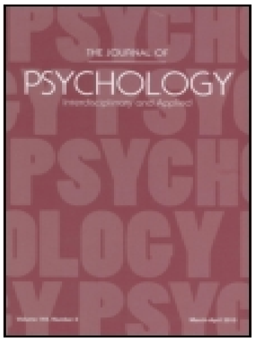

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Are Math Readiness and Personality Predictive of First-Year Retention in Engineering?

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ABSTRACT. On the basis of J. G. Borkowski, L. K. Chan, and N. Muthukrishna's model of academic success (2000), the present authors hypothesized that freshman retention in an engineering program would be related to not only basic aptitude but also affective factors. Participants were 129 college freshmen with engineering as their stated major. Aptitude was measured by SAT verbal and math scores, high school grade-point average (GPA), and an assessment of calculus readiness. Affective factors were assessed by the NEO–Five Factor Inventory (FFI; P. I. Costa & R. R. McCrae, 2007), and the Nowicki–Duke Locus of Control (LOC) scale (S. Nowicki & M. Duke, 1974). A binary logistic regression analysis found that calculus readiness and high school GPA were predictive of retention. Scores on the Neuroticism and Openness subscales from the NEO-FFI and LOC were correlated with retention status, but Openness was the only affective factor with a significant unique effect in the binary logistic regression. Results of the study lend modest support to Borkowski's model.

Keywords: calculus readiness, college retention, engineering students, Five Factor Model, Locus of Control, STEM fields

THE NEED FOR TRAINED ENGINEERS IN THE U.S. WORKFORCE is constantly increasing, and the number of students graduating from engineering programs is not keeping up with this demand (Duderstadt, 2001). Even though students are applying to engineering programs at rates that match those of other college

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programs such as medicine and law, the retention and graduation rates for engineering students remain low (Duderstadt, 2001; House, 2000; Whalen & Shelley, 2010). While the number of applicants to engineering programs is growing, there are still not enough engineers to meet the workforce demand (Morton, 2007).

Countries outside of the United States are beginning to see increased numbers of applicants to their engineering programs (Morton, 2007). China and India are using engineering technology to enhance lives with research and development. The numbers of graduates in these countries are astonishing with about 500,000 graduates in 2004–2005 for China and 170,000 graduates in 2005 for India (Morton, 2007). The United States and United Kingdom are nowhere near these numbers in undergraduate degrees awarded for engineering. While the number of individuals considering engineering as a field is increasing, the United States and United Kingdom are falling short of meeting current and future demands in the workforce (Morton, 2007).

One of the concerns with the engineering programs in the United States is that while applicant and acceptance rates have remained constant over the past few years, the retention rates for these programs are low (Daempfle, 2003; Morton, 2007). House (2000) found that "only 35% of students who began college in SEM (science, engineering, and mathematics) majors persisted to eventually graduate from SEM disciplines" (p. 207). The retention rates are the lowest for women and ethnic minority students. Ethnic minorities make up approximately one-third of the school-age population, yet they are less likely to graduate from engineering programs than nonminorities (Tsui, 2007). The numbers of ethnic minority students pursing a degree in the science, technology, engineering, and mathematics (STEM) fields are increasing, but African Americans, Hispanic/Latino, and Native Americans represent only about 11% of those employed STEM occupations (Tsui, 2007). For retention rates in engineering programs alone, only 32.3% of African Americans who enroll in the beginning of the program continue to graduate (Georges, 2000). Georges states that "a minority student entering engineering is only half as likely to obtain a bachelor's degree as a non-minority student" (p. 34).

One way of improving retention and graduation rates among students entering engineering programs is to address their ability to succeed academically in these programs. A model by Borkowski, Chan, and Muthukrishna (2000) suggests that academic success is based on a number of interactive components. These components can aid an individual in using his or her ability efficiently and effectively if basic aptitude is present, and metacognition is one of those factors. "Metacognition" has been defined as awareness of cognitive processes and how to strategically employ these processes in order to be more efficient and effective when engaged in a learning task (Meichenbaum, 1986). It is used to regulate thinking and learning processes including planning, monitoring, and evaluation. Borkowski's model proposes that there are two key aspects to the metacognitive process. One aspect of metacognition involves acquisition procedures (executive system), and the other focuses on affective factors (Borkowski et al., 2000). The executive system helps the individual analyze components of a learning task and then be able to determine what approach will be the most effective and efficient (i.e., rote memory versus organization and mnemonic strategies). It is based on an individual's knowledge of his or her own learning styles and the use of this personal knowledge in an effective and efficient manner (Hall, Smith, & Chia, 2008). The affective component includes an individual's self-efficacy, motivation, locus of control (LOC), and personality characteristics or traits. When an individual demonstrates high levels of executive processes and the affective factors are such that they benefit the individual in academic endeavors, then that individual is more likely to be successful.

Entering math skill has also been proposed as one of the primary factors influencing retention in the STEM fields, especially engineering (Astin & Oseguera, 2005; Robinson, 2003). Robinson (2003) indicated that students who took advanced math and science courses while in high school were more likely to be successful in college. In looking at the choice of majors among these students upon entering college, he found a strong relationship between students who took these advanced courses and choice of a STEM major. Specific to engineering, his research also indicated a strong correlation between advanced courses in high school and success in the engineering program. These advanced courses at the high school level were especially influential in encouraging minority students to pursue engineering as a college major with engineering representing the most popular choice for minority students. Nonminority female students were still less likely to choose engineering, however.

As noted in Borkowski's model (Borkowski et al., 2000), one of the affective factors beyond aptitude that may contribute to being successful academically is personality. One way of assessing personality characteristics that has gained popularity in recent years involves the Five Factor Model (FFM; Costa & McCrae, 1992). The factors from the FFM are Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. Numerous research studies have been conducted in recent years on the personality factors of the FFM and academic success (Conard, 2006; Komarraju & Karau, 2005). Conard's (2006) research assessed the incremental validity of the Five Factor model in predicting academic success beyond that accounted for by cognitive ability. He found personality measures (conscientiousness, in particular) showed promise in predicting academic outcome, and he further suggested the potential use of such measures in college education.

Research has also been conducted on the affective factor of LOC as a predictor of academic success (Brownlow & Reasinger, 2000; Bursik & Martin, 2006; Silberstein, 2005). LOC can be viewed as a person's perception of influences on life outcomes or the underlying causes of events. Individuals with an internal LOC credit success and failure to personal attributes or their actions, while individuals with an external LOC credit outside forces such as luck or powerful others as being in control of their success and failure (Silberstein, 2005). The Nowicki–Duke Locus of Control Scale (ND–LOC) has been frequently used by researchers to assess LOC in college populations (Nowicki & Duke, 1974, 1989). Research has shown the scale to be useful in predicting academic success in students. Individuals expressing internal LOC traits were more likely to succeed in academics compared to those with external LOC. Recent studies have also used LOC as one of the affective factors contributing to academic success (Brownlow & Reasinger, 2000; Gifford, Briceño-Perriott, & Mainzo, 2006; Hulse et al., 2007; Uguak, Elias, Uli, & Suandi, 2007). Hulse et al. conducted research on the influence of LOC on academic success and found those students with higher internal LOC were more likely to succeed in academics.

The current study foci are on both entering scholastic aptitude and affective factors of personality in aiding in the prediction of retention in engineering at the end of the freshman year. Aptitude is measured by the Assessment and Learning in Knowledge Spaces (ALEKS) examination; Scholastic Assessment Test (SAT), Verbal and Math sections; and high school grade point average (GPA). Affective factors in the current study include the five personality traits as measured by the NEO–FFI and locus of control as measured by the ND–LOC.

Engineering programs attract many students around the world, but within a few years many of these same students opt to change majors and drop out of the program before completion. The numbers of students completing engineering programs are low in comparison to the numbers who initially enter these programs. Identifying factors that aid in determining which students are more likely to experience problems with engineering could also allow for effective interventions that could help retain students.

Method

Participants

Out of a possible 147 college freshmen, 139 agreed to participate in the study. All participants indicated engineering as their major and were enrolled in an introductory engineering course specifically designed for entering freshman students. Of the initial 139 students' surveys, 10 had incomplete data sets and were eliminated from analysis, leaving 129 students (111 men and 18 women). At the end of their freshman year, data sets from students were separated into retainees ($n = 65$; 57 men and 8 women) and nonretainees ($n = 64$; 54 men and 10 women). *Retainees* were defined as students still declaring engineering as their intended major at the end of the freshman year. Of the retainees, 2 indicated their race or ethnicity as African American, 6 indicated it as Hispanic or Latino, 1 indicated it as Asian, 53 indicated it as Caucasian, and 3 indicated it as other. Nonretainees were students who no longer declared engineering as their intended major. Of the nonretainees, 2 indicated their race or ethnicity as Native American, 9 indicated it as African American, 4 indicated it as Asian, 43 indicated it as Caucasian, and 2 indicated it as other. The nonretainee group included 48 students who changed to a different declared major, 3 students who transferred to another university, and 13 students who dropped out of school at the end of their freshman year due to poor academic performance.

As previously noted, not all students who left the engineering program at the end of their freshman year were in poor standing academically, but this was the key factor for 20% of the nonretainees. There was a significant difference with respect to college grade-point average (GPA) between the two groups, $t(127) = 6.95$, $p < .01$. Students who were retained in the engineering program had higher college GPAs at the end of their freshman year than did nonretainees, $M = 2.71$ ($SD = 0.66$) and $M = 1.86$ ($SD = 0.73$), respectively. Due to college GPA being a factor in determining grouping of students at the end of the freshman year, it was not used in the binary regression analysis to predict retention status.

Instruments

Assessment and Learning in Knowledge Spaces

The Assessment and Learning in Knowledge Spaces (ALEKS) is a calculus readiness exam used by the engineering program as a means of measuring students' mathematical readiness for college-level calculus. Scores from the ALEKS are used to determine if a student has the prerequisite knowledge to be placed in college calculus in the fall of their freshman year. For admission into East Carolina University's engineering program, each student was administered the ALEKS test during the summer before beginning college in the fall.

The Scholastic Assessment Test

The Scholastic Assessment Test (SAT) scores are part of students' applications to the university where this study took place, and students' scores were obtained from admission records. While the SAT has undergone substantial modification since its inception, it remains one of the primary assessment instruments used in college admission (Cech, 2008). The latest revision of the SAT in 2005 added a writing component to the verbal and mathematics components (College Board, 2009; Coyle & Pillow, 2008). The SAT has been used by universities as a way of determining who would be more likely to succeed in the university setting (Cech). The SAT is also related to general aptitude, and researchers have used it as an estimate of college students' aptitude (Frey & Detterman, 2004).

Nowicki–Duke Locus of Control Scale

The Nowicki–Duke Locus of Control Scale (ND–LOC) measures locus of control in adolescents and young adults (Nowicki & Duke, 1992). The scale is a 40-item assessment that asks how a person feels during different life experiences, such as "Do you believe wishing can make good things happen?" Each question is answered by marking a "yes" or "no," and a point is assigned for every yes answer.

A high score on the assessment is associated with high levels of External LOC (Nowicki & Duke, 1974, 1992). Nowicki and Duke (1974) cite sound psychometric properties for the ND–LOC across 12 separate studies involving a total of 766 participants. Split-half reliabilities range from .74 to .86, and test–retest reliability over a 6-week interval is .83.

The Nowicki–Duke scale is similar to the Rotter scale for LOC based on social learning (Beretvas, Suzzio, Durham, & Yarnell, 2008). Beretvas et al. searched PsychInfo for any articles relating to internal validity or reliability of the ND–LOC and standardized the individual measurements to obtain an overall rating between Rotter and ND–LOC. In a fixed-effects model analysis, the ND–LOC proved to be statistically more reliable than Rotter's scale.

NEO Personality Inventory

The NEO Personality Inventory NEO-FFI is a personality assessment of five major personality factors: Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness (Costa & McCrae, 1992). The original NEO Personality Inventory, created in 1985, measured only three personality factors: Neuroticism, Extraversion, and Openness. In 1989, the NEO was revised to become the NEO-PI, and Agreeableness and Conscientiousness were added (Costa & McCrae). The NEO-FFI was introduced to provide a shortened version of the original scale (Costa & McCrae). Each question is rated on a five-point Likert scale ranging from *strongly agree* to *strongly disagree*.

Studies have supported the reliability of the scale scores. Costa and McCrae (1992) reported test–retest reliability with 208 college students over a 3-month period yielding coefficients of .79, .79, .80, .75, and .83 for Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness, respectively. However, a reliability generalization study by Caruso (2000) reported large amounts of variability in the reliability of the NEO scores, especially for Agreeableness and Openness. A 7-year longitudinal study using the full NEO-PI-R tested long-term stability. For the five-domain scale, coefficients ranged from .63 to .81. Internal consistency as measured by coefficient alpha has been reported to range from .56 to .81 for the domains and factors (Costa & McCrae).

Procedure

The data collected for the present study was a subset of a larger, ongoing longitudinal study that is examining the recruitment and retention of engineering students over the course of their college career. Participants in the current study were recruited in the fall of 2007 and fall of 2008 from a COAD 1000 Student Development and Learning in Higher Education class. Of the 147 students enrolled in this specific course, 139 volunteered to participate in this study. The university offers several freshman COAD seminars, ranging from general sections that are open to any freshman student to specific faculty-taught major sections that are open to students with a declared major. The COAD seminar for engineering majors was specific to freshmen students with engineering as their stated major and was taught by an engineering faculty member. The course provided an opportunity for students to meet peers with the same declared major and learn more about different fields open to engineering majors. Participants were recruited from this engineering seminar for the current study.

Participation in the study was voluntary, and choosing not to participate did not negatively affect a student's academic standing in the COAD 1000 course or the engineering program. The students who agreed to participate were asked to sign a consent form, and any questions regarding the study were answered. The consent form requested the students' permission for the researchers to access their SAT scores (Verbal and Mathematics), calculus readiness test scores as measured by the ALEKS, and both their high school and college GPAs as part of the study. Next, students were asked to complete a series of self-report questionnaires on basic demographic information (i.e., gender, age, classification, and ethnic origin), the NEO-FF, and the ND–LOC. Administration of the assessment battery took approximately 60 min. The Institutional Review Board (IRB) reviewed and approved the current study, and APA ethical guidelines for research with human participants were followed.

Results

Table 1 presents correlations, means, and standard deviations for the participants' scores on the various measures. For the purpose of the analyses, retainees are designated as 1, and nonretainees are designated as 2. The ALEKS score is based on a 0–100 point scale, high school GPA is on a scale of 0.00–4.0, while the SAT verbal and math scores are based on minimum of 200 and a maximum of 800 points for each. The correlations show that scores on the ALEKS as a measure of entering math skills, high school GPA, and scores on the SAT Math scale were predictive of retention in the engineering program. Personality factors associated with retention/nonretention are Openness, Neuroticism, and LOC. Higher scores on the measure of Openness, lower scores on Neuroticism, and more of a self-reported internal locus of control were significantly related to retention in the engineering program. Note that higher scores on the ND–LOC scale are indicative of a more external locus of control.

Scores on the ALEKS demonstrated a significant positive relationship with the SAT math section. However, there was not a significant relationship with high school GPA or any of the personality factors and scores on the ALEKS. High school GPA demonstrated a significant positive relationship with Conscientiousness. The SAT verbal score was significantly correlated with lower scores on Neuroticism and, surprisingly, lower scores on Conscientiousness. Scores on the SAT math were not significantly related to any of the personality variables. Among the personality variables, Neuroticism showed a negative relationship to

TABLE 1. Intercorrelations Among Study Variables ($N = 129$)

Variable	1	2	3	4	5	6	7	8	9	10	11	*M*	*SD*
1 Retainees (1) Nonretainees (2)		−44**	−.17*	−.08	−.27**	.14*	−.01	−.17*	−.01	−.05	.16*		
2 ALEKS			.12	.07	.37**	−.12	.03	.00	−.06	.08	−.12	49.56	17.61
3 HS GPA				.06	.17*	.05	.01	−.15*	−.12	.22**	.01	3.07	0.39
4 SAT Verbal					.46**	−.27**	−.02	−.01	−.02	−.21**	−.17*	489.30	65.35
5 SAT Math						−.13	−.01	−.00	−.02	−.13	−.05	553.41	70.16
6 Neuroticism						(.68)	−.24*	−.05	−.06	−.09	.40**	21.35	5.93
7 Extraversion							(.63)	.26**	.33**	.18*	−.05	29.76	4.58
8 Openness								(.49)	.09	.02	−.11	26.20	4.28
9 Agreeableness									(.53)	.18*	−.05	27.23	5.03
10 Conscientiousness										(.61)	−.23*	29.34	4.80
11 LOC											(.69)	11.94	5.39

Note. Scores shown in parentheses are alpha internal consistency reliabilities for NEO Five Factor Inventory Scales of Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness and the Nowicki-Duke Locus of Control Scale (LOC). Individual item scores were unavailable for other measures. ALEKS = Assessment and Learning in Knowledge Spaces; HS GPA = high school grade point average; SAT = Scholastic Aptitude Test.

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

Extraversion and a positive relation to scores on the ND–LOC (as noted earlier higher scores on ND–LOC indicate a more-external locus of control). Conscientiousness demonstrated a significant negative relationship to the ND–LOC scores and a positive relationship with Agreeableness. Extraversion was significantly and positively related to Openness, Agreeableness, and Conscientiousness.

A binary logistic regression analysis was then performed. The criterion was the dichotomous retention–nonretention variable. The predictors were entered starting with trait variables (i.e., personality) based on Borkowski's model (Borkowski et al., 2000) that posits that personality factors can serve to benefit the individual in academic endeavors beyond aptitude. Measures of aptitude were entered next. The order of entry was (a) the five personality factors from the NEO-FFI scale; (b) LOC scores; (c) scores on the ALEKS (taken once students had been accepted to ECU but before beginning their first semester of college); (d) SAT Verbal and Math scores; and (e) high school GPA. College GPA was not included in the regression model as it was used to define a portion of the nonretention group (i.e., students who failed to meet minimum academic standards as defined by college GPA).

Table 2 presents the results of the binary logistic regression analysis. When predictors are added to the model, the -2 Log likelihood, $-2LL$, should decrease if they improve the fit of the model. The change in $-2LL$ is evaluated on χ^2 with degrees of freedom equal to the number of predictors added in the step. The p value provided for each step is for the change in $-2LL$ from the previous step. For each predictor, at each step, "OR" is the odds ratio, the multiplicative amount by which the odds of nonretention change per 1 point of change in the predictor, after the researcher holds constant all of the remaining predictors in the model at that step. For example, an *OR* of 1 indicates that the predictor had no unique effect, while an OR of 0.9 indicates that the odds of nonretention are decreased by a multiplicative amount of 0.9 for each one point change in the predictor. The unique contribution of each predictor is evaluated by the Wald χ^2.

Before the entry of any predictors, the retention at end of freshman year of entering college students with engineering as their stated major was 50.4%, and nonretention was 49.6%. Based on the binary regression analysis, Block 1 entry of the five NEO-FFI subscales failed to reach statistical significance. The change in $-2LL$ after the first block of personality factors from the NEO-FF was 7.30, which was not statistically significant with change in overall percentage of correct classifications at 64.3%. However, Openness had a significant partial effect. The odds ratio was .914, which means that the odds of dropping out of the program were reduced by a multiplicative factor of .914 for each 1-point increase in the score on the Openness scale. Block 2 entry of LOC produced a change in $-2LL$ of 1.39, which was not statistically significant. Block 3 entry of ALEKS scores produced a significant change of 25.68 in $-2LL$ with each 1-point change in ALEKS indicating a change in odds of dropping out by a multiplicative factor of .938 with a percentage of correct classifications as 69.8%. Adding the SAT scores

TABLE 2. Sequential Binary Logistic Regression Predicting Retention in the Engineering Program ($N = 129$)

Variables	B	OR	$-2LL$	$\Delta - 2LL$	Wald χ^2	p	% correct
Step 1			171.52	7.304		.199	64.3
NEO-FFI							
Neuroticism	0.055	1.056			2.923	.087	
Extraversion	0.039	1.040			0.911	.340	
Openness	−0.090	0.914			3.925	.048*	
Agreeableness	−0.005	0.995			0.015	.903	
Conscientiousness	−0.019	0.981			0.242	.622	
Step 2			170.131	1.389		.239	58.9
NEO-FFI							
Neuroticism	0.040	1.040			1.293	.255	
Extraversion	0.034	1.034			0.661	.416	
Openness	−0.089	0.915			3.902	.048*	
Agreeableness	−0.004	0.996			0.012	.914	
Conscientiousness	−0.008	0.992			0.038	.845	
LOC	0.045	1.046			1.357	.244	
Step 3			144.455	25.676		<.001	69.8
NEO-FFI							
Neuroticism	0.029	1.030			0.633	.426	
Extraversion	0.045	1.047			1.008	.315	
Openness	−0.105	0.901			4.594	.032*	
Agreeableness	−0.023	0.978			0.265	.607	
Conscientiousness	0.005	1.005			0.016	.898	
LOC	0.044	1.044			1.037	.309	
ALEKS	−0.064	0.938			19.775	<.001**	
Step 4			142.515	1.941		.379	76.7
NEO-FFI							
Neuroticism	0.027	1.027			0.510	.475	
Extraversion	0.045	1.046			1.005	.316	
Openness	−0.105	0.900			4.584	.032*	
Agreeableness	−0.018	0.982			0.166	.684	
Conscientiousness	−0.001	0.999			0.001	.979	
LOC	0.046	1.047			1.133	.287	
ALEKS	−0.057	0.944			14.483	<.001**	
SAT verbal	0.001	1.001			0.130	.719	
SAT math	−0.005	0.995			1.813	.178	
Step 5			137.831	4.683		.030	79.1
NEO-FFI							
Neuroticism	0.037	1.038			0.872	.350	
Extraversion	0.059	1.061			1.583	.208	
Openness	−0.131	0.877			6.357	.012*	
Agreeableness	−0.037	0.963			0.674	.412	
Conscientiousness	0.026	1.027			0.312	.576	

(Continues on next page)

TABLE 2. Sequential Binary Logistic Regression Predicting Retention in the Engineering Program (N = 129) *(Continued)*

Variables	B	OR	$-2LL$	$\Delta - 2LL$	Wald χ^2	p	% correct
LOC	0.053	1.054			1.403	.236	
ALEKS	−0.059	0.943			14.961	<.001**	
SAT Verbal	0.002	1.002			0.289	.591	
SAT Math	−0.004	0.996			1.125	.289	
HS GPA	−1.276	0.279			4.423	.035*	

Note. Before the entry of any predictors, the cases that we retained were 50.4%, and the non-retained cases were 49.6%. −2LL = −2 log likelihood; ALEKS = Assessment and Learning in Knowledge Spaces; HS GPA = high school grade point average; LOC = Nowicki–Duke Locus of Control Scale; NEO–FFI = NEO Five Factor Inventory; SAT = Scholastic Assessment Test.
$^{*}p < .05$. $^{**}p < .01$.

did not produce a significant change in $-2LL$. The addition of high school GPA produced a significant change in $-2LL$, with the final model correctly classifying 79.1% of the cases.

The final model fit the data significantly better than an intercept-only model, $\chi^2(10, N = 129) = 40.993$, $p < .001$, and was able correctly to classify 79.1% of the cases (using a cutoff of .5), with sensitivity of 76.9% and specificity of 81.3%. Predictors with significant unique effects included the Openness subscale of the NEO-FFI (those scoring lower on Openness were less likely to be retained), ALEKS (those scoring lower were less likely to be retained), and high school GPA (those with lower high school grades were less likely to be retained).

Discussion

A binary logistic regression was run in order to determine if any of the affective factors or entering academic aptitude measures were predictive of retention. Three personality variables (Openness, LOC, and Neuroticism) had significant zero-order correlations with retention, but only Openness made a significant, unique contribution in the binary logistic model. While the unique contribution of Openness for predicting retention at the end of the 1st year was small in comparison to the contribution of ALEKS, it demonstrated an attribute associated with retention in an engineering program. It should be noted that the coefficient alphas for the NEO-FF scales were relatively low, with lower reliabilities making it less likely to find significant relations. This may be a factor in the other scales not being identified as significant predictors, but it also points to the strength of the Openness scale (lowest alpha) in emerging as a significant predictor. The Openness factor is often associated with the active seeking and appreciation of new experiences

(Costa & McCrae, 2007). McCrae and Costa (1999) also cite Openness as the most difficult of the Five Factors to measure as well as grasp. They posit that it may reflect an approach to intellectual matters that includes creativity, imagination, insightfulness, and wide interests as well as openness to new experiences. All of these may be important traits for a career in professions such as engineering, and it is not surprising that Openness was related to academic issues.

The model proposed by Borkowski suggests that it is the indirect role of the affective factors that can assist the metacognitive factors in increasing chances of academic success when aptitude is held constant (Borkowski et al., 2000). Results from the current study failed to support a direct effect of affective factors in the prediction of student retention at the end of the freshman year in engineering but did support the indirect affect. It should be noted, however, that the current study looked at retention for a specific college major and not overall college retention. While prior research has shown that certain personality factors from the FFM (i.e., Conscientiousness and Neuroticism) and LOC are predictive of overall college retention (Chamorro-Premuzic & Furnham, 2003; Conard, 2006; Hall et al., 2008; Komarraju & Karua, 2005), the present study was one of the first studies to look at these factors in regard to retention in a specific program. Of the 64 students who were not retained in the engineering program, 51 left the engineering program with GPAs that did not place them in academic jeopardy (i.e., probation or suspension) as defined by the university. Only 13 of the 64 nonretainees failed to meet academic standards. This is different from failure to be retained in college due to academic difficulties and may account for the different findings in this study as compared to the studies noted above. For engineering specifically, only the personality factor of Openness demonstrated a significant, unique influence in the regression analysis.

While there was a significant correlation between the SAT math score and retention, the SAT math was not found to be a significant predictor in the context of the other predictors in the binary logistic regression. In addition, SAT verbal failed to add significantly to the regression model. However, the scores from the ALEKS and high school GPA did add significantly to the model. Prior research by Robinson (2003) indicated that there was a significant correlation between students who took advanced math and science courses in high school and later retention in engineering. Students who failed to take these advanced courses were more likely to experience difficulties in the engineering curricula. Interestingly, the math section of the SAT was not a significant predictor. While the SAT math is an assessment of overall math preparation, the ALEKS is a measure specific to calculus readiness. The current study supports Robinson's findings that it is the advanced courses in math and science that better prepare students for STEM majors and not just the standard college preparatory courses. Freshmen engineering students entering college who are not only academically successful at the high school level but who are also prepared for calculus may experience less frustration and may be less likely to consider another major. However, if students enter college without this background, they may start at a disadvantage and struggle to catch up. These are the students who may decide that it is important to look at other options rather than staying with a major where they are already behind.

Given Robinson's (2003) research and the findings of this study showing the importance of high school preparation especially in regard to advanced math preparedness in retaining college students in engineering, there are important implications when looking at which students are more likely to take advanced math courses in high school. A study by Hall, Dickerson, Batts, and Kauffmann (2010) looked at high school students nominated by their teachers to attend a 3-week summer program to increase their awareness of STEM fields, engineering in particular. Results indicate both male and female students reported a higher likelihood of taking advanced science courses after completion of the summer program, with female students showing a marked increase. However, in regard to math, a higher proportion of male students than female students indicate they would be likely to take advanced math courses before attending the summer program, and this gap remained at the end of the program with females not indicating an increased likelihood of taking advanced math courses. In looking at the data from the current study, less than half of the women who start in engineering remain at the end of the freshman year. While women now represent over half of the students entering college, they are still a small minority in majors such as engineering (Cassell & Slaughter, 2006; Corbett, Hill, & St. Rose, 2010). Further research is needed in the areas of advanced placement courses in math and how this relates to the STEM fields with a particular emphasis on gender.

Past studies have suggested that a substantial number of students drop out of the STEM programs within the first 2 years (House, 2007; Spring & Schonberg, 2001; Tsui, 2007), so this time period represents a critical period. In addition, engineering is a major that is not easily chosen after the freshmen year of college. Much of the curriculum is set, and late entry may be viewed as not being a viable option by many students. This makes it even more critical to not only attract students but also retain them. Given the role of calculus readiness in predicting retention in the current study, evaluating students' advanced math skills before they enter engineering might be beneficial. Students who are weak in advanced math skills could be engaged in skill building before they enter certain courses. In addition, high school GPA is a significant predictor of retention in engineering in the current study. This is interesting given there was a restricted range for high school GPAs in the current sample (2.14–4.0). It suggests the importance of high school in preparing students to take on the challenges of college. A much broader emphasis in attracting students to engineering as well as other STEM fields would be interventions aimed at high school personnel and the encouragement of students, regardless of gender or minority status, to pursue advanced math courses before college.

Limitations of the current study need to be noted. Participants in the current study were from a recently developed program in engineering at a southeastern university, perhaps limiting the generalizability of the findings. The program that we evaluated was also somewhat different from other engineering programs in that it identified majors with incoming freshman to help guide them in program requirements. In addition, there are limitations in regard to gender and minority representation in the current study. The limited number of women and minority students does not allow for analyses to be conducted on possible differences for minorities and women in retention rates. Unfortunately, the low representation of women and minorities in the current study mirrors findings by other researchers (Chubin, May, & Babco, 2005; Corbett et al., 2008; Daempfle, 2003; Georges, 2000). Future researchers should use more participants from various backgrounds.

A further limitation in the current study was the lower coefficient alphas for the personality factors on the NEO-FF scale. Lower reliabilities make it much less likely to obtain significance, and this may have influenced the lack of significance for four of the five factors on the NEO-FF in the binary logistic regression. As previously noted, only Openness emerged as a significant predictor even though the reliability obtained on this factor was the lowest. Due to this circumstance, Openness emerged as an especially strong predictor in the current study.

In conclusion, a need for individuals who have trained in engineering exists now and will exist in the future, but educators are neither attracting a large number of students to this field nor showing great success in retaining those we do attract. This situation is further complicated by the high attrition rates for women and minority students. The current study found that advanced math readiness, high school GPA, and the personality factor of openness are significant predictors of retention at the end of the freshman year. How well these factors continue to predict retention throughout students' college careers needs to be determined. Much more research in this area is needed if we are to meet the demands of tomorrow's workforce in the STEM fields and engineering in particular.

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