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ABSTRACT

The study sought to develop predictive models of persistence and success in baccalaureate engineering at the end of the sophomore year by analyzing 11 intellective and 9 non-intellective variables. A total of 1,C'3 students in the 1984 entering freshman class in the College of Engineering at Pennsylvania State University served as the population. Three models were developed to predict sophomore persistence and success at different points in time: pre-enrollment, freshman year, and sophomore year. For the pre-enrollment model, the variables best predicting success were high-school grade point average, algebra score, gender, non-science points, chemistry score, and reason for engineering choice. For the freshman year model, best predictors included grades in Physics I, Calculus I, and Chemistry I. In the sophomore year model, the variables of grades in Calculus II, Physics II, and Physics I were the best predictors. Thus, it was found that the variables which are predictive depend on the student's point of progress through the first 2 years of an engineering program. Includes four references. (JDD)

STUDENT CHARACTERISTICS THAT PREDICT PERSISTENCE AND SUCCESS IN BACCALAUREATE ENGINEERING

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PURPOSE

The purpose of this study was to develop predictive models of persistence and success in baccalaureate engineering at the end of the sophomore year by analyzing eleven intellective and nine non-intellective variables in relation to these criteria.

METHOD

Data Source

The 1984 entering freshman class in the College of Engineering at The Penn State University served as the population for this study. From a total class of 1605, data were obtained on 1220 students. Because of unusable data the final sample size was 1043, representing 65% of the population.

Data Collection

The Freshman Testing, Counseling and Advising Program (FTCAP) is provided for all entering freshmen at The Penn State University. This Program has two stages, one day each: 1) testing and 2) counseling and advising. These two stages, plus undergraduate admissions office records and transcript information after two years of enrollment, provided the data for this study. Table 1 lists the dependent and independent variables, a description of the variables, their measurement levels and the data source for each variable.

Statistical Analysis

As listed in Table 1, Sophomore Enrollment Status (STATUS) was the dependent variable. The nineteen intellective and non-intellective independent variables are also listed in Table 1.

For purposes of analysis, "persistence and success" in engineering was defined as students who qualified for an engineering major at the end of the sophomore year and enrolled in an engineering major in the first semester of their junior year.

Three models were developed. Each model predicted sophomore persistence and success at a different point in time. The first model used those variables available at pre-enrollment prior to the start of the freshman year.

The second model used all of the intellective and non-intellective variables in Model I, as well as the grades in Calculus I, Physics I and Chemistry I. Typically students complete these courses by the end of the freshman year.

The third model used all of the variables in Model II as well as the grades in Calculus II and Physics II. These courses are usually completed by the end of the third semester.

The discrete dependent variable STATUS was analyzed in terms of logit models. The log odds of the status ratio of PERSISTING IN BACCALAUREATE ENGINEERING SUCCESSFULLY TO ALL OTHER ENROLLMENT STATUSES was assumed to be estimated as linear combination of the independent variables (fourteen for Model I; seventeen for Model II; nineteen for Model III). The models were built using the CATMOD procedure in SAS, using maximum-likelihood estimation of the model parameters (Statistical Analysis System, 1985). The significance level for entry of a variable into the model was set at $P = .10$. The variables

TABLE 1: DESCRIPTIONS OF VARIABLES

VARIABLE NAMES	VARIABLE DESCRIPTION	MEASUREMENT LEVEL	SOURCE OF DATA
Dependent Variables			
Sophomore Enrollment Status (STATUS)	enrollment status after two years	. persisting successfully in engineering (ENGR) . science/mathematics oriented baccalaureate program (SCBAC) . non-science baccalaureate program (NSBAC) . associate program (ASSOC) . nondegree (NDEG) . discontinued enrollment (DISC) . academically dropped (DROP)	student transcripts and registration data
Independent Variables - Intellective			
High School Grade Point Average (HSGPA)	converted grade point average based on high school academic courses only	continuous variable (0.00 to 4.00)	admission records
Scholastic Aptitude Test Score Mathematics (SATM)		continuous variable (200 to 800)	admission records
Scholastic Aptitude Test Score Verbal (SATV)		continuous variable (200 to 800)	admission records
Algebra Score (ALG)	subscore of University's mathematics placement test	continuous variable (0 to 32)	FTCAP - testing phase
Chemistry Score (CHEM-S)	score on University's chemistry placement test	continuous variable (0 to 20)	FTCAP - testing phase
Calculus I Grade (CALC I)	grade in Calculus I	.A .B .C .D .F	student transcripts

TABLE 1: DESCRIPTION OF VARIABLES (con't)

VARIABLE NAMES Independent Variables - Intellective	VARIABLE DESCRIPTION	MEASUREMENT LEVEL	SOURCE OF DATA
Calculus II Grade (CALC II)	grade in Calculus II	.A .B .C .D .F	student transcripts
Physics I Grade (PHYS I)	grade in Physics I	.A .B .C .D .F	student transcripts
Physics II Grade (PHYS II)	grade in Physics II	.A .B .C .D .F	student transcripts
Chemistry I Grade (CHEM I)	grade in Chemistry I	.A .B .C .D .F	student transcripts

TABLE 1: DESCRIPTION OF VARIABLES (con't)

VARIABLE NAMES	VARIABLE DESCRIPTION	MEASUREMENT LEVEL	SOURCE OF DATA
Independent Variables Non-Intellective			
Gender (GEN)		· male · female	admission records
Attitude Towards High School Mathematics (MATH)	students' reactions to high school mathematics	. like . indifferent/dislike	FTCAP - counseling and advising phase
Attitude Towards High School Physics (PHYS)	students' reactions to high school physics	. like . indifferent/dislike	FTCAP - counseling and advising phase
Attitude Towards High School Chemistry (CHEM)	students' reactions to high school chemistry	. like . indifferent/dislike	FTCAP - counseling and advising phase
College Study Hours (ST)	anticipated college study hours per week	continuous variable (0 to 60)	FTCAP - testing phase
Non-science Points (NSPTS)	consistency of major choices	continuous variable (0 to 100)	FTCAP - testing phase
Reason for Engineering Choice (REAS)	intrinsic (genuine) vs extrinsic (superficial) reasons	. genuine . superficial	FTCAP - counseling and advising phase
Certainty (CERT)	expressed certainty regarding intended major	. very certain . about 50/50 . slightly uncertain . uncertain	FTCAP - counseling and advising phase
Knowledge of Intended Major (KNOW)	accuracy of student's knowledge of engineering major	.accurate .inaccurate	FTCAP - counseling and advising phase

ALG, HSGPA, NSPTS, SATM, SATV, ST and CHEM-S were treated as continuous variables and modeled with a single parameter.

FINDINGS

At the end of the sophomore year 510 students (48.90%) of the 1043 who began in engineering were in an engineering major (71 of 176 females = 40.34%, 439 of 867 males = 50.36%).

Each model identified significant predictor variables for given points in time: pre-enrollment, freshman year and sophomore year.

<u>Model I - Pre-Enrollment Variables (Intellective and Non-intellective): The logistic regression model that best predicts the log odds of the ratio of</u> the status PERSISTING IN BACCALAUREATE ENGINEERING SUCCESSFULLY TO ALL OTHER ENROLLMENT STATUSES included six of the fourteen eligible independent variables. In order of the contribution to the total chi-square these are High School Grade Point Average (HSGPA), Algebra Score (ALG), Gender (GEN), Non-Science Points (NSPTS), Chemistry Score (CHEM-S), and Reason for Engineering Choice (REAS). (Table 2).

<u>Model II - Pre-Enrollment Variables plus grades in Calculus I, Physics I and Chemistry I: The logistic regression model that best predicts the log odds of the ratio of</u> PERSISTING IN BACCALAUREATE ENGINEERING SUCCESSFULLY TO ALL OTHER ENROLLMENT STATUSES included three of the seventeen eligible independent variables. Listed in order of contribution to the total chi-square these are grades in Physics I (PHYS I), Calculus I (CALC I), and Chemistry I (CHEM I). (Table 3).

<u>Model III - Pre-Enrollment Variables plus grades in Calculus I and II, Physics I and II, and Chemistry I: The logistic regression model that best</u> predicts the log odds of the ratio of PERSISTING IN BACCALAUREATE ENGINEERING SUCCESSFULLY TO OTHER ENROLLMENT STATUSES included three of the nineteen eligible independent variables. In order of contribution to the total chi-square these are grades in Calculus II (CALC II), Physics II (PHYS II), and Physics I (PHYS I). (Table 4).

DISCUSSION

The three models that predict students qualifying for and choosing to enroll in a major in the College of Engineering at the end of the sophomore year indicate that the predictive variables are not constant over time. As students progress through the first two years of college and more data becomes available (academic performance), variables which at an earlier point in time were predictive are replaced by new variables. Therefore the model which is used for any individual student is determined by the data which is available.

Thus in the case of a student who has not yet begun college the pre-enrollment variables of high school grade point average (HSGPA), algebra score (ALG), gender (GEN), non-science points (NSPTS), chemistry score (CHEM-S) and reason for choosing engineering (REASON) are the predictors of status. Typically after the freshman year when the student has completed Physics I, Calculus I and Chemistry I, grades in these courses replace the pre-enrollment variables as predictors. As a student completes the sophomore year and has taken Physics II and Calculus II the new predictors become grades in Calculus II, Physics II and Physics I. This is consistent with the finding that the grades in mathematics and science courses are good indicators of potential success in future engineering courses (Jakabowski et. al., 1988).

To the authors' knowledge the only previous study that attempted to predict simultaneously both persistence and success in engineering using both intellective and non-intellective variables was Levin and Wyckoff, 1988. This study used the same population as the present study, and used pre-enrollment variables to predict persistence and success in engineering at the end of the freshman year. With a few exceptions the same pre-enrollment variables that predicted persistence and success at the end of the freshman year also predicted students qualifying for and deciding to enroll in a major in the College of Engineering at the end of the sophomore year. However, the order of the predictors' contributions to the total chi-square did change.

In the case of sophomore predictions, the SAT verbal score was not significant whereas it had a slightly negative effect as a freshman year predictor. The two most prominant variables, the algebra score (ALG) and high school average (HSGPA), changed positions with the HSGPA being the most predictive for the sophomore year. However, the most noteworthy change was gender (GENDER) which was the least predictive for the freshman year, but became the third most important variable for the sophomore year, with males being more likely to successfully persist than females. The variables non-science points (NSPTS), chemistry score (CHEM) and reason for choosing engineering (REASON) remained in the same positions relative to each other. Students with genuine reasons for choosing engineering were more likely to successfully persist than those with superficial reasons.

The two variables that contribute most to predictive Model I (high school average, algebra score) are intellective and reflect general academic achievement as well as specific achievement in mathematics. Such variables typically reflect the use of abilities over a period of time, which is determined by such personal student characteristics as motivation, attitudes and study habits. Such variables are well-established predictors of overall academic performance in science-oriented programs of study (Dorio, et. al, 1980; Wyckoff, 1982). These findings demonstrate a commonly held belief that the best predictor of future behavior is past behavior. However, in this study these variables are predicting not only academic performance, but also a student's decision to enroll in a College of Engineering major after the completion of the sophomore year. Although it is acknowledged that academic performance may contribute to a student's decision to persist in any given major, there are always students who do not persist in engineering even though they achieve at high levels. The complex interaction between persistence and academic performance is an area that requires further study.

A noteworthy outcome of this research is the finding that the variables which are predictive depend on the student's point of progress through the first two years of an Engineering program. The pre-enrollment variables of Model I (both intellective and non-intellective) are all replaced by academic performance variables in Models II and III as a student progresses through an engineering program. A reasonable hypothesis (to be tested in a future study) is that performance in calculus, physics and chemistry is a function of the pre-enrollment characteristics of students.

TABLE 2: Model I - Logistic Regression for Persisting in Baccalaureate Engineering Successfully vs. All Other Enrollment Statuses at the End of the Sophomore Year

EFFECT	DF	ESTIMATE	CHI-SQ	PROB
INTERCEPT	1	-4.665	44.73	.0001*
HSGPA	1	0.751	14.63	.0001*
ALG	1	0.055	10.97	.0009*
GENDER	1		10.07	.0015*
MALE		0.314		
FEMALE		-0.314		
NSPTS	1	-0.016	8.85	.0029*
CHEM-S	1	0.053	6.82	.0090*
REASON	1		5.93	.0149*
GENUINE		0.223		
SUPERFICIAL		-0.233		

*P≤.10

TABLE 3: Model II - Logistic Regression for Persisting in Baccalaureate Engineering Successfully vs. All Other Enrollment Statuses at the End of the Sophomore Year

EFFECT	DF	ESTIMATE	CHI-SQ	PROB
INTERCEPT	1	-0.731	9.25	.0024*
PHYS I	2		72.55	.0001*
A/B		1.046		
C		0.130		
D/F		-1.176		
CALC I	2		32.39	.0001*
A/B		0.744		
C		-0.084		
D/F		-0.660		
CHEM I	4		24.46	.0001*
A		1.082		
B		0.648		
C		0.169		
D		-0.720		
F		-1.179		

*P≤.10

TABLE 4: Model III - Logistic Regression for Persisting in Baccalaureate Engineering Successfully vs. All Other Enrollment Statuses at the End of the Sophomore Year

EFFECT	DF	ESTIMATE	CHI-SQ	PROB
INTERCEPT	1	0.016	0.01	.9350
CALC II	2		38.34	.0001*
A/B		0.918		
C		0.174		
D/F		-1.092		
PHYS II	4		35.95	.0001*
A		1.479		
B		0.874		
C		0.241		
D		-0.618		
F		-1.976		
PHSY I	2		7.58	.0226*
A/B		0.459		
C		0.083		
D/F		-0.542		

$*P \leq .10$

REFERENCES

Dorio, H. F.; Kildow, C. A. and Slover, J. A. T. (1980). Mathematics Achievement Level Testing As a Predictor of Academic Performance and Retention in Engineering Students. Paper presented at the third annual meeting of the Southwest Educational Research Association, San Antonio, TX. February.

Jakabowski, G. S.; Lovett, G.; and Ehasz-Sanz, M. (1988). External Factors That Affect The Retention of Engineers: An Urban University Perspective. Proceeding 1988 Annual Conference, American Society for Engineering Education, 838-842.

Levin, J. and Wyckoff, J. (1988). Effective Advising: Identifying Students Most Likely to Persist and Succeed in Engineering. Engineering Education, 78(110, 178-182.

Wyckoff, J. H. (1982). A Profile of College of Engineering Graduates at The Pennsylvania State University. Division of Undergraduate Studies, Report 1982.2, Pennsylvania State University, University Park, PA.