
23	0.795	0.406	2	Difficult
All Items	0.756	1.057	—	Difficult

Based on the data in Table 17, item number 4 ranked the most difficult with a difficulty index of 0.885 in determining displacement given a velocity-time graph. Items 18 and 23 are considered as "Difficult". Lastly, item number 20 with index equal to 0.628 is verbally interpreted as "Moderate Difficult". This shows that students have the difficulty in determining area under a curve or a line. As stated in Table 1, students have area ignorance that is, students do not recognize the meaning of areas under kinematics graph curves. Moreover, students also have area/slope/height confusion wherein they perform slope calculations or inappropriately use axis values when area calculations are required.

Table 18. Difficulty Indices: Acceleration-Time Graph – Determine Change in Velocity

Item	Index	SD	Rank	Remark
1	0.936	0.247	1	Very Difficult
10	0.615	0.490	3	Moderately Difficult
16	0.731	0.446	2	Difficult
All Items	0.761	0.682	—	Difficult

Table 18 illustrates the difficulty of the students in determining the change in velocity given an acceleration-time graph. Item 1 is considered the most difficult with a difficulty index of 0.936 which is interpreted as "Very Difficult", while items number 10 and 16 are regarded as "Moderate Difficult" and "Difficult" respectively. As discussed in Table 15, it indicates the low level of understanding of students when it comes to determining the area under a curve or a line. According to Cardona (2012), students use incorrect methods to get correct answers such as calculating the area under the curve or a line.

Table 19. Difficulty Indices: A Kinematics Graph – Select Another Corresponding Graph

Item	Index	SD	Rank	Remark
11	0.808	0.397	1	Very Difficult
14	0.731	0.446	3	Difficult
15	0.782	0.416	2	Difficult
All Items	0.774	0.860	—	Difficult

Item number 11 ranked one with a difficulty index of 0.808 as the most difficult item in selecting another corresponding graph given a kinematics graph. Items 14 and 15 are regarded as "Difficult" by the students with indices 0.731 and 0.782 respectively. This shows that the students have difficulty in selecting another corresponding graph given a kinematics graph. According to McDermott (1987), one of the difficulties of the students in understanding kinematics graph is by relating one type of graph to another. This also illustrates that the students have difficulty connecting or converting one graph to another graph.

Table 20. Difficulty Indices: A Kinematics Graph – Select Textual Description

Item	Index	SD	Rank	Remark
3	0.769	0.424	4	Difficulty
8	0.936	0.247	1	Very Difficult
21	0.756	0.432	5	Difficult
24	0.872	0.336	2	Very Difficult
25	0.833	0.375	3	Very Difficult
All Items	0.833	0.932	—	Very Difficult

Table 20 confirms the difficulty of students in selecting textual description given a kinematics graph. Out of the 5 items used by Beichner on TUG-K, three items (8, 24, and 25) were considered as “Very Difficult” and two items (3 and 21) were interpreted as “Difficult”. In the study of graphing errors by McDermott (1987) there were two categories of difficulties in kinematics: (1) difficulty in connecting graphs to physical concepts, and (2) difficulty in connecting graphs to the real world. The difficulties are not due to inadequate experience with kinematics concepts but to the inability of students to interpret graphs. This implies that the students have difficulty in describing kinematics graphs.

Table 21. Difficulty Indices: Textual Motion Description – Select Corresponding Graph

Item	Index	SD	Rank	Remark
9	0.782	0.416	1.5	Difficult
12	0.782	0.416	1.5	Difficult
19	0.692	0.465	3	Moderately Difficult
All Items	0.752	0.711	—	Difficult

Table 21 tells that students’ when it comes to selecting corresponding graph given a textual motion description. Items number 9 and 12 yield difficulty index of 0.782 which is verbally interpreted as “Difficult” while item number 19 yields a difficulty index of 0.692 which is verbally interpreted as “Moderately Difficulty”. As mentioned by Cadorna, et al (2012), students believe that kinematics variables behave identically or very similarly and should therefore be graphed similarly; and see graphs as representing the physical path of motion. In addition, students use kinematics terms interchangeably and inappropriately (acceleration is used rather than velocity when position is uniformly changing).

Table 22. Difficulty Indices: Summary

Given	Objective	Index	SD	Rank	Remark
Position-time graph	Determine velocity	0.786	0.755	2	Difficult
Velocity-time graph	Determine acceleration	0.785	0.923	3	Difficult
Velocity-time graph	Determine displacement	0.756	1.057	6	Difficult
Acceleration-time graph	Determine change in velocity	0.761	0.682	5	Difficult
A kinematics graph	Select Another correspond graph	0.774	0.860	4	Difficult
A kinematics graph	Select textual description	0.833	0.932	1	Very Difficult
Textual motion description	Select corresponding graph	0.752	0.711	7	Difficult
	Overall	**0.778**	**3.590**	—	**Difficult**

Table 22 indicates the overall performance of students in kinematics graph given the seven objectives listed by Beichner. As observed from the graph, the most difficult graph given its objective is "*A Kinematics Graph - Select textual description*" with an index of 0.833 and standard deviation of 0.932.The most difficult items (1 and 8) were found at objectives – acceleration-time graph: determine change in velocity and a kinematics graph: select textual description. Apparently, the same with the study conducted by Beichner (1994) in developing the TUG-K, question 1 was the hardest item in the test. Beichner (1994) recommended that a test begins with the most difficult question though this item was not expected to be as challenging.

In the study of Dasalla (2002), the importance of students' abilities to graph and the reasons for investigating graphing was investigated. The results of the study revealed that students at all age levels have difficulties with graph construction and interpretation. These difficulties include a static conception of graphs, a view of the graph as a picture of the event, and confusion between slopes versus height.

Likewise, Cadorna, et al (2012) in their study mentioned that generally, the engineering students under study only had an average skill in interpreting kinematics graph. They were found to have a moderate skill in interpreting *v-t* graphs and *a-t* graphs but high skills in interpreting *x-t* graphs. Moreover, they were skillful in finding the velocity given the *x-t* graph but not skillful in finding the acceleration and distance, given the *v-t* graph. Likewise, they were not skillful in finding the change in velocity, given the *a-t* graph; in identifying corresponding kinematics graph and text explanation of a graph, given the kinematics graph, and in identifying the corresponding graph, given the text explanation of the graph.

In totality, as suggested by Beichner shown in Table 1 verified these findings. Several students have difficulties with kinematics such as graph as picture errors, slope/height confusion, nonorigin slope errors, area ignorance, and area/slope/height confusion. In addition, it was also mentioned that regardless of the type of errors student make, it is generally agreed that an important component understanding the connection between reality and the relevant graphs is the ability to translate back and forth in both directions.

The results show that the students have difficulties in kinematics graph. This implies that the students have to be further assisted in understanding kinematics graphs. One such assistance is the use of supplementary material.

Problem #2: *What is the acceptability of the supplementary material based on the ratings of the experts?*

The level and difficulties of the students in understanding kinematics graphs were already identified. The data given above laid the foundation of developing the supplementary material. The developed supplementary material was validated by four Physics experts. Table 21 shows the expert's validation on the supplementary material. The comments and suggestions given by the Physics experts were taken into considerations in order to revise the said material.

Table 23. Expert's Validation of Supplementary Material

Criterion	A	B	C	D	Mean	SD	Rank*	Remark
I. Objectives	4.67	4.67	4.67	4.33	4.58	0.167	1	Very Much Acceptable
II. Content and Simulations	4.75	4.92	4.58	4.00	4.56	0.399	2	Very Much Acceptable
III. Language	4.50	4.50	4.00	4.00	4.25	0.289	3	Acceptable
IV. Layout	4.33	4.33	3.67	4.00	4.08	0.319	4	Acceptable
Overall	4.64	4.72	4.37	4.05	**4.45**	**0.302**	4.64	Acceptable

* Based on mean

Table 23 shows the evaluation of the four Physics experts. As gleaned from this table, the objectives of the supplementary material which received the highest mean of 4.58 with a standard deviation of 0.167 which is verbally interpreted as "Very Much Acceptable" tells that the objectives develop active cognitive learning. Content also receives a verbal interpretation of "Very Much Acceptable" with a mean score of 4.56 and standard deviation of 0.399 which means that the supplementary material offers accurate and applicable principles, simulations, computer-based activities, and calculations.

Language got a mean of 4.25 with the lowest standard deviation of 0.289, verbally interpreted as "Acceptable" which means that the supplementary material in terms of correctness, spelling, and thought flow is relatively acceptable. Lastly, the layout received mean of 4.08 and standard deviation of 0.319 with a verbal interpretation of "Acceptable" which means that the outline and general appearance are suitable to the learning process of the students. Since, the layout ranked number 4 among the criterion, the researcher gave emphasis to this following the suggestions given by the experts.

Finally, the overall rating got a mean score of 4.45 and a standard deviation of 0.302 with a verbal interpretation of "Acceptable" which means that the supplementary material has high acceptability rating by the experts.

However, there are some suggestions by the experts that were taken into considerations for the final revision of the supplementary material before it would be implemented to the students. One expert commented that, "*The module is too wordy for a student (I presume high school students). My concern is that the students might find it boring to continue reading. My suggestion is to make the text more engaging to read. And use a better looking text font. Since the text is procedural in nature, why not number each step or write it in a bulleted form. I also suggest that you let the students use the PhET simulation for kinematics, I've tried it and I found it more entertaining and give a physical meaning to a given graph. And also students can use it without connecting to the internet*". Another expert commented, "*Provide a consistent set of terminology and symbols throughout your materials. Reduce wordiness in your writings"; Page 13, case 1: you said that the given graph is an example of a zero velocity motion, this graph is not a zero velocity motion; instead it is a constant velocity motion…"*

Problem #3.1: *Is there a significant difference between the pretest and posttest scores of the control group?*

Table 24. Performance Profile: Control Group

Category	Posttest						Pretest						Mean Difference*
	f	%	Min	Max	Mean	SD	f	%	Min	Max	Mean	SD	
High	6	24.0	18.00	19.00	18.33	0.516	0	0.0	0.00	0.00	0.00	0.000	18.33
Average	16	64.0	9.00	17.00	14.31	2.414	0	0.0	0.00	0.00	0.00	0.000	14.31
Low	3	12.0	7.00	8.00	7.67	0.577	25	100.0	0.00	5.00	2.72	1.339	5.15
All Categories	25	100.0	7.00	19.00	14.48	3.641	25	100.0	0.00	5.00	2.72	1.339	11.76

* Posttest Mean – Pretest Mean

Table 24 illustrates the performance of the control group with 25 respondents during pretest and posttest. As observed from this table, all of the respondents from control group are in the “Low” level on TUG-K as based in the data of Table 2. It has a mean score of 2.72, minimum score of 0 and maximum score of 5, and a standard deviation of 1.339. Meanwhile during the posttest, 6 out of 25 respondents belong to the “High” level with a mean of 18.33 and a standard deviation of 0.516. Majority of the respondents (64%) are in the “Average” level with a mean score of 14.31. Lastly from 100% of the respondents who performed in the “Low” level during the pretest, only 12% of the total respondents were left in “Low” level with a mean score of 7.67 and standard deviation of 0.577 during the posttest.

Comparing all categories during pretest and posttest, the mean score of the respondents during the pretest is equal to 2.72 with a standard deviation of 1.339 which is verbally interpreted as “Low” while the mean score of respondents during the posttest is equal to 14.48 with a standard deviation of 3.641 which is on other hand is verbally interpreted as “Average”. This means that the respondents relatively performed better during the posttest. Finally, the mean difference which can be calculated by subtracting pretest mean from the posttest mean yielded a score of 11.76. This indicates that there is a significant difference between the performance of the respondents during pretest and posttest. However, to further show that significant difference between the pretest and posttest, Table 23 is presented.

Table 25. ANOVA Control Group: Posttest vs. Pretest

Source of Variation	df	Sum of Squares	Mean Squares	F-value	p-Level	Remark
Phase	1	1 728.720	1 728.720	219.195	0.000	Extremely Significant
Subject	24	172.000	7.167	0.909	0.592	Not significant
Error	24	189.280	7.887			
Total	49	2 090.00				

Table 25 represents the computed two-way ANOVA of the control group for the pretest and posttest results. The sources of variations are phase, subject, and error. Phase represents the treatment in between the pretest and posttest. Treatment is said to be the discussion of the "Graphical Analysis of Motion" to the respondents that was done by the researcher. The subject represents the respondents themselves. Finally, the error is said to be the residual or error sum of squares. This error term is a combination of interaction and error effects.

As presented above, the obtained F-value for phase is 219.195. The obtained F is significant for 1,49 degrees of freedom which has a critical value of 4.260. In addition, a p-level of 0.000 with a verbal interpretation of "Extremely Significant" using the data presented in Table 11 directly rejects the null hypothesis. Therefore, there is a significant difference between the pretest and posttest scores of the control group.

Moreover with 24,49 degrees of freedom (critical value equal to 1.984), the obtained F value for subjects of 0.909 is not significant since it does not exceed the critical value, indicating that the characteristics of the respondents did not interact or affect during the conduct of study. The p-level yields a value of 0.592 which also indicates that it is also not significant.

Problem #3.2: *Is there a significant difference between the pretest and posttest scores of the experimental group?*

Table 26. Performance Profile: Experimental Group

Category	Posttest						Pretest						Mean Difference*
	f	%	Min	Max	Mean	SD	f	%	Min	Max	Mean	SD	
High	11	55.0	18.00	24.00	20.27	1.679	0	0.0	0.00	0.00	0.00	0.000	20.27
Average	9	45.0	13.00	17.00	15.22	1.481	0	0.0	0.00	0.00	0.00	0.000	15.22
Low	0	0.0	0.00	0.00	0.00	0.000	20	100.0	0.00	6.00	2.70	1.455	-2.70
All Categories	20	100.0	13.00	24.00	18.00	3.009	20	100.0	0.00	6.00	2.70	1.455	15.30

* Posttest Mean – Pretest Mean

Table 26 demonstrates the performance of experimental group during pretest and posttest. After the pretest was given to the experimental group, discussion of the "Graphical Analysis of Motion" was administered to them as same as what was administered to the control group. However after the discussion of the said topic, the supplementary material was given to the experimental group following the schedule of activities.

As observed in Table 26, during the pretest 100% of the total respondents from the experimental group performed "Low" on the TUG-K with a minimum score of 0 and maximum of 6, mean score of 2.70, and a standard deviation of 1.455. This indicates that the respondents have low performance on graph interpretation skills in kinematics.

On the other hand during the posttest, 45% or 9 out of 20 respondents are in the "Average" level with a mean score of 15.22 and standard deviation of 1.481.Moreover, 11 out of 20 or 55% of the respondents are in the "High" level with a minimum score of 18 and a maximum of 24, mean score of 20.27, and standard deviation of 1.679.

Comparing all categories, it can also be seen from this table that during the pretest as discussed above, all of the respondents from the control group performed in the "Low" level. Conversely during the posttest, the experimental group got a mean score of 18 with a standard deviation of 3.009 which is verbally interpreted as "High".

From these data, it can be deduced that there is a significant difference in the performance of the experimental group between pretest and posttest. The computed mean difference of 15.30 for the experimental group is relatively high.

Table 27. ANOVA Experimental Group: Posttest vs. Pretest

Source of Variation	df	Sum of Squares	Mean Squares	F-value	p-Level	Remark
Phase	1	2 340.900	2 340.900	379.822	0.000	Extremely Significant
Subject	19	95.100	5.005	0.812	0.673	Not significant
Error	19	117.100	6.163			
Total	39	2 553.100				

As presented above, the ANOVA F-values for the phase and subject of the experimental group were computed. The sources of variations are phase, subject, and error as same as the control group. Phase represents the treatment in between the pretest and posttest. Treatment is said to be the discussion of the "Graphical Analysis of Motion" and the use of the developed supplementary material to the respondents. The subject represents the respondents themselves. Finally, the error is said to be the residual or error sum of squares. This error term is a combination of interaction and error effects.

As presented above, the obtained F-value for phase is 379.822. The obtained F is said to be significant for 1,39 degrees of freedom since it extremely exceeded the critical value of 4.381. In addition, a p-level of 0.000 with a verbal interpretation of "Extremely Significant" directly rejects the null hypothesis. Therefore, there is a significant difference between the pretest and posttest scores of the control group.

Additionally with 19,39 degrees of freedom, the obtained F value for subjects of 0.909 is not significant since it does not go beyond the critical value of 2.168, signifying that the characteristics of the respondents did not interact or was not affected during the conduct of study. Furthermore, the p-level yields a value of 0.673 which also supports that it is also not significant.

Problem #4: *Is there a significant difference between the change scores of the control and experimental groups?*

Table 28. Difference Between Change Scores of Control and Experimental Groups

	Control ($\bar{X}$=14.48)	Experimental ($\bar{X}$=18.00)	Mean Difference	t	p-Level	Remark
Change Score	11.76	15.30	3.54	**3.13**	**0.001**	Highly Significant

Table 28 shows the result of the computed *t* value of both control and experimental groups. There are a total of 45 respondents in this quasi-experimental design to test the effectiveness of the supplementary material. 44.44% of the total respondents are from the experimental group while 55.56% are from the control group. During the posttest, the experimental group got a mean score of 18 with a minimum score of 13 and a maximum of 24 whereas; the control group obtained a mean score of 14.48, a minimum score of 7 and maximum score of 19. This indicates that the experimental group is considered in the “High” level compared to the control group which is in the “Average” level on the TUG-K.

A mean difference of 3.54 was obtained. The computed *t* value which is 3.13 exceeded the critical value of 2.021 (df = 40) with 95% level of confidence as well as the p-level obtained a value of 0.001 which states that it is “Highly Significant”. As a result, it is therefore concluded that there is a significant difference between the performance of the students with or without the supplementary material.

This result also agreed to the study conducted by Anir (1996) which compared the achievement and attitude toward Science and Technology III of students taught using the teaching resource package with those students taught without the teaching resource package. The study found out that the teaching resource package was an effective supplementary instructional material for teaching selected topics in Chemistry. Based on the conclusion, it can be deduced that the teaching resource package is an effective supplementary instructional material for teaching selected topics in chemistry.

In addition, in the study conducted by McKee, et al (2010) which examined the influence of an online learning course on student exam results. The online learning course was supplementary material for a first year biological sciences module in a four year nursing degree programme. The results revealed that there was a significant difference in the exam results of General and ID nursing students. Spearman's correlation identified a very significant relationship between exam results and usage of the online course (n = 185, r = 0.288, p = 0.0001 (one tailed)). This indicated that usage of the online course accounted for 8% of the variability in exam results.

Similarly, in the study conducted by Shu-Mei Chwo (2010) which investigated if supplementary materials can be adopted to enhance college EFL learners' listening and speaking strategy use. The findings indicate the effectiveness of adopting supplementary materials to enhance strategy use as well as learning outcomes. It is then suggested that in order to expand students' learning capacity, more and diverse materials should be used to supplement the existing textbook in the listening and speaking course.

In totality, it can be deduced that the developed supplementary material can be used as an aid to help the students increase their level of graph interpretation skills in kinematics.

CHAPTER V

SUMMARY, CONCLUSION, AND RECOMMENDATION

This chapter presents the summary of findings, its conclusions, and recommendations based on the statement of the problem given in Chapter I.

Summary of Findings

After the tabulation and interpretation of the data, the salient findings were obtained:

1. The results revealed that majority of the students (79.5%) performed "Low" on the TUG-K with a mean score of 5.67. In the determination of the difficulties of the students in interpreting kinematics graphs using the seven objectives listed by Beichner in his study, results showed that the most difficult objective was "Select textual description" given a kinematics graph with a difficulty index of 0.833 which is considered as "Very Difficult". The remaining six objectives were: determine velocity, determine acceleration, determine displacement, determine change in velocity, select another corresponding graph, select textual description, and select corresponding graph, were considered as "Difficult" based on the performance of the students on the TUG-K. These results also verified the findings given by Beichner in Table 1 that students have difficulties with kinematics such as graph as picture errors, slope/height confusion, nonorigin slope errors, area ignorance, and area/slope/height confusion. The findings showed that the students have difficulties in kinematics graph as hypothesis number 2 is accepted.
2. Based on experts' assessment, the developed supplementary material on graphical analysis of motion is "Acceptable" with an overall rating of 4.45. The objective received

the highest mean of 4.58 which is verbally interpreted as "Very Much Acceptable". Content and simulation also received a verbal interpretation of "Very Much Acceptable" whereas language and layout got a verbal interpretation of "Acceptable" with mean scores of 4.25 and 4.08 respectively.

3. Findings showed that there is a significant difference between the pretest (2.72) and posttest (14.48) scores of the control group. The obtained F-value for phase is 219.195 which is significant for 1,49 degrees of freedom since it exceeded the critical value of 4.260. In addition, a p-level of 0.000 with a verbal interpretation of "Extremely Significant" directly rejected the null hypothesis.
4. Conversely, the data obtained also revealed that there is a significant difference between the pretest (2.70) and posttest (18.00) scores of the experimental group. The obtained F-value for phase is 379.822. The obtained F is said to be significant for 1,39 degrees of freedom since it extremely exceeded the critical value of 4.381. In addition, a p-level of 0.000 with a verbal interpretation of "Extremely Significant" directly rejected the null hypothesis.
5. Results revealed that during the posttest the experimental group with a mean score of 18.00 (High) performed better than the control group with a mean score 14.48 (Average) in terms of level of graph interpretation skills in kinematics. In order to statistically show if there is a significant difference between the change scores of control and experimental groups, t-value was computed. A mean difference of 3.54 was obtained. The computed *t* value which is 3.13 exceeded the critical value of 2.021 (df = 40) with 95% level of confidence as well as the p-level obtained a value of 0.001 which states that it is "Highly

Significant”. As a result, it is therefore concluded that there is a significant difference between the performance of the students with or without the supplementary material.

Conclusions

On the bases of findings as hereby summarized, the following conclusions are drawn:

1. Students do not have ample knowledge in understanding the slope and area under a curve or a line in a kinematics graph. They use incorrect methods to get correct answers. They believe that kinematics variables behave identically or very similarly and must therefore be graphed similarly; and see graphs as representing the physical path of motion. As stated by Beichner (1994), recent work has uncovered a consistent set of student difficulties with graphs of position, velocity, and acceleration versus time. In addition, he also mentioned that students entering introductory Physics classes understand the basic construction of graphs, but have difficulty applying those skills to the tasks they encounter in the Physics laboratory.
2. The developed supplementary material is proven to have high validity as assessed by experts. It can therefore be concluded that the material is effective in supplementing the learning of students in terms of the graphical analysis of motion
3. With the posttest mean scores of the control group (14.48) and experimental group (18.00), it can be concluded that the Test of Understanding Graphs – Kinematics developed by Dr. Robert Beichner is comparatively difficult considering that the total score of the said test is 26.
4. The developed supplementary material enhanced the graph interpretation skills of the students. The use of multiple representations of Redish (2003) in the supplementary

material such as graphing, simulations, problem solving, and picture representations of events enhance the graph interpretation skills of the students. This is also supported by the *"Cognitive Theory of Multimedia Learning"* of Mayer (2001) which states that learners are regarded as sense makers, and that they construct meaning from information, experience, and some mental models or representations of knowledge. In addition, the activities in the supplementary material gave meaningful learning that engaged the students in appropriate cognitive processing during learning (active-processing assumption).

Recommendations

Based on the aforementioned conclusions, the following recommendations are hereby presented:

- The developed supplementary material must be used after the discussion of graphical analysis of motion in order for the learners to further understand kinematics graphs.
- There must be coordination between Mathematics and Physics teachers in the teaching of kinematics graphs in as much as these topics are included in the Mathematics subject matter plan. This will help the Physics teachers reduce the difficulties of students in understanding slope and area under a line or a curve in a graph.
- Physics teachers must utilize graphs more frequently in their Physics classes to strengthen students' understanding of Physics concepts and to enhance their problem-solving capabilities.
- Similar study can also be conducted with students belonging to Basic Education Curriculum as respondents to test the effectiveness of the supplementary material. As

much as possible, more time must be given to the students to use the supplementary material.

- The topics – Free Fall and Projectile Motion can be included to the supplementary material to further enhance the graph interpretation skills of the students.
- Conduct a seminar-workshop for Physics teachers especially those who do not have specialization in Physics that focuses on graphical analysis of motion.

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APPENDICES

APPENDIX A

TUG-K

TUG-K v3 development data collection
Dr. XXXX PY211 summer session I class

Write these instructions on the board:

Fill in your NAME, BIRTHDATE and SEX in the spaces provided

Fill in your STUDENT IDENTIFICATION NUMBER in boxes A-I.

Put the SPECIAL CODE on the board in boxes K-P   10x042 (x is section number)

Read the following to the students:

Good morning. The Physics Education R & D Group at NC State is working on a multiple-choice test of physics graphs. Taking this test is voluntary and the results will have no impact on your grade in this course. We do, however, appreciate your help and promise to use the information you give us to make this and other courses better for future students. We can't do it without you!

- Please sign and date the Informed Consent Form. Today is the 24th.
- Use a number 2 or H/HB pencil to fill out the scantron form. We have pencils if you need one. You may use a calculator, if you want to.
- Fill in the information listed on the board.
- Please do the best job you possibly can on the test. There may be some questions that have not been covered in class. If that happens, just make your best guess.
- You can take up to 45 minutes on the test. If you get done before then, you may leave after turning in your two forms.
- Thanks for helping us out!

After the completed scantrons has been collected:

1) Fill in a scantron according to the directions below.
   a) Put the **name of each test** given in the space marked NAME (e.g. TUGK 3)
   b) Put **today's date** in the space marked BIRTHDATE
   c) Put the special code in boxes K-P
2) Place the scantron on top of the student scantrons.

The special code uses six digits to identify the course, section, and semester in which the test was given. The digits are determined as follows:

first digit:	8 for PY208, 5 for PY205, 1 for PY211
second and third digits:	last 2 digits of the course section number (e.g. "07" for section 007)
fourth and fifth digits:	last 2 digits of the year (e.g. "00" for 2000)
sixth digit:	1 for spring semester 2 for 1st summer session 3 for 2nd summer session

Test of Understanding Graphs– Kinematics *version 3.2*

Instructions

Wait until you are told to begin, then turn to the next page and begin working. Answer each question as accurately as you can. There is only one correct answer for each item. Feel free to use a calculator and scratch paper if you wish. Note that all graphs relate to motion along one direction. So "Position" refers to position along the *x*-axis, "Velocity" really means the *x*-component of velocity, and "Acceleration" is along the *x* direction.

Use a #2 pencil to **record your answers** on the computer sheet, but **please do not write in the test booklet.**

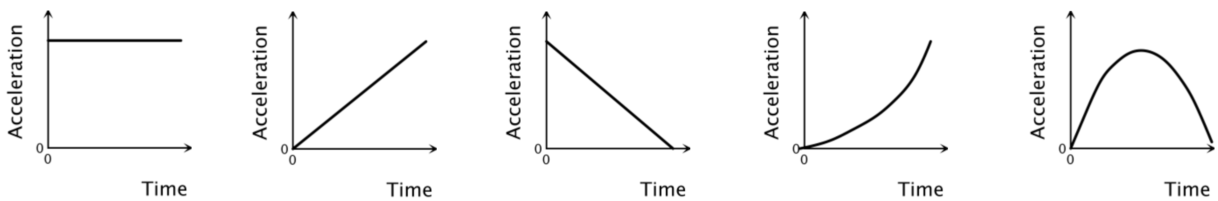
You will have approximately 45 minutes to complete the test. If you finish early, check over your work before handing in both the answer sheet and the test booklet.

North Carolina State University
Raleigh, NC 27695-8202
Beichner@NCSU.edu

and Genaro Zavala
Tecnológico de Monterrey
Monterrey, NL, México 64849
genaro.zavala@itesm.m

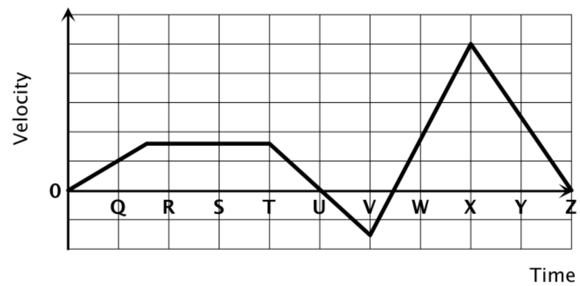
1. Acceleration versus time graphs for five objects are shown below. All axes have the same scale. Which object had the greatest change in velocity during the interval?

(E) (A) (B) (C) (D)



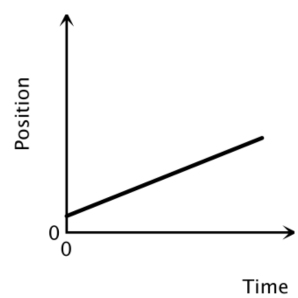
2. The following figure shows the velocity versus time graph of an object. Which of the following options corresponds to the case when its acceleration is the most negative?

A) V to X
B) T to V
C) V
D) X
E) X to Z



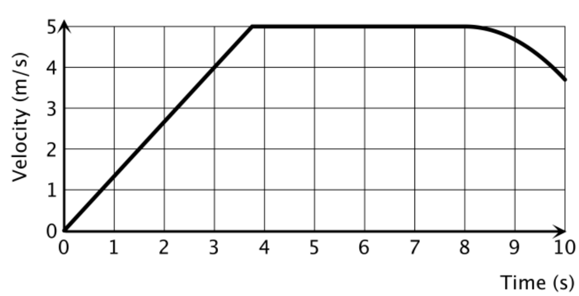
3.To the right is a position versus time graph of an object´s motion. Which sentence is the best interpretation?

A) The object is moving with a constant, non-zero acceleration.
B) The object does not move.
C) The object is moving with a uniformly increasing velocity.
D) The object is moving at a constant velocity
E) The object is moving with a uniformly increasing acceleration.

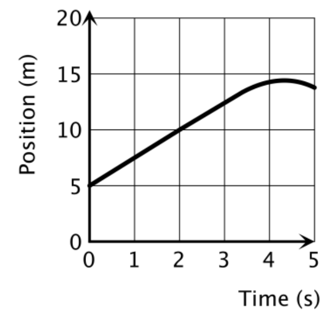


4. An elevator moves from the basement to the tenth floor of a building. The mass of the elevator is 1000 kg and it moves as shown in the velocity-time graph below. How far does it move during the first three seconds of motion?

A) 0.75 m
B) 1.33 m
C) 4.0 m
D) 6.0 m
E) 12.0 m

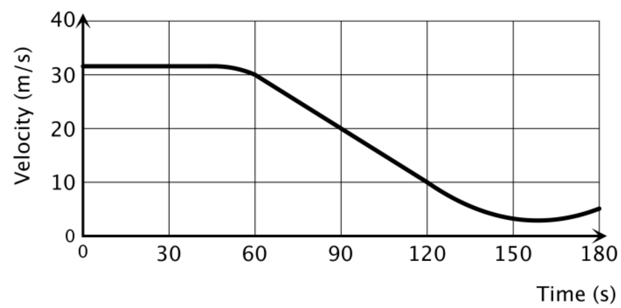


5. The following figure shows the position versus time graph of an object. The velocity of the object at
$t = 2$ s is:



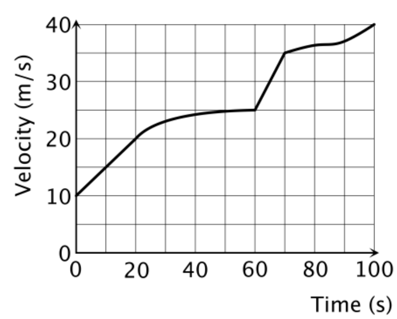
A) 0.5 m/s
B) 8.5 m/s
C) 2.5 m/s
D) 5.0 m/s
E) 10.0 m/s

6. The graph below shows the velocity as a function of time for a car of mass 1.5×10^3 kg. What was the acceleration at $t = 90$ s?



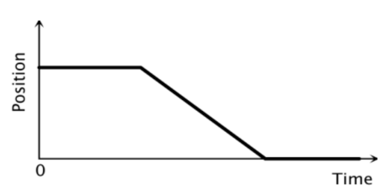
A) -0.22 m/s^2
B) -0.33 m/s^2
C) -1.0 m/s^2
D) -2.0 m/s^2
E) 20 m/s^2

7. The graph shows the velocity as a function of time for an object that is moving in a straight line. At
$t = 65$ s the instantaneous acceleration of the object was most nearly:



A) 1.0 m/s^2
B) 2.0 m/s^2
C) 0.46 m/s^2
D) 30 m/s^2
E) 34 m/s^2

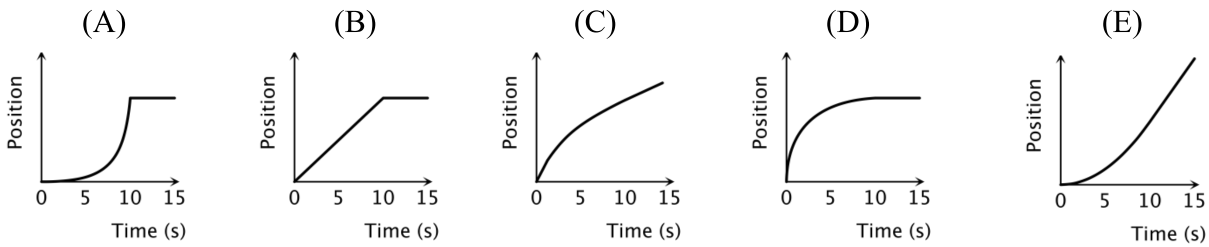
8. The following graph shows the position versus time graph of an object´s motion. Which sentence is a correct interpretation?



A) The object rolls along a flat surface. Then it rolls forward down a hill, and then finally stops.
B) The object doesn´t move at first. Then it rolls forward down a hill, and finally stops.

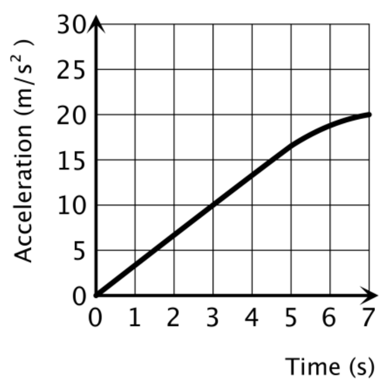
C) The object is moving at a constant velocity. Then it slows down and stops.
D) The object doesn´t move at first. Then it moves backwards, and then finally stops.
E) The object moves along a flat area, moves backwards down a hill, and then it keeps moving.

9. An object starts from rest and undergoes a positive, constant acceleration for ten seconds, it then continues on with constant velocity. Which of the following graphs correctly describes this situation?

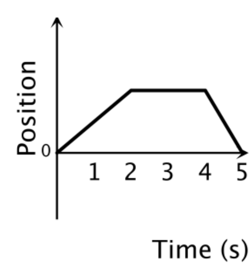


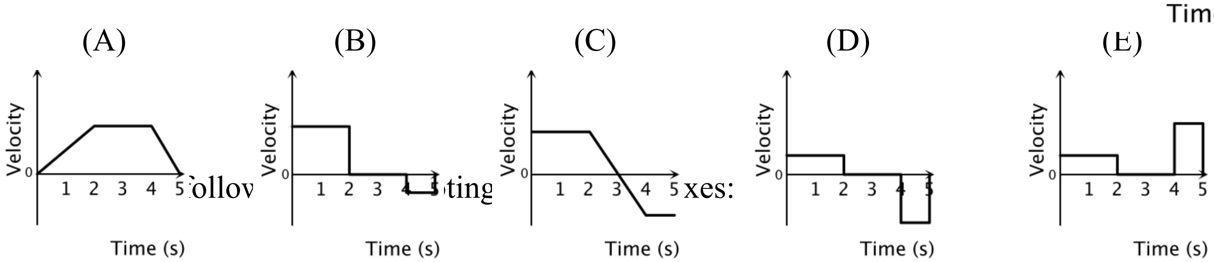
10. The following is an acceleration versus time graph of an object. If you would like to use the graph to know the object's change in velocity during the interval from $t = 0$ s to $t = 3$ s, what would you do?

A) Find the area between that line segment and the time axis by calculating (10x3)/2.
B) Find the slope of that line segment by dividing 10 by 3.
C) Read 10 directly off the vertical axis.
D) Find the value by dividing 3 by 10.
E) Find the value by multiplying 10 by 3.



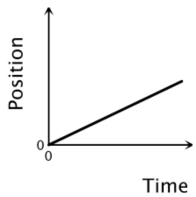
11. The figure to the right represents the position versus time of an object´s motion during a 5 s time interval. Which of the following graphs of velocity versus time would best represent the object's motion during the same interval?



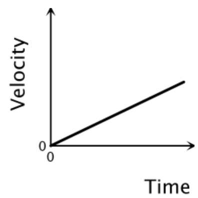


12. ollov ting xes:

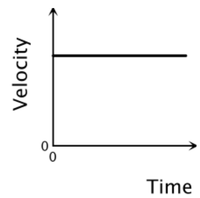
(I)



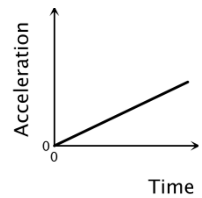
(II)



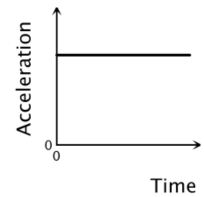
(III)



(IV)



(V)

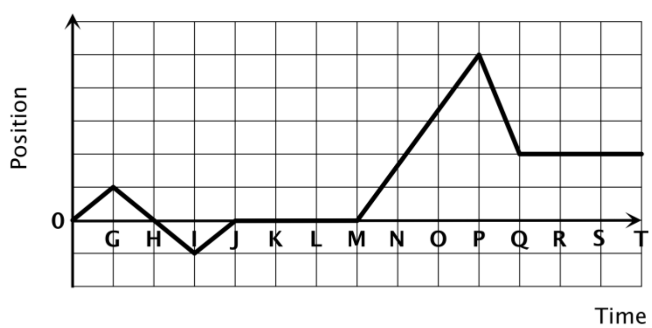


Which of these represent(s) motion at constant velocity?

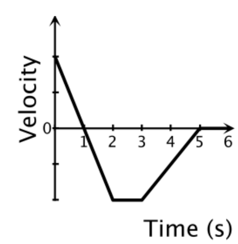
A) I, II and IV
B) I and III
C) III only
D) III and V
E) I, III and V

13. The graph shows the position versus time of an object moving in a straight line. Which of the following options corresponds to the case when its velocity is the most negative?

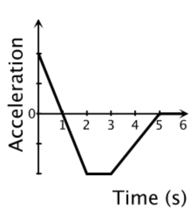
A) P to Q
B) I
C) M to P
D) G to I
E) P



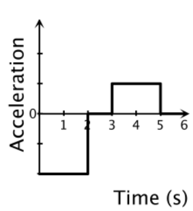
14. The figure to the right represents the velocity versus time graph of an object´s motion during a 6 s time interval. Which of the following graphs of acceleration versus time would best represent the object's motion during the same interval?



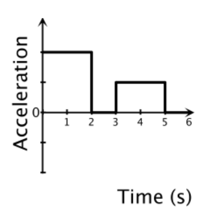
(A)



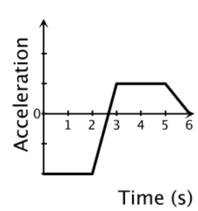
(B)



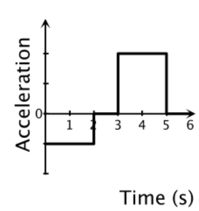
(C)



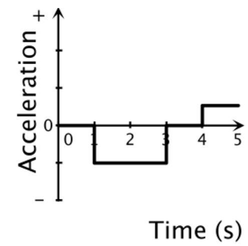
(D)



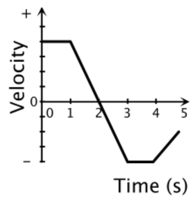
(E)



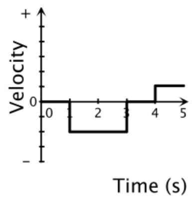
15. The graph on the right represents the acceleration of an object during a 5 s time interval. Which of the following graphs of velocity versus time would best represent the object´s motion during the same time interval?



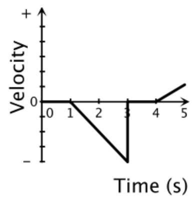
(A)



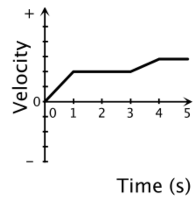
(B)



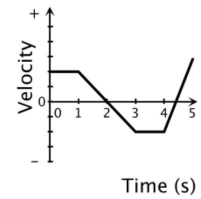
(C)



(D)

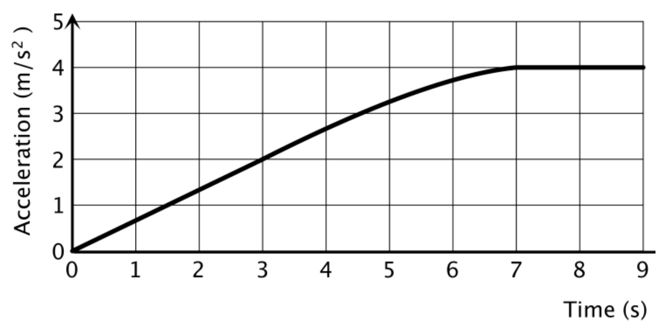


(E)



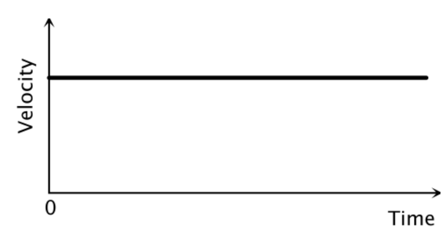
16. An object moves according to the acceleration versus time graph below. The change in velocity of the object in the first three seconds of motion was:

A) 1.5 m/s
B) 0.67 m/s
C) 2.0 m/s
D) 3.0 m/s
E) 6.0 m/s

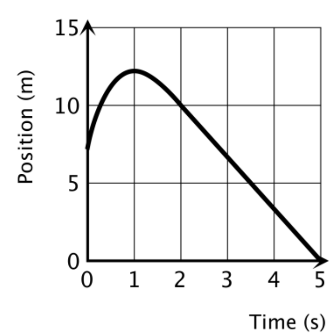


17 . The graph to the right shows the velocity of an object moving in a straight line. Which sentence is the best interpretation?

A) The object is moving with a uniformly increasing position.
B) The object´s position is constant.
C) The object is moving with a uniformly increasing acceleration.
D) The object is moving with a constant, non-zero acceleration.
E) The object is moving with a uniformly increasing velocity.



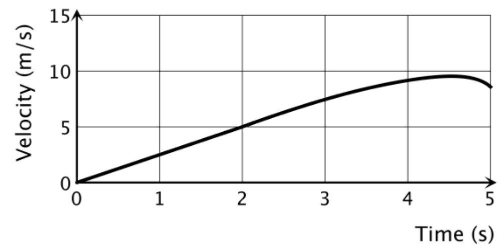
18. The figure to the right shows the position as function of time for an object. The velocity of the object at $t = 3$ s is about:
A) -3.3 m/s
B) -2.0 m/s
C) -0.67 m/s



D) -2.3 m/s

E) 7.0 m/s

19. The graph below represents the velocity versus time graph of an object. If you wanted to know the change in position of the object during the interval from t = 0 s to t = 2 s, from the graph you would:



A) read 5 directly off the vertical axis.

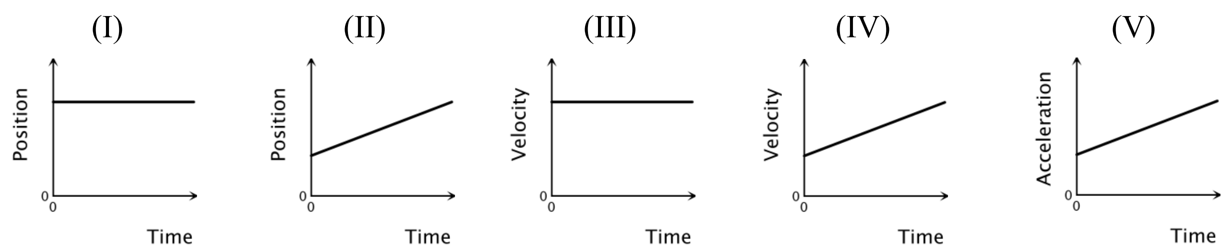
B) find the area between that line segment and the time axis by calculating (5x2)/2.

C) find the slope of that line segment by dividing 5 by 2.

D) find the value of the distance by multiplying 5 by 2.

E) find the value by dividing 2 by 5.

20. Consider the following graphs, noting the different axes:



Which of these represent(s) the object´s motion with an acceleration that increases uniformly?

A) II and III

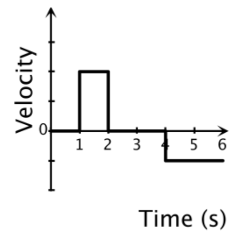
B) IV and V

C) V only

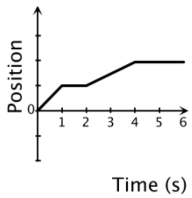
D) II, IV and V

E) IV only

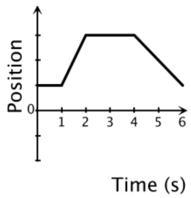
21. The graph to the right represents the velocity of an object during a 6 s time interval. Which of the following graphs of position versus time would best represent the object's motion during the same interval?



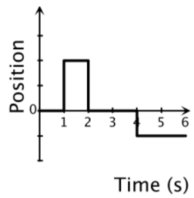
(A)



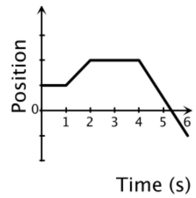
(B)



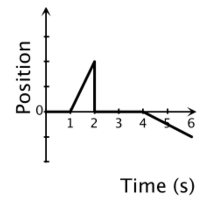
(C)



(D)

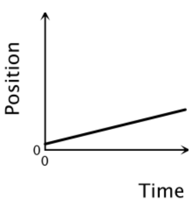


(E)

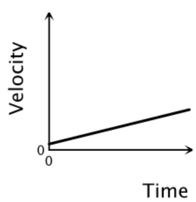


22. Consider the following graphs, noting the different axis:

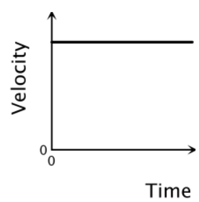
(I)



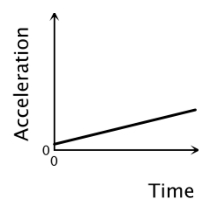
(II)



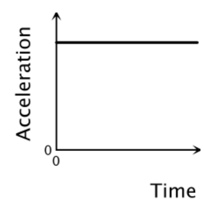
(III)



(IV)



(V)

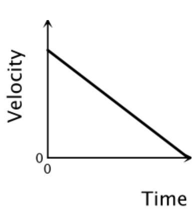


Which of these represent(s) the object´s motion with a constant, non-zero acceleration?

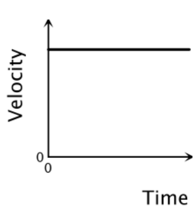
A) I, II and IV
B) V only
C) II and V
D) IV only
E) III and V

23. Velocity versus time graphs for five objects are shown below. All axes have the same scale. Which object had the greatest displacement during the interval?

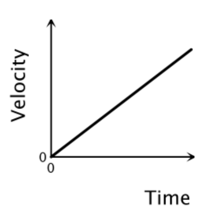
(A)



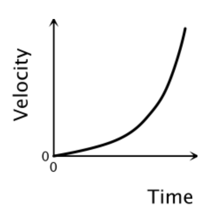
(B)



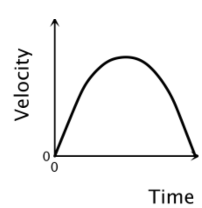
(C)



(D)

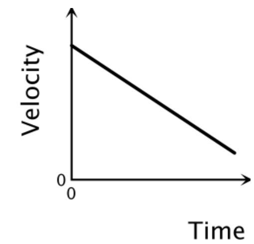


(E)



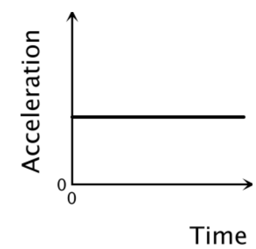
24. The graph to the right represents the velocity of an object´s motion. Which sentence is the best interpretation?

A) The object is moving with a constant acceleration.
B) The object is moving with a uniformly decreasing acceleration.
C) The object is moving with a uniformly increasing velocity.
D) The object is moving at a constant velocity.
E) The object does not move.

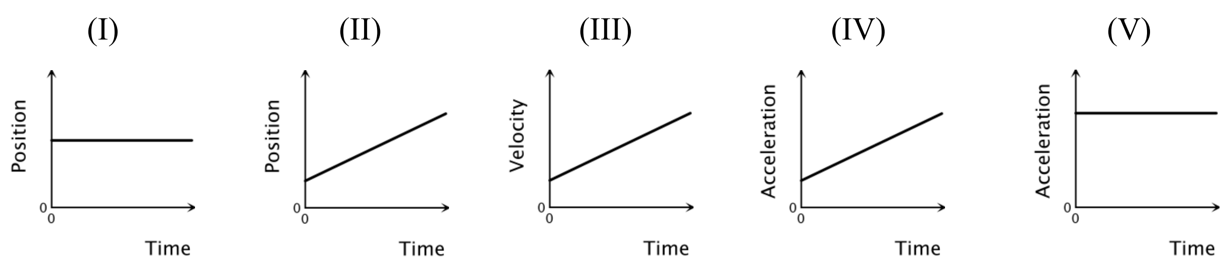


25. The graph to the right represents the acceleration as a function of time for a moving object. Which sentence is the best interpretation?

A) The object is moving with a uniformly increasing acceleration.
B) The object does not move.
C) The object is moving with a uniformly increasing velocity.
D) The object is moving at a constant velocity.
E) The object is moving with a uniformly increasing position.



26. Consider the following graphs, noting the different axis:



Which of these represent(s) the object´s motion with a uniformly increasing velocity?

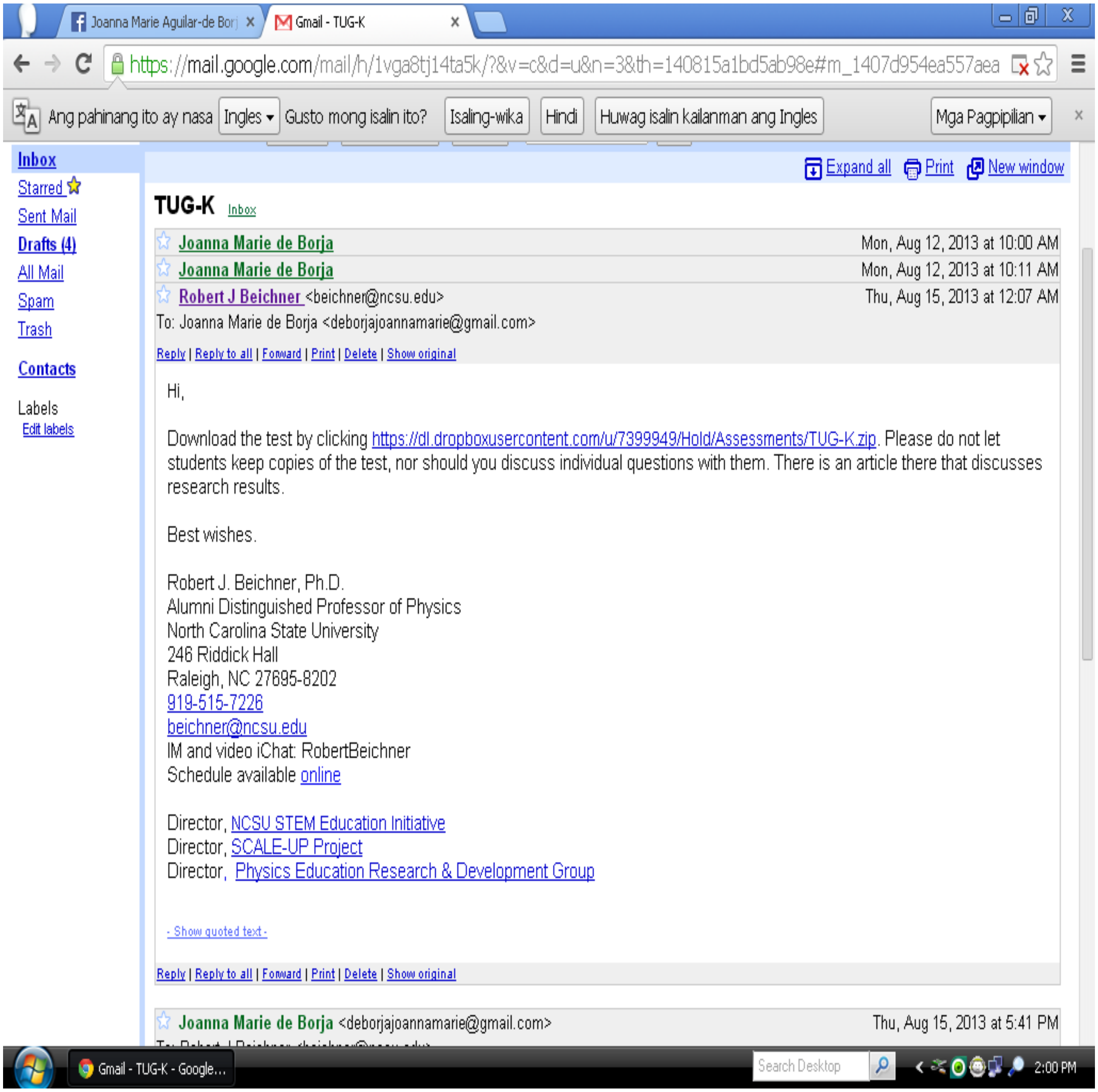
A) II only
B) III and V
C) IV only
D) II, III and IV
E) III only

Answer Key

1. A
2. E
3. D
4. D
5. C
6. B
7. A
8. D
9. E
10. A
11. D
12. B
13. A
14. B
15. A
16. D
17. A
18. A
19. B
20. C
21. B
22. C
23. B
24. A
25. C
26. B

APPENDIX B

LETTER OF APPROVAL FROM DR. BEICHNER



TUG-K Inbox

Joanna Marie de Borja — Mon, Aug 12, 2013 at 10:00 AM

Joanna Marie de Borja — Mon, Aug 12, 2013 at 10:11 AM

Robert J Beichner <beichner@ncsu.edu> — Thu, Aug 15, 2013 at 12:07 AM

To: Joanna Marie de Borja <deborjajoannamarie@gmail.com>

Hi,

Download the test by clicking https://dl.dropboxusercontent.com/u/7399949/Hold/Assessments/TUG-K.zip. Please do not let students keep copies of the test, nor should you discuss individual questions with them. There is an article there that discusses research results.

Best wishes.

Robert J. Beichner, Ph.D.
Alumni Distinguished Professor of Physics
North Carolina State University
246 Riddick Hall
Raleigh, NC 27695-8202
919-515-7226
beichner@ncsu.edu
IM and video iChat: RobertBeichner
Schedule available online

Director, NCSU STEM Education Initiative
Director, SCALE-UP Project
Director, Physics Education Research & Development Group

Joanna Marie de Borja <deborjajoannamarie@gmail.com> — Thu, Aug 15, 2013 at 5:41 PM

APPENDIX C

LETTER TO EXPERTS

Philippine Normal University
National Center for Teacher Education
Manila

16 November 2013

____
____
____

____________________,

I am *Joanna Marie A. de Borja,* currently working with my master's thesis entitled, "*Development of Supplementary Material to Enhance the Graph Interpretation Skills of the Students*". In this regard, I would like to seek for your assistance to evaluate the supplementary material I prepared. I believe that your expertise in Physics will help me improve the said supplementary material.

Attach to this letter is the evaluation form and the copy of the supplementary material. Please feel free to write on the supplementary material in case you have comments and suggestions. If you have questions, these are my contact number and email address – 0922-843-4824 and deborjajoannamarie@gmail.com.

Hoping for your favorable response regarding this matter.

Respectfully,

Joanna Marie A. de Borja
Researcher

Noted by:

Prof. Abel Ole

Dr. Violeta Arciaga
Thesis Advisers

APPENDIX D

LETTER TO THE PRINCIPAL

Colegio de San Juan de Letran Calamba
Basic Education Department – High School

02 September 2013

Prof. Simplicio P. Alba
Principal

Dear Sir:

Greetings of Peace!

I am currently working with my thesis at the Philippine Normal University – Manila with the course Master of Arts in Science Education with Specialization in Physics entitled, *"Development of Supplementary Material to Enhance the Graph Interpretation Skills of the Students"*.

In this concern, I would like to ask permission from you to give me consent to administer the "*Test of Understanding Graph – Kinematics (TUG-K)*" that was developed by Dr. Robert J. Beichner of North Carolina State University to 4th Year BEC students on September 9, 2013. Their participation is very significant and beneficial for my thesis undertaking.

In addition, as part of the Educational Research Ethics, a Letter of Consent is attached to ask permission to the parents of the said respondents.

Thank you very much for your support and may the Almighty God bless you a hundredfold.

Respectfully yours,

Ms. Joanna Marie A. de Borja
HS Faculty

Approved/Disapproved by:

Prof. Simplicio P. Alba
BED Principal

Colegio de San Juan de Letran Calamba
Basic Education Department – High School

26 November 2013

Prof. Simplicio P. Alba
Principal

Dear Sir:

Greetings of Peace!

I am currently working on my thesis at the Philippine Normal University – Manila with the course Master of Arts in Science Education with Specialization in Physics entitled, *"Development of Supplementary Material to Enhance the Graph Interpretation Skills of the Students"*.

In this concern, I would like to ask your permission to allow me to administer the pre-test and posttest to the 3rd Year SSC students on the first week of December 2013. Part of the methodology is the introduction of the treatment to be facilitated by yours truly. Their participation is very significant and useful to pursue my thesis undertaking.

In addition, as part of the Educational Research Ethics, a Letter of Consent is attached to ask permission from the parent/guardian of the said respondents to allow them to be part of the said study.

Thank you very much for your support and may the Almighty God bless you a hundredfold.

Respectfully yours,

Ms. Joanna Marie A. de Borja
HS Faculty

Approved/Disapproved by:

Prof. Simplicio P. Alba
BED Principal

APPENDIX E

LETTER OF CONSENT

Colegio de San Juan de Letran Calamba
Basic Education Department – High School

26 November 2013

Dear Parent/s:

Greetings of Peace!

I am currently working on my thesis at the Philippine Normal University – Manila with the course Master of Arts in Science Education with Specialization in Physics entitled, *"Development of Supplementary Material to Enhance the Graph Interpretation Skills of the Students"*. The *"Test of Understanding Graph – Kinematics (TUG-K)"* that was developed by Dr. Robert J. Beichner of North Carolina State University will be administered to the 3rd Year SSC students on the first week of December 2013. Part of the methodology is the introduction of the treatment to be facilitated by yours truly. Their participation is very significant and useful to the success of my thesis undertaking.

In this regard, I would like to ask your permission to allow your child to take the said test. Rest assured that the results will have no impact on the grade of your child in Basic Physics. In addition, I assure you that all data that will be collected from this study will be treated with utmost confidentiality. However, the topic that will be discussed by yours truly will be part of their 3rd Periodical Exam.

Thank you very much for your support and may the Almighty God bless you a hundredfold.

Respectfully yours,

Ms. Joanna Marie A. de Borja
HS Faculty

Noted and Approved by:

Prof. Simplicio P. Alba
BED Principal

REPLY SLIP

☐ I am allowing my child to be part of the study.

☐ I am not allowing my child to be part of the study.

Name of Student: ____ Section: ______________

____
Signature over printed name of Parent/Guardian

APPENDIX F

EXPERTS EVALUATION FORM

Dear Evaluator,

Please check the box that corresponds to your assessment on the "*Graphical Analysis of Motion: A Supplementary Material*". Below is the Likert-type scale for the criterion in the evaluation of the supplementary material. The following will be the interpretation for each point.

5 – Strongly Agree
4 – Agree
3 – Uncertain
2 – Disagree
1 – Strongly Disagree

Items to be Evaluated	**5**	**4**	**3**	**2**	**1**
Criterion: A. OBJECTIVES					
1. The objectives include multimedia learning such as a) reading comprehension b) visual-picture comprehension					
2. The objectives encompass active cognitive processing by which learners construct meaningful learning outcomes from words and pictures.					
Mean Rating					
Criterion: B. CONTENT					
1. It contains the general objectives.					
2. The sequence of topics builds conceptual understanding of the general topic.					
3. The material contains a wide range of resources for additional information.					
4. The content is complete in scope without missing important information.					
5. It promotes critical thinking, problem-solving, and reasoning.					
6. The activities promote active learning.					
7. The material used different forms of representation such as texts, pictures, and videos.					
8. The learners construct ideas through multiple representations such as text and diagrams.					

9. The diagrams such as pictures and graphs represent the concept being discussed.					
10. The simulations and videos represent the ideas accurately.					
11. The material is equipped with exercises and quizzes to measure student learning.					
12. Learners do not need any guidance in organizing and making sense of the presented information.					
Mean Rating					
Criterion: C. LANGUAGE	**5**	**4**	**3**	**2**	**1**
1. The grammar and vocabulary used in the material are accurate.					
2. The language used is appropriate to the level of the students.					
3. The material allows effective communication.					
4. The concepts and key terms are presented clearly in simple language.					
Mean Rating					
Criterion: D. LAYOUT	**5**	**4**	**3**	**2**	**1**
1. Graphs, layouts, and presentations are well presented in the material.					
2. Document format such as font, font style, etc. were maintained.					
3. The format and general appearance of the layout is appropriate to the material.					
Mean Rating					

Comments and Suggestions

____

____

APPENDIX G

SCORES OF SELECTED 4TH YEAR BEC STUDENTS ON TUG-K

Student	Score
1	3
2	5
3	2
4	6
5	6
6	13
7	4
8	3
9	4
10	5
11	5
12	3
13	4
14	3
15	9
16	4
17	3
18	5
19	4
20	2
21	3
22	8
23	2
24	10
25	2
26	10
27	3
28	5
29	9
30	5
31	6
32	3
33	3
34	12
35	6
36	4
37	11
38	3
39	2
40	2
41	6
42	14
43	2
44	2
45	3
46	12
47	4
48	2
49	12
50	2
51	13
52	2
53	5
54	14
55	5
56	3
57	13
58	3
59	8
60	7
61	7
62	4
63	4
64	7
65	10
66	5
67	6
68	4
69	14
70	4
71	5
72	6
73	14
74	6
75	1
76	4
77	4
78	3

APPENDIX H

PROFILE OF SUBJECTS

STUD	GRP	SEX	AGE	Q1	Q2	PRE	POST
1	0	1	15.00	89.23	86.93	5	18
2	0	1	15.00	92.77	94.23	2	19
3	0	1	14.00	84.48	82.10	4	13
4	0	1	14.50	90.08	87.38	0	18
5	0	1	14.00	94.38	95.15	2	19
6	0	1	15.00	85.51	88.70	5	15
7	0	1	14.50	88.63	86.68	2	17
8	0	1	15.00	86.81	89.18	3	8
9	0	1	15.00	93.88	92.38	2	18
10	0	0	14.50	91.07	86.10	1	12
11	0	0	14.50	84.19	83.75	2	9
12	0	0	15.00	94.33	94.50	4	15
13	0	0	14.50	84.27	92.18	4	16
14	0	0	14.50	89.63	87.68	4	8
15	0	0	15.00	90.12	91.90	2	18
16	0	0	14.50	88.60	84.13	2	17
17	0	0	14.50	87.36	80.30	2	7
18	0	0	14.50	96.38	95.55	1	16
19	0	0	15.00	92.80	89.53	3	15
20	0	0	14.50	86.54	80.80	3	16
21	0	0	15.00	85.90	83.73	3	16
22	0	0	14.50	93.90	91.80	5	15
23	0	0	14.50	91.94	94.93	3	15
24	0	0	15.00	88.83	86.00	3	10
25	0	0	14.00	90.76	91.18	1	12
26	1	1	15.00	84.74	87.28	2	19
27	1	1	15.00	86.83	86.05	3	13
28	1	1	14.00	93.38	93.85	2	22
29	1	1	15.00	88.93	89.10	6	13
30	1	1	14.50	90.01	90.70	4	20
31	1	0	15.50	93.59	92.00	5	21
32	1	0	15.50	94.38	91.58	3	21
33	1	0	14.50	93.33	88.98	3	19
34	1	0	14.50	88.16	85.35	0	17
35	1	0	15.00	92.15	91.53	2	19
36	1	0	14.50	88.23	92.38	2	15
37	1	0	14.50	89.35	88.38	2	20
38	1	0	15.00	91.30	90.58	0	15
39	1	0	14.50	90.62	89.48	2	20
40	1	0	15.00	83.02	81.33	3	15
41	1	0	14.50	86.75	90.78	2	18
42	1	0	14.00	90.74	92.48	3	16
43	1	0	14.50	86.67	89.43	4	16
44	1	0	15.50	94.20	94.13	2	24
45	1	0	14.50	88.40	84.45	4	17

Legend:

Group: 0- control, 1-experimental
Sex: 0-Female, 1-Male
Q1 – 1^{ST} Quarter Grade in Basic Physics
Q2 – 2^{nd} Quarter Grade in Basic Physics

APPENDIX I

Scores of Four Physics Experts on the Supplementary Material

Criterion		A	B	C	D
Objectives	1	5	5	5	4
	2	4	4	4	4
	3	5	5	5	5
Content and Simulations	1	5	5	5	5
	2	4	5	5	4
	3	4	5	5	4
	4	5	5	5	4
	5	4	5	4	4
	6	5	5	5	3
	7	5	5	5	4
	8	5	5	5	4
	9	5	5	4	4
	10	5	5	4	4
	11	5	4	4	4
	12	5	5	4	4
Language	1	5	4	5	4
	2	4	5	4	4
	3	5	4	3	4
	4	4	5	4	4
Layout	1	4	4	4	4
	2	4	5	4	4
	3	5	4	3	4