FACTORS AFFECTING ACHIEVEMENT IN GENERAL CHEMISTRY COURSES AMONG SCIENCE MAJOR STUDENTS

FEN ÖĞRENCİLERİNİN GENEL KİMYA DERSLERİNDEKİ BAŞARILARINI ETKİLEYEN FAKTÖRLER

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ABSTRACT

The purpose of the present study is to evaluate how gender, number of siblings, family income, amount of time spent on homework, attitudes towards chemistry, learning styles, and the college admission test scores effect chemistry related achievement in a group of college students majoring in science. A total of 331 university students participated in the study. The data were collected by three questionnaires, a demographic questionnaire, the Chemistry Attitude Scale (CAS) and Kolb's Learning Style Inventory (LSI). The results indicated that among the selected variables, gender, amount of time spent on homework, attitudes and learning modes of the students were influential on achievement in two general chemistry courses.

Keywords: *Attitudes to chemistry, learning style, achievement in general chemistry*

ÖZET

Bu araştırmanın amacı, cinsiyet, kardeş sayısı, ailenin geliri, ev ödevine ayrılan zaman, kimyaya yönelik tutumlar, öğrenme stilleri, üniversite giriş puanları gibi değişkenlerin genel kimya derslerindeki başarıyı nasıl etkilediklerini incelemektir. Araştırmaya toplam 331 üniversite öğrencisi katılmıştır. Bilgiler üç ayrı anket kullanılarak toplanmıştır. Bunlar Öğrenci Anketi, Kimyaya Yönelik Tutum Ölçeği ve Kolb Öğrenme Stilleri envanteridir. Sonuçlar seçilen değişkenler arasından cinsiyet, ev ödevine ayrılan zaman, tutumlar ve öğrenme stillerinin genel kimya derslerindeki başarıyı etkilediğini göstermektedir.

Anahtar Kelimeler: *Kimyaya yönelik tutum, öğrenme stilleri, genel kimya derslerindeki başarı*

It has been the concern of many researchers to explain the factors affecting the achievement level of students in various subject areas. A special emphasis is given to science as a subject matter since low achievement levels are generally reported in this field by various projects across different countries (Martin et.al, 1997). Exploring the possible causes of low achievement became the concern of many research studies with the ultimate purpose of enhancing students' learning in this field. Among the countless variables studied, some cognitive factors as well as the affective variables were used to explain possible reasons for low achievement in science. Within this framework, some studies focused on specific subject matters such as chemistry. For instance, the impact of cognitive variables, mode of instructional techniques, and the materials used during the teaching and learning processes on the level of chemistry achievement were studied by various researchers. Among them, Johnstone (1983) and Pilot, Roossink and Kramer-Pals (1980) reported that students experience difficulty with short-term memory overload in dealing with chemistry topics and with solving mathematical chemistry problems. Bender and Milakofsky (1982) reported that performance in classification and proportional reasoning problem areas, as measured by an inventory of Piaget's Developmental Tasks test, correlated with course achievement in introductory chemistry classes. On the other hand, Gabel (1983) emphasised the importance of reducing the amount of teaching aids by condensing the material. Having too many teaching aids often resulted in a superficial treatment of topics, which could not promote student understanding in quantifying concepts. Crosby (1986) pointed out that a textbook with a great deal of abstract material would deter a large percentage of high school students from enrolling in chemistry and benefiting from an important discipline that could help them to understand more about the natural and man made environment. Chandran, Treagust, and Tobin (1987) reported that four cognitive factors namely, formal reasoning ability, prior knowledge, field dependence/ independence, and memory capacity were all influential in chemistry achievement. Friedel and Gabel (1990) indicated that students' spatial visualisation skills and proportional reasoning ability were all important factors in determining chemistry achievement.

In contrast, some other studies included demographic variables and affective factors in explaining the achievement levels of the students. However, these studies take

the concepts and principles of science as the dependent variable rather than chemistry topics only. For instance, Schibeci and Riley (1986) and Schibeci (1989) investigated the influence of a set of students' background characteristics and perceptions on their science attitudes and achievements. Among the several variables, home environment was shown to have a substantial influence in explaining science achievement. On the other hand, Schibeci (1989) emphasised the importance of the school-specific influence of background variables on student learning in science, variables that may differ from one school environment to another.

Among the variables considered, special emphasis was given to attitudinal measurement and the impact of attitudes on student achievement in various disciplines of science. For instance, the interrelationship between achievement in science and mathematics and attitudes toward those subjects, and the impacts of certain programs on students' attitudes in science were extensively studied by various researchers (Rothman, Wolberg, Welch, 1968; Osborne, 1976; Weaver, Honushell, Colbe, 1979; Piper, Hough, 1979; Cavin, Cavin, Jogowski, 1981; Hassan, Shringley, 1984). In general, these studies indicate that attitudinal changes are related to achievement in science.

With increasing understanding of human learning, learning styles have drawn special attention as one of the important variables worth investigating at different educational tracks. The term learning style refers to the motivation students choose, attend to, and perform well in a course of training exercise (Canfield, 1988). Kolb (1981, 1984) explains it as a style which is a fairly stable, consistent way of learning across a variety of activities, experiences, and environmental demands. No matter how it is defined, many studies about learning style support the common agreement among researchers about the existence of this construct. Studies on learning styles basically focus on determining the type of learning styles of various group of students. For instance, Matthews (1994) studied the learning style characteristics of students in various colleges and universities. It is reported that students majoring in mathematics and science fell into the applied categories more often than those students majoring in humanities, social sciences and education who fell mainly into conceptual categories with respect to the Canfield learning style model. Matthews and Jones (1994) also investigated the learning styles of prospective teachers. The education students selected conceptual styles of learning as their predominant styles. They also investigated the differences between black and white students' learning style characteristics. The study also reported that within the majors there are sex and race differences. The studies are basically descriptive in terms of determining the type of learning styles of students in various disciplines. On the other hand, the relationship between learning styles and academic success is quite important for understanding the impact of this trait on learning and curriculum development activities.

Even though the research studies summarised above basically indicated that affective characteristics as well as cognitive variables are important determiners of the success in science, the impact of affective variables on student achievement has not been clearly explored, especially in specific branches of science such as chemistry. Studies are thus needed in different cultural settings and school environments, to investigate the impacts of different backgrounds and affective variables on students' achievement in chemistry. In the present study, within the framework of linear structural modelling, the achievements of students in two consecutive chemistry courses were evaluated in order to answer the question of how attitudes and some other student-related variables such as gender, number of siblings, family income, amount of time spent on homework, learning styles, and the college entrance admission test scores effect chemistry-related achievement, of college students majoring in science. The variables, which are presumably influential on achievement, were chosen in such a way as to represent the socioeconomic status, such as family income and number of siblings, the study habits such as amount of time spent on home work, and the learning styles of the students; also some background cognitive characteristics such as college entrance examination scores. It is expected that the findings of this study will have a significant impact on curriculum design in general chemistry courses at university level and shed some light on the factors affecting general chemistry achievement among college students.

METHOD

Subjects

In the study, 331 college students filled out three questionnaires in the Middle East Technical University (METU) during the Fall semester, 1995. They were all enrolled in general chemistry classes. Science major students from the Faculty of education and Faculty of Arts and Sciences participated in the study. Even though they have different curricula and are in different programs, all of the students who participated to the study took two general chemistry courses which were compulsory for all science majors in METU.

General Chemistry Courses

The first course, General Chemistry I, focuses on Atomic Structures, Chemical Bonding, Molecular Ge-

ometry, Chemical Equations and Quantitative Equations. The second course, General Chemistry II is related to Gasses, Liquids and Solids, and Solutions and Electrochemistry. The content of the first course is more abstract and theoretical in terms of the nature and structure of the concepts and principles taught. General Chemistry II is more experimental and the concepts and principles taught are more concrete when compared to the first course. Even though different instructors teach these courses, the textbooks, hand-out materials, syllabus used and all the laboratory activities and examinations are the same for all sections. A general chemistry examination prepared by a group of instructors teaching in the parallel sessions is administered to all the sections at the same time. The basic mode of instruction in both courses is lecturing. Besides the lectures, students are supposed to attend laboratory sessions for a set of experiments. In the laboratory, all students from different sections use the same syllabus and instructions and are guided by laboratory assistants.

Questionnaire

Three questionnaires were used in the study. In the first questionnaire, students answered questions about their gender, family income, number of siblings, and time spent on homework. The scores of college admission tests were also collected here. The second questionnaire consisted of a 24 likert type item Chemistry Attitude Scale (Berberoğlu, 1990). This scale was designed in such a way as to include attitudinal statements sampling out various aspects of the chemistry-related opinions and feelings of the university students. The Learning Style Inventory (LSI) developed by Kolb (1985) was used as the third questionnaire. The first two questionnaires were administered in Turkish, but the Learning Style Inventory was administered in English, because translating the scale from English into Turkish might have jeopardised the validity of the original version. Thus, the researchers preferred to use the original English version of the scale rather than translating it into the Turkish language, since the students at METU can be regarded as bilinguals. It is assumed that administering the LSI scale in English has no, or only a negligible, effect on the validity of the data collected.

The Learning Style Inventory (LSI) evaluates how one learns and deals with ideas and day-to-day situations (LSI Manual, p.2). Kolb's Experiential Learning Theory provides for the hypothesis that the successful learner integrates and utilises different modes of learning (Kolb, Rubin and McIntyre, 1991). These are Concrete Experience (CE), Reflective Observation (RO), Abstract Conceptualisation (AC), and Active Experimentation (AE). The effective learner participates in new experiences (CE) and then reflects upon these experiences (RO) in order to develop theories (AC). The learner then uses these theories to make decisions or solve problems (AE) (Veres, Sims, & Locklear, 1991). In the learning situation an average learner adopts a particular set of learning abilities, and when confronted with a learning task the learner faces a conflict between concrete experiencing of events versus abstract conceptualisation, and active experimentation versus reflective observation (Kolb, 1981, p.290). In the present study, it is anticipated that concrete experiencing versus abstract conceptualisation and active experimentation versus reflective observation influence chemistry-related achievement in general chemistry courses.

Statistical Analysis

The principle component analysis was used in order to understand in which way students perceive and experience the chemistry related attitudes as sampled out by the items of the attitude scale. In understanding the effect of each selected variable on the achievement in general chemistry courses, the Linear Structural Modelling (LISREL) procedure was used in testing the causal model among the directly observed variables (Jöreskog & Sörbom, 1984). Within the framework of LISREL, the bivariate regression procedure was used in order to assess the direct causal contribution of each observed variable to another variable in a non-experimental condition. The casual relations between the set of exogenous and endogenous variables were tested by t-test in order to retain the significant relations among the variables in the proposed model.

The exogenous and endogenous variables used in the bivariate regression model are listed and explained below:

Exogenous variables: Gender, number of siblings in the family, family income, amount of time spent on homework, first and second stage college admission test scores and Learning Style Inventory scores were used as independent exogenous variables besides the subdimensions of the Chemistry Attitude Scale as derived through the principle component analysis in the research sample. As explained in the result section, four subscale scores were derived in the Chemistry Attitude Scale, being enjoyment, negative feelings and anxiety in chemistry, perception of success in chemistry, and laboratory work in chemistry.

The college admission test scores are also taken as two important predictor variables in the bivariate regression model.

Another exogenous variable used is that of the scores obtained on Kolb's Learning Style Inventory. Kolb's Learning Style Inventory (LSI) gives four different subscale scores for the four stages of learning modes as ex-

plained previously. However, in the path analytic model, two subscale scores which were derived from these four scores were used. The difference between AC and CE indicates the learning style, which changes between concrete and abstract modes. It shows whether one learns through concrete direct experiences or more abstract logical understandings of problems rather than relying on feelings. On the other hand, the difference between AE and RO reflects whether one learns more with active participation and practical approaches or with patience, objectivity, and judgment without taking any action. The way an individual resolves the conflict in between these extremities determines his or her learning style. In the bivariate regression analysis used in the present study, however, the differences between the scores mentioned above are used as predictor variables. In the data analysis, the AC-CE difference is called the Concrete-Abstract Learning mode, and the AE-RO difference is called the Active-Reflective Learning mode. As the AC-CE score increases, students prefer more abstract experiences, rather than concrete. On the other hand, as AE-RD score increases students prefer more active participation in the learning experiences.

Endogenous variables: The grades of the students in General Chemistry I and General Chemistry II courses were used as endogenous variables in the bivariate regression analysis. As explained before, these grades are the students' GPA scores obtained in these two chemistry courses. The tests used in the general chemistry classes are general tests and administered throughout the different sections.

The bivariate regression model as tested by LISREL is a just identified model which computes the impact of each exogenous variable on the endogenous variables.

RESULTS

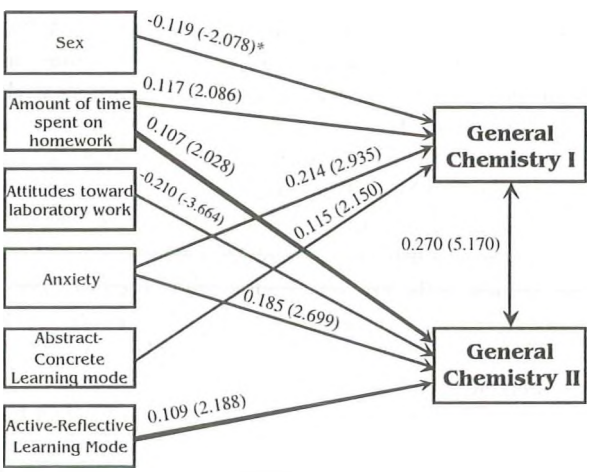
Dimensions of the CAS

In the first step of the analyses, the Chemistry Attitude Scale (CAS) was analysed in terms of dimensionality of the items by the Principle Component Analysis. Items in the Chemistry Attitude Scale were designed in such a way as to measure attitudes towards chemistry in different dimensions. The Principal Component (PC) method with Varimax rotation clearly indicates the four dimensions of the CAS in the research sample. The four factors explain 55 percent of the total variation. The eigenvalues of the three orthogonal dimensions are 16.57, 2.22, 1.96 and 1.33 respectively. The factor loadings obtained in PC analysis with the Varimax orthogonal rotated solutions are presented in Table 1 with the English version of the attitudinal statements. The students in the sample perceive the chemistry attitudes in four orthogonal dimensions. When closely investigated, the four orthogonal dimensions are items clustered in such a way that the first dimension is enjoyment, the second dimension is anxiety, the third dimension is academic self-concept in chemistry, and finally the fourth dimension is laboratory work. As may be seen in Table 1, the second dimension, which is identified as anxiety, includes items that are generally contraindicative and those items are also loaded on the first and third dimensions in some of the cases. The Cronbach alpha reliability of the Chemistry Attitude Scale was found to be 0.92 in 24 items. The reliabilities of the subscales were 0.93 for the enjoyment subscale, 0.75 for the anxiety subscale, 0.68 for the academic self-concept subscale, and 0.82 for the laboratory work subscale. The dimensions derived were scored separately and treated as predictor variables in the bivariate regression analysis, besides the other predictor variables such as gender, number of siblings, family income, amount of time spent on homework, two subscale scores of LSI, and college admission test scores.

Bivariate Regression Model

When the LISREL model is used within the framework of bivariate regression analysis, some of the variables seem to be significant predictors of achievement in general chemistry classes as seen in Figure 1*. For instance gender, amount of time spent on homework, the

Figure 1** : The maximum likelihood estimates and t-values obtained in the bivariate repression.



* : The values in parantheses are the t-values
** : Only the significant coefficients are indicated

anxiety subscale, and AC-CE scores predict the grades in General Chemistry I. On the other hand, amount of time spent on homework, attitudes toward laboratory work, anxiety, and AE-RO scoresh predict the grades in General Chemistry II. It is also observed that grades in the two chemistry courses are significantly related to each other. The other relations tested by LISREL are not significant at 0.05 level of significance.

Table 1. Items from the Chemistry Attitude Scale and Their Respective Factor Loadings

	Factor 1	Factor 2	Factor 3	Factor 4
I like chemistry very much.	**.82**	.23	.17	.07
If I were asked to teach one high school science course, I would chose chemistry.	**.81**	.15	.14	.11
Chemistry is a profession I would choose to work in.	**.76**	.16	.14	.11
I enjoy reading chemistry books.	**.77**	.16	.04	.07
Chemistry is more interesting than other branches of science.	**.74**	.13	.05	.06
I am happier in my chemistry courses than I am in other courses.	**.73**	.02	.16	.11
I would like to learn more about chemistry.	**.72**	.06	.21	.21
I enjoy working on chemistry problems.	**.72**	.27	.17	.11
A career in chemistry would be enjoyable.	**.72**	.16	.25	.22
My mind tends to wander in chemistry class.	.03	**.67**	-.06	.02
I am more scared of chemistry courses than other courses.	.11	**.58**	.36	.09
"Chemistry" is a word that bothers me.	.35	**.54**	.26	.13
I do not regret spending time in chemistry.	.42	**.50**	-.08	.06
I feel depressed when I work in chemistry.	.40	**.48**	.44	.16
I feel anxious when attending chemistry classes.	.20	**.47**	.37	.21
I am afraid of chemistry courses.	.19	.20	**.76**	.02
I have doubts about being successful in the chemistry field	.11	.03	**.69**	.02
Chemistry is a difficult subject for me to learn.	.12	.33	**.63**	.00
I do not understand why people are afraid of chemistry.	.42	.14	**.48**	.07
I do not believe that content of chemistry courses is applicable to daily life	.17	-.06	**.32**	.20
I enjoy starting a new experiment in the chemistry laboratory.	.25	.11	.04	**.82**
Laboratory work is the most boring part of learning chemistry.	.03	.10	.09	**.78**
I enjoy doing experiments in chemistry classes.	.31	.02	.10	**.77**
I prefer doing other things than working in the chemistry laboratory.	.28	.37	.06	**.61**

DISCUSSION

The items clustered as a result of principle component analysis in the Chemistry Attitude Scale indicate that science major students perceive chemistry related attitudes and opinions in four orthogonal dimensions such as enjoyment, anxiety, academic self-concept, and laboratory work. Among the four dimensions extracted, some of the items loaded in the anxiety subdimension are also loaded in other dimensions. For instance 'I do not regret spending time in chemistry' and 'Chemistry is a word that bothers me' are also loaded on the enjoyment dimension. On the other hand, 'I feel depressed when I work in chemistry' is loaded on both enjoyment and academic self-concept subdimensions. Two other items such as 'I am more scared of chemistry courses than other courses' and 'I feel anxious when attending chemistry classes' are loaded on the academic self-concept subdimension. Similarly, an item in the academic self-concept subdimension, 'I do not understand why people are afraid of chemistry' is loaded on the enjoyment subdimension. When the contents of these items are closely evaluated, it could be seen that the ideas imposed in the statements are more or less related to the other extracted factors in the PC solution. Even though the items are clustered into different subdimensions, the anxiety dimension somehow reflects the opinions and feelings of students related to enjoyment and academic self-concept in chemistry. As was found in the bivariate regression analysis, this particular subdimension is the most important predictor variable of achievement in general chemistry courses. Considering overlapping item level factor loadings across the subdiminsions, it can somehow be claimed that besides the anxiety, enjoyment and academic self-concept are also influential on achievement in general chemistry courses.

Among the set of variables considered in the model, very few are influential in determining the general chemistry course grades of students. For instance, the gender effect was observed only in General Chemistry I. Males have slightly higher mean scores in General Chemistry I than females. As was stated before, this course includes concepts and principles, and is more abstract compared to General Chemistry II. In the sample, males are more abstract learners than females, and this is reflected in the gender effect. This finding was also verified by the significant effect found between abstract concrete learning mode scores and General Chemistry I grades. As students' learning modes become more abstract as measured by Kolb's LSI inventory, they become more successful in General Chemistry I. This clearly implies that the abstractness of the course content is reflected in the teaching learning process and students who are more concrete experiential oriented are not as successful as those who prefer more abstract learning experiences. On the other hand, active reflective learning mode scores predict the grades in General Chemistry II. These results are expected when the content of the chemistry classes is taken into consideration. For instance, as was explained before, General Chemistry II is rather more experiential in terms of content and laboratory work than General Chemistry I. Thus students who prefer more active learning modes are more successful in General Chemistry II. On the other hand, preference of the active mode has nothing to do with the success in General Chemistry I since here, as its content implies, students who prefer more abstract learning experiences are more successful. This clearly suggests the need for reorganising the chemistry course contents in line with the learning modes of the students as the findings of the study clearly support the relationship between the students' learning mode and their academic success in different chemistry courses.

As expected, the amount of time spent on homework predicts grades in both courses. In terms of CAS subscale scores, there are some contradictory results obtained in LISREL. Among the four subscale scores, only the anxiety dimension predicts the grades obtained in general chemistry courses. As the anxiety level of the students increase, their scores increase in both chemistry courses. The positive coefficient between this subdimension of CAS and general chemistry course grades implies that the students' anxiety level makes them study hard and spend more time in getting satisfactory grades in both chemistry courses. Even though these students are highly anxious towards chemistry subjects and topics, they get higher grades. However, as discussed before, the items of this particular subdimension are also loaded on enjoyment and academic sef-concept in chemistry. Considering this fact, it can be argued that students' attitudes towards chemistry are important variables in predicting success in general chemistry courses. In terms of the prediction of subscale scores, the negative coefficient observed between the laboratory work subscale and General Chemistry II course grades clearly indicates that this variable functions as a suppressor variable, since the ordinary correlation between this subscale and General Chemistry II classes is almost zero (Darlington, 1990). This variable is weighted negatively in the regression equation, which means that the anxiety subdimension is a better predictor of success in the chemistry classes than the laboratory work subdimension.

The socio economic measures, such as number of siblings and family income are not important significant predictors in this particular sample This might be the result of using university students as the subjects of the study, since they are relatively more independent of their

families in terms of economic status and living standards compared to students at earlier educational levels.

The surprising result was the insignificant association between the college admission test scores and the achievement in general chemistry courses. This result seems to invalidate the college admission tests scores in a predictive sense, but it can be explained when the content of the college admission tests and the content of the chemistry courses are taken into consideration. The content of the college admission tests is more heterogeneous, in terms of the abilities and achievement domain being assessed, than the tests used in the general chemistry courses, which are pure measure of achievement of chemistry concepts and principles in various content areas. Moreover, in terms of the cognitive skills measured, there might be differences between the course examinations and the college admission tests. Course examinations are apt to include questions which basically concern the level of knowledge and comprehension. College admission tests, on the other hand, include items in the higher order thinking skills according to Bloom's taxonomy of educational objectives.

In summary, among the several variables, the amount of time spent on homework, learning modes, and the students' anxiety in chemistry are important variables in predicting grades in general chemistry courses. These results clearly support the findings and suggestions of Schibeci and Riley (1986) in such a way that not only the cognitive variables but also some affective characteristics are important factors in influencing science achievement. An important finding of the present study is the relationship between type of learning modes and the content of chemistry courses. This result might affect curriculum designers' decisions in developing teaching learning aids to enhance science major students' success in chemistry.

It is expected that the findings of this very first study will initiate more comprehensive research studies in chemistry education by including different variables within the framework of a path analytic model.

REFERENCES

Bender, D.S., Milakofsky, L. (1982). "College chemistry and Piaget: The relationship of aptitude and achievement measures". *Journal of Research in Science Teaching.* 19(3), pp: 205-216.

Berberoğlu, G. (1990). "Measuring Chemistry Attitudes". *Education and Science.* 14 (76).l pp: 16-27 (In Turkish).

Bloom, S.B. (Ed.).(1979). *Taxonomy of educational objectives: Cognitive domain. Handbook 1.* London: Longman.

Cavin, C.S., Cavin, E.D., Jogowski, J.J. (1981). "The effect of computer-assisted instruction on the attitudes of college students toward computers and chemistry". *Journal of Research in Science Teaching.* Volume 18, Issue 4..

Chandaran, S., Treagust, D.F., Tobin, K. (1987). "The role of cognitive factors in chemistry achievement". *Journal of Research in Science Teaching.* 24(2) pp: 145-160.

Crosby, G.A. (1986). *The evaluation of chemistry texts. Science Books and Films: Chemistry Textbooks.* 21 (5) 248.

Darlington, R.B. (1990). *Regression and Linear Models.* New York: McGraw-Hill Publishing Company.

Friedel, W.A., Gabel, L.D., Samuel, J. (1990). "Using analogs for chemistry problem solving: Does it increase understanding?"*School Science and Mathematics.* 90(8) pp: 674-682.

Gable, D.L. (1983). "What high school chemistry textbooks do well and what they do poorly". *Journal of Chemical Education.* 60(10) pp: 893-89.

Hassan, A.M.A., Shrigley, R.L. (1984). "Designing a Likert scale to measure chemistry attitudes". *School Science and Mathematics.* Volume 84, Issue 8.

Johnstone, A.H. (1983). "Nyholm lecture: Chemical education research: Facts, findings and consequences". *Journal of Chemical Education.* 60(11) pp: 968-971.

Joreskög, K.G. & Sörbom, D. (1984) *LISREL VII: Analysis of linear structural relationships by the method of maximum likelihood.* Chicago: National Educational Resources Inc.

Kolb, D.A. (1981). "Learning styles and disciplinary differences". In W. Chickering and Associates (Eds.), *The modern American College.* San Fransisco, CA: Jossey-Bass.

Kolb, D.A. (1984). *Experiential learning.* Englewood Cliffs, NJ: Prentice-Hall.

Canfield, A. (1988). *Learning Styles Inventory Manual.* Los Angeles, CA: Western Psychological Services.

Kolb, D.A. (1985). *Learning Style Inventory: Technical manual.* Boston: McBer and Company.

Kolb, D.A., Rubin, I.M., and McIntyre, J.M. (1991). *Organizational psychology: An experiential approach.* Englewood Cliffs, NJ: Prentice-Hall.

Martin, O.M., Mullis, I.V.S., Beaton, A.E., Gonzales, E.J., Smith, T.A., and Kelly, D.L. (1997). *Science Achievement in the Primary School Years. IEA's Third International Mathematics and Science Study.* Chestnut Hill: TIMSS International Study Center. Boston College.

Matthews, D.B. (1994). "An investigation of student's learning styles in various disciplines in college and universities". *Journal of Humanistic Education and Development.* Dec 94, Volume 33, Issue 2, p. 65.

Matthews, D.B., Jones, M.C. (1994) "An investigation of the learning styles of students in teacher education programs". *Journal of Instructional Psychology.* Sep 94, Volume 21, Issue 3, p.234.

Mettes, C.T.C.W., Pilot A., Roossink, H.J., Kramer-Pals, H. (1980). "Teaching and learning problem solving in science". Part I: General strategy. *Journal of Chemical Education.* 57(12) pp:882-885.

Osborne, R. (1976). "Using student attitudes to modify instruction in physics". *Journal of Research in Science Teaching.* Volume 13, Issue 6.

ÖSYM. (1984). *The system of student selection and placement in higher education institutions in Turkey.* Ankara: Higher Education Council. Student Selection and Placement Center.

Piper, M.K., Hough, L. (1979). "Attitudes and open-mindedness of undergraduate students enrolled in a science methods course and a freshman physics course". *Journal of Research in Science Teaching.* Volume 16, Issue 3.

Rothman, J.A., Walberg, H.J., Welch, W.W. (1968). "Effects of summer institute on attitudes of physics teachers". *Science Education.* Volume 52, Issue 5.

Rowe, M.B. (1983). "Getting chemistry off the killer course list". *Journal of Chemical Education.* 60(11) pp: 954-956.

Schibeci, R.A., Riley, J.P. (1986). "Influence of students' background and perceptions on science attitudes and achievement". *Journal of Research in Science Teaching.* 23(3) pp:177-187.

Schibeci, R.A. (1989). "Home, school, and peer group influences on student attitudes and achievement in science". *Science Education.* 73(1) pp:13-24.

Weaver, M.H., Hounshell, B.P., Coble, B.C. (1979). "Effects of science methods courses with and without field experience on attitudes of preservice elementary teachers". *Science education.* Volume 63, Issue 5.

Veres III, G.J., Sims, R.R., Locklear, T.S. (1991). "Improving the reliability of Kolb's revised learning style inventory". *Educational and Psychological Measurement.* 51.