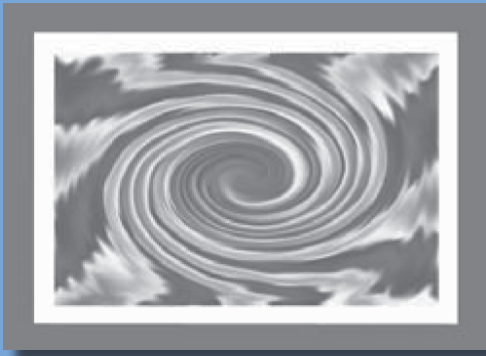


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Deriving Enrollment Management Scores from ACT Data

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Abstract

This study is an investigation of the derivation of scores that predict whether or not prospective first-time freshmen will apply or will enroll and whether or not first-time freshman enrollees will graduate using data from the ACT (American College Testing) assessment. Using a regression methodology, four basic scores are derived to be independent of academic ability, which is indicated by a fifth score. Using cross-validation populations, each of the scores is shown to predict the desired behavioral criterion quite well, and each should serve its intended purpose. The paper discusses potential uses of the scores and examines the inclusion or exclusion of no-response items (where the individual did not give a response), the optimal number of data items to include in an enrollment management score, and other characteristics of the scores.

Deriving Enrollment Management Scores from ACT Data

A component of enrollment management is the identification

of potential freshman applicants who possess characteristics specified by goals of the college or university (Hossler, Bean, & Associates, 1990; Hossler & Kemerer, 1986; Penn, 1999). An institution can use characteristics of potential students who are most likely to apply for admission, be admitted, enroll, and graduate, to focus marketing and recruitment strategies to target students who are expected to further the institution's mission and goals.

The concept of maximizing student-institution fit (Williams, 1986) is to match students with characteristics that are consistent with the institution's mission and goals. An assumption of this paper is that the students who apply, are admitted, enroll, and graduate are more likely to fit the college or university than those who do not.

The paper introduces a procedure for developing enrollment management scores that are useful in the identification of potential students who possess characteristics specified by the goals of the institution and are most likely to fit the institution. The scores are calculated from

ACT (American College Testing) assessment data for potential students that are made available to colleges and universities for those students who specify the institution when they complete the assessment and for students that meet criteria specified by the institution.

The paper describes and illustrates procedures for the development of an *ability score* that reflects the student's academic ability and four enrollment management scores: (a) an *application score* intended to predict whether or not the prospect will apply to the university, (b) a *prospect-enroll score* intended to predict whether or not the prospective student will (apply, be admitted and) enroll, (c) an *admit-enroll score* intended to predict whether or not an admitted student will enroll, and (d) a *graduation score* intended to predict whether the enrolled first-time freshman student will graduate within six years. Using the *ability score*, the other scores are derived to be generally independent of ability. Four additional scores that are combinations of the *ability score* and the other enrollment management scores also are derived. These combination scores provide for the overall prediction of the four target behaviors without distinguishing ability from the other predictive variables of the ACT data.

The ACT Program offers a predictive modeling service that includes data similar to the *prospect-enroll score* of the present study and a retention predictor. The ACT indicators are stated as probabilities rather than scores, and they incorporate ability indicators (Hovlind, 2003, 2005).

Alternatives in the calculation of enrollment management scores and characteristics of the scores are examined. The calculation issues

are (a) the treatment of missing responses to the ACT Student Profile items and missing data for other pieces of ACT data and (b) the optimal number of items of ACT data to include in the calculation of the score.

Finally, the following questions about characteristics of the enrollment management scores are addressed: (a) What is the nature of the overlap of ACT data items among the several scores? (b) What is the relative contribution of the ability and non-ability items to the combination enrollment management scores? (c) What are the relationships among scores based on differing numbers of items? (d) What are the relationships between scores including and scores excluding no-response items? (e) How highly related are the several scores? (f) Are any of the scores sufficiently similar that one or more can be used to predict more than one of the behaviors for which the set of scores is designed?

Literature

There is evidence that student background characteristics condition students' decisions regarding aspirations for a college education, college choice, and college success (e.g., Bean, 1980, 1982; Jackson & Weathersby, 1975; St. John, 1991; Tinto, 1975). College choice is a multi-stage model where student and institutional attributes affect a potential student's aspiration for college, selection of a choice set of institutions, and—finally—their ultimate college choice (e.g., DesJardins, Ahlberg, & McCall, 2006; Hossler, Braxton, & Coppersmith, 1989; Hossler & Gallagher, 1987; Jackson, 1978). Empirical research has identified a number of student attributes

that influence college choice decisions including race, gender, socioeconomic status, parental education, and the student's peer group (e.g. Curs & Singell, 2002; DesJardins et al., 2006; Ehrenberg & Sherman, 1984; Fuller, Manski, & Wise, 1982; Hossler et al., 1989).

Student departure from college defined as transfer, stop-out, or a failure to graduate generally exists as the result of an unsuccessful integration into the campus community (Tinto, 1993). Empirically, students who are likely to have difficulty integrating include minority, low-income, older, and disabled students, those attending college a long distance from home, those from backgrounds where college attendance is infrequent, and those from communities very different from the ones they find at college (DesJardins, Ahlberg, & McCall, 1999; Langbein & Snider, 1999; Light & Strayer, 2000; Robst, Keil, & Russo, 1998; Wetzels, O'Toole, & Peterson, 1999). Student success in college, indicated by grades and graduation, has been found to be predicted by admissions test scores, grade-point average (GPA) or rank in class (e.g., Cabrera, Nora, & Castaneda, 1993; DesJardins, Ahlberg, & McCall, 2002; St. John, 1992) as well as by noncognitive variables including social networks and institutional commitment (Cabrera et al., 1993).

The ACT data provided to colleges and universities include selected demographic and high school information, ACT Interest Inventory scores, ACT test scores, and student responses to the 190 items of the ACT Student Profile instrument (ACT, 2004, 2005). Many of these items of data reflect characteristics of students found in previous research to predict college aspiration,



college choice, and college success. Specifically, the Student Profile includes items on expected enrollment status, place of residence in college, educational achievement, education deficiencies, educational aspiration, extracurricular plans, financial aid, family income, size of home community, distance from home of college expected to attend, characteristics of college that influence choice (e.g., level of tuition, size of student body), characteristics of student's high school, and student's accomplishments while in high school. Many of these items correspond to the variables previously found to condition aspiration for college, college choice, and success. Consequently, these data should be useful in identifying potential students who meet a college's or university's enrollment goals that involve desired levels of student ability, desired numbers of students, and expectations of student success. Perkhounkova, Noble, and McLaughlin (2006) found that ACT variables are useful in predicting retention and that variables that predict retention for freshman also predict retention for transfer students.

Midwestern university that has moderately selective freshman admissions standards.¹ The research population for the *application score*, the *prospect-enroll score*, and the *admit-enroll score* consists of students with ACT data in the subject university's first-time freshmen prospect file for the fall 2002 or fall 2003 term. The validation population for these scores consists of the students in the corresponding file for fall 2004. The research population for the *graduation score* is the population of enrolled first-time freshmen for the fall 1997 and fall 1998 semesters, and the validation population for this score includes fall 1999 first-time freshmen. To know whether or not the students graduated within six years, it is necessary to use earlier students for the latter populations. *Ability scores* are derived using each research population.

Deriving Ability Scores

The methodology for deriving enrollment management scores that are generally independent of academic ability requires that *ability scores* be developed before enrollment management scores. *Ability scores* are derived from the ACT Composite score and four

other ability indicators in the ACT data. These four indicators are (a) the high school GPA derived by ACT from course grades provided by the student, (b) an item on the student's estimate of her or his first-year college GPA, (c) an item on the student's high school class rank, and (d) an item asking the student to report his or her overall high school GPA. *Ability scores* are derived as follows:

1. The ACT-calculated high school GPA is collapsed into seven ranges from 0.00–1.49 and 1.50–1.99 to 3.50–3.99 and 4.00.
2. Contingency tables are created in which one dimension contains responses to the ACT ability item and the other dimension is the first-year GPA collapsed into two categories, below 3.00 and 3.00 and above. The contingency table percentages are examined to see if response categories with small numbers of students should be combined or if the relationship between the item and first-year GPA can be improved by collapsing categories. For example, responses to the ACT item on class rank are as follows:

Data for and Methodology of the Study

The study involves deriving parameters for the *ability score* and for the four enrollment management scores using data from a research population and examining the stability of the scores using a validation population. These populations are from a large

<u>Response</u>	<u>First Year GPA</u>		
	<u>Below 3.00</u>	<u>3.00 & Above</u>	<u>Total</u>
no-response	325 (64%)	179 (36%)	504 (100%)
top quarter (1)	1,918 (45%)	2,338 (55%)	4,256 (100%)
second quarter (2)	969 (79%)	263 (21%)	1,232 (100%)
third quarter (3)	209 (88%)	28 (12%)	237 (100%)
fourth quarter (4)	18 (86%)	3 (14%)	21 (100%)

¹ The mean ACT Composite score for fall 2006 first-time freshmen was over 25, and almost one-third of them were in the top 10% of their high school classes.

After considering these data, the third quarter and fourth quarter response categories are combined in subsequent analyses because of the small numbers of students in the fourth quarter and the similarity of the two percentages with 3.00 or above first-year GPAs.

3. The regression, including probability-values for regression estimates, for predicting the student's actual first-year GPA from the ACT Composite score and the four other ability indicators of ACT data is estimated. Any predictor that does not contribute significantly or materially to the regression is eliminated from additional consideration.
4. The regression is estimated again with the reduced number of predictor variables. The regression estimates of this final regression are expressed as whole numbers and become the multipliers for the ACT data items that are combined to yield the desired *ability score*. The intercept estimate is used in the regression model, but it is not used in the formula that produces the *ability score* since that estimate has no bearing on the differences among students and its omission simplifies calculation of the score..

The formula derived in this manner is based upon students with complete data on the ACT data items and can be calculated only for those potential students with complete data. In order to calculate ability scores for all potential students, including those with missing data, it is necessary to assign values to no-response or missing data categories prior to carrying out step 3 of the procedure.

These values are assigned on the basis of the percentages of students in each response category with first-year GPAs in the 3.00 and above group. Specifically, "no-response" is assigned the value of the valid response for which this percentage is closest to the percentage for the no-response category. The no-response category of the first-year GPA item, for which data are shown above, is assigned the value of "2" because the no-response percentage (36%) is closer to the percentage for the second quarter response (21%) than to the percentage for any other response. The formula for *ability scores* that include no-response items is developed by carrying out the preceding steps 3 and 4. This produces two equations for *ability scores*: one for those with complete item responses and one for everyone created by estimating a score for the instances where the individual did not provide a valid response.

Deriving Application Scores

The *application score* is used to describe the procedure for

developing an enrollment management score. There are four steps in the procedure:

1. Contingency tables of responses to individual items of ACT data and whether or not the potential student applied for admission are created and examined. Two types of decisions are made on the basis of these contingency tables:
 - a. Items that have little or no relation to whether or not the student applied are identified and eliminated from the remaining steps of the procedure.
 - b. Response categories for some items not eliminated are collapsed on the basis of small numbers of responses or in order to maximize the relationship of the responses to whether or not the student applies. For example, assume the following are the data for responses to the item "Upon entering college, I plan to live in...":

<u>Response</u>		<u>Did Not Apply</u>	<u>Did Apply</u>	<u>Total</u>
no-response		290 (66%)	147 (34%)	437 (100%)
residence hall	(1)	11,421 (61%)	7,176 (39%)	18,597 (100%)
off-campus room ...	(2)	2,689 (77%)	821 (23%)	3,510 (100%)
parent's or ... home	(3)	2,039 (86%)	319 (14%)	2,358 (100%)
married student ...	(4)	88 (70%)	38 (30%)	126 (100%)
fraternity or sorority	(5)	1,326 (54%)	1,112 (46%)	2,438 (100%)

The value of "1" is assigned to responses 2, 3, and 4 (23%, 14%, and 30% applied), and the value of "2" is assigned to the responses 1 and 5 (39% and 46% applied). The students with the largest percentages applying are separated from those with the lowest percentages. Also, responses chosen by small numbers of students are combined with other responses.

2. The regression for predicting whether or not (expressed as "1" or "0") the student applies for admission is estimated from the *ability score*. The residuals of the predicted values from this regression are calculated and then become the criterion for deriving an *application score* that is generally independent of the student's academic ability.²
3. Stepwise regression is used to identify the ACT data items not discarded in step 1 that are most predictive of the residuals from the *ability score* regression and is used to produce the regression estimates for these items. To maximize the number of subjects on which the *application score* is based, the following steps are followed:
 - a. A stepwise regression is stopped for a somewhat larger number of items, say 30, than desired for the final score, say 20 items.
 - b. The items selected in step 3a are used in a second

stepwise regression that is stopped when the desired number of items, say 20, is entered. The 30-item analysis includes more subjects than the initial analysis that includes only students who had responded to all selected ACT items.

4. The desired number of items, say 20, identified by the second stepwise analysis is used in a standard regression analysis. The regression estimates of this analysis, multiplied by 100, are the multipliers of the formula for calculating *application scores*. The regression constant is not used. This regression analysis makes use of more subjects than does the step 3b regression.

As with the *ability score*, *application scores* developed by these four steps are based upon only students with complete data and can be calculated only for potential students with complete data. In order to include students with no-response or missing data, values of valid responses are assigned to no-response categories, and this is done by means of the same rule followed for the data items used to define *ability scores*. In the example, using data for the item "Upon entering college, I plan to live in..." the no-response category is assigned the value "2" on the basis of the similarity of the percentage applied for the no-response students to the percentages for the other responses assigned this value.

Then in step 3, the stepwise regression is stopped when the desired number of items has been entered, because all students are included. In the study, scores based upon differing numbers of item are calculated and compared, and the differing sets of items are identified by a single stepwise procedure. Step 4 is then carried out for each desired number of items. This results in five scores, calculated from 40, 30, 20, 10, and 5 items, respectively.

For the study, *application scores* that include no-response items are developed using the research population of students in which students who did not respond to at least 10% of the ACT items were eliminated. The 10% value is clearly arbitrary, but it does lead to the exclusion of subjects for whom a substantial number of items are omitted and permits inclusion of a sizable number of subjects for whom only a small number of items were omitted. This 10% rule determines the number of prospects, or students from the original research population, used to define the score and the number in a future population for whom the score can be calculated. This results in another five scores calculated from 40, 30, 20, 10, and 5 items, respectively.

Combination scores, based upon *ability scores* and *application scores*, are derived for each of the five including no-response and five excluding no-response scores. Regression estimates for the *ability score* and the *application score*, from the prediction of whether or

² Because the variables to be predicted in developing the enrollment management scores are dichotomous, consideration was given to comparing the use of logistic regression to ordinary least squares (OLS) in finding residuals from the criterion and *ability score* regression. It turns out that the residuals from the logistic procedure and those from the OLS procedure are perfectly correlated. Hence, it would have been redundant to have calculated and analyzed both types of residuals.

not the student applies, are used to define the score based upon the combination of the two scores. Altogether, 22 scores are developed for the application criterion. This includes the two *ability scores*, the ten *application scores*, and the ten scores developed from regressing the behavioral outcome of application on the appropriate pair of *ability scores* and *application scores*.

Deriving Other Enrollment Management Scores

Procedures for deriving the formulas for calculating the several versions of the *prospect-enroll score*, the *admit-enroll score*, and the *graduation score* are the same as those given above for the *application score*, except that the criterion variables for the several regressions are whether or not the prospect enrolls, whether or not the admitted student enrolls, and whether or not the enrolled student graduates.

ACT data items that ask the student to identify gender, disability, and ethnic origin are not used in the specifications for enrollment management scores. Thus, the derived enrollment management scores are not specifically influenced by these variables.

Analyses of Enrollment Management Scores

Comparisons of correlations of scores with criterion behaviors, application, enrollment, and graduation lead to conclusions regarding the treatment of no-response items and the optimal number of items to be included in determining the enrollment management score. Correlations are calculated for students in the research population and those in the

validation population. The validation correlations and the shrinkages in the correlations between the research and validation populations are of most interest. Tables of percentages of prospects (or students exhibiting the criterion behavior, e.g., applying for admission), displayed by ranges of the *ability score* and the other-than-ability score, are used to portray the utility of the several scores in predicting whether or not the student applies for admission or exhibits the other criterion behaviors.

Finally, the array of *ability scores* and enrollment management scores are calculated for the students in the fall 2004 validation population. Correlations among selected scores for this population lead to answers to other questions regarding these scores.

Results

Ability Scores

Specifications for two *ability scores*, one including no-response items and one excluding such items, are developed for each of the two research populations. In each

case, the ACT item on class rank in high school does not contribute significantly to the prediction of first-year GPA and is excluded from the final regression that produces the formula for calculating the *ability score*. When the four *ability scores* are calculated for subjects in the fall 2004 validation population, five of the six correlations among the scores exceed .99, and the sixth is .98. Consequently, characteristics of a single *ability score* can be used to represent all four scores. Table 1 shows the results of the regression analysis, multiple correlation of .54, that produced the formula for the *ability score* including no-response items using the fall 2002 and fall 2003 population. The coefficients for the *ability score* are the regression estimates multiplied by 100. Three of the four parameter estimates have P-values less than .0001. The P-value for the Estimated First-Year GPA item is .0002. The standardized estimates reflect the relative contributions of the four predictors to the prediction of the first-year GPA.

Table 1
Regression Estimates Used to Define Ability Score Including No-Response Items, Fall 2002 and 2003 Population. N = 5,094, R = .54

Predictor Variable	Regression Estimates	Coefficients for Ability Score	Standardized Regression Estimates
Intercept	-0.50458	--	--
ACT Composite Score	0.05071	5.071	0.24
H.S. Average ¹	0.20586	20.586	0.25
Est. 1st Year Coll. GPA ²	0.05910	5.931	0.05
High School Average ³	0.20640	20.640	0.18

¹ Calculated from self-reported grades.

² Student Profile item: "1" if B- or less, "2" if B- to B, "3" if B to B+, "4" if A- to A.

³ Student Profile Item: "1" if < 3.0, "2" if 3.0 to 3.4, "3" if 3.5 to 4.0.

The calculated high school average contributes as much as the ACT Composite score to the prediction of first-year college GPA. The two ACT Student Profile items make smaller, but significant, contributions.

Enrollment Management Scores
Numbers of subjects and correlations of enrollment management scores with applicable criterion behaviors are displayed in Table 2. Scores with labels A to H are developed to be independent

of ability, and those with labels AA to HA are combination scores that include the ability measure. Data are displayed for the 5-item, 10-item and 20-item scores that include no-response items and corresponding scores that exclude no-response

Table 2
Numbers of Subjects and Correlations of Enrollment Management Scores with Behavioral Criteria for Scores Including and Excluding No-Response Items for 5-Item, 10-Item, and 20-Item Scores, Research and Validation Populations

Score Definition			Application Score					Prospect-Enroll Score				
Label	No Resp Items	Numb of Items	Research Population		Validation Population		Shrink-age	Research Population		Validation Population		Shrink-age
			N	R	N	R		N	R	N	R	
A	Incl	5	27,466	0.47	14,471	0.48	-0.01	27,466	0.43	14,474	0.43	0.00
B	Incl	10	27,466	0.49	14,471	0.50	-0.01	27,466	0.44	14,471	0.44	0.00
C	Incl	20	27,466	0.49	14,471	0.50	-0.01	27,466	0.44	14,471	0.44	0.00
F	Excl	5	23,219	0.46	13,921	0.48	-0.02	25,286	0.42	13,858	0.43	-0.01
G	Excl	10	22,409	0.47	13,198	0.49	-0.02	23,991	0.43	13,058	0.44	-0.01
H	Excl	20	20,742	0.48	12,285	0.49	-0.01	20,010	0.44	10,512	0.45	-0.01
AA	Incl	5	27,466	0.53	14,471	0.54	-0.01	27,466	0.47	14,471	0.47	0.00
BA	Incl	10	27,466	0.54	14,471	0.55	-0.01	27,466	0.48	14,471	0.48	0.00
CA	Incl	20	27,466	0.55	14,471	0.56	-0.01	27,466	0.48	14,471	0.48	0.00
FA	Excl	5	23,219	0.52	12,855	0.53	-0.01	23,795	0.47	12,839	0.47	0.00
GA	Excl	10	22,409	0.53	12,351	0.54	-0.01	22,777	0.47	12,263	0.48	-0.01
HA	Excl	20	20,742	0.53	11,579	0.54	-0.01	19,155	0.48	9,985	0.49	-0.01

Score Definition			Admit-Enroll Score					Graduation Score				
Label	No Resp Items	Numb of Items	Research Population		Validation Population		Shrink-age	Research Population		Validation Population		Shrink-age
			N	R	N	R		N	R	N	R	
A	Incl	5	8,817	0.39	4,747	0.42	-0.03	5,741	0.17	2,802	0.15	0.02
B	Incl	10	8,817	0.39	4,747	0.43	-0.04	5,741	0.22	2,802	0.18	0.04
C	Incl	20	8,817	0.40	4,747	0.42	-0.02	5,741	0.25	2,802	0.20	0.05
F	Excl	5	7,800	0.38	3,985	0.42	-0.04	5,578	0.17	2,716	0.14	0.03
G	Excl	10	7,590	0.39	3,865	0.43	-0.04	5,451	0.18	2,647	0.16	0.02
H	Excl	20	6,780	0.40	3,533	0.43	-0.03	5,294	0.23	2,549	0.21	0.02
AA	Incl	5	8,817	0.39	4,747	0.42	-0.03	5,741	0.31	2,802	0.30	0.01
BA	Incl	10	8,817	0.39	4,747	0.43	-0.04	5,741	0.33	2,802	0.31	0.02
CA	Incl	20	8,817	0.40	4,747	0.42	-0.02	5,741	0.35	2,802	0.31	0.04
FA	Excl	5	7,550	0.39	3,985	0.43	-0.04	5,255	0.31	2,646	0.29	0.02
GA	Excl	10	7,356	0.39	3,865	0.43	-0.04	5,147	0.32	2,585	0.31	0.01
HA	Excl	20	6,594	0.41	3,533	0.43	-0.02	5,006	0.34	2,491	0.32	0.02

items. Correlations for the research population and for the validation population and shrinkages between their correlations are shown.

The table does not include data for the 30-item and 40-item scores that were calculated. Typically, the correlations and shrinkages for these scores are similar to the correlations for the 20-item scores. The exception occurred with the *graduation scores* for which the correlations in the research population increase as the number of items in the scale increases. However, the *graduation score* correlations in the validation population increase only slightly or not at all with increases in the numbers of items. Thus, inclusion in the table of data for the 30-item and 40-item scores would add little, if any, information to that provided for the 5-item, 10-item, and 20-item scores.

Correlations of the several enrollment management scores with their corresponding *ability scores* in the research and validation populations range from -.10 to .12. There is no systematic variation in these correlations on the basis of number of items in the score or whether or not no-response items are included in the score.

The correlations of the 5-item enrollment management scores with their respective criteria are very modestly lower than the correlations for the 10-item scores in the research and the validation populations. The correlations for the 20-item scores are essentially the same as the correlations for the 10-item scores in the validation population. The exceptions occur for the *graduation scores* for which

there are noteworthy increases in the correlations as the number of items in the score increases. The increases occur in the research population through the 40-item scores, but are smaller for the 30-item and 40-item scores. In the validation population, the correlations for *graduation scores* increase more modestly or not at all for the 30-item and 40-item scores.

Shrinkages of the correlations of the enrollment management scores with their respective criteria are surprisingly small. In many cases, particularly for the *admit-enroll scores*, the correlations in the validation population are higher than those in the research population. The shrinkages for the *graduation scores* are consistently positive, but still not large. Apparently, all of the enrollment management scores, regardless of number of items, are quite stable.

While it is not a purpose of the study to contribute to an understanding of factors involved in students' application, enrollment, and graduation behavior, it may assist in understanding the derivation of enrollment management scores to examine the ACT data items that contribute to these scores. Table 3 identifies the items included in the several 5-item scores.³ Items are displayed that contribute to 5-item scores including no-response items and to scores excluding these items. The weights, or multipliers, for the items are shown in the table and reflect generally the relative contributions of the items to the scores. These weights were obtained by

multiplying the regression weights by 100 and rounding to convert them to integer values. The manners in which numerical values are assigned to responses to the items, including the values assigned to "no-response" responses, are shown.

The grade classification and college choice number items are not Student Profile Section items. The student-reported grade classification comes from the background section of the ACT assessment file. College choice is the student's ranking of his or her interest in the indicated college or university.

The overlap of data items among the several scores can be read from the table. In most, but not all, cases the items of the score including no-response items are the same as the score excluding these items, but there are exceptions.

The college choice variable was the first to enter the stepwise analysis for the *application score* including no-response items. The correlation with application for this item is .38. The addition of the grade classification item increased the correlation to .43, and the correlation for all five items is .46.⁴ The college choice and grade data items are major components of the *application score*, but the other three items contribute to the prediction. For the *application score* excluding no-response items, the item on when the prospect plans to enter college substitutes for the grade classification item of the score that includes no-response items.

The college choice variable was also the first item to enter

³ Tables showing items included in the 10-item and 20-item scores are included in a set of additional and more comprehensive tables that are available from the junior author at cursb@missouri.edu.

⁴ The correlations from the stepwise analysis differ slightly from those in Table 2 due to the rounding of regression estimates in the formulas for enrollment management scores.

Table 3
ACT Data Items Included in 5-Item Enrollment Management Scores with Item Weights and Coding

Item Weights		ACT Student Profile or Other Data Item	Item Content	Coding of Item Responses	Code for No Response
Include	Exclude				
No Resp Items	No Resp Items	Item Numb			
Application Score					
19		--	Grade classification	"1" if 12th grade; "0" otherwise	"1"
	18	3	I plan to enter college	"1" if a year after next fall; otherwise "0"	
9	10	4	I plan to live in	"1" if off-campus, parent's or relative's home, married student housing; "2" if residence hall or fraternity/sorority.	"1"
2	2	59	Combined income of parents	"1" if bottom 3 categories; "2" if middle 2 categories; "3" to "6" for next 4 categories	"3"
8	8	60	Community in which you live	"1" if farm or town with less than 10,000; "2" if 10,000 to 499,999; "3" if larger	"2"
33	32	--	College Choice Number	"1" first; "0" otherwise	"0"
Prospect-Enroll Score					
10	19	--	Grade classification	"1" if 12th grade; "0" otherwise	"1"
	10	4	I plan to live in	"1" if off-campus, parent's or relative's home, married student housing; "2" if residence hall or fraternity/sorority.	
	3	59	Combined income of parents	"1" if bottom 3 categories; "2" if middle 2 categories; "3" to "6" for next 4 categories	
4	8	60	Community in which you live	"1" if farm or town with less than 10,000; "2" if 10,000 to 499,999; "3" if larger	"2"
4		63	How far do you live from the college you expect to attend?	"1" if 100 miles or less; "3" if more than 100 miles; "2" if undecided	"1"
3		70	The size of the college I prefer	"1" to "5" for under 1,000 to 20,00 and over	"4"
29	32	--	College Choice Number	"1" first; "0" otherwise	"1"
Admit-Enroll Score					
4		47	Plan to participate in religious organizations	"1" if Yes; "2" if No.	"1"
	4	50	Plan to participate in varsity athletics	"1" if Yes; "2" if No.	
-4		63	How far do you live from the college you expect to attend	"1" if 100 miles or less; "3" if more than 100 miles; "2" if undecided	"1"
5	5	68	In which state do you prefer to attend college?	"1" if Missouri; "0" otherwise	"0"
2	3	70	The size of the college I prefer	"1" to "5" for under 1,000 to 20,00 and over	"4"
	4	125	Gave a public recital (individual or group)	"1" if Yes; "2" if No.	
34	35	--	College Choice Number	"1" if first; "0" otherwise	"1"
Graduation Score					
-6	-6	21	Need help in improving my reading speed and comprehension	"1" if Yes; "2" if No.	"1"
-5	-5	58	Hours per week you plan to work first year	"1" if None to "5" if 31 or more.	"3"
3		59	Combined income of parents	"1" if bottom 3 categories; "2" if middle 2 categories; "3" if top 4 categories	"3"
6	6	69	I prefer a college with a maximum yearly tuition of	"1" if \$500 to \$4000 or No preference; "2" if \$5000 to \$10000	"1"
10	10	78	The high school from which I will graduate	"1" if public, private-independent, military or other; "2" if Catholic or private, denominational	"2"
	3	88	Years studied Spanish	"1" if none to 2 ½ years; "2" if 3 to 4 or more years	"1"

the stepwise analysis for the *prospect-enroll score* that included no-response or missing data, and the initial correlation was .39. Addition of the grade item increased the correlation to .41, and the correlation for all five items was .42. College choice is clearly the principal component of the *prospect-enroll score*, but the other four items did make contributions to the prediction of enrollment.

The college choice variable was again the first variable to enter the stepwise analysis for the *admit-enroll score* that included no-response or missing data, and the initial correlation for this score was .37. The correlation for all five items entered for the 5-item score was .38. While the college choice variable almost defines the *admit-enroll score*, three of the other four

items had P-values less than .0001, and the other one had a P-value of .0002. For the *graduation score*, the first variable to enter the stepwise analysis for the score that included no-response or missing data was the item concerning the hours per week the prospect planned to work during the first college year. The initial correlation is .13. The addition of the item on type of high school increases the correlation to .16, and the correlation for all five items was .19. The P-values of each of the five items was less than .0001. Three of the items of the 5-item *graduation score* including no-response items were economic in nature. Students at this university who do not plan to work, whose parents have higher incomes, and who prefer a college with high tuition are more likely to graduate than other students.

Combined Enrollment Management Scores

Correlations of the combined scores with their respective criteria are shown in Table 2. The combined scores are based upon the regressions for predicting the criterion behavior from the *ability score* and the relevant enrollment management score. Results of these regressions from the research population for the 5-item and 10-item enrollment management scores are shown in Table 4. The table includes the standardized regression estimates. These values indicate the relative contributions of the two variables in the combined scores. The regression estimates for the several 20-item, 30-item, and 40-item scores are similar to the estimates in the table. The unstandardized regression

Table 4
Regression Estimates from Regressions for Predicting Criterion Behavior From Ability and Other Enrollment Management Scores

Numb of Items	Include No Response Items				Exclude No Response Items				
	Weight*		Std. Weight**		Weight*		Std. Weight**		
	Ability Score	Other Score	Ability Score	Other Score	Ability Score	Other Score	Ability Score	Other Score	
Ability/Application Scores									
5	0.197	1.019	0.242	0.450	0.195	1.018	0.238	0.434	
0	0.193	1.013	0.237	0.465	0.197	1.014	0.241	0.451	
Ability/Prospect-Enroll Scores									
5	0.129	0.982	0.195	0.412	0.126	0.780	0.190	0.412	
10	0.126	0.998	0.191	0.420	0.127	0.753	0.191	0.420	
Ability/Admit-Enroll Scores									
5	-0.0374	1.020	-0.0320	0.383	-0.0294	1.002	-0.0245	0.384	
10	-0.0362	1.006	-0.0310	0.388	-0.0250	1.026	-0.0208	0.392	
Ability/Graduation Scores									
5	0.288	1.040	0.259	0.184	0.292	1.012	0.257	0.176	
10	0.274	0.981	0.247	0.212	0.303	0.986	0.267	0.205	

* These are the weights used to calculate the combined scores. They are the products of the unstandardized regression estimates and 100.

** These are the standardized regression weights.

estimates multiplied by 100 are the weights of the two variables in the formula for the combined score.

The contributions of the *application scores* and the *prospect-enroll scores* to the respective combined scores exceed the contribution of the *ability scores*. While ability contributes to the prediction in these two cases, it contributes less than the enrollment management score.

The *ability scores* make a very small and negative contribution to the *ability/admit-enroll scores*. The *admit-enroll score* is almost entirely responsible for the prediction of enrollment for students who have been admitted to the subject university.

Ability scores make larger contributions than *graduation scores*

to *ability/graduation scores*, but both make positive contributions and the differences are not large. While ability is clearly important in predicting graduation, the variables of the *graduation score* also are involved.

Accuracy of Predictions by Enrollment Management Scores

The correlations in Table 2 provide one indication of the accuracy of the scores. Another indication is provided by percentages of subjects meeting the relevant criterion displayed by ranges of an *ability score* and ranges of the enrollment management score. In order to calculate these percentages, the distributions of *ability scores* and enrollment management scores are collapsed into ranges. For

display purposes, each distribution is collapsed into five ranges that have the following labels and approximately these percentages of the scores in the distribution:

Label	Range
5	Top 12% of scores
4	Next 22% of scores
3	Middle 32% of scores
2	Next 22% of scores
1	Bottom 12% of scores

Table 5 contains the percentages for 10-item enrollment management scores including no-response items calculated for the validation population. Percentages for the associated combination scores are included. The arrays of percentages for other versions of the four enrollment management scores are quite similar to those for the scores of the table.

Table 5
Percentage of Subjects Meeting Behavioral Criterion by Ranges of 10-Item Enrollment Management Scores Including No-Response Items and Ranges of Ability Scores and by Ranges of Combination Scores for Validation Populations

Ability Score	Application Score						Prospect-Enroll Score					
	1	2	3	4	5	Total	1	2	3	4	5	Total
5	18%	27%	45%	73%	95%	57%	8%	7%	15%	43%	66%	28%
4	8%	19%	33%	61%	89%	47%	5%	4%	10%	37%	65%	24%
3	7%	12%	26%	56%	79%	37%	4%	4%	9%	31%	57%	20%
2	4%	7%	15%	35%	63%	23%	2%	2%	5%	18%	29%	10%
1	1%	3%	9%	15%	40%	11%	1%	0%	1%	4%	3%	1%
Total	7%	13%	25%	51%	78%	36%	4%	4%	8%	29%	51%	17%
BA ¹	4%	12%	25%	53%	85%	36%	2%	4%	8%	25%	60%	17%

Ability Score	Admit-Enroll Score						Graduation Score					
	1	2	3	4	5	Total	1	2	3	4	5	Total
5	28%	26%	55%	77%	83%	49%	63%	82%	78%	93%	89%	82%
4	21%	23%	47%	77%	80%	50%	63%	74%	82%	85%	88%	79%
3	29%	24%	49%	74%	78%	53%	49%	68%	71%	74%	88%	71%
2	30%	33%	55%	73%	86%	58%	39%	56%	53%	62%	70%	56%
1	43%	45%	51%	70%	74%	57%	27%	40%	52%	52%	69%	48%
Total	29%	29%	51%	74%	80%	53%	48%	66%	68%	73%	82%	68%
BA ¹	27%	29%	57%	75%	81%	53%	41%	58%	70%	81%	89%	68%

¹ Combined ability and "other" 10-item score.

The positive relationships between the *ability* and *application* scores and application are evident in the table. Percentages of prospects applying for admission vary from 1% for those in the lowest ranges of the *ability* and *application* scores to 95% for those in the highest ranges of the two scores. In other words, of those prospects who have an *ability* score in the range labeled as 1 (the lowest 12%) and an *application* score in the range labeled as 1, only 1% apply. On the other hand, for those prospects who have both an *ability* score in the range labeled as 5 (in the top 12%) and an *application* score in the range labeled as 5, about 95% can be expected to apply. Percentages for the combined *ability/application* score range from 4% to 85% when grouped into a similar five-category scale. This is shown in Table 5 in the row labeled "BA."

The positive relationships between the *ability* and *prospect-enroll* scores and enrollment also are evident in the table. Percentages of prospects enrolling vary from 1% for those in the lowest ranges of *ability* and *prospect-enroll* scores to 66% for those in the highest ranges of the two scores. Percentages for the combined *ability/prospect-enroll* score range from 2% to 60%.

The positive relationship between the *admit-enroll* score and enrollment is evident in the table. Percentages enrolling range from 29% to 80%, as shown in the Total row for that section of the table. The modest negative relationship between the *ability* score and enrollment also can be seen in the table for *admit-enroll* scores. Percentages enrolling range from 49% enrolled in the highest *ability* score group to 58% and 57% in the two lowest *ability* score groups.

For students in the lower ranges of the *admit-enroll* score, the percentages enrolling decrease from the lower to the higher ranges of the *ability* score. In the higher ranges of the *admit-enroll* score, the percentages who enroll increase as the *ability* scores increase. The interpretation of this interaction between *ability* score and *admit-enroll* score in percentage enrolling, however, is beyond the purpose of this paper.

The positive relationships between the *ability* and *graduation* score and graduation are evident in the table. Percentages of enrolled students graduating vary from 27% for those in the lowest ranges of *ability* and *graduation* scores to 89% for those in the highest ranges of the two scores. Percentages for the combined *ability/graduation* score range from 41% to 89%. Despite the relatively low correlations between *graduation* score and graduation and between *ability/graduation* score and graduation shown in Table 2, these differences among the percentages for the *graduation* score in Table 5 are noteworthy.

Other Questions about Enrollment Management Scores

In order to examine other characteristics of the enrollment management scores, all defined scores are calculated for the prospects in the fall 2004 validation population. Correlations among differing types of scores are calculated for the subjects in this population and are used to examine the relationships among scores differing by the indicated characteristics as described below:

Scores Based upon Different Numbers of Items. Correlations between enrollment management

scores differing only in the number of items on which the score is based are uniformly high. Excluding *graduation* scores, all of these correlations exceed .90, and many are .98 or .99. Typically, the highest correlations are among the scores based upon 20, 30, and 40 items. This result is not surprising, because each of these pairs of scores is calculated from mostly common items. The lowest correlations are those between 5-item and 20-, 30-, or 40-item scores. These scores have the lowest proportions of common items. Correlations among *graduation* scores vary from .67 and .72 for 5-item and 40-item scores to .91 and .98 for scores involving 20, 30, and 40 items.

Scores Including and Scores Excluding No-response Items. Correlations between scores that differ only in whether or not no-response items are included in the determination of the score also are uniformly high, ranging from .92 to .99 for scores other than *graduations* scores. This result also is not surprising, because each of these pairs of scores is based upon mostly common items in their equations. Typically, the pair of corresponding 5-item scores has the highest correlation, and the pair of 40-item scores has the lowest. The correlations between the pairs of *graduation* scores range from .85 for the 40-item scores to .92 for the 5-item ones.

Scores With Different Behavioral Criteria. All of the correlations between *application* scores and *prospect-enroll* scores are in the .90s, ranging from .92 for the 10-item scores including no-response items to .98 for five of the other pairs of scores. The correlations for four of the five pairs of combination scores were .98. For the subject university,

at least, the *application score* and the *prospect-enroll* score are nearly interchangeable.

The next highest correlations between scores with different criteria are between the *application scores* and *admit-enroll scores* and between *prospect-enroll scores* and *admit-enroll scores*. These correlations range from .50 to .85. It is not surprising that *application scores* and *prospect-enroll scores* have similar correlations with *admit-enroll scores*, because of the high correlations between these two scores. Although these are substantial correlations, the *admit-enroll scores* are not interchangeable with the other two scores.

The correlations between *graduation scores* and *application* and *prospect-enroll* scores that include no-response items are consistently positive, but smaller, ranging from .14 to .37. The corresponding correlations between *graduation scores* and *application* and *prospect-enroll* scores that exclude no-response items are higher, but still moderate, ranging from .47 to .61. The reason for the difference between the include and exclude no-response item scores in this regard is not clear.

The lowest correlations among scores with different criteria are those between *admit-enroll scores* and *graduation scores*. These correlations range from -.08 to .15. The prediction of enrollment for admitted students appears to be quite different from the prediction of graduation for enrolled students.

Discussion

The results of the study indicate that enrollment management scores calculated from data received from ACT should be useful.⁵ The *ability score*, calculated from variables in addition to the ACT Composite score, should be more useful than the ACT Composite score alone. One or more of the enrollment management scores calculated to be independent of the ability indicator could be useful either alone or in conjunction with the ability measure. A combination score, e.g., the *ability/application score*, may be the preferred indicator in some circumstances. An advantage of the combination scores defined here is that they can be economically calculated from the data provided by ACT as soon as these data are received.

The results also indicate that the inclusion of no-response or missing data items in the calculation of any of the scores derived in the study is to be preferred to their exclusion. Typically, the scores that include these items predict the criterion behaviors at least as well as the scores that exclude them. This finding is important for two related reasons. First, if a student in the research population does not respond to an ACT item and the student's response to this item is treated as missing, then that student is omitted from the analyses involving the item. This omission leads to a reduction in the number of students used in the analyses that lead to the identification of items

and multipliers to be included in the score and to a decrease in the stability of the statistical estimates involved. Second, if the no-response is treated as missing data, an instance of no-response prohibits the enrollment management score from being calculated for a prospective student and limits the number of such students for whom the score can be used.

Enrollment management scores based upon 10 items of ACT data generally are as accurate as scores with more than 10 items. It might have been expected that a score based upon a larger number of items would be a better predictor of the behavior it is intended to predict, but it is also possible that after some maximum number of items, the stability of the score or its ability to predict the subject behavior would not be increased and might even be decreased by the addition of additional items. The latter seems to be the case. An exception to the finding regarding 10-item scores is that the 20-item *graduation score* appears to be modestly superior to the 10-item score.

The finding regarding 10-item scores is a desirable one for a couple of reasons. First, the smaller the number of items, the less cumbersome is the calculation of the score. Second, if students with missing responses to individual items are omitted, more students are used in deriving parameters for scores with small numbers of items than for scores with larger numbers.

⁵ The College Board also sends electronic score reports that include responses to items of the "SAT Questionnaire" to colleges and universities for students who take the SAT. Thus, it should be possible to derive enrollment management scores from SAT data using the procedures described in this report.

Similarly, after the derivation of the scoring equations, those based on a smaller number of items have the advantage of being usable on a larger proportion of the students on which estimates are being computed.

A college or university might be able to use the *ability score* to estimate whether or not the student would meet the admission standards of the institution and could, on the basis of the score, eliminate students from its pool of applicants and reduce the number of mailings to prospective students. Similarly, the *application score* could be used to identify prospects unlikely to apply and to eliminate them from the pool of prospects. On the other hand, the strategy might be to use the *ability score* to identify high ability students whose *application scores* suggest they are unlikely to apply and to intensify recruitment of these students. The *prospect-enroll score* or the *admit-enroll score* might also be used to identify prospects or admitted students unlikely to enroll and to either curtail communications with them or, in combination with the *ability score*, to identify students to recruit more intensively. The *graduation score* might be used to identify prospective students who, if they enrolled, would be unlikely to graduate and for whom further recruitment should be curtailed. The *graduation score* might also be used to identify students likely to graduate and to intensify recruitment of them in order to increase the institution's graduation rate. The *graduation score* could also be used to identify enrolled students who should receive special attention designed to increase the likelihood of graduation.

This research has evaluated nine possible scores based on four behavioral criteria, an *ability score*, four enrollment management scores, and four scores combining the *ability score* and the enrollment management score in a regression equation. It is unlikely that the enrollment management program of a college or university would make use of all nine of these scores. The focus of the enrollment management program of the institution will determine which, if any, or how many of the scores might be useful for that institution.

The *application score* and *prospect-enroll score* are very highly correlated and can be treated as interchangeable. Correlations between other pairs of the four enrollment management scores are not high enough for other pairs of scores to be considered interchangeable.

The results of the present study should not be extrapolated uncritically to other colleges or universities. The findings suggest that the techniques of the study would be useful elsewhere, but differences among college and universities may lead to different results for different institutions. For example, differences in the manners in which prospect files that include the ACT data are assembled may lead to differences in the compositions of these files, which could impact the results of the development of enrollment management scores. Different admission standards and different student clienteles might also lead to differences in the results of enrollment management score calculations. Size, control, location, and reputation are other characteristics that might influence the ACT items and multipliers that

define the enrollment management scores.

The scales of the several enrollment management scores calculated for the present study vary appreciably, with some having means that exceed 100. This is not a limitation to the scores, but they might be made more meaningful were each transformed to some standard score scale, for example, one with a mean of 50 and a standard deviation of 10. Similarly, the scores of this study could be simplified by converting them from two- or three-digit scores to one- or two-digit scores or, perhaps, to five-point scales.

Also, the scores readily could be converted to probabilities that the student would exhibit the target behavior. For example, an *application score* could be converted to a value that reflects the probability that the prospect would apply for admission.

Enrollment management scores other than those of the present study could be developed and prove useful. For example, a *persistence score* that predicts whether or not the entering freshman will return for the second year could be developed. This score might be similar to the *graduation score* of the present study, but might be particularly helpful in identifying students who should receive special attention during their freshman year. Another score that could be developed to serve an enrollment management goal is the *prospect-graduation score* that would predict graduation for all prospects.

Also, the goals of an enrollment management program might require the development of enrollment management scores for different populations of prospective students. The scores

and their uses may differ for state residents and non-residents, men and women, categories of ethnic groups, and prospects of traditional college-age and older prospects. It may be useful to distinguish self-referred prospects from those for whom the ACT data has been acquired by other means. Clearly, differing enrollment goals and related circumstances can lead to the development of a significant variety of differing ability and enrollment management scores that are targeted at meeting specific objectives of the college or university.

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