DOCUMENT RESUME

ED 360 944 HE 026 683

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TITLE Noncognitive Predictors of Achievement in Introductory College Chemistry. AIR 1993 Annual Forum Paper.
PUB DATE May 93
NOTE 29p.; Paper presented at the Annual Forum of the Association for Institutional Research (33rd, Chicago, IL, May 16-19, 1993).
PUB TYPE Speeches/Conference Papers (150) -- Information Analyses (070) -- Reports - Research/Technical (143)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Academic Achievement; *Chemistry; *College Entrance Examinations; College Freshmen; College Science; Higher Education; High Schools; *Mathematics Achievement; *Predictor Variables; Questionnaires; Science Instruction; Secondary School Mathematics; Self Evaluation (Individuals); *Student Attitudes; Student Reaction; Undergraduate Study
IDENTIFIERS *AIR Forum

ABSTRACT

This study investigated the predictive relationship between initial student attitudes, admissions test scores, years of high school math taken, and the student's subsequent achievement in introductory college chemistry. A group of 179 students who began as new freshmen during the same fall semester and took an introductory chemistry course during their first year of college, participated in the study. All students completed a survey which included several items that measured students' self-ratings of their academic abilities and their expectancies for academic achievement. The results indicated that students' initial attitudes are significant predictors of their subsequent grade achievement in introductory college chemistry. In addition, it was found that self-ratings of mathematical ability were significant predictors of earning a grade of C or better, while the number of years of high school math taken was a significant predictor of earning a passing grade (D or better). These results suggest that there is a set of minimum mathematical skills necessary for passing introductory chemistry and that initial attitudes become significant predictors only for students who have the prerequisite math skills. Contains 54 references. (GLR)

Noncognitive Predictors of Achievement

in Introductory College Chemistry

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Paper presented at the Association for Institutional Research

Annual Forum, May 16-19, 1993, Chicago, Illinois.

AIR

for Management Research, Policy Analysis, and Planning

This paper was presented at the Thirty-Third Annual Forum of the Association for Institutional Research held at the Chicago Marriott Downtown, Chicago, Illinois, May 16-19, 1993. This paper was reviewed by the AIR Forum Publications Committee and was judged to be of high quality and of interest to others concerned with the research of higher education. It has therefore been selected to be included in the ERIC Collection of Forum Papers.

Jean Endo
Chair and Editor
Forum Publications
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Abstract

The purpose of this study was to investigate the predictive relationship between initial student attitudes, admissions test scores, years of high school math taken, and subsequent achievement in introductory college chemistry. Students included in this study were a sample of 179 students who began as new freshmen during the same fall semester and took an introductory chemistry course during their first year of college. The results of this study indicated that noncognitive variables were significant predictors of student performance. These findings also indicated that, for some types of academic outcomes, noncognitive variables may be better predictors of achievement than traditional measures such as admissions test scores.

A number of noncognitive variables have been identified as being related to academic achievement. For example, Messick (1979) discussed variables such as student interests, affects, attitudes, curiosity, creativity, cognitive styles, and motivation and their potential relationships to educational outcomes. Some of these relatively broad categories have been further defined into specific areas of study. For example, studies on the relationship between motivation and educational outcomes have included research on students' locus of control and attribution theory (Kelley & Michela, 1980; Weiner, 1979) and students' self-efficacy beliefs regarding their ability to perform specific academic tasks (Schunk, 1991). Similarly, studies of the relationship between attitudes and academic achievement have included research on students' general self-concept as a predictor of achievement (Pottebaum, Keith, & Ehly, 1986; Rubin, 1978) and on the identification of a multifaceted structure of self-concept that is comprised of students' self-concepts of their abilities in specific areas (Byrne & Shavelson, 1986; Marsh, 1992; Marsh & Shavelson, 1985). There is a continuing interest in the utility of noncognitive variables as predictors of student achievement and it has been pointed out that further studies that examine students' actual classroom performance outcomes are needed (Pintrich, Cross, Kozma, & McKeachie, 1986).

Two of the more commonly studied noncognitive characteristics are academic self-concept and achievement expectancies. Both characteristics have been found to be significant predictors of the subsequent achievement of students of varying ages on a number of types of academic tasks. For instance, Gordon (1989) noted that students' expectations regarding their academic performance explained significant proportions of variance in three measures of college course performance (next test grade, final exam grade, and final course grade). Similarly, it has been found that achievement expectancies were significant predictors of exam grades in college social science courses even after the effects of prior student achievement, student goals, and student self-confidence were controlled for (Vollmer, 1984, 1986). Holen and Newhouse (1976) noted that achievement expectancies explained a significant proportion of variance in exam grades in a college educational psychology course even after considering the effects of high school grades and previous college grades. Finally, Morrison, Thomas, and Weaver (1973) found a significant correlation between students' estimations of their grade on a course paper and the grade they actually received.

Considering academic self-concept, several studies have noted a significant relationship with academic achievement (Hansford & Hattie, 1982). With regard to elementary school students, academic self-concept has been found to be a significant predictor of achievement test scores (Lyon & MacDonald, 1990) and school performance (Mintz & Muller, 1977). Similar findings have also been noted for high school students (Mboya, 1986; Song & Hattie, 1984, 1985). Considering college students, Gerardi (1990) found that academic self-concept was a significant predictor of the subsequent grade performance of minority engineering students. Wilhite (1990) found students' academic self-concept to account for a significant proportion of the variance in a multiple regression analysis of college course peformance. Finally, House (1992a, 1992b, 1993) found that students' academic self-concept and achievement expectancies were significant predictors of withdrawal from college.

A limited number of studies have investigated the utility of cognitive and noncognitive variables as predictors of achievement in chemistry. With regard to noncognitive predictors, a recent study found that the achievement of students in high school chemistry was significantly related to initial student attitudes and previous achievement (Gooding, Swift, Schell, Swift, & McCroskery, 1990). Also considering high school students, Levin, Sabar, and Libman (1991) found that science self-image was a significant predictor of subsequent student performance. Other research has examined the efficacy of cognitive variables as predictors of student achievement in college chemistry. Several studies have found college admissions test scores and high school performance to be significant predictors of later performance in college chemistry (Craney & Armstrong, 1985; Noble & Sawyer, 1987; Ozsogomonyan & Loftus, 1979; Pederson, 1975; Reiner, 1971). In addition, other types of measures of cognitive abilities such as Piagetian-style logic tests have been shown to be significantly related to achievement in college chemistry (Demko, Ventre, & Lester, 1985-a; Good, 1983). Also, scores on the mathematical subtests of the Toledo Chemistry Placement Examination have been found to be significant predictors of grade performance in introductory college chemistry (Demko, Ventre, & Lester, 1985-b). However, as pointed out by Good (1983), math skills and Piagetian-style logic tests accounted for only about 15% of the variance in introductory chemistry grades, leaving 85% of the variance due to other student characteristics. Consequently, research that investigates the effects of both cognitive and noncognitive variables toward the prediction of college chemistry performance is needed.

The purpose of this study was to investigate the predictive relationship between initial student attitudes, admissions test scores, high school curriculum, and subsequent achievement in introductory college chemistry. Several previous studies have examined either cognitive measures or student attitudes as predictors of chemistry achievement but few studies have evaluated the contributions of both types of variables toward the explanation of grade performance in college chemistry.

Methods

Students

Students included in this study were a sample of 179 students (mean age = 18.11 years, <u>SD</u> = 0.32) who began as new freshmen at a large university during the same fall semester. In this sample, there were 76 male students and 103 female students.

Measures

During an on-campus orientation period before the start of the fall semester of the freshmen year, all students were requested to complete a survey which included several items that measured students' self-ratings of their academic abilities and their expectancies for academic achievement. For use in this study, four academic self-concept items were included: self-ratings of overall academic ability, drive to achieve, mathematical ability, and students' self-confidence in their intellectual ability. On these items, students rated themselves as: (a) lowest ten percent, (b) below average, (c) average, (d) above average, and (e) highest ten percent. In addition, two items that measured students' achievement expectancies were selected for use in this study: expectations of earning at least a B average in college and expectations of graduating with honors. On these items, students indicated their probability of these academic outcomes as: (a) no chance, (b) little chance, (c) some chance, and (d) very good chance. Finally, the dependent measure used in this study was the grade earned in an introductory chemistry course taken during the first year of college. Grades for this course were assigned using a traditional four-point scale.

Procedure

The data from this study were analyzed in several ways. First, as has been done in other studies of predictive validity (House & Johnson, 1992), correlation coefficients were computed to examine the relationships between each of the predictor variables. Second, correlation coefficients were computed to determine the relationships between each predictor variable and subsequent grade performance in introductory chemistry. It has been noted that the relationships between attitudes and achievement can be different for male and female students (Ethington, 1992). Consequently, correlation coefficients were computed for the entire sample and separately for male and female students. The correlations obtained for male and female students were tested for any significant differences using a Z-transformation procedure (Kleinbaum & Kupper, 1978).

Least-squares multiple regression analyses were used to determine the relative ordering of student attitudes for predicting chemistry achievement. Regression analyses were performed for the entire sample and separately for male and female students.

A second set of multiple regression analyses were also conducted that, in addition to attitudes, included a measure of prior cognitive achievement (ACT Composite scores) and a measure of previous instructional experience (the number of years of high school math that were completed). These analyses provided insight into the relative ordering of cognitive variables and attitudes for explaining chemistry achievement.

It is known that the order of variable entry in stepwise regression procedures may be impacted by sampling error and, when sample sizes are large enough, cross-validation analysis provides insight into the impact of sampling error on the ordering of the predictor variables (House & Johnson, in press). A commonly proposed cross-validation procedure is to divide the original sample into two cross-validation samples and perform stepwise multiple regression analyses on each cross-validation sample to examine consistency in the ordering of the predictor variables (Henderson & Denison, 1989; Pedhazur, 1982). Consequently, a cross-validation analysis was performed for the entire sample using both cognitive and noncognitive variables as predictors. The entire sample was divided into two random samples and stepwise multiple regression analyses were performed on each cross-validation sample. Similarities and differences between the two cross-validation samples for ordering of the predictor variables were examined.

In addition to the specific grade received by students, a second outcome variable of interest is whether or not students passed the course. Therefore, analyses were done to investigate the relationships between cognitive and noncognitive variables and whether or not students had satisfactorily passed introductory chemistry. Stepwise logistic regression procedures were used to analyze the relative contributions of cognitive and noncognitive variables toward the explanation of passing introductory chemistry. Logistic regression is a procedure particularly suited to the analysis of binary outcomes such as passed/failed; it can be used to describe the relationship between a binary dependent variable and a set of predictor variables that may be either categorical or continuous. Logistic regression is also a stepwise procedure that provides an analysis of the relative contribution of each predictor variable toward the explanation of the dependent variable (Afifi, 1990). Several separate logistic regression analyses were conducted. For the first set of analyses, grades of A, B, and C were considered to be passing grades while grades of D and F were considered to be unsatisfactory. Logistic regression analyses were done using attitude variables only and were done for the entire sample as well as separately for male and female students. Analyses were also done using both cognitive and noncognitive predictors and were done for the entire sample as well as separately for male and female students.

For the second set of logistic regression analyses, grades of A, B, C, and D were classified as passing grades while a grade of F was considered failing. As before, logistic regression analyses were done using attitude variables only and were done for the entire sample as well as separately for male and female students. Finally, analyses were also done using both cognitive and noncognitive predictors and were done for the entire sample as well as separately for male and female students.

Results

Descriptive statistics for each predictor variable and grades earned in introductory chemistry are summarized in Table 1. Preliminary analyses were performed to determine if significant differences between male and female students were present for two predictor variables (ACT Composite scores and years of high school math taken) and for grades earned in chemistry; these analyses were performed because previous research has indicated that female students tend to take fewer elective math courses in high school and earn lower grades in college science (Oakes, 1990). For this sample, male students enrolled in introductory chemistry showed significantly higher ACT scores ($\underline{t}(177) = 3.27$, $\underline{p} = .0013$). In addition, the male students in this sample earned significantly higher grades in chemistry ($\underline{t}(177) = 2.37$, $\underline{p} = .0189$). However, when an analysis of covariance was used to control for the effects of ACT scores and years of high school math taken, no differences between the grades earned by male and female students were noted ($\underline{F}(1, 175) = 1.68$, $\underline{p} > .15$).

Correlations between each of the predictor variables are presented in Table 2. As can be seen, correlations for the entire sample are presented as well as for male and female students. A considerable number of significant correlations

Table 1

Descriptive Statistics (For All Students and by Student Sex)

	All		Males		Females	
Variable	M	SD	M	SD	M	SD
Self-rating of overall academic ability	3.82	0.58	3.87	0.57	3.78	0.58
Self-rating of drive to achieve	3.93	0.77	3.93	0.81	3.93	0.74
Self-rating of mathematical ability	3.50	0.91	3.71	0.95	3.35	0.86
Self-confidence in intellectual ability	3.67	0.76	3.80	0.77	3.57	0.74
Expect to graduate with honors	2.63	0.75	2.74	0.64	2.55	0.81
Expect to make at least a B average	3.40	0.59	3.39	0.52	3.40	0.65
ACT Composite	22.53	3.02	23.37	3.21	21.91	2.72
Years of high school mathematics	3.60	0.58	3.70	0.46	3.53	0.65
Chemistry GPA	2.40	1.02	2.61	0.97	2.24	1.04

between predictor variables were obtained. Considering the entire sample, self-ratings of overall academic ability, mathematical ability, expections of graduating with honors, and expectations of earning at least a B average in college were significantly correlated with ACT Composite scores. Students'

Table 2

Intercorrelations Between Predictor Variables (All Students and by Student Sex)

Predictor Variable (All Students)	2	3	4	5	6	7	8
1. Self-rating-academic ability	.15*	.37**	.23**	.48**	.26**	.49**	.13
2. Self-rating-drive to achieve	---	.26**	.36**	.28**	.22**	.02	.12
3. Self-rating-mathematical abil.		---	.24**	.31**	.12	.23**	.38**
4. Self-conf.-Intellectual abil.			---	.28**	.18*	.06	.22**
5. Expect to graduate with honors				---	.47**	.33**	.18*
6. Expect to make at least B avg.					---	.18*	.07
7. ACT Composite						---	.11
8. Years of high school math							---

Predictor Variable (Males)	2	3	4	5	6	7	8
1. Self-rating-academic ability	.15	.35**	.18	.45**	.36**	.44**	.10
2. Self-rating-drive to achieve	---	.31**	.32**	.41**	.29*	-.05	.23*
3. Self-rating-mathematical abil.		---	.21	.33**	.15	.22	.31**
4. Self-conf.-Intellectual abil.			---	.35**	.20	.03	.17
5. Expect to graduate with honors				---	.28*	.22	.27*
6. Expect to make at least B avg.					---	.10	.28*
7. ACT Composite						---	.09
8. Years of high school math							---

Predictor Variable (Females)	2	3	4	5	6	7	8
1. Self-rating-academic ability	.15	.38**	.26**	.50**	.21*	.54**	.14
2. Self-rating-drive to achieve	---	.22*	.39**	.21*	.18	.07	.06
3. self-rating-mathematical abil.		---	.22*	.28**	.10	.17	.40**
4. Self-conf.-Intellectual abil.			---	.22*	.18	.02	.23*
5. Expect to graduate with honors				---	.56**	.38**	.12
6. Expect to make at least B avg.					---	.26**	-.02
7. ACT Composite						---	.08
8. Years of high school math							---

**p < .01; *p < .05.

self-ratings of mathematical ability, self-confidence in their intellectual ability, and expectations of graduating with honors were significantly correlated with the number of years of high school math taken. Interestingly, there was not a significant correlation between the number of years of high school math taken and ACT Composite scores.

Correlations between each predictor variable and subsequent chemistry grades are presented in Table 3. When the entire sample was considered, only one predictor variable (expectations of making at least a B average in college) was not significantly related to later grade performance. Correlations between predictor variables and chemistry grades were also computed separately for male and female students and those correlations were compared for any significant differences. Only one significant difference was found; the relationship between expectations of making at least a B average in college and later chemistry achievement was significantly stronger for male students than for female students.

Table 3

Intercorrelations Between Predictor Variables and Chemistry Grades (All Students and by Student Sex)

Predictor Variable	All	Males	Females	Z
Self-rating of overall academic ability	.34**	.48**	.24**	1.81
Self-rating of drive to achieve	.21**	.38**	.10	1.95
Self-rating of mathematical ability	.43**	.47**	.37**	0.79
Self-confidence in intellectual ability	.21**	.18	.20*	-0.14
Expect to graduate with honors	.27**	.30**	.22*	0.56
Expect to make at least a B average	.13	.34**	.02	2.17*
ACT Composite	.28**	.28*	.22*	0.42
Years of high school math	.21**	.15	.21*	-0.40

(a) Note: Z-transformation contrasts the correlations found for male and female students.

$^{**}p < .01$; $^{*}p < .05$.

Findings from the multiple regression analysis of noncognitive variables as predictors of chemistry grades are summarized in Table 4. For the entire sample, two variables (self-ratings of mathematical ability and overall academic ability) entered the regression equation significantly. When analyzed by student gender, self-ratings of mathematical ability entered the regression equation first for female students while self-ratings of overall academic ability entered the regression equation first for male students. In addition, self-ratings of mathematical ability and drive to achieve also entered the regression equation

Table 4

Summary of Stepwise Multiple Regression Analysis of Chemistry Grades Using Noncognitive Predictors (All Students and by Student Sex)

Step	Variable Entered	Model R-Square	F	p
All Students				
1	Self-rating of mathematical ability	.188	41.01	.0001
2	Self-rating of overall academic ability	.227	8.90	.0033
3	Self-rating of drive to achieve	.236	1.97	.1622
4	Self-confidence in intellectual ability	.239	0.70	.4048
5	Expect to graduate with honors	.240	0.28	.6005
6	Expect to make at least a B average	.240	0.00	.9594
Male Students				
1	Self-rating of overall academic ability	.232	22.38	.0001
2	Self-rating of mathematical ability	.336	11.45	.0012
3	Self-rating of drive to achieve	.388	6.06	.0162
4	Expect to make at least a B average	.402	1.63	.2057
5	Expect to graduate with honors	.405	0.39	.5327
6	Self-confidence in intellectual ability	.405	0.04	.8484
Female Students				
1	Self-rating of mathematical ability	.140	16.48	.0001
2	Expect to graduate with honors	.155	1.73	.1911
3	Expect to make at least a B average	.167	1.42	.2366
4	Self-confidence in intellectual ability	.179	1.45	.2320
5	Self-rating of drive to achieve	.180	0.14	.7130
6	Self-rating of overall academic ability	.180	0.12	.7257

$^{**}p < .01$; $^{*}p < .05$.

significantly for male students. For the entire sample, the overall regression equation was significant ($F(6,172) = 9.06$, $p = .0001$) and explained 24.0% of the variance in chemistry grades. For male students, the overall regression equation was significant ($F(6,69) = 7.83$, $p = .0001$) and explained 40.5% of the variance in grades while for female students, the overall regression equation was significant ($F(6,96) = 3.54$, $p = .0033$) and accounted for 18.0% of variance.

Table 5

Summary of Stepwise Multiple Regression Analysis of Chemistry Grades Using Cognitive and Noncognitive Predictors (All Students and by Student Sex)

Step	Variable Entered	Model R-Square	F	p
All Students				
1	Self-rating of mathematical ability	.188	41.01	.0001
2	Self-rating of overall academic ability	.227	8.90	.0033
3	ACT Composite	.238	2.48	.1171
4	Self-rating of drive to achieve	.248	2.40	.1230
5	Self-confidence in intellectual ability	.252	0.87	.3510
6	Years of high school math	.253	0.29	.5925
7	Expect to graduate with honors	.254	0.07	.7922
8	Expect to make at least a B average	.254	0.01	.9178
Male Students				
1	Self-rating of overall academic ability	.232	22.38	.0001
2	Self-rating of mathematical ability	.336	11.45	.0012
3	Self-rating of drive to achieve	.388	6.06	.0162
4	Expect to make at least a B average	.402	1.63	.2057
5	ACT Composite	.411	1.09	.2999
6	Years of high school math	.416	0.56	.4577
7	Expect to graduate with honors	.419	0.37	.5476
8	Self-confidence in intellectual ability	.419	0.02	.8997
Female Students				
1	Self-rating of mathematical ability	.140	16.48	.0001
2	ACT Composite	.165	2.99	.0869
3	Self-confidence in intellectual ability	.180	1.83	.1793
4	Expect to make at least a B average	.188	0.87	.3521
5	Expect to graduate with honors	.199	1.39	.2415
6	Self-rating of overall academic ability	.200	0.15	.7014
7	Self-rating of drive to achieve	.202	0.16	.6904
8	Years of high school math	.203	0.10	.7537

**$p < .01$; *$p < .05$.

Findings from the multiple regression analyses using both cognitive and noncognitive variables as predictors are shown in Table 5. The variables that entered the equations significantly were the same as seen in Table 4. ACT scores and years of high school math did not significantly enter the equations for the entire sample or for male and female students. For all students, the overall regression equation was significant ($F(8, 170) = 7.23$, $p = .0001$) and explained 25.4% of the variance in chemistry grades. For male students, the overall regression equation was significant ($F(8,67) = 6.03$, $p = .0001$) and explained 41.9% of the variance in chemistry grades while for female students, the overall regression equation was significant ($F(8,94) = 2.98$, $p = .0050$) and explained 20.3% of the variance in chemistry grades.

The results of the cross-validation analyses using both cognitive and

Table 6

Cross-Validation Using Cognitive and Noncognitive Predictors (All Students)

Step	Variable Entered	Model R-Square	F	p
Cross-Validation Sample No. 1				
1	Self-rating of mathematical ability	.202	22.51	.0001
2	ACT Composite	.306	13.25	.0005
3	Self-rating of drive to achieve	.333	3.41	.0681
4	Years of high school math	.349	2.19	.1428
5	Self-rating of overall academic ability	.355	0.78	.3789
6	Self-confidence in intellectual ability	.356	0.15	.6988
7	Expect to make at least a B average	.357	0.14	.7045
8	Expect to graduate with honors	.358	0.04	.8396
Cross-Validation Sample No. 2				
1	Self-rating of mathematical ability	.172	17.88	.0001
2	Self-rating of overall academic ability	.196	2.55	.1143
3	Self-confidence in intellectual ability	.200	0.43	.5145
4	Years of high school math	.204	0.34	.5640
5	Expect to graduate with honors	.207	0.33	.5660
6	ACT Composite	.208	0.16	.6893
7	Self-rating of drive to achieve	.209	0.04	.8344
8	Expect to make at least a B average	.209	0.00	.9555

**$p < .01$; *$p < .05$.

and noncognitive variables as predictors are presented in Table 6. As was the case for the entire sample, self-ratings of mathematical ability were the first variables to enter the regression equations for both cross-validation samples significantly. In the analysis of the first cross-validation sample, ACT Composite scores also entered the regression equation significantly while in the analysis of the second cross-validation sample, only self-ratings of mathematical ability entered the regression equation significantly. Both cross-validation samples produced significant overall regression equations. The overall regression equation for the first cross-validation sample was significant ($F(8,82) = 5.70$, $p = .0001$) and explained 35.8% of the variance in chemistry grades while the regression equation for the second cross-validation sample was also significant ($F(8,79) = 2.61$, $p = .0139$) and explained 20.9% of the variance in chemistry grades.

Results from the logistic regression analysis using noncognitive variables as predictors of earning a passing grade (A, B, C) vs. an unsatisfactory grade (D, F) are presented in Table 7. For the entire sample, only one variable (self-rating of mathematical ability) entered the regression equation significantly. Similarly, self-ratings of mathematical ability entered the regression equations first for both male and female students. For male students, three additional variables (self-ratings of overall academic ability and drive to achieve, and expectations of graduating with honors) also entered the regression equation significantly. In addition, the logistic regression procedure provides an analysis of the joint significance of the explanatory variables. When all students were included in the analysis, the overall logistic regression equation was significant when all six noncognitive variables were included ($\chi^2(6, N = 179) = 27.25$, $p = .0001$). When analyzed by student gender, the overall model was significant for male students ($\chi^2(6, N = 76) = 26.95$, $p = .0001$) but not for female students ($\chi^2(6, N = 103) = 11.23$, $p = .0816$).

Results from the logistic regression analyses using both cognitive and noncognitive variables as predictors of earning a passing grade (A, B, C) vs. an unsatisfactory grade (D, F) are presented in Table 8. For each analysis in Table 8 (all students and by student gender), the variables that were significant were the same variables identified as significant in Table 7. Neither ACT Composite scores nor years of high school math taken significantly entered any of the three logistic regression analyses presented in Table 8. The overall logistic regression equation using both cognitive and noncognitive

Table 7

Summary of Stepwise Logistic Regression Analysis of Earning a Passing Grade (A,B,C) vs. Failing (D,F) in Chemistry Using Noncognitive Predictors (All Students and by Student Sex)

Step	Variable Entered	Chi-Square	p
All Students			
1	Self-rating of mathematical ability	24.41	.0001
2	Self-rating of overall academic ability	3.19	.0743
3	Self-rating of drive to achieve	0.71	.3990
4	Self-confidence in intellectual ability	0.34	.5579
5	Expect to make at least a B average	0.21	.6433
6	Expect to graduate with honors	0.22	.6425
Male Students			
1	Self-rating of mathematical ability	15.30	.0001
2	Self-rating of overall academic ability	4.58	.0324
3	Self-rating of drive to achieve	6.87	.0088
4	Expect to graduate with honors	4.63	.0314
5	Expect to make at least a B average	0.52	.4703
6	Self-confidence in intellectual ability	0.00	.9703
Female Students			
1	Self-rating of mathematical ability	9.32	.0023
2	Expect to graduate with honors	0.86	.3535
3	Self-confidence in intellectual ability	0.52	.4718
4	Self-rating of drive to achieve	0.82	.3654
5	Self-rating of overall academic ability	0.07	.7885
6	Expect to make at least a B average	0.00	.9289

**$p < .01$; *$p < .05$.

variables as predictors was significant for the entire sample (χ^2(8, N = 179) = 27.97, p = .0001) and for male students (χ^2(8, N = 76) = 28.28, p = .0004). However, the overall model was not significant for female students (χ^2(8, N = 103) = 13.16, p = .1061).

Table 8

Summary of Stepwise Logistic Regression Analysis of Earning a Passing Grade (A,B,C) vs. Failing (D,F) in Chemistry Using Cognitive and Noncognitive Predictors (All Students and by Student Sex)

Step	Variable Entered	Chi-Square	p
All Students			
1	Self-rating of mathematical ability	24.41	.0001
2	Self-rating of overall academic ability	3.19	.0743
3	Self-rating of drive to achieve	0.71	.3990
4	ACT Composite	0.82	.3659
5	Self-confidence in intellectual ability	0.42	.5152
6	Expect to make at least a B average	0.14	.7101
7	Expect to graduate with honors	0.30	.5811
8	Years of high school math	0.09	.7705
Male Students			
1	Self-rating of mathematical ability	15.30	.0001
2	Self-rating of overall academic ability	4.58	.0324
3	Self-rating of drive to achieve	6.87	.0088
4	Expect to graduate with honors	4.63	.0314
5	Years of high school math	2.22	.1365
6	Expect to make at least a B average	1.79	.1804
7	ACT Composite	0.38	.5366
8	Self-confidence in intellectual ability	0.06	.8139
Female Students			
1	Self-rating of mathematical ability	9.32	.0023
2	ACT Composite	2.08	.1496
3	Self-confidence in intellectual ability	0.75	.3866
4	Self-rating of drive to achieve	0.77	.3814
5	Expect to graduate with honors	0.17	.6785
6	Years of high school math	0.15	.7008
7	Self-rating of overall academic ability	0.09	.7687
8	Expect to make at least a B average	0.05	.8235

**p < .01; *p < .05.

Results from the logistic regression analysis using noncognitive variables as predictors of earning a passing grade (A,B,C,D) vs. a failing grade (F) are presented in Table 9. For the entire sample, only one variable (expectations of graduating with honors) entered the regression equation significantly. For male students, none of the noncognitive variables entered the logistic regression equation significantly. The first variable to enter the regression equation for female students was not significant; however, the second variable to enter the equation (expectations of making at least a B average in college) accounted

Table 9

Summary of Stepwise Logistic Regression Analysis of Earning a Passing Grade (A,B,C,D) vs. Failing (F) in Chemistry Using Noncognitive Predictors (All Students and by Student Sex)

Step	Variable Entered	Chi-Square	p
All Students			
1	Expect to graduate with honors	5.99	.0144
2	Expect to make at least a B average	3.36	.0669
3	Self-rating of mathematical ability	1.21	.2714
4	Self-confidence in intellectual ability	0.55	.4593
5	Self-rating of overall academic ability	0.14	.7115
6	Self-rating of drive to achieve	0.00	.9826
Male Students			
1	Self-rating of drive to achieve	2.80	.0943
2	Expect to graduate with honors	1.40	.2363
3	Self-rating of overall academic ability	0.25	.6150
4	Self-confidence in intellectual ability	0.28	.5936
5	Expect to make at least a B average	0.09	.7695
6	Self-rating of mathematical ability	0.03	.8634
Female Students			
1	Expect to graduate with honors	2.98	.0843
2	Expect to make at least a B average	5.40	.0202
3	Self-confidence in intellectual ability	1.53	.2158
4	Self-rating of drive to achieve	0.40	.5256
5	Self-rating of mathematical ability	0.28	.5970
6	Self-rating of overall academic ability	0.02	.8893

$^{**}p < .01$; $^{*}p < .05$.

for a significant proportion of the remaining variance. When all students were included in the analysis, the overall logistic regression equation was not significant when all six noncognitive variables were included (χ^2(6, N = 179) = 10.47, p = .1063). When analyzed by student gender, the overall regression

Table 10

Summary of Stepwise Logistic Regression Analysis of Earning a Passing Grade (A,B,C,D) vs. Failing (F) in Chemistry Using Cognitive and Noncognitive Predictors (All Students and by Student Sex)

Step	Variable Entered	Chi-Square	p
All Students			
1	Years of high school math	8.97	.0027
2	Expect to graduate with honors	4.04	.0445
3	Expect to make at least a B average	3.60	.0578
4	ACT Composite	1.53	.2155
5	Self-rating of overall academic ability	1.54	.2140
6	Self-rating of drive to achieve	0.16	.6916
7	Self-confidence in intellectual ability	0.00	.9862
8	Self-rating of mathematical ability	0.00	.9896
Male Students			
1	Self-rating of drive to achieve	2.80	.0943
2	Expect to graduate with honors	1.40	.2363
3	Self-rating of overall academic ability	0.25	.6150
4	Self-confidence in intellectual ability	0.28	.5936
5	ACT Composite	0.10	.7492
6	Expect to make at least a B average	0.05	.8189
7	Years of high school math	0.02	.8840
8	Self-rating of mathematical ability	0.03	.8575
Female Students			
1	Years of high school math	7.38	.0066
2	Expect to graduate with honors	2.22	.1362
3	Expect to make at least a B average	5.31	.0212
4	ACT Composite	1.51	.2198
5	Self-rating of overall academic ability	0.45	.5034
6	Self-rating of math ability	0.14	.7111
7	Self-confidence in intellectual ability	0.14	.7090
8	Self-rating of drive to achieve	0.07	.7924

$**p < .01$; $*p < .05$.

equation was not significant for either male students (χ^2(6, N = 76) = 4.08, p = .3950) or female students (χ^2(6, N = 103) = 10.02, p = .1239).

Results from the logistic regression analysis using both cognitive and noncognitive variables as predictors of earning a passing grade (A,B,C,D) vs. a failing grade (F) are presented in Table 10. For the entire sample, two variables (years of high school math taken and expectations of graduating with honors) entered the regression significantly. A follow-up analysis indicated that 66.7% of the students who earned a passing grade had taken four years of high school math while only 37.5% of the students who earned a failing grade had taken four years of high school math. Similarly, only 3.5% of the students who earned a passing grade had taken only two years of high school math while 37.5% of the students who earned a failing grade had taken only two years of high school math.

When analyzed by student gender, none of the predictor variables entered the logistic regression equation significantly for male students. For female students, two variaoles entered the regression equation significantly. The number of years of high school math taken significantly entered the regression equation first. Expectations of making at least a B average in college entered the regression equation third and accounted for a significant proportion of the remaining variance. Finally, when all students were included in the analysis, the overall logistic regression equation was significant when all eight predictor variables were included (χ^2(8, N = 179) = 18.02, p = .0211). When analyzed by student gender, the overall regression equation was not found to be significant for male students (χ^2(8, N = 76) = 4.57), p = .8020). For female students, however, the overall logistic regression equation was found to be significant (χ^2(8, N = 103) = 16.19, p = .0397).

Discussion

The results of this study indicate that students' initial attitudes are significant predictors of their subsequent grade achievement in introductory college chemistry. These findings are consistent with the results of previous research on college students in other academic areas (Gordon, 1989; Vollmer, 1984, 1986; Wilhite, 1990) and high school students in chemistry (Gooding, Swift, Schell, Swift, & McCroskery, 1990; Levin, Sabar, & Libman, 1991). A second finding of interest from this study was that students' attitudes were better predictors of grade achievement in chemistry than ACT Composite scores or the number of years of high school math taken. This finding differs somewhat from the results of a recent study of college freshmen (Ferrari & Parker, 1992). In that study, high school achievement was significantly related to first-year college grade performance while initial student attitudes were not.

Yet another finding from this study was that self-ratings of mathematical ability were significant predictors of earning a grade of C or better while the number of years of high school math taken was a significant predictor of earning a passing grade (D or better). These results suggest that there is a set of minimum mathematical skills necessary for passing introductory chemistry and that initial attitudes become significant predictors only for students who have the prerequisite math skills.

The results of this study provide support for the consideration of initial student attitudes when designing instructional units in science. Considerable instructional design research has focused on the identification of cognitive processes involved in science learning and on the development of effective instructional procedures for teaching science concepts. For example, Ploger (1988) examined how biochemists solved a metabolism problem and noted differences between the problem-solving strategies of experts and novices. Other researchers have investigated the effects of instructional approaches such as note taking strategies, visualization strategies, and elaboration strategies on the learning and recall of science concepts (Walko & Dwyer, 1990; Wilshire & Dwyer, 1991; Wood & Dwyer, 1989). A common component of numerous instructional design models is an initial assessment of learner characteristics prior to instruction (Andrews & Goodson, 1980) and there is an increasing recognition that students' affective characteristics may be significantly related to achievement outcomes (Keller, 1983). For example, students' attitudes and motivation have been identified as components of a recently proposed cognitive model for instructional design (Tennyson, 1992) and a recent model of instructional design has been proposed that gives extensive consideration to students' motivational characteristics (Keller & Kopp, 1987). These findings provide support for the consideration of initial student attitudes when designing instructional programs in chemistry.

There are some limitations to the present study. First, no analysis of the causal nature of the relationship between noncognitive and cognitive variables and subsequent chemistry achievement was made. Helmke (1990) has noted that future research is needed to examine the causal mechanisms by which student attitudes exert effects on achievement. Second, there was no attempt in this study to identify the effects of background variables such as family characteristics or prior academic achievement on the development of students' attitudes. Finally, only traditional-aged college students were included in this study. Further research is needed to determine if these findings would also be noted for adult learners.

The results of this study provide a number of directions for further research. For example, only one type of achievement outcome, grade performance, was examined in this study. Additional research is needed to examine other types of chemistry achievement outcomes such as enrollment in advanced chemistry courses or the completion of a degree in chemistry. It has been observed that learner attitudes may be involved in the selection of advanced science courses and persistence in science majors (Oakes, 1990). Yet another direction for further study is to determine if these results would be replicated for other academic subjects such as other sciences, mathematics, English, or the social sciences. Finally, further study is needed to determine if initial learner attitudes are predictive of grade performance in courses taken after the first year of college. Such research would determine the predictive validity of learner attitudes for long-term achievement outcomes.

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