ACT Research & Policy

Technical Brief

May 2017

Relating ACT Composite Score to Different Levels of First-Year College GPA

Jeff Allen, PhD and Justine Radunzel, PhD

Introduction

In 2005, ACT established College Readiness Benchmarks representing the ACT scores associated with a 50% chance of earning a B or higher grade in common first-year credit-bearing courses at a typical postsecondary institution (Allen & Sconing, 2005). Benchmarks were established for English, mathematics, reading, and science and have been used as indicators of college readiness. The Benchmarks were updated in 2013 (Allen, 2013), the ACT STEM Benchmark was established in 2015 (Mattern, Radunzel, & Westrick, 2015; Radunzel, Mattern, Crouse, & Westrick, 2016), and a preliminary ACT ELA Benchmark was developed in 2017 (Radunzel, Westrick, Bassiri, & Li, 2017). The ACT STEM Benchmark measures readiness for first-year college courses in mathematics and sciences most commonly taken by science, technology, engineering and mathematics (STEM)-related majors, and the ACT ELA Benchmark measures readiness for some of the most commonly taken first-year English Language Arts (ELA)-related courses in English and the social sciences. Similar to the original Benchmarks, students scoring at the STEM and ELA Benchmarks have a 50% chance of earning a B or higher grade, in the respective courses, at a typical postsecondary institution. Table 1 provides the ACT College Readiness Benchmarks and the respective college courses used to establish the Benchmarks.

Table 1. ACT College Readiness Benchmarks

ACT Test Score	College Courses	Benchmark
English	English Composition I	18
Mathematics	College Algebra	22
Reading	American History, Other History, Psychology, Sociology, Political Science, Economics	22
Science	Biology	23
STEM[1]	Calculus, Chemistry, Biology, Physics, Engineering	26
ELA[2]	English Composition I, American History, Other History, Psychology, Sociology, Political Science, Economics	20

[1] The ACT STEM score is the rounded average of the ACT mathematics and science test scores.
[2] The ACT ELA score is the rounded average of the ACT English, reading, and writing scores.

Acknowledgement: The authors thank Krista Mattern and Emily Neff for their reviews and suggestions for improving this report.

Jeff Allen is a statistician in the Research division at ACT. He specializes in longitudinal research linking test scores to educational outcomes and student growth models.

Justine Radunzel is a principal research scientist in Statistical and Applied Research specializing in postsecondary outcomes research and validity evidence for the ACT® test.

Email research.policy@act.org for more information. © 2017 by ACT, Inc. All rights reserved.

The Benchmarks provide actionable data, linking content-area knowledge and skills to expectations of success in corresponding college courses. ACT has not established an overall Benchmark for the ACT Composite score. Instead, stakeholders are encouraged to assess readiness for each subject area using the ACT College Readiness Benchmarks. However, some states may have interest in a single indicator of readiness, based on the ACT Composite score, for accountability purposes. The goal of this study is to provide empirical evidence linking ACT Composite score to different levels of first-year college GPA to support decisions around college readiness cut scores. To support coherence with the ACT College Readiness Benchmarks, the methods used in this study are similar to those used for the ACT College Readiness Benchmarks.

Methods

Data Sources

ACT data were matched to first-year cumulative college GPA (FYGPA) records provided by postsecondary institutions. Through research partnerships or participation in research services offered by ACT, postsecondary institutions provide ACT with FYGPA for first-year students. For students who persisted through the first year of college, FYGPA represents performance through the spring semester. For students who dropped out after the first semester of college, fall GPA is carried forward as FYGPA.

Student background data, including gender, race/ethnicity, and grades earned in high school courses, were obtained from students' ACT test records. Later, we describe how these data were used in the statistical analyses. We matched students' ACT scores from their last ACT test record to the course grade data.

Sample

Postsecondary institutions. Data from each institution cohort were used for the analysis if they met the following criteria: 1) N≥50 students with FYGPA data available; 2) availability of institutional data, including type (2-year or 4-year), admissions policy (open, liberal, traditional, selective, or highly selective), and control (public or private) through ACT's Institutional Data Questionnaire; and 3) percentage of students earning a 3.00 or higher FYGPA of at least 20% but less than 80%.[3] Student cohorts from 2009 through 2012 were used. The original Benchmarks study (Allen & Sconing, 2005) used data for student cohorts from 1995 through 2002 and the updated Benchmarks (Allen, 2013) used data for student cohorts from 2005 through 2012.

The sample of 267 institutions is summarized in Table 2. Most of the institutions (56%) were classified as less selective 4-year colleges, and the remainder was evenly split among 2-year colleges and more selective 4-year colleges. Most of the institutions (67%) were public. The institutions were predominantly located in the Midwest and South regions of the United States, with only 3% from the Northeast and 6% from the West.

Student sample. The student sample size was 416,668; students' gender, race/ethnicity, ACT Composite score, and high school GPA are summarized in Table 3. For comparison, the relative frequencies for the population of ACT-tested high school graduates of 2016 from states where at least 50% took the ACT are provided.

Table 2. Institutions in Sample

Institutional Characteristic	N (%)
Total	267 (100%)
Type	
2-year	60 (22%)
Less selective 4-year	149 (56%)
More selective[4] 4-year	58 (22%)
Control	
Public	180 (67%)
Private	87 (33%)
Census Region	
Midwest	89 (33%)
Northeast	8 (3%)
South	154 (58%)
West	16 (6%)

Relative to the ACT-tested high school graduate population, the sample has fewer African American, Hispanic, and male students. Relative to the population, the sample has higher mean ACT Composite score (22.1 vs. 20.2), which is expected given that students with higher academic achievement are more likely to enroll in college. Comparing the sample to the population of ACT-tested college enrollees, we see there is less representation of students at more selective 4-year institutions (24% vs. 38%), and greater representation of students at less selective 4-year institutions (61% vs. 38%).

[3] This criterion was imposed to increase the stability of the analyses. Groups with very high (or very low) success rates are rare but could have a large influence on the distribution of scores associated with a 0.50 probability of success. Such groups are less likely to have an optimal cut score (a score associated with a 0.50 probability of success).

[4] Admission policy was reported by institutions according to the high school class ranks of their accepted freshmen: the majority of freshmen at *highly selective* schools are in the top 10%, *selective* in the top 25%, *traditional* in the top 50%, and *liberal* in the top 75% of their high school class. Institutions with *open* admissions policies accept all high school graduates to limit of capacity. For our analysis, we classified 4-year institutions as more selective (*selective* or *highly selective*) or less selective.

Table 3. Description of Student Sample

Characteristic	Sample	Weighted Sample	ACT-tested High School Population[5]
Gender			
Female	54.9%	53.5%	50.3%
Male	45.1%	46.4%	47.1%
Unknown	<0.1%	0.1%	2.7%
Race/Ethnicity			
African American	12.0%	15.3%	14.7%
Asian	2.1%	3.1%	3.0%
Hispanic	4.0%	11.3%	13.2%
Other	4.5%	5.7%	5.5%
White	74.5%	58.6%	55.9%
Unknown	2.7%	6.1%	7.8%
ACT Composite score			
Mean	22.1	20.7	20.2
Standard deviation	4.5	5.0	5.4
High school GPA			
Mean	3.37	3.20	3.15
Standard deviation	0.53	0.62	0.68
Enrolled Institution Type	Sample	Weighted Sample	ACT-tested College Population[6]
2-year	14.9%	20.8%	24.0%
Less selective 4-year	61.4%	59.1%	38.4%
More selective 4-year	23.8%	20.1%	37.6%

To address the disparities between the sample and population frequency distributions, we applied weights based on ACT Composite score level, high school GPA level, race/ethnicity, and institution type to the sample data so that the sample was representative of the larger population. The weights were applied in two stages. In the first stage, student weights were applied based on the population to sample ratio of the relative frequency of ACT Composite score level, high school GPA level, and race/ethnicity combination. In the second stage, institution weights were applied based on the population to sample ratio of frequency of students at each institution type (2-year, less selective 4-year, or more selective 4-year). Table 3 also compares the student sample, after the first stage of weighting, to the population. After the first stage of weighting, the sample is very similar to the population on ACT Composite score, high school GPA, and race/ethnicity.

Statistical Methods

FYGPA success levels. For five different levels of success, we estimated the probability of success for each ACT Composite score. The five levels of success we considered were: 2.00 or higher FYGPA (C or higher grade average), 2.50 or higher FYGPA, 2.67 or higher FYGPA (B- or higher grade average), 3.00 or higher FYGPA (B or higher grade average), and 3.50 or higher FYGPA. Multiple levels were examined to give states and districts additional evidence that can be used in setting college readiness cut scores. Four of the five levels of success span the success levels used for the College Readiness Benchmarks, which considered grades of C or higher (similar to the 2.00 or higher FYGPA level) and B or higher (similar to the 3.00 or higher FYGPA level). We also considered the 3.50 or higher FYGPA level to provide evidence for a higher level of academic success, corresponding to what's typically used for Dean's List designations.

Hierarchical logistic regression. We used hierarchical logistic regression to determine the probability of success for each ACT Composite score and to determine the score at each institution associated with a 50% chance of attaining each FYGPA level. The logistic regression model relates ACT Composite scores (X) to probability of course success (p) through Equation (1):

$$\ln\left(\frac{p}{1-p}\right) = \alpha + \beta X \qquad (1)$$

The relationship between ACT Composite score and the log-odds of success in Equation (1) is specified as a simple intercept-slope model. In the hierarchical version of the model, the intercepts (α) and slopes (β) are treated as random effects, so that each parameter can vary by institution. The hierarchical model is appropriate because of the nesting of students within institutions (Raudenbush & Bryk, 2002). This model is the same as that used for the previous Benchmark studies. As described earlier, student weights were used to make the samples

[5] ACT-tested high school graduates of 2016 from states where at least 50% took the ACT.
[6] ACT-tested high school graduates of 2015 that enrolled in college in fall 2015. College enrollment data obtained through the ACT Class Profile Service and the National Student Clearinghouse.

similar to the ACT-tested high school graduate population with respect to ACT Composite score, high school GPA, and race/ethnicity. The student weights (first stage weights) were applied to the hierarchical logistic regression models.

Calculating the typical cut scores. The hierarchical logistic regression model produced an estimated intercept and slope for each institution. For each institution, we then calculated the score associated with a 50% chance of success—we refer to these scores as the institution-specific cut scores.[7] Weights were applied to the institution-specific cut scores to make each sample similar to the ACT-tested college enrollee population with respect to institution type (2-year, less selective 4-year, and more selective 4-year). The typical cut scores were then calculated as the weighted median of the cut scores across institutions. This process was repeated for each of the five FYGPA levels. The typical cut scores represent the ACT test scores associated with a 50% chance of attaining the FYGPA level at a typical college. While we estimated probabilities of success for each level of success, we focus on the typical cut scores for the ≥2.67 and ≥3.00 levels because they are most consistent with the B or higher level of success used to establish the ACT College Readiness Benchmarks.

Table 4. Proportion Meeting FYGPA Levels

ACT Composite Score	N	FYGPA Success Level				
		≥2.00 (C)	≥2.50	≥2.67 (B-)	≥3.00 (B)	≥3.50
<11	139	*	*	*	*	*
11	553	0.494	0.255	0.195	0.132	0.031
12	2,024	0.506	0.297	0.223	0.147	0.050
13	4,632	0.541	0.338	0.261	0.177	0.060
14	7,645	0.574	0.365	0.286	0.188	0.052
15	11,648	0.607	0.394	0.305	0.197	0.053
16	16,731	0.627	0.420	0.336	0.223	0.063
17	22,096	0.665	0.463	0.376	0.251	0.076
18	27,291	0.695	0.502	0.413	0.275	0.081
19	31,238	0.721	0.540	0.453	0.314	0.099
20	34,160	0.761	0.588	0.503	0.360	0.124
21	36,218	0.790	0.635	0.552	0.405	0.151
22	34,531	0.821	0.682	0.605	0.466	0.190
23	32,154	0.847	0.725	0.653	0.514	0.234
24	31,135	0.874	0.770	0.708	0.576	0.279
25	27,528	0.890	0.797	0.741	0.618	0.321
26	23,309	0.905	0.823	0.771	0.657	0.365
27	19,914	0.916	0.845	0.801	0.700	0.416
28	16,208	0.930	0.865	0.823	0.725	0.454
29	12,386	0.935	0.882	0.845	0.760	0.497
30	9,490	0.946	0.899	0.866	0.782	0.545
31	6,679	0.950	0.908	0.883	0.808	0.587
32	4,528	0.956	0.921	0.895	0.833	0.639
33	2,555	0.968	0.944	0.929	0.877	0.690
34	1,338	0.966	0.943	0.930	0.891	0.722
35	478	0.967	0.950	0.929	0.904	0.755
36	60	1.000	0.983	0.983	0.933	0.833
Total	416,668	0.801	0.666	0.596	0.473	0.231

Results

Table 4 provides the raw proportion of students meeting each FYGPA level by ACT Composite score. These proportions do not incorporate the sample weighting or hierarchical regression analyses, but provide a descriptive look at the data. The overall success rates varied by FYGPA level, from 80% for the 2.00 level to 23% for the 3.50 level. The percentage of students meeting each FYGPA level increases with ACT Composite score. For example, 25% of students with an ACT Composite score of 17 met the 3.00 success level, and 51% of students with an ACT Composite score of 23 met the 3.00 success level.

[7] The cut score is calculated as the intercept divided by the slope, multiplied by -1, and then rounded to the next integer. For example, an intercept of -4.10 and slope of 0.20 would yield a 50% cut score of 20.5 (21).

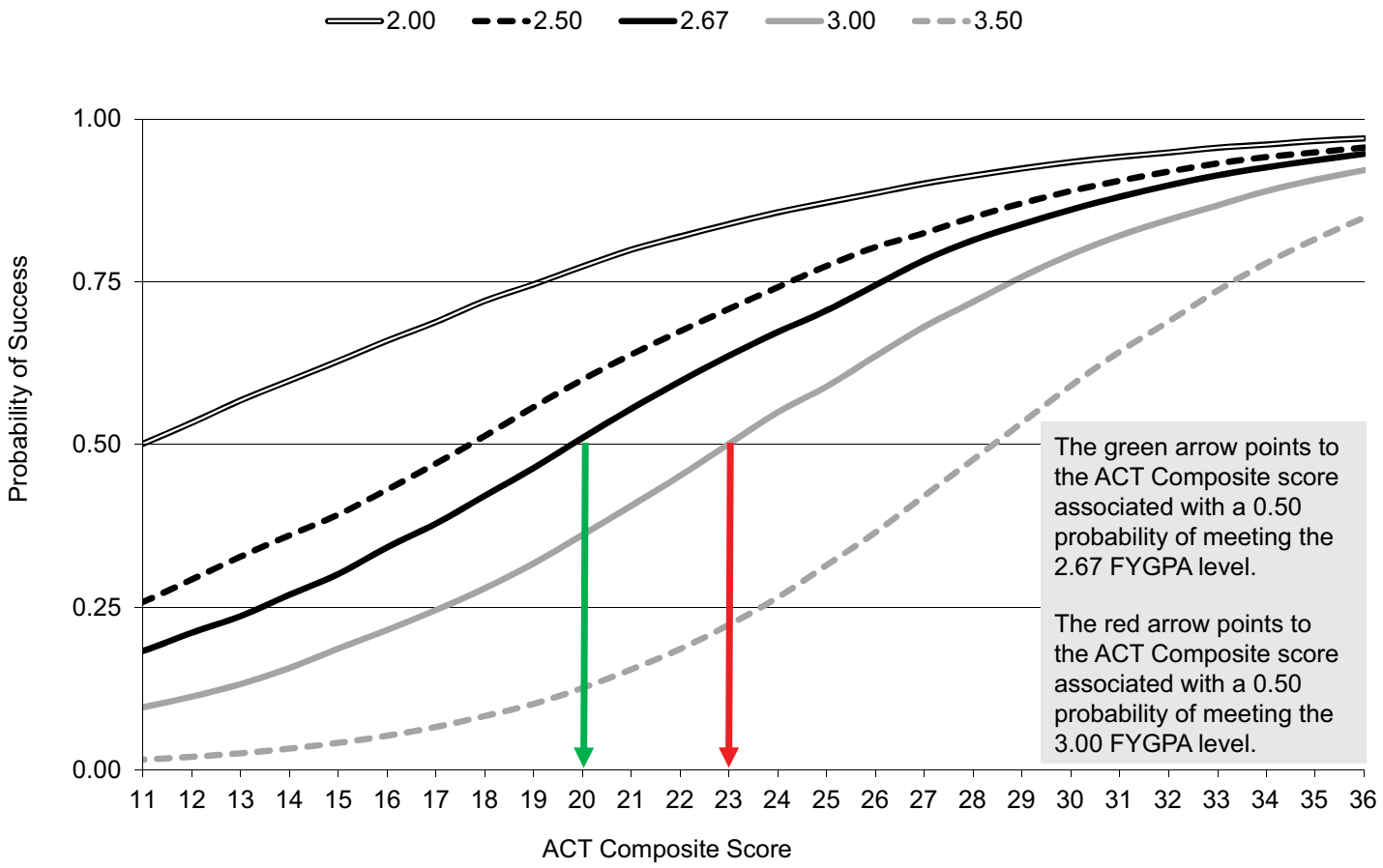

Figure 1. Probability of FYGPA success levels, by ACT Composite score

Typical probabilities of success and typical cut scores

The hierarchical logistic regression model produces a probability curve for each institution, and Figure 1 shows the weighted median of the probabilities across all institutions.[8] The probability curve for the ≥2.67 FYGPA level crosses the 0.50 probability at an ACT Composite score of 20, and the probability curve for the ≥3.00 FYGPA level crosses the 0.50 probability at an ACT Composite score of 23. Table A2 of the appendix provides the weighted median probabilities in tabular form.

From Figure 1, we see that the probabilities of success increase steadily with ACT Composite score. The slopes are greater for the higher FYGPA levels. This is consistent with previous research that has shown that ACT scores discriminate more at higher performance levels (Allen, 2013; Noble & Sawyer, 2002; Sawyer, 2013).

Table 5. Distributions of Institution-Specific Cut Scores

FYGPA Level	1st Quartile	Median (Typical Cut Score)	3rd Quartile
≥2.67 (B-)	19	20	22
≥3.00 (B)	22	23	25

The distributions of institution-specific cut scores are summarized in Table 5. The median score associated with a 50% chance of a 2.67 or higher FYGPA is 20, and the median score associated with a 50% chance of a 3.00 or higher FYGPA is 23. Therefore, if a state or district determined that a college-ready student should have at least a 50% chance of earning a FYGPA of at least 2.67 (B- average), they could choose an ACT Composite score of 20 as the cut score for college readiness. Similarly, 23 is the typical score associated with a 50%

[8] The results of the hierarchical logistic regression models are given in Table A1 of the appendix. The values in Table A1 represent estimates of the mean intercept and slope across institutions, prior to the second stage weighting. The parameter estimates describe the relationship between ACT scores and course success at a typical institution. Table A1 includes estimates (and standard errors) of the mean intercept and slope, as well as estimates (and standard errors) of the variance of the intercepts and slopes.

chance of earning ≥3.00 FYGPA. There is variability in cut scores across institutions, with interquartile ranges of 3 for both success levels.

Discussion

The evidence summarized in this report can help states and districts set cut scores for the ACT Composite score indicating overall readiness for college. While ACT chose the B or higher success criterion and 0.50 probability level when establishing the ACT College Readiness Benchmarks, states and districts might deem other levels of success and/or different probability levels as appropriate for an overall measure of college readiness. Once a readiness cut score is determined, it can be described with respect to multiple levels of success. For example, a state or district might determine that a college-ready student should have a 0.50 probability of earning a 3.00 or higher FYGPA, and thus choose an ACT Composite score of 23 as the readiness cut score. Students with an ACT Composite score of 23 also have an 84% chance of earning a 2.00 (C average) or higher FYGPA, and a 22% chance of earning a 3.50 or higher FYGPA.

Using the 3.00 or higher FYGPA level and 0.50 probability level is most consistent with the ACT College Readiness Benchmarks and results in a typical cut score of 23. However, we note that an ACT Composite score of 20, resulting from the 2.67 or higher FYGPA level and 0.50 probability level, is related to a 77% chance of earning a C or higher grade average, and so is also consistent with an important property of the ACT College Readiness Benchmarks.[9]

[9] The ACT College Readiness Benchmarks are related to an approximate 75% chance of earning a C or higher grade in the respective course(s).

Table 6. Consistency of ACT Composite Cut Score of 20 with Meeting all ACT College Readiness Benchmarks

	ACT Composite Score ≥20	
ACT College Readiness Benchmarks	**Met**	**Did Not Meet**
Met all four	26.4%	0.0%
Did not meet all four	28.5%	45.1%

Table 7. Consistency of ACT Composite Cut Score of 23 with Meeting all ACT College Readiness Benchmarks

	ACT Composite Score ≥23	
ACT College Readiness Benchmarks	**Met**	**Did Not Meet**
Met all four	26.2%	0.2%
Did not meet all four	10.2%	63.4%

The classification consistency of overall college readiness cut scores with the ACT College Readiness Benchmarks can be evaluated to determine how often the indicators will give consistent signals about readiness. For example, in Table 6, we consider the consistency of meeting all four ACT College Readiness Benchmarks (in English, mathematics, reading, and science) and meeting an ACT Composite score of 20. Students from the 2016 ACT-tested high school graduated class are used (N=2,090,342). Overall, 71.5% of students received the same classification. Nearly half of students (45%) met neither readiness threshold. Many students (28.5%) met the ACT Composite cut score of 20, but did not meet all four ACT College Readiness Benchmarks. Because the minimum ACT Composite score is 21 (=(18+22+22+23)/4) for students who meet all four Benchmarks, there are no students who met all four Benchmarks but not the ACT Composite cut score of 20.

In Table 7, we consider the consistency of meeting all four Benchmarks and meeting an ACT Composite score of 23. Overall, 90% of students received the same classification. A majority of students (63%) did not meet either readiness threshold. Among students who received different classifications, a vast majority met the ACT Composite cut score of 23 but did not meet all four Benchmarks. Among these students, it was very common to miss meeting only one of the four Benchmarks.

Table 8 shows the impact of different college readiness cut scores, by subgroup, for students from the 2016 ACT-tested high school graduated class. The percentage meeting each college readiness cut score is presented for the total group, by family income level, and by race/ethnicity.

Table 8. Percentage Meeting College Readiness Cut Scores, 2016 ACT-Tested Graduating Class

		ACT College Readiness Benchmarks					ACT Composite Cut Scores	
Group	**N**	**English**	**Mathematics**	**Reading**	**Science**	**All 4**	**20**	**23**
Total	2,090,342	61.4%	40.7%	44.5%	36.1%	26.4%	54.9%	36.4%
Family income								
<$36K	464,399	41.9%	20.8%	26.6%	17.8%	10.3%	33.5%	16.8%
$36K-$60K	313,450	59.7%	34.9%	40.7%	31.0%	20.1%	52.1%	30.5%
$60K-$100K	339,758	72.9%	49.2%	53.0%	44.0%	31.6%	66.7%	44.5%
>$100K	369,187	83.7%	65.2%	66.3%	58.6%	47.1%	79.8%	60.8%
Race/ethnicity								
African American	272,363	32.5%	13.3%	18.8%	10.9%	5.9%	23.2%	10.3%
Asian	93,493	75.3%	69.8%	58.8%	55.9%	46.3%	74.0%	58.4%
Hispanic	337,280	45.6%	27.2%	30.5%	21.4%	14.0%	38.7%	21.2%
Two or more races	85,494	63.7%	39.6%	46.1%	36.1%	25.8%	56.1%	36.4%
White	1,119,398	73.2%	50.2%	54.6%	45.9%	34.0%	67.2%	46.4%

References

Allen, J. (2013). *Updating the ACT College Readiness Benchmarks*. Iowa City, IA: ACT.

Allen, J., & Sconing, J. (2005). *Using ACT Assessment scores to set benchmarks for college readiness*. Iowa City, IA: ACT.

Mattern, K., Radunzel, J., & Westrick, P. (2015). *Development of STEM Readiness Benchmarks to assist educational and career decision making.* Iowa City, IA: ACT.

Noble, J., & Sawyer, R. (2002). *Predicting different levels of academic success in college using high school GPA and ACT Composite Score.* Iowa City, IA: ACT.

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models.* Thousand Oaks, CA: Sage Publications.

Radunzel, J., Mattern, K., Crouse, J., & Westrick, P. (2015). *Development and validation of a STEM benchmark based on the ACT STEM score*. Iowa City, IA: ACT.

Radunzel, J., Westrick, P., Bassiri, D., & Li, D. (2017). *Development and validation of a preliminary ELA readiness benchmark based on the ACT ELA score.* Iowa City, IA: ACT.

Sawyer, R. (2013). Beyond correlations: Usefulness of high school GPA and test scores in making college admission decisions. *Applied Measurement in Education, 26*(2), 89-112.

Appendix

Table A1. Parameter Estimates from Hierarchical Logistic Regression Models for FYGPA Success Levels

	Mean		Variance	
FYGPA Level	**Intercept (SE)**	**Slope (SE)**	**Intercept (SE)**	**Slope (SE)**
2.00	-1.5011 (0.0732)	0.1379 (0.0034)	1.0543 (0.1240)	0.0021 (0.0003)
2.50	-2.9224 (0.0737)	0.1666 (0.0034)	1.1583 (0.1286)	0.0024 (0.0003)
2.67	-3.5180 (0.0751)	0.1778 (0.0035)	1.2240 (0.1340)	0.0025 (0.0003)
3.00	-4.4642 (0.0875)	0.1944 (0.0040)	1.7269 (0.1840)	0.0035 (0.0004)
3.50	-6.7243 (0.1031)	0.2371 (0.0044)	2.2836 (0.2508)	0.0041 (0.0005)

Note: SE = standard error

Table A2. Typical Probabilities of Attaining FYGPA levels, by ACT Composite Score

	FYGPA level				
ACT Composite Score	**≥2.00**	**≥2.50**	**≥2.67**	**≥3.00**	**≥3.50**
1	0.211	0.069	0.042	0.016	0.001
2	0.234	0.079	0.048	0.019	0.002
3	0.258	0.091	0.056	0.023	0.002
4	0.283	0.104	0.066	0.028	0.003
5	0.309	0.119	0.076	0.034	0.004
6	0.338	0.136	0.089	0.040	0.005
7	0.370	0.156	0.104	0.048	0.006
8	0.402	0.176	0.122	0.057	0.008
9	0.435	0.201	0.141	0.069	0.010
10	0.469	0.229	0.162	0.081	0.013
11	0.501	0.258	0.183	0.096	0.016
12	0.533	0.292	0.211	0.112	0.020
13	0.568	0.328	0.236	0.132	0.026
14	0.598	0.360	0.269	0.156	0.033
15	0.628	0.392	0.301	0.186	0.041
16	0.659	0.430	0.342	0.215	0.052
17	0.688	0.471	0.378	0.245	0.066
18	0.720	0.513	0.421	0.279	0.083
19	0.746	0.557	0.464	0.317	0.101
20	0.773	0.600	0.510	0.361	0.126
21	0.799	0.638	0.555	0.406	0.154
22	0.819	0.674	0.597	0.452	0.186
23	0.839	0.708	0.636	0.501	0.223
24	0.857	0.742	0.673	0.549	0.265
25	0.872	0.774	0.706	0.589	0.315
26	0.886	0.803	0.745	0.636	0.365
27	0.901	0.825	0.783	0.681	0.421
28	0.913	0.849	0.814	0.719	0.477
29	0.924	0.870	0.838	0.758	0.533
30	0.934	0.889	0.861	0.792	0.590
31	0.942	0.905	0.880	0.821	0.643
32	0.948	0.919	0.898	0.845	0.689
33	0.956	0.932	0.913	0.867	0.736
34	0.961	0.942	0.926	0.889	0.779
35	0.966	0.949	0.936	0.907	0.815
36	0.970	0.956	0.946	0.921	0.848