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AUTHOR Sobolewski, Stanley J.

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ABSTRACT

One of the difficulties encountered by novice problem solvers in introductory physics is in the area of problem solving. It has been shown in other studies that poor problem solvers are affected by the surface aspects of the problem in contrast with more efficient problem solvers who are capable of constructing a mental model of the physical situation before the mechanics to solve the problem are begun. It was hypothesized that a neophyte physics problem solver focuses on the technical terminology of physics rather than on the underlying process; the new vocabulary that is introduced confounds the process of problem solving. The treatment in the experimental study was a reading passage in potential and kinetic energy along with examples in solving energy problems. Two treatments are being developed which are identical except in the use of traditional or non-traditional terms. The non-traditional terms were invented, nonsense terms. A population of 31 high school students ages 15-18 were randomly assigned to two groups. It was found that there was no statistically significant difference between the means of the two groups. (Author)

The Effect of New Vocabulary on Problem Solving in Novice Physics Students

Stanley J. Sobolewski

Center for Learning and Technology
217 Baldy Hall
State University of New York at Buffalo
Buffalo, New York 14260

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Abstract

One of the difficulties encountered by novice problem solvers in introductory physics is in the area of problem solving. It has been shown in other studies that poor problem solvers are effected by the suiface aspects of the problem in contrast with more efficient problem solvers who are capable of constructing a mental model of the physical situation before the mechanics to solve the problem are begun. It was hypothesized that a neophyte physics problem solver focuses on the technical terminology of physics rather than on the underlining process; the new vocabulary that is introduced confounds the process of problem solving. The treatment in the experimental study was a reading passage in potential and kinetic energy along with examples in solving energy problems. Two treatments are being developed which are identical except in the use of traditional or non-traditional terms. The non-traditional terms were invented, nonsense terms. A population of 31 high school students ages 15 to 18 were be randomly assigned to two groups. It was found that there was no statistically significant difference between the means of the two groups.

Background

Students in the introductory high school and college physics course traditionally have a difficult time solving problems; the difficulty stems from the need to isolate several dynamic variables and understand the inter relationships. Over the course of time the expert problem solver has developed steps in his problem solving strategy. When the unsuccessful novice physics student attempts to model the expert, the result is usually confusion; the student will say the correct words but use them in an inappropriate manner. What results is not an understanding of problem solving but a series of remembered terms. The question being proposed deals with the use of the technical terms of physics. Is there an interfering effect between the learning of the new terms and the physics concepts? The problem then is part science instruction and part semantics and language usage. The science student is learning both the subject matter and new terms.

A second question that we may be asked is: how do the students distinguish between the concept and the semantics? The point of science education is to make the learning of science more efficient and lucid. Gamble (1986) states that science education is at a dangerous stage when both the teacher and the student know the meaning of a word and each assumes that both share the same meaning. It is the proposition here that the terminology is unimportant, that what Jacobson (1984) calls "absolute synonymy" applies to physics instruction and that the students who are not required to learn new terms as well as new concepts will score higher on achievement tests. The use of technical terminology in a scientific discipline is mearly nomenclature and therefore is not part of language. The technical terminology is based in extralinguistic reality, that is the nature of the object in discipline of question (Coseriu 1974). It is appropriate therefor to distinguish between the subject matter and the terminology. The terms used in the discipline are separate entities from the concepts themselves.

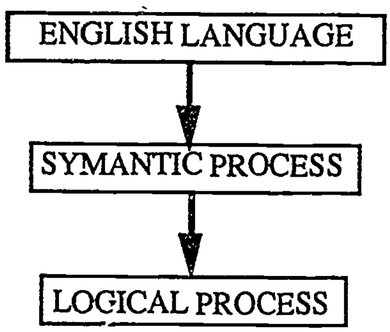
The number of studies which deal with the use of language in physics instruction are few. Kwok (1982) compared the physics achievement of tenth grade Chinese speaking students who received physics instruction in Chinese with similar students receiving physics instruction in English. Kwok states that previous research in the use of a second language as the medium of science instruction to be detrimental to the science learning. He predicts that the Anglo-Chinese students will measure lower on the achievement scale than the receivers of instruction in Chinese. The results of the study show there to be no statistically significant difference between the two instruction groups. (

Student who are provided a non-verbal introduction to physics will have higher mean scores on problem solving task than those who are not. Mass and Finegold (1985) have found that one of the differences between good and poor physics problem solvers is that good problem solvers have the ability to translate problems and statements more correctly than poorer problem solvers. The poorer students lack the ability to make subtle differentiations in the meanings of words. They discovered that even when information is presented pictorially in the form of graphs or charts, the use of language in the representation causes difficulty with the poorer problem solvers.

In a similar study, Larkin and Reif (1981) found that there are two models of problem solving, one that is characteristic of the expert and one characteristic of the novice physics problem solver. The novice problem-solver initiate problem solving by generating a mathematical model of the given situation. Relevant principles are identified and applied to the problem. The mathematical equations are then manipulated to arrive at the solution. This method of problem solving is contrasted with the expert who has a general approach; the expert constructs a low detail description of the problem which he uses to select a method of approach in arriving at the solution. The difference between these approaches is in the formation stage; where the problem solver is initially moving from the problem on the paper to the image of the model in his head. The novice moves directly from the stated problem to the mathematical representation. In this process the use of the technical terms which have no bearing on the concept underlying the problem may befuddle the poorer problem solver. The expert on the other hand moves from the problem to an intermediate step of constructing an overview of the problem. A number of studies have established that students who enter a physics course arrive with definite concepts about the way in which physics works. A corollary thesis is concerned with the use of inappropriate terminology when solving problems. It is proposed that students who are learning a rote method of problem solving will interpret their problem solving strategies as being valid when they are able to mimic a sequence of phrases or reproduce a series of equations on paper and pencil test. In the traditional class room these are the operational definitions of problem solving.

Pallrand and Seeber (1984) found that physics achievement was directly related to entering spatial visual abilities and that student spatial visual abilities increased as a result of taking a physics course. Research in the field of problem solving is relevant to physics instruction. A part of the introductory course in physics is in the instruction of a type of problem solving. Studies have been done on determining factors which differentiate the poor and and good problem solvers. De Jong and Ferguson (1986) found that the poor problem solvers lack a cognitive structure for problem solving; the better problem solving students had a extensively developed schemata upon which a plan of problem solving may be built. The authors also noted an interesting point, that a set of problem solving rules which is good for the novice is not necessarily good for the expert. When learning a new discipline, it is often difficult to master both the concepts and the new vocabulary. In the authors personal experience as a physics instructor students have been observed who are placing terms together in a manner with out evidence of understanding. The student is confusing the content of the concepts with the terms that label the concepts. This could be from a lack of understanding the differences between the two or a genuine lack of understanding of the concept. The question at hand deals with language and concepts. Is it possible to teach a method of problem solving without the use of language? If problems were presented with familiar terminology, the effect of the new terms would be eliminated and the knowledge of the concepts themselves could be studied.

When people communicate they of necessity use language. The language can in some cases increases the depth in understanding. In other situations the language will produce confusion. The main function of language is for one individual to communicate ideas and feelings to another. In all scientific disciplines, a model is constructed to combine the research that has been done and to provide a guide for further research.This paper derives itself from an informational processing model; a model which has grown out of the artificial intelligence area. The model that will be adopted here is adapted from Wilks which represents the input process students must perform when solving a problem in written form. Most research in the area of problem solving deals with the logical representation and abstractions; more specifically, the way in which the student processes the logical abstractions. While this is an important part of the process, here the emphasis is on input process. The crutial link is that between the english language and the process of decoding the meaning from the language.



Population

Thirty one high school students from age 16 to 18 years in age, all of which are presently enrolled in a physics class. The group consisted of three physics section, and remedial section, an average ability section and an honors section. Students were randomly assigned to one of two groups at the time the test was administrated. The tests were stacked alternatively and the subjects took a question paper and reading passage

Research design

The null hypothesis is that the difference of the means between the two groups will not be statistically significantly different from each other. If the introduction of the novel terms produces a measurable effect on the problem solving, there will be a difference between the means of the two groups.

The subjects were given a two page reading passage on the subject of kinetic and potential energy. The passage was taken from two high school physics texts, Hulsizer and Lazarus, and Murphy and Smoot. The first passage consisted of a description of the concepts and gave anecdotal examples of each concept.The second example contained a example which modeled the calculation of potential energy, kinetic energy and speed. The measuring instrument was a 15 item multiple choice paper and pencil test. The relatively small number of items were dictated by the time allotted. The treatment group's reading passage and test was identical to that of the control group except for invented novel terms. The word substitution was as follows:

Potential - Hepumcile
Current - Pobbrik
Energy - Umedit
Kinetic -Tamarn
Work - lert
gravitational - arnitalerit
weight - jart
weighing - jarting
velocity - distrafity
Seconds - Certos
meters - namrens
Newtons - wurtnings
Joules - opplics

The invented terms were chosen to be meaningless to increse the power. When students learn a new discipline, the terminology may be foreign to them or the terms are used in a novel context . The closer a nonsense term is to a recognizable word the easier it is to remember. By replacing the terms specific to the subject matter with terms that are meaningless, the effect of the unfamiliarity of terms will be maximized.

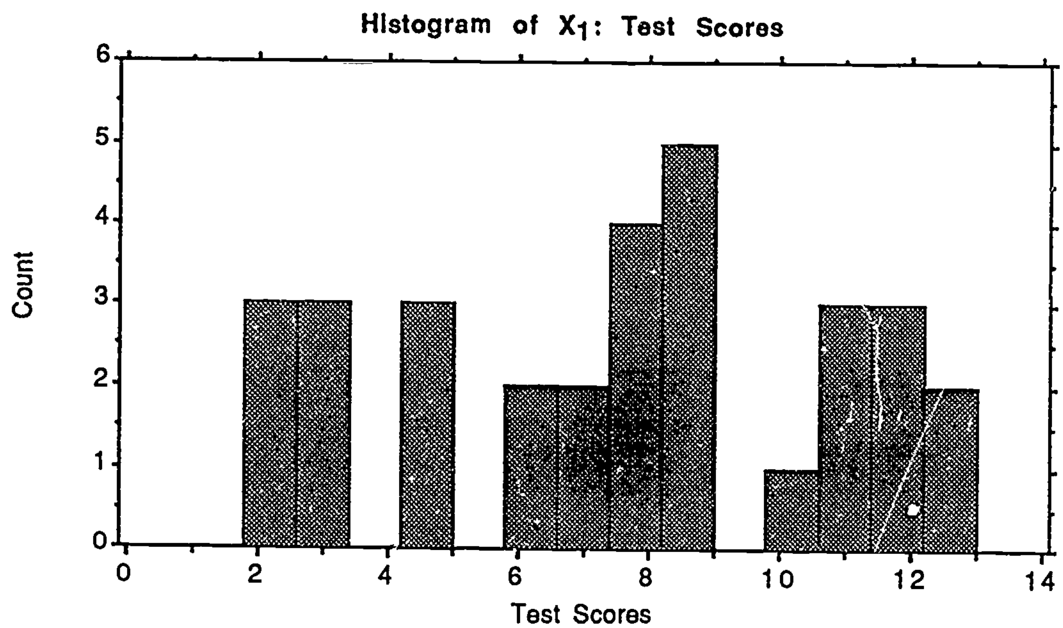
Power

When a student is first introduced to new subject matter, the terms used may be either recognizable or unfamiliar to the student. To maximize the unfamiliarity of the new terms, the subjects in this experiment were introduced to nonsense terms to maximize the effect size. From Kenny we can see that for a large effect size (Cohen's d) the power for this study using 31 subjects will be 0.60

Results

A two tailed, un-paired t test was performed on the two groups, at the 95% confidence level. The resulting P = 0.36 indicates that the difference between the means can be attributed to chance; the null hypothesis cannot be rejected. Terminology which is unfamilar to this group of students did not cause a significant difference in the test score.

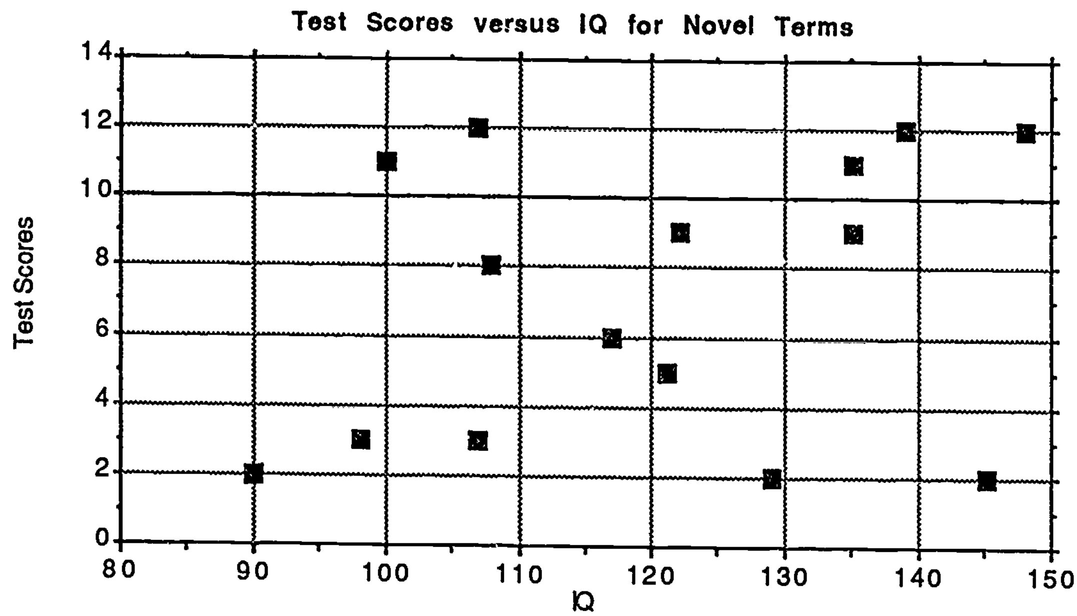
The students who actively realized that the terms were familiar physics terms and translated them as such..this cannot be done when students are truly learning a new discipline for they have no terms to build the concepts upon.

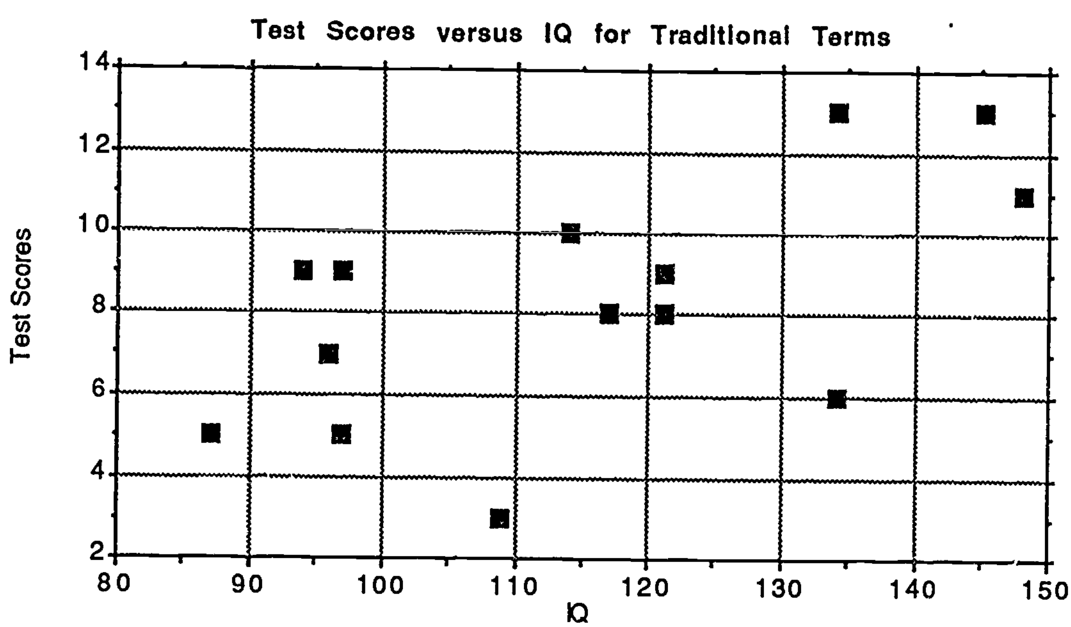


Unpaired t-Test X_1: Treatment Y_1: Test Scores

DF:	Unpaired t Value:	Prob. (2-tail):
29	-.927	.3617

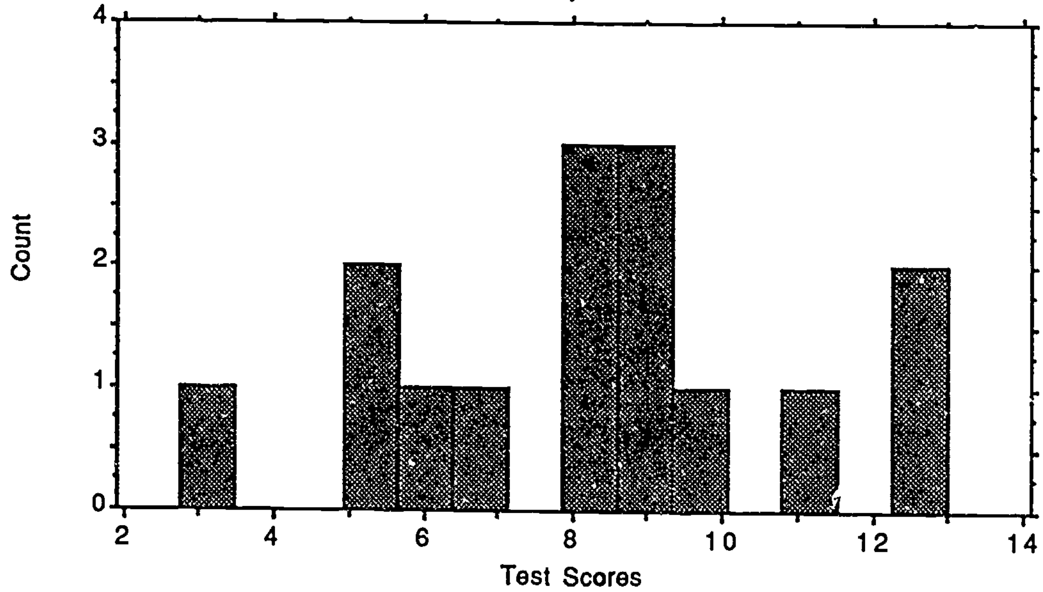
Group:	Count:	Mean:	Std. Dev.:	Std. Error:
Novel Terms	16	7.125	3.897	.974
Traditional Ter...	15	8.267	2.84	.733





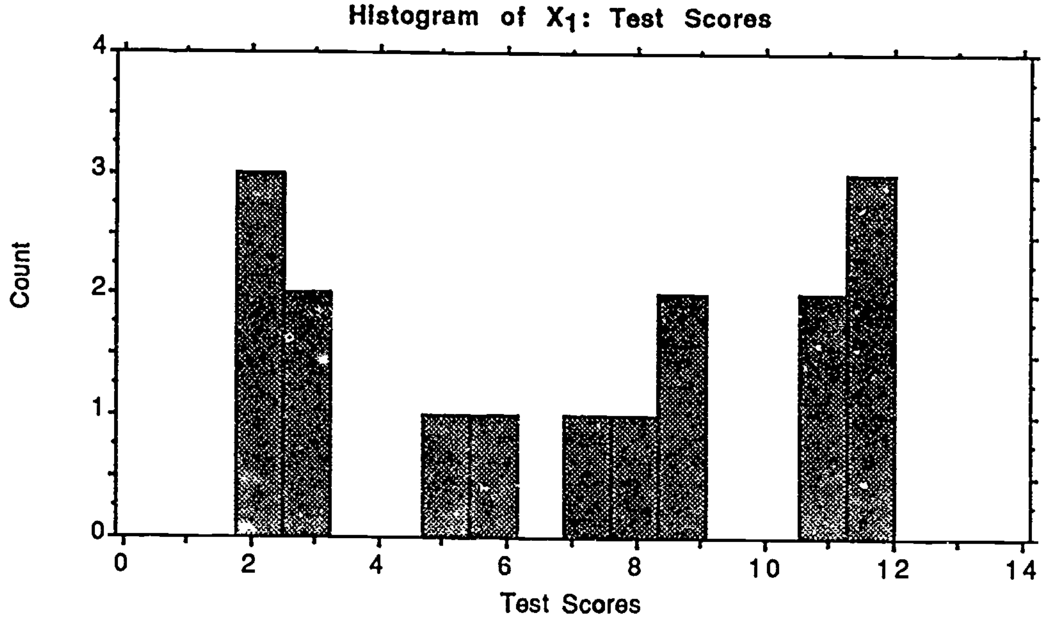
Traditional Terms

Histogram of X_1: Test Scores



Novel Terms

Histogram of X_1: Test Scores



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