https://doi.org/10.21061/jte.v4i1.a.2

A Comparison of Principles of Technology and High School Physics Student Achievement Using a Principles of Technology Achievement Test

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Society has traditionally taken the position that education is a primary means of achieving national goals. Unfortunately, we have never collectively agreed upon "what kind" of education is needed--general or vocational. The present K-12 public educational system in the United States is comprised of general and vocational education tracts.

Historically, one of the goals of vocational education has been to provide entry-level job skills. In contrast, general education, as the title implies, has attempted to equip students for living or for further education. In preparing students to enter the workforce, vocational education can provide an opportunity to obtain hands-on experiences with many of the theoretical concepts presented within the general education classes. Many secondary education students, however, never take vocational courses because they do not view them as relevant to college preparation (Meier, 1991). Conversely, many vocational education students are not taught the theoretical mathematics and science concepts that are needed to cope with a rapidly changing society.

Vocational education has been considered a separate discipline within the broad context of education and has been in continuous competition with general education for students and resources. Vocational education has been concerned with providing people with gainful employment after graduation. A "Blue Collar" affiliation is considered undesirable by those students wanting to attend college or obtain further education. The unfortunate outcome is that the average high school graduate is "nonfunctional" in our modern society (Cummins, 1989).

If education is designed to help the individual attain self- fulfillment in a technologically complex, work-oriented society, then education must be a synthesis of both general and vocational education. Anything less jeopardizes the individual's opportunity for self-fulfillment.

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A knowledge of how to integrate mathematics and science into technology is a necessity in today's society and those individuals who cannot function at that level will effectively be disenfranchised from participating fully in our national life. In fact, those citizens not educated in science will be unable to make informed decisions regarding such issues as nuclear energy, radiation, and pollution (The National Commission on Excellence in Education, 1983).

Many Iowa high school vocational education programs provide minimal exposure to anything beyond basic principles of mathematics and science. Consequently, students choosing the vocational rather than general education track run the risk of not obtaining an adequate mathematics and science background. They will be incapable of comprehending the technologically complex society of the 1990s and beyond. This common occurrence might be avoided by establishing a stronger relationship between general and vocational education programs at the high school level.

Newly approved federal legislation has been designed to improve existing vocational programs by strengthening the linkage with general education in the areas of mathematics and science. The Carl D. Perkins Acts of 1984 provided considerable emphasis on the importance of mathematics and science principles within vocational education programs, and was seen as a positive step toward better academic relationships between vocational and general education programs. The newly approved Carl D. Perkins Vocational and Applied Technology Education Act of 1990 became law on September 25, 1990. In signing this law, President George Bush authorized $1.6 billion in federal funds to improve:

> ...educational programs leading to academic and occupational skills competencies needed to work in a technologically advanced society (Section 2).

The Perkins Act of 1990 holds considerable opportunity for both vocational and general education in building and reinforcing what Erekson and Herschbach (1991) refer to as "strategic partnerships." These collaborative efforts can be instrumental in providing educational programs which integrate vocational and general education concepts, making them relevant in today's technological society.

One promising development designed to infuse general education mathematics and science concepts into the high school vocational education curriculum is entitled Principles of Technology (PT). This program was developed by the Center for Occupational Research and Development (CORD) in Waco, Texas in the mid 1980s to supplement vocational offerings in secondary programs.

Principles of Technology--Purposes and Description

The PT program is a two-year, high school course in applied physics, made up of fourteen units, each investigating an important principle. The content for each module is specified in Figure 1. Each of the individual four-

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teen concept modules is studied within the context of electrical, mechanical, fluid and thermal energy systems.

FIRST YEAR CONCEPTS	Force Work Rate Resistance Energy Power Force Transformation
SECOND YEAR CONCEPTS	Momentum Waves and vibration Energy conversions Transducers Radiation Optical systems Time constraints

Figure 1. Principles of Technology Concepts

The physics concepts are taught within a laboratory setting, which allows students to obtain both theory and hands-on application of each principle. The students enrolled in the PT program are from the vocational education track and not typically enrolled in physics courses. For the most part, PT courses in Iowa are taught by industrial technology teachers. In Iowa, industrial technology education is included under the vocational umbrella. The primary benefit of the PT curriculum is the emphasis on application skills using mathematics and science concepts.

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Purpose of the Study

Since the State of Iowa had invested heavily in the Principles of Technology program through vocational education, it was important to complete a summative evaluation of this program. The amount of achievement gained by students based on exposure to the first year Principles of Technology program was of interest to the State of Iowa and program developers. Since the program was designed to cover basic physics concepts, it was also important to compare the gain with any gain that was due to exposure to a basic high school physics class. Accordingly, the purpose of this study was to compare student achievement regarding certain basic physics concepts between students who had completed first year Principles of Technology and students who had completed high school Physics.

Method of Study

The methodology employed in this study included population and sampling procedures, instrument development procedures, data collection, and data analysis. A pre-test post-test control design was utilized with two treatment groups. The following figure depicts this design.

Principles of Technology	T1	X1	T2
Physics	T1	X2	T2
Control	T1		T2

T1 = Pre-
T2 = Post-
X1 = PT Treatment
X2 = Physics Treatment

Figure 2. Research Design Model

Population and Sample

The population for this study was all secondary vocational programs in Iowa where Principles of Technology was offered. With more than 50 sites of implementation, Iowa was a good location for the study. The sites were at various stages of implementation. Sixteen sites had offered the program for two years or more. In order to obtain a better estimate of the effectiveness of the program, only sites that had offered the program for at least two years were utilized. Therefore, the sample included these 16 Iowa sites.

Of these sites, 14 programs were being taught by industrial technology education teachers who had participated in one two-week workshop to prepare for teaching the Principles of Technology. The remaining two sites were taught by certified Iowa high school physics teachers. During the data collection for the first year programs, one program taught by an industrial technology edu-

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cation teacher failed to complete the study. Therefore, the sample for this study consisted of 15 Iowa high schools where Principles of Technology and physics were taught as a part of the regular curriculum.

Instrument Development

The procedure involved the generation of a test item bank covering all objectives for the first seven units or the first year of Principles of Technology. Conversations with many people involved with the course suggested that during the first year only six units could be covered rather than seven. Therefore, the questions on the instrument were limited to only those first six units. The item bank was generated by participants and project staff at Iowa State University during the summer Principles of Technology workshops. Multiple items for each objective were generated. These items were then examined by the project staff and modified to improve clarity and assure good testing procedure. Five secondary physics teachers and one community college physics instructor were hired to revise items as necessary to standardize terminology that may differ in Principles of Technology materials and Iowa high school physics materials. It was determined that a number of terms differed and where differences existed, both the Principles of Technology term and the term found in typical physics textbooks or materials were used.

These items were then formed into 40 question unit tests and administered at the 15 sites. An analysis of the six unit test yielded degree of difficulty scores for each item and the degree to which each item correlated with the total unit score. This information was utilized in the selection of items to be included in the overall first year Principles of Technology instrument. This instrument consisted of 120 questions and covered each of the six units.

Data Collection

The data collection phase involved two steps. The first step was the administration of the pre-test, a form of the 120 question instrument developed in the previous phase. The second step was the administration of a post-test at the end of the academic year at each of the 15 sites.

The two treatment groups included students enrolled in a Principles of Technology first year class and students enrolled in a high school physics class at each of the 15 sites. The control group consisted of students who were enrolled in neither the Principles of Technology nor physics, but had a similar male-female ratio and similar achievement on the Iowa Test of Educational Development (I.T.E.D.) as the students enrolled in the Principles of Technology class.

The pre-test data were collected during the first two weeks of September. The post-test data were collected during the first two weeks of May. The relatively early post-test data collection was necessary since many seniors complete their coursework during this time.

Data Analysis

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The data analysis procedures included both an item analysis of the pre-test and post-test results along with a one-way analysis of variance of the treatments and control groups. The results of these analyses are reported in the next section.

Results

The focus of this section is on the achievement measures for both the pre-tests and post-tests for all three groups. Pre-test and post-test scores are listed for all groups in Tables 1 and 2.

Table 1
Differences Between Pre- and Post-test Scores For Treatment and Control Groups

	Pretest		Post-test		*t*
	Mean (SD)	*n*	Mean (SD)	*n*	
PT	47.80 (11.30)	257	80.14 (17.16)	139	20.0*
Physics	55.07 (12.07)	275	65.77 (16.33)	136	9.3*
Control	37.78 (8.62)	135	36.45 (10.94)	83	0.942

*p<.01

The higher mean pre-test by the physics students suggests that science achievement may be initially higher in this group.

The number of subjects taking the post-test was reduced significantly when compared to the pre-test numbers. Follow-up calls to the sites indicated that many seniors were not available during post-test administration. It was discovered that many Iowa schools release their seniors up to three weeks prior to the end of the semester. Normal class attrition was also a factor.

The Principles of Technology students scored significantly higher than the other two groups on the first year post-test. Although the physics group displayed a gain, it was not nearly as great as the gain for the PT students. Pre-test, post-test, and levels of significance for each of the three groups are listed. A significant increase in student achievement was one outcome of exposure to the first six Principles of Technology units.

Implications

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Based on Principles of Technology pre- and post-test results, it appears that exposure to the first six units of the Principles of Technology results in significant student achievement gains regarding basic physics principles. It appears reasonable to conclude that the methodologies employed by this very structured program are appropriate for the content covered. If one assumes that the content is necessary and useful for the majority of the students, then most school districts should seriously consider the Principles of Technology as an offering for a wide range of students. This is consistent with the claim that PT was designed for students that fall between the 25th and 75th percentiles.

Although never intended to replace Physics, the Principles of Technology first year course does a significantly better job in increasing student achievement regarding basic physics concepts as defined by the Principles of Technology program. One must exercise caution in drawing inferences regarding the two programs since physics also is responsible for covering higher level concepts that are not considered basic and may be considered non-intuitive.

One may conclude that the Principles of Technology does an excellent job in addressing the objectives as listed at the beginning of each unit. The test questions used for the pre- and post-test were drawn from these objectives.

Several questions remain however:

1. How will students who have completed Principles of Technology perform on standardized physics achievement tests?
2. If Principles of Technology is taught entirely by certified physics teachers, will the student achievement scores increase or decrease?
3. Can the repetition of subsystems (mechanical, fluid, electrical, and thermal) be useful when organizing high school physics content?

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