Predicting Academic Success of First-Year Engineering Students from Standardized Test Scores and Psychosocial Variables*

SIU-MAN RAYMOND TING
North Carolina State University, Department of Educational Research and Leadership and Counselor Education, Raleigh NC 27695-7801, USA. E-mail: raymond_ting@ncsu.edu

The author proposes a model combining standardized test scores and psychosocial variables to predict students' academic success. The Scholastic Aptitude Test (verbal, mathematics, and total) scores and the Non-Cognitive Questionnaire (NCQ) were used for predicting grade-point-average (GPA) of 690 engineering freshmen in a public research university in Southeastern United States of America. Multiple step-wise regression analysis revealed SAT scores and psychosocial variables for predicting student academic performance. Different predictor variables were found based on gender. This study shed light on admissions criteria and academic intervention programs for enhancing academic success of engineering students.

INTRODUCTION

THE FIRST YEAR in college is a time for adjustment and turmoil for many late adolescents [1, 2]. Some experience difficulties sufficient to cause them to drop out [3]. Academic performance and retention of college students has been studied extensively and theoretical models developed to describe various factors affecting college students' adjustment and academic performance [4–7].

At present, the Scholastic Aptitude Test (SAT) is a commonly used standardized test for undergraduate admissions in the USA. The College Board first administered the SAT to about 8000 candidates in 1926 at Columbia University. The test produced verbal and math score. A score of 500 was defined as the average, and all scores were considered equivalent from one year to the other. In 1941, the norms with a range of 600 and a standard deviation of 100 were established based on a mostly white male student population [8]. Only minor modifications were made, and the SAT remained primarily in the same form until 1993. In 1995, new norms were created. However, a disparity of scores between Caucasian and ethnic minorities still exists.

Questioning the use of the SAT for admissions decisions, Sedlacek pointed out that [9]:

- the College Board never intended to make the SAT to be the primary factor for college admissions;
- the SAT was designed primarily to predict first-year college grades which was found to be incomplete if used alone;

- the test originally was designed to measure attributes in a highly homogeneous population;
- the SAT, in essence, still measures what it did in 1929 verbal and math ability.

In conjunction with standardized tests such as SAT scores, Sedlacek suggested adding non-cognitive variables for admissions criteria, which better explain students academic performance.

The professional literature provides information about this recent efficacious approach for college admissions and predicting college grades, which employs non-cognitive variables to explain academic performance and retention [10–17]. These studies also showed the ineffective use of standardized test scores alone for predicting student academic performance. The effective non-cognitive variables are psychological, social, and cultural factors such as positive self-concept, coping with racism, and demonstrated community service.

Designed to explain admissions decisions, the Non-Cognitive Questionnaire (NCQ) has been well studied and applied at some universities in the USA [14]. There is evidence supporting the use of psychosocial variables as predictors of students' academic performance and retention, including: Caucasians and African Americans [13–17], Asian Americans [10], Hispanics [18], international students [19], specially-admitted students [11, 20], student athletes [21], and low-income and first-generation students [12]. In summary, the NCQ was effective explaining students academic performance. The findings of the above studies shed light on admission criteria and academic intervention programs for enhancing student success. However, comparatively little information has been found for engineering students.

The purpose of this study was to examine the predictive ability of selected cognitive and psychosocial variables on engineering students academic success as measured by grade-point-average (GPA).

METHOD

Participants

In Fall of 1996, at North Carolina State University, a Southeastern public research university, about 2,800 students responded to the survey conducted by the Non-Cognitive Variables Research Committee, including 735 responses of engineering students. This sample represents over 90% of the new freshmen at the School of Engineering. Therefore, the sample can represent the engineering freshman population in the university. Only Caucasian and African American students were included in this study (n = 690). The participants' mean age was 18.11. Of the 619 Caucasians, 501 were men and 118 were women. Of the 71 African American students, 43 were men and 28 were women.

Measures

The Scholastic Aptitude Test (SAT; verbal, mathematics, and total scores) and eight psychosocial variables were employed in the Non-Cognitive Questionnaire (NCQ; Tracey & Sedlacek, 1984, 1989) as *predictors* of the students' grade-point-average (GPA) in the first year of college.

The NCQ was designed to assess psychosocial aspects of students that influence college success. It contains 23 items: 18 Likert-formatted, 2 multiple choice, and 3 open-ended. It consists of measures of eight variables with possible score ranges printed in brackets in the following:

- positive self-concept (7–27);
- realistic self-appraisal (4–14);
- demonstrated community service (2–8);
- knowledge acquired in a field (2–8);
- successful leadership experience (3–13);
- preference of long-range goals over short-term, immediate goals and ability to defer gratification to attain goals (3–13);
- ability to understand and cope with racism (5–25);
- availability of a strong support person (3–15).

Tracey and Sedlacek (1984) reported a 2-week test-retest reliability of a range from 0.74 to 0.94, with a median of 0.85 for the NCQ items [14]. Interrater reliability on the three open-ended NCQ items ranged from 0.73 to 1.00. The NCQ appears to have promising content validity, strong construct and predictive validity [14–17].

College grade-point-average (GPA) and student enrollment were the *criterion variables*. In the United States, a college student's GPA is an individual's total grade points divided by his/her total credits (class hours). Student grades are recorded with the following corresponding points:

A = 4.0, A– = 3.67;
B+ = 3.33, B = 3.0, B– = 2.67;
C+ = 2.33, C = 2.0, C– = 1.7;
D = 1.0, and F = 0.0.

Academic credits represent the academic workload of a student with one credit for a class requires an hour of class time per week. Students taking twelve or more credits are regarded as full-time, typically taking four three-credit classes per week. Usually students enroll 15 to 18 credits in Fall and Spring of the first year of college. Owing to the small number of drop-outs, student retention was not studied.

Procedure

The students met in small groups during the orientation and they were invited to participate voluntarily in the study by responding to the NCQ. As a result, about 2800 usable responses were collected, including 735 responses of engineering students. Only the information of the 690 Caucasian and African American students was used in this study.

The responses were analyzed by the whole sample and by gender. Multiple step-wise regression analyses were employed using the SPSS for window 8.0 for predicting student GPA for the Fall and Spring semesters in the freshman year. SAT scores and NCQ variables were used as predicting variables. Because the number of the African American students was small, no prediction models for them was computed. Instead, predictions were computed separately for male and female students. Only the predicting variables found to have significant correlation coefficients with Fall and Spring GPA were computed for the multiple regression analysis. As a result, only the variables of SAT-math, SAT-verbal and SAT-total scores, positive self-concept, leadership experiences, acquired knowledge in a field, preference of long-term goals, and demonstrated community service were included in the regression analysis.

RESULTS

Predicting GPA

Table 1 shows the means and standard deviations for the predictor and criterion variables. These figures were similar to those reported in another study [13].

Table 2 demonstrates Pearson zero-order correlation coefficients between Fall GPA and multiple predictors for the participants.

Table 3 shows the selected multiple regression models in the first semester for all participants and by gender. The prediction models ranged from 11.8% to 22% of the variance. Among all participants, SAT total score was the most effective single

Table 1. Means and standard deviations of criterion and predictor variables

Variable	All M	All SD	Men M	Men SD	Women M	Women SD
SAT – mathematics scores	632.26	70.09	640.15	68.19	602.88	69.46
SAT – verbal scores	588.17	75.18	590.20	73.70	580.62	80.28
SAT – total scores	1220.4	126.25	1230.4	122.57	1183.5	133.19
Positive self-concept	18.71	2.39	18.71	2.49	18.72	1.99
Self appraisal system	10.07	1.72	10.06	1.74	10.13	1.66
Coping with racism	18.42	2.17	18.38	2.23	18.63	1.93
Preference of long-term goals	8.95	1.51	8.93	1.54	9.04	1.41
A strong support person	13.40	1.49	13.32	1.56	13.74	1.12
Leadership experiences	9.23	1.72	9.14	1.76	9.57	1.51
Demonstrated community service	5.40	1.15	5.30	1.15	5.76	1.07
Acquired knowledge in a field	3.85	1.05	3.74	1.09	4.27	0.76
Fall GPA	3.04	0.81	3.03	0.83	3.08	0.73
Spring GPA	2.72	0.88	2.74	0.86	2.63	0.96
Number of students in Fall (n)	690		544		146	

Note: SAT = Scholastic Aptitude Test

Table 2. Pearson zero-order correlation coefficients between fall GPA and predictor variables for all students

Predictor	All students: All	All students: M	All students: F
SAT – math scores	0.26***	0.26***	0.34***
SAT – verbal scores	0.20***	0.19**	0.28***
SAT – total	0.27***	0.26***	0.35***
Positive self-concept	−0.14***	−0.12***	−0.24**
Self-appraisal system	0.04	0.04	0.02
Coping with racism	−0.01	0.03	−0.17*
Preference of long-term goal	0.06	0.09*	−0.12
A strong support person	0.00	0.03	−0.15
Leadership experiences	0.09*	0.07	0.18*
Demonstrated community service	0.09*	0.08	0.12
Acquired knowledge in a field	0.09*	0.07	0.16

Note: SAT = Scholastic Aptitude Test
*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

Table 3. Multiple regression models for fall semester

Student Group	Predictors	R	R^2	R^2 change	Unstandardized B	t	**Standardized** Beta
All students	SAT – total	0.27	0.07	0.07	0.00175	7.59***	0.27
	Positive self-concept	0.30	0.09	0.02	−0.0699	−5.33***	−0.21
	Leadership experiences	0.33	0.11	0.02	0.0538	3.04**	0.11
	Preference of long-term goals	0.34	0.12	0.01	0.0597	2.90**	0.11
All men	SAT – math	0.26	0.07	0.07	0.00327	6.62***	0.26
	Positive self-concept	0.29	0.08	0.01	−0.0611	−4.25***	−0.13
	Preference of long-term goals	0.33	0.11	0.03	0.0898	3.84***	0.17
All women	SAT – total	0.35	0.12	0.12	0.00185	4.46***	0.35
	Leadership experiences	0.41	0.17	0.05	0.13	3.46***	0.23
	Positive self-concept	0.47	0.22	0.05	−0.0836	−2.98**	−0.23

Note: SAT = Scholastic Aptitude Test.
**$p < 0.005$. ***$p < 0.0001$.

variable explaining 7.2% while NCQ variables including positive self-concept, leadership experience, and preference of long-term goals totaled 5%. For all students, after SAT scores and NCQ variables were entered into the equation, $R^2 = 0.12$; $F(4, 685) = 22.94$; $p < 0.0001$, indicating that SAT-total scores, positive self-concept, leadership experiences, and preference of long term goals were significantly predictive of Fall GPA.

Once the student population was separated by gender, different predictor variables were found. For male students, SAT math scores explained 7% of their Fall GPA and positive self-concept, and long term-goals of the NCQ variables totaled another 4% ($R^2 = 0.11$; $F(3, 540) = 21.88$; $p < 0.0001$).

For women, SAT total scores were the most important predictor (11.8%); however, the

Table 4. Multiple regression models for spring semester

Student Group	Predictors	R	R^2	R^2 change	Standardized Beta	t	Unstandardized B
All students	SAT – math scores	0.29	0.09	0.09	0.29	7.73***	0.00358
	Positive self-concept	0.31	0.10	0.01	−0.14	−3.61***	−0.0515
	Leadership experiences	0.33	0.11	0.01	0.10	2.49*	0.0491
All men	SAT – math	0.29	0.08	0.08	0.29	6.84***	0.00359
	Positive self-concept	0.30	0.09	0.01	−0.10	−2.36*	−0.0345
All women	SAT – math	0.28	0.08	0.08	0.25	3.01**	0.00344
	Positive self-concept	0.33	0.11	0.03	−0.18	−2.21*	−0.0868

Note: SAT = Scholastic Aptitude Test.
*$p < 0.05$. **$p < 0.005$. ***$p < 0.0001$.

noncognitive variables, successful leadership experience and positive self-concept also explained 10% of the total variance ($R^2 = 0.22$; $F(3, 142) = 13.20$; $p < 0.0001$.

Similar results were found for all students in the Spring semester. The prediction models ranged from 9% to 11%. For all students, after SAT scores and NCQ variables were entered into the equation, $R^2 = 0.10$; $F(3, 660) = 25.68$; $p < 0.0001$, indicating that SAT-total scores, positive self-concept, and leadership experiences were significantly predictive of Spring GPA. The total variances for males and female students' GPA were smaller than those in Fall, $R^2 = 0.09$; $F(2, 520) = 26.15$; $p < 0.0001$ and $R^2 = 0.11$; $F(2, 138) = 8.5$; $p < 0.0001$ respectively. Both SAT-mathematics scores and positive self-concept explained male and female students' GPA.

DISCUSSION

The prediction models in the present study explained a range of 9% to 22% of the variance for the engineering students' GPA in the first year. It is clear that combining SAT scores and the psychosocial variables to predict academic performance of the engineering students is more effective than using SAT scores alone. Other findings also showed psychosocial variables as effective predictors. For example, self-concept, personal development, long-term goals, and involvement in extracurricular activities [13] and community service and leadership experience [12] have been effective. In addition, some predicting variables were found only in Fall, e.g. preference for long-term goals for all engineering students and male students.

The current study revealed that the multivariate models to predict academic performance using cognitive and noncognitive variables across gender are more effective than a general model for the whole sample, at least in the Fall prediction model. For example, higher percentage of the variances for Fall GPA was found for women (22%).

A gender difference was found in the current study. First, a higher percent of variance accounted for GPA was found for women than men. This implies that the study found stronger predictors for women's academic performance than for men's. Second, the predictors for men's GPA were different from those for women. For example, the leadership experience variable was related to women, and men who had a preference for long-term goals were found to have a higher Fall GPA. Some common predictor variables were also found for the men and women. Both the men and women who possessed a better self-concept and high SAT scores (total or math) had higher GPA for the freshman year. In addition, Gardner and Broadus found that women felt they were neglected and received less support than men in the classroom, laboratory, and work place [22].

Although racial differences were not studied in the present study, professional literature shows that the predictors for students' academic success vary from one race to another. It appears that students of color may face more challenges in a predominantly Caucasian university. These challenges included loneliness and alienation [23], identity formation [24], and bias and oppression [25]. As a result, the ethnic minorities had a different coping style [26]. These students may need more time than Caucasians to adjust into a White-dominated university campus. Other studies show similar findings [13, 18]. Perhaps, longitudinal research studies may reveal additional psychosocial predictors for students of color. For the Caucasian students, a high level of self-concept, a preference of long-term goals, and leadership experience often are effective psychosocial predictors [14, 16, 17].

Several limitations of the current study need to be addressed here. First, the study was based on a single institution. Second, the author studied only academic success of the first year. Third, no racial differences was studied. More students of color could be included in future studies by studying more institutions.

The findings of the current study suggest that different types of models of predicting academic performance apply for engineering students as compared to others, given the particular gender for which the prediction exists. Therefore, the psychosocial development of the students by gender should be carefully considered with standardized test performance such as SAT scores. Based on this study, no general prediction model

can be applied for all engineering student groups. Although there were some similarities between male and female engineering students, significant differences were found. Educators, especially instructors for first-year engineering programs, should focus on helping students adjust to the university, creating diversified atmosphere and designing multiple teaching and learning environments. Particular attention may be devoted to enhancing students' self-concept, increasing their knowledge about the engineering field, the curricula for the degree program, and study methods for success in engineering. For example, in conjunction with providing additional academic support, engineering faculty can work with counselors for students who may have psychosocial problems.

In addition to using standardized test scores, universities may explore the possibility of including psychosocial variables for admissions decisions. University personnel are challenged to design more student programs and academic support services to enhance this adjustment. University administrators may need to incorporate the diverse variables in designing academic and co-curricular programs which may include freshmen transition activities, learning contracts, female role models/mentors, peer counseling, cooperative learning, a study center and financial assistance.

Finally, because there is still room for unexplained variance for academic success, future studies should continue to explore additional noncognitive variables as well as investigate student performance beyond the first year in order to confirm the trend for effectiveness of psychosocial predictors.

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Siu-Man Raymond Ting is an assistant professor at North Carolina State University at Raleigh, USA. He is also the coordinator of Student Development in Higher Education program in the Department of Educational Research, Leadership, and Counselor Education. He graduated from the Chinese University of Hong Kong and obtained his Ph.D. in counselor education from the University of Iowa in USA. in 1995. He received several professional awards including Scholar of the National Association of College Admission Counseling in 1999. His current interests are academic performance and retention, and professional development issues.