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A quantitative analysis of the effectiveness of LOGO as an instructional aid for teaching mechanics in physics

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A Quantitative Analysis of the Effectiveness of LOGO as an Instructional Aid for Teaching Mechanics in Physics

MASTERS PROJECT

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by

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DEDICATION

This study is dedicated in memory to John H. Conrad. Without his lessons and guidance, I would never have gotten here.

CHAPTER I

INTRODUCTION TO THE PROBLEM

Purpose for the Study

The computer has had an ever increasing presence in the lives of every person on this planet. In Mindstorms, Papert (1980) described this best when he said,

> The computer is the Proteus of machines. Its essence is its universality, its power to stimulate. Because it can take on a thousand forms and can serve a thousand functions, it can appeal to a thousand tastes (p. viii).

As educators, to ignore the computer and its influence would be negligent. Educators must find a way to make the computer both user friendly yet demanding. Many attempts have been made to meet such a challenge. Such attempts as Microsoft windows or CD-ROM technology have tended to alienate the user from the internal mechanisms and logic of the computer. Computer applications are and have been constructed around specific computer languages. The use of these languages as an instructional tool has become a valid method of teaching physics. The question for physics teachers has become, which language to use?

There is a program language that claims to have met the challenge and has kept the user close to the inner workings of the computer. That program is LOGO. Papert (1980) explained the justification for such a programming language. He stated:

> In 1967 before the children's laboratory at MIT had been officially formed, I began thinking about

> a computer language that would be suitable for children. This did not mean it should be a "toy" language. On the contrary, I wanted it to have the power of professional programming languages, but I also wanted it to have easy routes for beginners (Papert, p. 210).

This statement implied that LOGO was simple enough to be used by young "computer illiterate" children and also could be complicated enough to challenge computer experts. This, he claims, would make LOGO a computer language for all ages and backgrounds.

This flexibility made it ideal for schools. With the help of the computer scientists at the Massachusetts Institute of Technology (MIT), Papert and his colleagues developed LOGO. LOGO was first tried and tested in an elementary classroom during the 1968-69 school year. It was a very simple version. It did not have the graphics capabilities of the newer LOGO versions (Papert, 1980, p. 218). Since then it was continuously improved and expanded.

Despite this persistent refinement, the literature review showed that very limited research had been done to investigate the effects of LOGO in high schools. Most of the studies located, were performed in the area of mathematics. Almost all of the studies done on the subject area of science were executed on elementary school children.

In <u>Mindstorms</u>, Papert claims that LOGO can be used to breath life into Newtonian physics (mechanics) (p. 154). Papert is not the only person that has advocated it as an instructional aid in Newtonian physics. Numerous educators

provided many examples of lessons that could be done with LOGO as applied to mechanics (Lough, 1986; Kolodiy, 1988; Osborne,1987). Descriptions of LOGO based mechanics lessons are not in short supply. The numerous descriptions of lessons did not in themselves prove LOGO's worth. "We need more studies (on LOGO) employing sound and appropriately varied methods" (Walker, 1987). The author decided to execute a study that tested Seymour Papert's claims of the value of LOGO in the learning of mechanics.

Problem Statement

The purpose for this study was to evaluate the effectiveness of LOGO as an instructional aid for teaching mechanics in high school physics.

Hypothesis

There was no significant difference between the pretest and posttest mean mechanics achievement scores after the subjects were exposed to a number of mechanics related projects that required programming in LOGO.

Assumptions

In the execution of this study, the author assumed that the participants in this study were giving an honest effort when working with the programming language. It was also assumed that the subjects answered the questions on the

pretest and posttest to the best of their ability.

Limitations

The design of this study, T_1 x T_2, is commonly known as quasi-experimental. This design was chosen because a number of external variables could not be controlled. These variables are discussed in terms of how they effected both the internal and external validity of this study.

There are four factors that could have effected the internal validity of this study (Isaac and Michael, pp. 60-61). The first could have been the effect of history. The students might have received instructions in mechanics outside of the LOGO projects. Since these LOGO projects were an addition to the preexisting methods of teaching mechanics in physics, it was not possible to definitely determine whether the LOGO projects or the standard instruction was the major contributor to the effects observed. Secondly, since these students received LOGO related instruction for a period of fourteen weeks, the subject's natural maturation could have adversely effected the internal validity of this study. A third factor threatening the internal validity of this study was considered to be pretesting procedures. By completing the pretest, the subjects of this study may have benefitted from it as a learning experience. Lastly, because these physics classes are voluntary and are normally filled with the students who have higher than average math and logic skills,

the study may have suffered from statistical regression.

Two possible variables could have had a negative effect on the external validity of this experiment. The first was the interaction effects of selection (Isaac and Michael, 1990, p. 62). Due to particular situations and facilities at this school, it was not entirely feasible to generalize as to the possible effects of LOGO on all students taking any high school physics course. The second factor that may have effected the external validity of this study was the reactive effect of experimental procedures (Isaac and Michael, 1990, p. 63). The fact that the subjects were aware of an experiment in progress may have made them behave in a manner other than normal. This could have hampered the ability to generalize the findings of this study.

Definition of Terms

Mechanics. This is the study of physics as it pertains to the following subjects: vectors, translational motion (this includes free fall and projectile motion), force, rotational motion, momentum, and energy. It is also commonly known as Newtonian physics.

LOGO. This is a user friendly computer language developed by a group of educators at the Massachusetts Institute of Technology.

Lecture Based Instruction. This is the method of teaching that includes any form of lecture, discussion, or

organized dialogue between the class and the instructor. This usually is used to introduce or explain a new theory or concept.

Problem Solving Instruction. This is the method of instruction that includes solving theoretical math based problems individually, in a small group, or as a class. This is usually used to practice a theory or concept.

Laboratory Based Instruction. This is the type of instruction that requires a physical piece of equipment that needs to be constructed and used in order to determine a mathematical relationship that exists in the real world. This relationship may or may not agree with predictions made by the laws of physics. This method is usually used to test and demonstrate the real world application of a theory.

Model Based Instruction. This is the method of instruction that has the student try to construct a representation of what is or should be observed. This representation can be mathematical (equations), visual (graphics), or computer generated (both equations and graphics). This method is usually used when it is desired that the student discover the theory or concept on his own.

Cognition. This is the act or process of knowing including both awareness and judgement. This includes procedural skills such as classification and seriation .Cognition also includes the product of this act.

Metacognition. This term is used to describe ones

ability to monitor and correct one's own thinking (Clements and Gullo, 1984).

CHAPTER II

REVIEW OF LITERATURE

In the review of the available literature and research, the author found that the information, supporting the need for studying the effectiveness of LOGO as an instructional aid in teaching mechanics, fell into three basic topic areas.

The first topic area concerned the common methods for instructing mechanical (Newtonian) physics. In order to conduct a study concerning the instruction of mechanics, the various instructional methods had to have been defined and evaluated. Four methods for the instruction of mechanical physics were discovered.

Lecture based instruction was found to be the oldest and most commonly used method of teaching mechanics. Surprisingly, little research was found on the lecture method. Due to its wide acceptance, research is concentrated on the other more controversial methods of instruction.

In an article to The Physics Teacher, Hudson (1985) acknowledged the fact that most collegiate physics courses were lecture based. He stated, "For a variety of reasons, some of which have little consideration for the learning process, the large lecture section has become common for the beginning classes" (Hudson, 1985). In this article, he

suggests ways in which and instructor could make a lecture class be more interesting and progress more smoothly.

Suggestions such as collection boxes for homework, answer set distribution, course organization and student information were all included. Hudson did not suggest the use of the computer as an aid in teaching the material. He did advocate the use of the computer to aid the instructor in handling grades and administrative duties. Hudson did not do a study on the effects of his suggestion on the effectiveness of the lecture. Despite this fact, the mere presence of this article articulates the fact that the lecture is a common method currently being used to instruct physics.

A research study was conducted on two example based lecture methods. Example based instruction is one of the cornerstones to the lecture method of teaching. Brown and Clements (1987) explored whether thought situations alone have an impact on the misconceptions of physics students. They also were trying to determine whether different methods of using thought situations have an effect on the misconceptions of physics students.

Thought situations are commonly known as thought experiments. A thought situation (experiment) is an example of a physical situation that is held in the mind. The variables that effect that situation can be changed quickly and easily. To physically carry out these situations in the

real world could be costly and time consuming.

Brown and Clements describe two types of the example based lecture method. When describing the first type, they stated, "Here the thought situations alone, without additional empirical experiences (experimentation), are intended to ground the principle into the experiences of the student. The student should then be able to apply the principle to other situations which are similar to the examples provide by the instructor." (Brown and Clements, 1987).

The second type of example based lecture method was described as treating thought situations as the primary focus of the explanation (Brown and Clements, 1987). The students were first given an "anchor". The "anchor" is a thought situation in which the student intuitively believes the answer that agrees with Newtonian physics (Brown and Clement, 1987). The students would then be given intermediate situations or "bridging analogies". These thought situations were intended to help the student learn how to apply the concept being instructed. These "bridging analogies" continued to increased in their complexity until the target situation was reached (Brown and Clements, 1987).

In their study, Brown and Clements concluded, "The results of this study indicate that it is possible in some cases to alter students beliefs with carefully chosen thought situations when students' positive anchoring

intuitions are extended to target problems involving misconceptions" (Brown and Clements, 1987). The study also indicated that different methods of using thought situations may be less effective than others. Some of the individual examples (thought situations) in the control explanations were counter-intuitive to many students (Brown and Clements, 1987). This seems to indicate that the particular method used while employing example based lecture can be crucial to learning.

Both the article by Hudson and the study by Brown and Clements go to proving the existence of the lecture method for instructing physics. It is a shame that there are not more studies concerning various types of lecture method. This would be extremely useful due to the fact that such a large majority of instructors use lecture in various degrees.

A more studied method is the instruction of mechanical physics through the use of problem solving. The teaching of problem solving is usually a main objective of most science courses. Few science courses rely on problem solving quite as much as physics. A student's use of problem solving techniques can be classified into two styles.

The first is the novice (process based) style of problem solving. In this style of problem solving the solver is dependent on a set of algebraic equations. The solver tends to define the problem by its surface features.

"When asked to state the general approach they would take to solve a problem, novices usually relate detailed information (e.g. equations and specific facts), rather than more general principles and concepts (Thibodeau Hardiman et al., 1989).

The second style is that used by experts. When using expert (structure based) style, the solver relies more on the deep underlying relationships and concepts. This usually means fewer algebraic equations. "As problem solving skills develop, the reliance on deep structure to categorize problems increases" (Thibodeau Hardiman et al., 1989).

A study was conducted by Ruth Stavy, Meir Meidav, Zehava Asa, and Yoram Kirsch. In this study the researchers were trying to determine whether high school physics students exhibited a preference of novice (process based) or expert (structure based)style problem solving. This study also compared the high school students results with the results of the more experienced high schools physics teachers.

This study employed 34 high school physics students (novices) and 22 high school physics teachers(experts). All had completed and mastered the study of energy and mechanics. The students had all achieved a grade of at least 80% in the topic areas of energy and mechanics (Stavy et al., 1991). Each of the individuals in both groups were

asked to answer five open ended physics problems. Each could be solved either by the process or structure based style. Also multiple choice questions were asked. These questions asked about the act of problem solving. Each multiple choice question had at least one correct response for the process based style as well as at least one correct answer for the structure based style.

This study determined that the majority of expert teachers preferred, as expected, the use of the structured based model (Stavy et al., 1991). However, most novice students clearly preferred the use of the process based model (Stavy et al., 1991).

The existence of this and other studies show that the method of instruction of mechanics through the use of problem solving techniques is valid and being used.

Laboratory (hands on) based instruction is a third method of instructing mechanics. The Georgia State Department of Education stated the laboratory based instruction is a valid method to be used in teaching the sciences. It said, "Laboratory experiences should provide students with increasingly real experimental situations (Science Guide).

The science guide provided by the State of Georgia specified how to use laboratory based instruction. It suggested that students be exposed to the materials and techniques employed by scientists. These experiences, or

exposers, "introduce or reinforce key concepts, and they develop scientific procedures such as hypothesis formation and testing and analyzing results" (Science Guide). The Georgia State Department of Education encouraged science instructor to laboratory based instruction as a basis for teaching statistical analysis. "Furthermore, students should learn how to design an experiment; how to express and analyze data statistically (chi square and t-tests to fit and significance) and how to report the results in a formal paper" (Science Guide).

As can be seen by the instructional guide developed by the State of Georgia Department of Education, laboratory based instruction is a valid method of teaching mechanical physics.

Instructional methods using mathematical, visual, or computer modeling is the fourth method for instructing mechanical physics. The instruction of mechanics through the use of modeling emphasizes learning through the relationships of the different variables affecting a given situation.

Mathematical modeling is described in an article in Physics Education. The article by Oke and Jones provided examples of how to use mathematical modeling to instruct various scientific principles. Major mechanics concepts were included in these examples. "The teaching approach is interactive, that is, a broad description of each problem is

presented to a group of students who are then invited to work with the lecturer in identifying the essential features and making a stab at the solution" (Oke and Jones, 1982). The authors found that each student approached the problem in different manners. "For example, when considering models involving air flow, some students automatically think in terms of drag and lift. Others may think in terms of wind pressure and Bernoulli's forces. Still others wish to consider the rate of change of momentum of air, invoking Newton's third law." (Oke and Jones, 1982) The students were then allowed chose the approach that best suits their background and understanding. The lecturer then allowed the students to select their own variables and to find relevant laws and relationships (Oke and Jones, 1982). Then students were then encouraged to check and see if the results of their relationships were reasonable from a common sense point of view. The final step, called validation, was to determine if the model was an accurate representation of reality. This meant setting up and doing an experiment to determine if the model was a useful one.

In the April 1991 issue of The Science Teacher, Wolff-Micheal Roth described the use of computers to model various situations involving mechanical physics. He advocated the use of different computer applications or hardware to facilitate each step of the modeling process. "More complicated mathematics may require specialized programs

(such as MathCad), keyboards, or graphing calculators with scientific functions. Some very important ideas can be simulated on older computers with simple BASIC programming." (Roth, 1991). Roth also suggested the use of sensors to collect the data for validation of the model produced.

Modeling, whether it is mathematical or computer, has been described in these two articles as a method of instructing physics. Of the methods for instructing mechanical physics, modeling seems to lend itself best to the use of the computer. "In this work, computers and graphic calculators are valuable tools, since they allow students to discover patterns without the tedious calculations" (Roth, 1991). Computer modeling seems to be more time efficient and less tedious.

Two types of computer modeling are currently being used to instruct mechanical physics. Computer modeling allows the student to experience the excitement of scientific process without the high expense of specialized equipment or the laborious paper work. Computer modeling has also provided a graphical environment in which students can see the mathematical model. This would allow them to visualize the mathematical relationships.

A type of computer modeling instruction involves the use of computer software simulations. A software simulation provides a computer environment in which the variables of a given situation can be changed and the effects of such a

change can be observed.

Many examples of simulation software, for the instruction of mechanics, have been out on the market for many years. One such example is the EME Laws of Motion. "Laws of Motion provides computer-simulated experiments to help students understand the basic concepts of motion and mechanics" (Risley, 1983). There are many other courseware reviews in various journals that describe other mechanics simulation software.

In a 1987 study the use of computer simulations as an instructional aid was researched. Computer programs were used to simulate the experiments that were conducted earlier by the students (Borghi et al., 1987). Like most other simulation software, the range of parameters could be changed to fit the observations of the student's earlier experiments. This part of the instruction allowed the student to experiment with physical situations under ideal conditions (Borghi et al., 1987). This is the strength of computer modeling by simulation. It creates environments in which only the variables being study have an effect on the phenomenon observed.

The study was concluded by saying, "While testing our unit we confirmed for ourselves the idea that interactive graphics computer packages (simulations) can be very effective in the teaching of mechanics" (Borghi et al., 1987).

Simulations are not the only way to conduct computer modeling. Simulations are created by writing programs in various computer languages. To try to encourage the understanding of the underlying concepts of mechanics, some instructors are having students create their own simulations from the computer language itself.

There are many computer languages available for students to write their own programs. Some of these include FORTRAN, PASCAL, BASIC, and LOGO. BASIC seems to be the language of choice for most high school physics teachers using computer modeling. "Dynamic modelling by computer has up to now been carried out in the BASIC language" (Wong, 1986). This is probably due to the relative ease in which the language can be assimilated and used. "The structure of BASIC is such that it is most convenient to have a program that incorporates within it a self-writing routine, which takes model and initial values as data input and converts them into program code" (Wong, 1986).

But some physics instructors have discovered a simpler and more efficient computer language. This language is called LOGO. LOGO unlike any of the other languages can be learned in a very short period of time. A few simple commands, once introduced, are sufficient for students to use LOGO for exploring a variety of physics concepts (Lough, 1986).

Because of the simplicity of the language, it is

generally believed that LOGO is only useful for younger children. "Although many regard LOGO as a computer language for young children, it is actually a powerful high level computer language closely related to LISP, a widely used artificial intelligence language" (Lough, 1986).

LOGO has become an accepted medium for the instruction of mechanical physics. Because of its use, the need for evaluating LOGO's effectiveness has been discussed. Many scholars have called for additional research concerning LOGO. "If LOGO has testable consequences for school-age children in school settings, let us first test them in a variety of systematic varying settings" (Becker, 1987).

Many claims have been made about the effectiveness of LOGO on the thinking skills and achievement of students who have used it. These claims have had to be substantiated by research. To do this, the thought process of students have been classified into three skills categories. These categories are problem solving skills, cognition skills, and metacognition skills.

The use of LOGO as a instructional aid increases the problem solving skills of the students using it. A study was conducted on 100 fourth through sixth graders from a private elementary school in the eastern United States. The students all had at least 30 hours previous LOGO programming (Swan and Black, 1990). This study determined if the LOGO programming domain was particularly supportive in the

teaching and learning of problem solving (Swan and Black, 1990). The subjects were tested on their ability to apply five problem solving strategies. They were then randomly assigned to one of three treatment groups. One group received instruction in problem solving through the use of LOGO. The second group received problem solving instruction using paper and pencil exercises. The last group worked with the LOGO without an instruction on problem solving techniques.

"Significant differences in pretest to posttest increases were found between treatment groups indicating that subjects receiving explicit problem solving instruction and LOGO programming, and that group alone, improved in the formation of problem solving skills" (Swan and Black, 1990). The results of this study indicated that the LOGO programming environment, as a tool for instructing problem solving strategies, was superior to the traditional paper and pencil method.

It has been claimed, that LOGO is an effective instructional aid when used to increase the cognition abilities of students. Papert (1980), the author of LOGO, proposed that the LOGO environment can create conditions in which young children master notions formally thought to be too abstract. Thus cognitive development may be accelerated. Many scholars have since called for studies to verify such a claim.

A study was conducted at Kent State University to "investigate the effects of computer programming on the cognitive skills (procedural skills)" of elementary school children (Clements, 1986). The subjects of the study consisted of 72 elementary school children. The children were randomly assigned to one of the following three groups: LOGO computer programming, CAI (computer aided instruction), and control. No pretest was administered. A posttest, designed to measure a child's cognitive skills, was given at the end of the various treatments.

Developmental improvement was evident in all groups (Clements, 1986). "LOGO posttest scores were higher than all others" (Clements, 1986). Thus, it was concluded that LOGO was an effective medium for increasing the cognition skills of elementary school children.

It has also been suggested that programming with LOGO is an effective method for increasing the metacognitive skills of students. It has been generally agreed upon by psychologists that metacognition is the act of a person monitoring and controlling his/her own thinking. "Computers can make the abstract concrete and personal as they help children learn more effectively by making their thinking process conscious" (Clements and Gullo, 1984). Making the thinking process conscious is metacognition. The thinking skill of metacognition has proven to be the most difficult skill to validate.

A 1984 study "investigated the effects of experiences in computer programming (LOGO), compared to experiences in computer-assisted instruction (CAI), on 6-year old children's metacognitive abilities" (Clements and Gullo, 1984). Eighteen first grade students from a middle class midwestern school system were assigned to one of two treatment groups. One group was treated with CAI, while the other group had experiences with LOGO programming. The students were given a pretest to determine their preexisting level of metacognition. Each group did activities that lasted approximately 80 minutes per week over a 12 week period. After the 12 week treatment, posttest were administered to assess the children's metacognitive ability.

The study found that the LOGO group tended to be able to better describe the logic and thinking process involved in a given problem or situation. "The LOGO programming group significantly outperformed the CAI group on both metacognition tasks. The ability to monitor one's own thinking and realize when one does not understand may be positively affected by computer programming environments" (Clements and Gullo, 1984). LOGO is such an environment.

A strong claim has been made to assert that LOGO is effective at increasing the thinking skills of the user. The three previously mentioned studies have shown that LOGO is effective at increasing problem solving skills, cognition

abilities, as well as metacognition skills.

In the currently available literature, LOGO has been shown to be a legitimate instrument for teaching mechanical physics through the method of modeling. The literature has also shown that mechanics can be instructed through the use of program languages as the modeling environment. Lastly, the literature has stated that LOGO positively impact the thinking skills of its user.

CHAPTER III

PROCEDURE

Subjects

The subjects of this study consisted of 29 juniors and seniors who were taking their first year of physics. The group consisted of nine females and twenty males. There were three juniors and 26 seniors. Most of the research subjects had completed at least three years of honors level math and three years of science. This course was voluntary and not needed as a minimum college entrance requirement. Because of the math requirements and the subject matter, this course was considered one of the most difficult in the school. The voluntary nature and the difficulty of course suggests the subjects were exclusively college bound students that were highly motivated.

Setting

School. This study was conducted in a high school that contained grades nine through twelve. There was approximately 700 students attending this institution.

Community. A small town in Southwest Ohio was the location of this study. This community was oriented toward professional occupations and business. The majority of the citizens of this town had some type of post secondary degree.

Data Collection

The Construction of Mechanics Achievement Test. All of the subjects were given parallel forms of a pretest and posttest. These tests consisted of 25 multiple choice questions. Ten questions were asked about the laws and theories of mechanics. Ten questions covered applications and situations in which the laws and theories of mechanics had to have been applied. Five questions required the subjects to solve a given situation using the mathematical relationships observed in mechanics. A list of applicable equations was provided with each test. The student were not told which equation(s) went with which question. Test questions came from various sources such as standardized tests found in the literature, test questions provided by text books, and questions that have been used on author written tests over the past five years. Each question was critiqued by at least two physical science teachers. This helped create valid and reliable tests.

Administration of the Mechanics Achievement Test. The author administered the pretest on August 26, 1993, the second day of school. This was done before any instruction on mechanical physics had occurred. The subjects placed their answers on a scantron form. The pretest questions were typed and copied clearly. To insure this each copy was proof read by a science teacher and a nonscience teacher. The subjects of this study were not told the correct answers

to the pretest questions. This helped lessen the effect of the pretest as a learning experience. After approximately 14 weeks of LOGO aided instruction, a parallel posttest was administered in the same manner as the pretest. To help insure the honesty of the subjects, the posttest was counted as a small grade.

Design

The design for testing the hypothesis regarding the effectiveness of LOGO as a instructional aid for teaching mechanics in high school physics, was T_1 x T_2.

Treatment

The independent variable in this study consisted of the integration of LOGO programming into the current mechanics curriculum. Each subject was be given equal class time to work with LOGO. The frequency of the treatment averaged one or two days a week. The treatment consisted of projects that required the students to simulate various mechanical situations using the LOGO languages. These mechanical situations included vectors, constant velocity, constant acceleration, trajectory motion and projectile motion. These programs were collected and graded. The treatment was administered in a laboratory situation in which 12 to 14 computers were available. The students usually had to work in pairs. To help insure that each student was using LOGO,

the students were encouraged to change partners after every project. Computers were available during other times of the day as needed. This treatment was done over approximately 14 weeks.

CHAPTER IV

RESULTS

Presentation of Results

The mean score for the pretest was found to be 11.72. The standard deviation was also calculated for the pretest. It was found to be 3.89. The mean score for the posttest was found to be 20.41. 2.50 was the standard deviation found for the posttest.

The t-test calculation, for dependent samples, was conducted. This was done to determine if any change in the score from the pretests to postests were significant or cause by random error. The t value was found to be 11.01. A two tailed test with 28 degrees of freedom and a 0.01 significance level was used to find the critical value. Such a high significance level was chosen in hopes of decreasing the chance that a variable other than the independent variable had an effect on my dependent variable. The critical value was found to be 2.763 (Isaacs and Micheal, p. 220). The above information has been placed in table 1, located on the next page.

TABLE I

ANALYSIS OF STUDENTS ACHIEVEMENT
IN MECHANICS

TEST	N	M	S
PRETEST	29	11.72	3.89
POSTTEST	29	20.41	2.50

$t= 11.01$; $df= 28$; $p < 0.01$ is significant
$p > 0.01$ is not significant

Discussion of Results

In Terms of Experiences and Research. Finding a workable and adequate form of LOGO was the first difficulty that this researcher faced. An IBM version of LOGO was needed. This was due to the fact the IBM computers were the only type of computers available in adequate numbers. Terrapin LOGO for IBM was initially decided upon. This IBM version was supposed to be available in July, 1993. However, due to legal problems and program glitches the publishers of Terrapin LOGO could not release it in time for it to be used in this study. So, a simpler version of LOGO was used. This version was called LOGO writer.

One difficulty arose once the actual treatment, programming, started. LOGO writer was found to have a few

weaknesses. It was discovered that this program had very limited capabilities when values had to be entered into formulas. This made some of the programming long and tedious. In the sixth week of the treatment, a method for entering values into formulas was found. This made programming in LOGO much more flexible and powerful.

As the students were programming with LOGO, I was struck by the different strategies each pair developed. Each group seemed to take a different path of logic towards reaching the same goal. This was similar to what was observed in the study conducted by Oke and Jones (1984). To encourage this diversity in thinking, it was emphasized that a program was good if it worked. No working program was ever said to be wrong. Some programs were more efficient than others. The students took pride in constructing the smallest most efficient programs.

These were the experiences that were observed during the conduct of this study. Most of the classroom observations seemed to agree with the reviewed literature. Students seemed to use critical thinking skills more often. The most important concepts of each of the topics chosen seemed to be at the forefront of every student's mind. The experiences with LOGO agreed with the literature reviewed.

<u>In Terms of Statistics</u>. The standard deviation for the pretest (3.89) was high. This implied that the students came in with a varied degree of knowledge about mechanical

physics. The standard deviation for the posttest (2.50) showed that the students had a varied degree of knowledge at the end to the treatment. This degree of variation was somewhat lower at the end of the treatment.

All of the students exhibited an increase in scores from their pretest to posttest. The mean increase for this sample of students was 8.69. The t value (11.01) was compared to the critical value (2.763). Because the t value was larger that the critical value, it was concluded that the increase in test scores was significant and not due to random error. The significant increase suggests that the null hypothesis is rejected. Thus, this study supports the belief in the effectiveness of LOGO as an instructional aid in teaching mechanics.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The study was conducted to test claims made by scholars and researchers as to the value of LOGO in the learning of mechanics. The purpose of this study was to evaluate the effectiveness of LOGO as an instructional aid for the teaching of mechanics in high school physics. The hypothesis, set forth at the beginning of this study, stated that there would be no difference between the pretest and posttest mean mechanics achievement scores after the subjects were exposed to a number of mechanics related projects that require programming in LOGO. The subjects (29 high school physics students) were given a pretest at the beginning of the school year before any instruction had begun. Along with the normal instruction, the students were asked to do a number of projects that use the LOGO programming language. Upon completion of this treatment, 14 weeks later, the students were given a posttest of the same difficulty. The study showed a significant increase in mean test scores. This significant increase suggests that the student's understanding of the major mechanics concepts had increased.

Conclusion

This study suggests that LOGO was a contributing factor to the increase in student understanding of the concepts of mechanics. This is supported by both the observations of the researcher as well as the statistics. It cannot be stated, however, with any degree of certainty, that LOGO was the sole cause for this increase in student understanding. To clarify the effects of LOGO as an instructional aid, further studies into the effect of LOGO programming on the learning of mechanical physics needs to be done.

Recommendations

I feel that LOGO, used in conjunction with other teaching strategies, is a beneficial way to get the students to think critically. The language itself requires the students to fully understand the relationships and concepts that exist in the situations they are trying to simulate. This is very difficult to have happen in the physical limits and budget constraints of the modern classroom. The computer has the flexibility and power to overcome these constraints. Programming allows the students to experience true discovery and experimentation without the expense of highly specialized equipment. The LOGO computer language, specifically, offers an inexpensive and relatively simple method for simulating mechanical physics.

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