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THE RELATIONSHIP BETWEEN FORMAL REASONING ABILITY, COMPUTER ASSISTED INSTRUCTION, AND CHEMISTRY ACHIEVEMENT

Hamide Ertepınar*

ABSTRACT:

Evidence from the research literature suggests that a variety of cognitive factors with the teaching style is responsible for achievement in science courses. This study investigated the role of a cognitive factor, namely formal reasoning ability, and two modes of the treatment (Computer Assisted Instruction (CAI) and worksheet) on achievement in chemistry. 119 tenth grade students from a high school participated in the study. The results indicated that formal reasoning ability and treatment were each statistically related to variation in chemistry achievement.

KEY WORDS:

Chemistry Achievement, Computer Assisted Instruction (CAI), Logical Thinking Ability

ÖZET:

Fen eğitiminde yapılan araştırmalar bilişsel faktörler ve öğretim tekniklerinin öğrenci başarısı üzerinde önemli katkıları olduğunu göstermiştir. Bu araştırmada mantıksal düşünme yeteneği ve iki farklı öğretim yönteminden oluşan öğretim uygulamasının (Bilgisayar Destekli Eğitim ve Çalışma Föyleri) Lise öğrencilerinin kimya başarılarına katkıları incelenmiştir. Uygulama toplam 119 öğrenci üzerinde yapılmıştır. Araştırma sonucunda iki değişik öğretim yönteminden oluşan uygulamanın ve mantıksal düşünme kabiliyetinin öğrencilerin kimya başarısına manidar bir katkıda bulundukları saptanmıştır.

ANAHTAR SÖZCÜKLER:

Kimya Başarısı, Bilgisayar Destekli Eğitim, Mantıksal Düşünme Kabiliyeti.

1. INTRODUCTION

A major focus of science instruction over the years has been the development of achievement in science courses. At various times during the history of science education, terms such as problem solving, scientific thinking, and formal reasoning abilities have been used to describe student reasoning abilities. These terms reflect a similar kind of thinking in science. This can be seen best when a student attempts to solve a scientific problem through the manipulation of variables or collection of data.

During the past decade, researchers in science education have brought to light the importance of the cognitive factors influencing achievement in science courses. One of them is the formal reasoning ability. Many of the concepts traditionally covered in high school chemistry are of highly abstract entities and require students to function at the level of formal operations to understand concepts and principles [1, 2]. Formal reasoning ability emanete from developmental psychology and include the abilities to identify and control variables and to use correlational, combinatorial, probabilistic, and proportional logic [3].

Positive relationships between cognitive factors such as formal reasoning ability and achievement in science courses have been described by a number of authors [4 - 9]. Most of the researchers indicate that an individual's structural organization of concepts depend upon the types of the formal operations [10, 11]. If the purpose of the instructional strategy is to provide practice in the use of certain formal operations, then students can solve the problems in which such operations are used. For this reason, one of the most important variables that affects achievement in science courses is the type of teaching strategy. As a result of technological development, microcomputers have become important tools in science education. Several capabilities of computers such as providing individualized instruction, teaching and problem solving, and immediate feedback make computers as the instructional devices for developing learning outcomes.

Some researchers have reported that Computer Assisted Instruction (CAI) produced significantly greater achievement in science courses than the other approaches [12 - 14]. Today, there is a great deal of room for cognitive ability and CAI in science education.

2. PURPOSE

The purpose of this study was to examine the relative influence and contribution of treatment and formal reasoning ability as a cognitive variable on achievement in chemistry. The specific question was:

* Prof. Dr. Hamide Ertepınar, Middle East Technical University, Faculty of Education, Department of Sicence Education, Ankara.

Do formal reasoning ability and instructional method account for a significant portion of variance in chemistry achievement?

3. METHOD

3.1. Sample

The sample consisted of 119 tenth grade students enrolled in four chemistry classes of two teachers in a high school. Two modes of the treatment were used in this study (CAI and worksheet). Each teacher had two classes. Each treatment was randomly assigned to one class of each teacher to minimize the teacher difference. Data were analyzed for 62 students participating in the CAI and 57 students participating in the worksheet study. CAI and worksheet study, both were the supplementary approaches to the regular classroom instruction.

3.2. Instruments

The Chemistry Achievement Test (CAT) was developed by the author for the dependent measure. 41 multiple- choice items were constructed from 55 items after item analysis. The test prepared from the same learning materials included in two modes of teaching approach (CAI and worksheet) and classroom instruction. The items in the test were related to mole concept and gases. A panel of a group of experts in chemistry and science education, and the classroom instructors evaluated the test items. The reliability of the test was found to be 0.86 for this study.

Students' levels of formal reasoning were assessed using the Logical Thinking Ability Test (LTAT). This test was originally developed by Tobin and Capie [15]. It was administered to all students at the begining of treatment for using a predictor variable in this study. The test consists of ten items that include identifiying and controling variables, correlational, combinatorial, probabilistic, and proportional logic. The reliability of the test was found to be 0.79.

3.3. Procedure

This study was conducted over a five week period. Two treatment groups were utilized. One group received the CAI as a supplement to the regular classroom instruction, and the other used the worksheet study as a supplement to the regular classroom session. The classroom instruction was taught by the classrooom teachers, but the CAI and worksheet study were taught by a person who had experience about computer usage and worksheet in science education.

The regular classroom sessions had two 45 minute periods per week. During the classroom instruction of all groups, the teacher used lecture and discussion methods to teach the chemistry subjects.

In the worksheet group section, some problems related to the mole concept and gases were asked on the worksheets. The instructor roamed the room, and was available to answer questions, make suggestions, and comments on student answers when requested to do so.

In the CAI sections, the same topics (mole concept and gases) were taught by the computer program. This was a tutorial software. The students were provided with text instruction, including graphic displays when necessary. This was followed by appropriate questions to check student comprehension. The program provided immediate feedback . After the correct answer, the program provided feedback verifying that the answer was correct, and sometimes allowed the students to see the solution of the problem if needed. After wrong answers, the program showed that the response was wrong, provided a hint, and permitted the learner to try again. The software also provided learner control. The students were allowed to start or re-examine any part of the program.

3.4. Design and Analysis

The experimental design and analysis for this study was represented by the regression model. This regression equation was:

$$Y^1 = B_0 + B_1 X_1 + B_2 X_2$$

Y^1 = predicted chemistry achievement test scores

X_1 = formal reasoning raw scores

X_2 = dummy variables to identify the CAI and worksheet treatment

B_i's = regression coefficients

The multiple regression program from SPSS/PC [16] was used to analyze the data.

4. RESULTS

Table 1 represents the mean scores and standard deviations for the Chemistry Achievement Test scores for the two treatment groups. N represents number of the students, M represents mean score and SD represents standard deviation.

Table 1. The Means and Standard Deviations of the Dependent Measure (Chemistry Achievement)

Treatment	N	M	SD
CAI	62	27.13	6.87
Worksheet	57	22.79	8.08

Table 2 represents the summary table for the regression of chemistry achievement on formal reasoning and treatment.

Neverthless, the role of the treatment on achievement in chemistry was significant in this study. The positive correlation coefficient of the treatment and higher mean score of the CAI group showed that CAI had more positive effect on chemistry achievement. The attributes of the computer program such as immediate feedback, learner control or response checking may have developed achievement better. When compared with the worksheet treatment, the students solved more problems and reexamined each part of the lesson in the computer software. Feedback is a very important factor and affects the quality of instruction. The students using the computer were given immediate feedback on errors, but there was no immediate feedback in the worksheet study.

Table 2. *Summary Table of Regression Analysis of Achievement on Formal Reasoning Ability and Treatment*

Dependent Variable: Achievement	Predictor Variables	B	Sum of Squares	df	F
	Formal Reasoning Ability	3.00	4849.19	1	333.79*
	Treatment	4.15	511.36	1	35.19
	Error				
R2= 76.24			1685.26	116	

*p<0.05 ; *p<0.0001

The F value for the full regression model was significant (F=186.14, p<0.0001). The two predictor variables together accounted for 76.24% of the variance in chemistry achievement. Also, formal reasoning ability and treatment, each made a significant contribution to the variation in achievement (see Table 2).

5. DISCUSSION

The results showed that formal reasoning ability is a strong predictor for the achievement in chemistry. It means that this ability is an underlying intellectual factor associated with science concept achievement. Many chemistry problems in this study required application of chemical principles and application of functional relationships among concepts. These applications require the ability to apply the formal thinking operations such as identifying and controling variables, combinatorial, probabilistic or proportional reasonings. Herron [17] has suggested that chemistry courses are generally taught at a level of abstraction requiring formal thought, even thought the majority of students have not yet attained a formal operations level of cognitive development.

In summary, the cognitive reasoning ability and well prepared software are underlying factors that affect achievement in science courses.

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