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AUTHOR Fletcher, John T.; Halpin, Gerald; Halpin, Glennelle
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ABSTRACT

Whether a set of predictor variables could be identified from pre-enrollment and post-enrollment data that would differentiate students who advance to a major in engineering from those who do not was studied with students at Auburn University, Alabama. Also studied was whether predictors could be isolated that would identify students likely to graduate with another major and whether any relationship exists between the grades earned by students and 15 courses selected from the pre-engineering curriculum. Participants were 868 freshmen who entered as pre-engineering students over the course of 7 years. Variables used were high school total grade index, high school mathematics grade index, high school science grade index, high school humanities grade index, and first quarter college grade point average. Analyses indicated that first quarter college grade point average was a significant indicator in the prediction of success in higher education. In addition, high school grade indices also predict at a high rate. (Contains 30 references.) (SLD)

High School and College Grades:

Is Past Performance a Predictor of Future Performance?

John T. Fletcher

Gerald Halpin

Glennelle Halpin

Auburn University

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Is Past Performance a Predictor of Future Performance?

Student attrition from institutions of higher education has long been a concern. This loss impacts not only the individual and the institution but also the world of work and society at large. An understanding of the factors related to student persistence is needed. Considered in this study were both high school and college grades used as predictors of advancement in and graduation from a professional college program.

Many previous studies (Astin, 1972; Astin, 1975; Bayer, 1973; Iffert, 1957; McNeely, 1937; Pantages & Creedon, 1978; Tinto, 1987) have repeatedly shown that the loss of students before graduation can be placed at approximately 45%-50% (Porter, 1990). The scale of the importance of retaining students in engineering programs can be seen by the large number of students who do not progress to the professional engineering program. Levin and Wyckoff (1990) found that only 48.9% of students who entered a pre-engineering program had advanced to the professional program by the end of their sophomore year. According to their study 40.3% of the female students advanced in comparison to 50.36% of their male peers. Felder, Felder, Mauney, Hamrin, and Dietz (1994) found in a very small study which examined specifically females enrolled in a pre-engineering program in chemical engineering that after the second year of college 8% of the male students had not been retained in the program and 16% of the females had not been retained. The reported difference in retention rate is interesting to note given that the female students generally had better academic credentials when entering the program. Astin (1993) reported in a national study of 2,771 students that only 44% of students who

started in engineering maintained their choice over 4 years. Benefield, Walker, Halpin, Halpin, and Trentham (1996) reported that approximately 53.6% of students who entered a pre-engineering program were able to complete successfully the transition to the professional program. As these studies indicate, the potential loss of students during the first years of a pre-engineering program is staggering and needs to be addressed.

The purpose of this study was, first to determine whether a set of predictor variables could be identified from pre-enrollment and post-enrollment data that would differentiate students who advance to a major in engineering from non-advancers. A second purpose was to determine whether a set of predictor variables could be identified from pre-enrollment and post-enrollment data that would differentiate students who differentiate students who will graduate from the College of Engineering from students who will not graduate and students who will graduate from another school or college within the University. A third purpose was to determine if any relationship exists between the grades earned by the students studied and 15 courses selected from the pre-engineering curriculum.

Review of Literature

Much literature is available in the area of retention. Many studies have been conducted and published. However, the information offered here is a brief review the available literature which relates directly to the research questions which have been asked.

High School Grades and Academic Success

Many investigators including Summerskill (1962); Astin (1975, 1977); Fetters (1977); Pantages and Creedon (1978); Pascarella, Duby, Miller, and Rasher (1981);

Hossler, Bean, and Associates (1990); and Smith (1993) have identified high school grade point average or general success in high school as a factor significantly correlating with persistence.

Two studies conducted during the 1960s are early evidence of the importance of high school grades as predictors of persistence. Irvine (1966), after a 5-year study of University of Georgia students, noted that high school grade point average was the best single predictor of persistence. Ivey (1966) indicated that high school rank was the most effective predictor of success in college.

Spady (1971) determined that "success in achieving extrinsic academic awards is minimally dependent on one's personality dispositions and structural relationships within the College, but glaringly contingent on one's academic potential" (p. 48). He further went on to say that the measures of this potential were high school grade performance, high school academic quality, and verbal and mathematical aptitude. Spady (1971) found that 14.77 % of the explained variance in grade performance in college could be attributed to academic potential for men and 13.06 % for women. However, Spady examined the variance in graduation and found in a stepwise analysis that academic potential only accounted for .30 % for men and .14 % for women. He stated in his conclusion that "the more academically competitive one's high school, the stronger his performance there, and the higher his mathematical and verbal aptitude, the greater are his chances of successfully meeting the formal academic demands of College" (p. 59).

Astin (1975) identified several characteristics of students who were likely to drop out. Among those were rural background; lack of educated parents; low college

aspirations; and, important for this study, a less-than-successful high school record. Further, Astin (1977) found a correlation of .29 for high school grades, out of a total multiple correlation of .42 for all freshman characteristics. In recent research, Astin, Tsui, and Avalos (1996) reported that high school grades are a major determinant of the students' completing college. In addition, Astin et al. (1996) noted that students who have the weakest academic preparation take longer than 4 years to complete the bachelor's degree. Utilizing high school grade point average only, Astin et al. (1996) was able to explain 29 % of the total variance. Further, Astin (1993) reported that students who were likely to maintain an interest in engineering had good grades in high school.

Bean (1980) found that the second most important indicator of dropout was performance in high school for women with a total effect of -.14. However, Bean (1980) did not identify performance in high school as an important indicator for men. He did note that for men, university grade point average was the most important predictor for dropout. An interesting point was that Bean (1980) found that university grade point average was highly correlated with performance ($\underline{r}$ = .50) indicating a very strong relationship. Further, Bean and Bradley (1986), in a study designed to address the relationship between satisfaction and performance, found that high school performance was the best predictor of grade point average. Further they stated "for both men and women, based on the beta weights, the effect of performance on grade point average was more than twice as powerful as any other variable" (p. 407).

Likewise, Hossler et al. (1990) identified a number of variables that affect student retention. They are high class rank in high school; college preparatory courses; realistic

goals; well educated parents; strong financial support; support from parents for college goals; and, important for this study, success in high school.

With these general findings as building blocks, it is important to note some specific findings for consideration. Pascarella et al. (1981) using discriminant analysis found that pre-enrollment variables including secondary school academic performance had an overall R^2 value of .126 and was significant at $p < .001$. Chaney and Farris (1991) found that students who had above the mean high school grade point averages graduated at a much higher rate than students who had high school grade point averages below the mean. In recent work, Smith (1993) reported that high school grade point average, class rank, and ACT composite score were important in predicting attrition. Gillespie and Noble (1992) reported finding that high school grade point average and the number of math courses taken were significant predictors of persistence. Myers and Pyles (1992) found that high school grade point average was a good predictor for both White and Black freshmen. In the area of engineering, Felder et al. (1994) reported that women often have higher pre-engineering credentials than men yet women are less successful in engineering programs. Levin and Wyckoff (1990) reported that, although high school grade point average as a variable used to predict success is not constant over time, it is an important predictor during an engineering student's first 2 years. Further, they found that during the sophomore year SAT verbal score was not significant, but the algebra score and high school grade average were significant. Their findings in general were that the "best predictor of future behavior is past behavior" (p. 11).

First Quarter College Grades and Academic Success

Several studies have shown a relationship between first quarter/semester college grades and graduation. Dalton, Anastasiow, and Brigman (1977) defined an underachiever as a student whose first semester college grade point average is below his or her expected GPA. Carney and Geis (1981) noted that successful students did have higher first semester GPAs and that GPA was correlated with the composite ACT score.

Pascarella et al. (1981) found that by including first quarter college grade point average the $\underline{R}^2$ jumped from .126 for pre-enrollment variables to $\underline{R}^2 = .224$ which was significant at $\underline{p} < .001$. Further, Pascarella et al. noted that first quarter grade point average made a significant contribution to the increase in $\underline{R}^2$ ($\underline{F} = 53.19$, $\underline{df} = 2,1700$, $\underline{p} < .001$) with all pre-enrollment variables held constant.

Levin and Wyckoff (1990) included grades for Physics I, Calculus I, Chemistry I, Physics II, and Calculus II into their model for predicting persistence of engineering students through the first 2 years of college. They found that the grades for these courses were better predictors during the sophomore year than pre-enrollment variables. Allen (1994) concluded that college grades are a significant factor in explaining the differences between dropouts and persisters. Further, he stated that students considering leaving school are positively influenced to persist if programs focus on academic ability, institutional commitment, and encouragement from family and friends.

Method

Participants in the Study

The participants in this study were the 868 first-time entering freshmen enrolled at Auburn University for the Summer or Fall Quarters of 1991 as pre-engineering students. Six groups were identified: students who advanced to a major in the engineering program, non-advancers who had good grades, non-advancers who had poor grades, graduates in the College of Engineering, graduates from another Auburn University school or college, and non-graduates.

The advancers group was defined as all students who were successful in moving into a major in the engineering program. The non-advancers group was defined as all students who did not advance into a major in the engineering program. Further, non-advancers were broken down into two groups. Those students who maintained a cumulative grade point average at or above a 2.2 were identified as non-advancers with good grades. Non-advancers who had a cumulative grade point average below a 2.2 were identified as non-advancers with poor grades.

The graduate group (completed B.S. degrees) was composed of all students who were enrolled as first-time entering freshman pre-engineering students for the Summer or Fall Quarters 1991 and who were awarded an undergraduate engineering degree from Auburn University by the conclusion of Spring Quarter 1997. Further, students who graduated from other Auburn University colleges and schools were identified as such, and students who did not graduate by Spring Quarter 1997 were identified as non-graduates.

Variables Used

The following variables were selected and utilized to predict advancement a major in the engineering program and graduation:

1. High school grades for individual courses (computed as indices)
2. Auburn University grades for 15 individual courses
3. First quarter college grade point average at Auburn
4. Sex
5. Engineering status which was determined by advancement into a major in the engineering program (yes, no by choice, and no because of poor grades)
6. Graduation status for Auburn University (graduated in College of Engineering, graduated from another college, and did not graduate from Auburn University)

Statistical Treatment of Data

The independent or predictor variables were high school math index, high school science index, high school humanities index, high school grade point index, Auburn University first quarter college grade point average. The dependent variables were engineering status and graduation status. Engineering status was defined as advancers, non-advancers with good grades, and non-advancers with poor grades. Graduation status was defined as graduates from the College of Engineering, graduates from another Auburn University school or college, and non-graduates.

The initial statistical treatment was to measure the relationships between the predictor variables utilized and the criterion variables of engineering status and graduation

from the University by using analysis of variance and bivariate correlation techniques. Further, a Fisher's Least Significant Difference (LSD) test was used to test which group means differed significantly on the predictor variables.

In addition, grades that students earned in the following 15 pre-engineering core courses with enrollments over 100 were examined using bivariate correlation techniques to examine possible correlation between each of the predictor variables and the grade earned in each respective course. The courses examined were Chemistry 101, Chemistry 102, Chemistry 103, Physics 220, History 101, History 102, History 103, History 121, Math 160, Math 161, Math 162, Math 264, Philosophy 102, Computer Science 120, and University Studies 102.

Results

Descriptive Data

The population studied included 868 students who entered Auburn University as freshmen in the pre-engineering program either Summer or Fall Quarter 1991. Of those students, 744 reported being White, 98 reported being Black, 2 reported being American Indian, 15 reported being Asian, 5 reported being Hispanic, 3 reported being non-resident aliens, and one did not report. The population was composed of 666 males and 201 females with sex not reported for one subject.

Engineering Status

Table 1 shows the relationships between the four high school indices (total high school grades, high school math, high school science, and high school humanities) and engineering status. Total high school grade index showed a significant difference existed

between the three engineering status groups tested, F (2, 649) = 70.87, $p < .001$. However, total high school grade index was not investigated further because of the high correlation with the other high school grade indices. The high school math index showed a significant difference existed between the three engineering status groups tested, F (2, 648) = 60.99, $p < .001$. A Fisher's LSD test revealed a significant difference ($p < .001$) in the means for those students who were admitted to a major in the engineering program (M = 26.09) and those students who were unsuccessful because of poor grades (M = 20.05). However, no significant difference was found between the group of students who were admitted (M = 26.09) and the group of students who were not admitted but who had good grades (M = 25.33). High school grade indices and engineering status had a strong relationship with an Eta of .397.

A significant difference existed between the three engineering status groups on high school science grade index, F (2, 649) = 45.84, $p < .001$. In addition, Fisher's LSD test showed that there was a significant difference between the means of those students who were admitted to the engineering program (M = 24.12) and those who were not admitted because of poor grades (M = 18.08). Additionally, there was a difference ($p <$ .05) between the means of those students who were admitted (M = 24.12) and those students who were not admitted but had good grades (M = 22.12). High school science grade index showed a moderately strong relationship with engineering status with an Eta of .352.

Table 1

Relationship Between High School Grade Indices and Engineering Status

Source	df	Sum of squares	Mean square	Eta	F
		Total high school grade index			
Status	2	60271.99	30135.99	.423	70.87*
Error	649	275961.40	425.21		
Total	651	336233.40			
		High school math index			
Status	2	4943.33	2471.67	.397	60.99*
Error	648	26262.17	40.53		
Total	650	31205.50			
		High school science index			
Status	2	4776.37	2388.19	.352	45.84*
Error	649	33809.01	52.09		
Total	651	38585.39			
		High school humanities index			
Status	2	11387.77	5693.89	.340	42.60*
Error	649	87741.14	133.65		
Total	651	98128.91			

* $p < .001$.

A significant difference existed between the three engineering status groups on the high school humanities grade index, F (2, 649) = 42.60, $p < .001$. A Fisher's LSD test indicated that there was a significant difference ($p < .001$) between the means of the group of student who were admitted (M = 58.09) and those students who were not admitted and had poor grades (M = 49.28). However, no significant difference was found between the means for those students who were admitted (M = 58.09) and those students who were not admitted but had good grades (M = 58.61) It is interesting to note that this group had a mean absolute value higher than the average for the entire group. Further a moderately strong relationship with engineering status was found with an Eta of .340.

The strongest relationship with engineering status was found to be with first quarter college grade point average. Table 2 clearly shows that a significant difference existed between first quarter college grade point average and the three engineering status groups, F (2, 833) = 287.18, $p < .001$.

Table 2

Relationship Between First Quarter College Grade Point Average and Engineering Status

Source	df	Sum of squares	Mean square	Eta	F
Status	2	313.15	156.58	.639	287.18*
Error	833	454.17	.55		
Total	835	767.32			

* $p < .001$.

A Fisher's LSD test determined that highly significant differences existed among all three engineering status group means. The first quarter college grade point average for the group of students who were admitted to engineering (M = 3.01) was significantly different ($p < .001$) from the first quarter college grade point averages of the group of students who were not admitted but had good grades (M = 2.62) as well as the group of students who were not admitted but had poor grades (M = 1.65). It is very evident that first quarter college grade point average is the most significant variable in process of being admitted to a major in the engineering program of choice.

Graduation

The relationships between graduation status and the computed high school grade indices were very similar across all variables. Table 3 shows that a significant difference existed between the total high school grade index and graduation, with F (2, 671) = 15.62, $p < .001$. However, as with previous variables, high school total grade index was not investigated further because of a high degree of correlation with the other high school grade indices. Further, an ANOVA indicated that a significant difference existed between group means of the three graduation groups and high school math index with F (2, 670) = 15.46, $p < .001$. A Fisher's LSD test indicated that a significant difference existed between the means of the group of students who graduated from the College of Engineering (M = 25.79) and both the group of students who graduated from another college (M = 23.01) and those who did not graduate (M = 22.65). Math high school grade index had the strongest relationship with graduation with an Eta of .210.

Further, an ANOVA indicated that there was a significant difference between high school science index for the three graduation groups with $F(2, 671) = 14.62$, $p < .001$. A Fisher's LSD test indicated that significant differences ($p < .001$) existed between the group means of students who graduated from Engineering ($M = 23.71$) and both the group of students who graduated from another college ($M = 20.75$) and the group of students who did not graduate ($M = 20.31$). High school science index also a moderately strong relationship with graduation with an Eta of .205.

An ANOVA revealed that significant differences existed between the three graduation groups on the high school humanities grade index with $F(2, 671) = 8.48$, $p < .001$. A Fisher's LSD test indicated that a significant difference ($p < .001$) existed between the group means of students who graduated from Engineering ($M = 57.05$) and those students who did not graduate ($M = 52.57$). However, no significant difference ($p < .218$) was found between the group means of students who graduated from Engineering ($M = 57.05$) and those students who graduated from other colleges ($M = 55.63$). The weakest relationship involving the high school grade indices was found to exist between the high school humanities grade index and graduation with an Eta of .158. However, it is important to keep in mind that this is still a positive relationship that was statistically significant.

Table 3

Relationship Between High School Grade Indices and Graduation

Source	df	Sum of squares	Mean square	Eta	F
			Total high school grade index		
Graduate	2	15225.66	7612.83	.210	15.62*
Error	671	327073.50	487.44		
Total	673	342299.20			
			High school math index		
Graduate	2	1420.44	710.22	.210	15.46*
Error	670	30783.13	45.95		
Total	672	32203.57			
			High school science index		
Graduate	2	1648.33	824.16	.205	14.62*
Error	671	37808.98	56.35		
Total	673	39457.31			
			High school humanities index		
Graduate	2	2475.06	1237.53	.158	8.47*
Error	671	97848.80	145.82		
Total	673	100323.90			

* $p < .001$.

An ANOVA indicated that there was a significant difference in the means of the three graduation groups for the first quarter college grade point average, F (2, 862) = 111.67, $p < .001$. (see Table 4). A Fisher's LSD test indicated that a significant difference ($p < .001$) existed between the mean first quarter college grade point averages of the group of students who graduated from the College of Engineering ($M = 3.01$) and both the group of students who graduated from another college ($M = 2.38$) and those students who did not graduate ($M = 1.99$). The single strongest relationship identified with graduation was the first quarter grade point average with an Eta of .454.

Table 4

Relationship Between First Quarter College Grade Point Average and Graduation

Source	df	Sum of squares	Mean square	Eta	F
Graduate	2	163.09	81.54	.454	111.67*
Error	862	629.43	.73		
Total	864	792.52			

* $p < .001$.

Correlation Between Grades Earned in 15 Classes With 100 or More Students and Predictor Variables

Tables 5 and 6 contain the Pearson correlations between the predictor variables and following courses: Chemistry 101, Chemistry 102, Chemistry 103, Physics 220, History 101, History 102, History 103, History 121, Mathematics 160, Mathematics 161, Mathematics 162, Mathematics 264, Philosophy 102, Computer Science 120, and University Studies 102. Relationships were examined for the following predictor variables: high school math index, high school science index, high school humanities index, total high school grade index, and first quarter college grade point average.

Table 19 indicates that in general the high school grade indices have a stronger more positive relationship with the grades earned in the 15 selected courses than was indicated by the ACT test score correlations. Further, all the high school grade indices had correlations significant at or above the $p < .05$ level.

Table 6 indicates that the strongest relationship between grades in the 15 selected courses and the predictor variables was with first quarter grade point average. The correlations for first quarter college grade point average and grades in selected courses indicate a strong positive relationship with all courses. For each course the significance level does not drop below $p = .001$.

Table 5

Correlations for Grades Earned in Selected Courses and High School Grade Indices

	High school grade indices			
Course	Total	Math	Science	Humanities
Chem 101	.426**	.411**	.431**	.292**
Chem 102	.361*	.352**	.329**	.253**
Chem 103	.362**	.321**	.338**	.266**
Phys 220	.181**	.155**	.221**	.094
Hist 101	.498**	.432**	.437**	.391**
Hist 102	.338**	.203*	.269**	.333**
Hist 103	.362**	.277**	.219*	.358**
Hist 121	.365**	.304**	.295**	.313**
Math 160	.349**	.385**	.260**	.261**
Math 161	.335**	.359**	.255**	.243**
Math 162	.341**	.339**	.300**	.241**
Math 264	.418**	.299**	.297**	.389**

(table continues)

Table 5. (continued)

Course	High school grade indices			
	Total	Math	Science	Humanities
Phil 102	.393**	.255**	.298**	.415**
Comp 120	.372**	.283**	.365**	.280**
Univ 102	.443**	.303**	.379**	.426**

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

Table 6

Correlations for Grades Earned in Selected Courses and First Quarter College Grade Point Average

Course	Correlations for First quarter college grade point average
Chem 101	.672**
Chem 102	.477**
Chem 103	.816**
Phys 220	.498**
Hist 101	.762**
Hist 102	.587**
Hist 103	.583**
Hist 121	.653**

(table continues)

Table 6. (continued)

Course	Correlations for First quarter college grade point average
Math 160	.777**
Math 161	.720**
Math 162	.600**
Math 264	.415**
Phil 102	.475**
Comp 120	.687**
Univ 102	.462**

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

Summary and Conclusions

Summary

The variables selected for study were a combination of variables that represented data about students prior to initial enrollment in college and during their first quarter of attendance. The variables utilized in this study were high school total grade index, high school math grade index, high school science grade index, high school humanities grade index, and first quarter college grade point average.

Information regarding the subjects was gathered for a period beginning with the Summer Quarter 1991 and ending with the Spring Quarter 1998 for a period of approximately 7 academic years of enrollment. Groups were formed as follows:

advancers, non-advancers with poor grades, non-advancers with good grades, graduates from the College of Engineering, non-graduates, and graduates from another school or college at Auburn University.

One way ANOVAs were performed on all the predictor variables followed by Fisher's LSD tests. All the predictor variables studied were found to be statistically significant in determining the differences between the group means of advancers and the group mean of non-advancers with poor grades. It is interesting to note that only two variables were found to be statistically significant in determining the differences between the group of advancers and the group of non-advancers with good grades. They were high school science grade index and first quarter college grade point average. In general, advancers differed from non-advancers with poor grades but not from non-advancers with good grades.

Further, each of the predictor variables were examined using a one way ANOVA and those analysis were followed by a Fisher's LSD test. Those investigations revealed that all the predictor variables were statistically significant when comparing the group of subjects who graduated from the College of Engineering and those subjects who did not graduate. However, high school math grade index, high school science grade index, and first quarter college grade point average were the only predictor variables for which a significant difference was found between the group of subjects who graduated from the College of Engineering and those students who graduated from another school or college at Auburn.

The third research question examined the degree of correlation that high school math index, high school science index, and high school humanities index had with 15 selected courses that had enrollment of over 100 students and were part of the pre-engineering program. The results were divided into two categories: high school grade indices and first quarter grade point average. The correlations with high school grade indices were on average generally strong, ranging from a high of .498 for the relationship between History 101 grade and total high school grade index to a low of .094 for the relationship between Physics 220 grade and high school humanities index. The strongest relationships were found to exist between the first quarter college grade point average and all 15 of the selected courses. The relationship between the first quarter college grade point average and the 15 selected courses was on average .612. Further, the correlations ranged from a high of .816 for the relationship between first quarter college grade point average and Chemistry 103 to a low of .415 for the relationship between first quarter college grade point average and Mathematics 264.

It is evident from the research presented that the first quarter college grade point average is a significant indicator in the prediction of success in higher education. In addition, high school grade indices also predict at a high rate.

Conclusions

It should be obvious to the reader from the review of literature found in the field of retention that research in this area indicates that concerns surrounding retention in higher education is not a new phenomenon. Further, those same studies of retention conducted during the last 50 years have consistently indicated that less than 40% of freshmen never

earn a baccalaureate degree from the original institution of entry (Astin, 1972; Astin, 1975; Bayer, 1973; Iffert, 1957; McNeely, 1937; Pantages & Creedon, 1978; Tinto, 1987a). A purpose of this study was to identify factors that could be identified prior to enrollment or during the student's first quarter at Auburn University which would discriminate successful students from those who were not successful.

First, by utilizing the high school grade indices, an innovative and different approach was developed to identify pre-engineering students who will be successful. Bean and Bradley (1986) found that high school performance was the best predictor for college grade point average. Gillespie and Noble (1992) reported that cumulative grade point average and ACT student background information were moderately effective in predicting freshman persistence (median multiple $\underline{R} = .52$). Astin et al. (1996) also concluded that students who enter with good high school grades are more likely to graduate. Further, Astin et al. (1996) suggested that although high school and SAT contribute independently to prediction, together they provide a significant predictor of graduation. In this study the relationship was moderately strong between all high school grade indices and both advancement to a major in the engineering program and graduation from the university. However, the strongest single predictor variable was first quarter college grade point average. First quarter college grade point average had an Eta of .639 for advancement to a major in engineering program and .454 for graduation from the College of Engineering. These two relationships were the strongest of the entire study.

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