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Final

NAEP Grade 12 Academic Preparedness Research:
Establishing a Statistical Relationship between NAEP and ACT Assessments in Reading and Mathematics

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Introduction

Starting in early 2003, the National Assessment Governing Board (Governing Board) embarked on an ambitious mission to redesign grade 12 assessments and reporting as recommended by the National Commission on 12th Grade Assessment and Reporting. The commission recommended that a state program similar to 4th and 8th grade should be implemented and that NAEP should start reporting on the readiness of 12th graders for college, training for employment, and entrance into the military. As a result of the second recommendation, a number of studies were conducted to assess whether and in what ways NAEP could report on *academic preparedness*.

According to the Governing Board[1], to be "academically prepared for college", 12th graders should have the knowledge and skills in reading and mathematics to qualify for placement into entry-level college credit courses that meet general education requirements, without the need for remedial coursework in reading or mathematics. Statistical linking studies were conducted to examine performance on NAEP in relation to the college readiness benchmark adopted by the College Board for the SAT critical reading and mathematics tests (Moran, Oranje, & Freund, 2012). The statistical linking studies used data from students who were sampled and assessed in the NAEP 12th grade reading or mathematics in 2009 and had also taken the SAT by June 2009.

After various content alignment studies, judgmental standard setting, secondary analyses, data collections, and statistical linking research (National Assessment Governing Board, 2009), potential benchmarks were identified on the 12th grade NAEP reading and mathematics scales to indicate what level of performance would correspond to a reasonable probability of being academically prepared for placement into first-year, general education college coursework without the need for remediation. Beginning with the 2013 12th grade NAEP assessments, the reporting of results included the percentage of students academically prepared for college, as indicated by a score of 302 on the grade 12 NAEP reading assessment (same as the *NAEP Proficient* cut score) and a score of 163 on the grade 12 NAEP mathematics assessment (between the cut scores for *NAEP Basic* and *NAEP Proficient*). The Governing Board is currently working to expand beyond academic preparedness for college, to report on preparedness for postsecondary endeavors more broadly using a dashboard of indicators.

As part of the second phase of the Governing Board's academic preparedness research, Michigan and Tennessee participated in the state-level statistical linking research[2] connecting NAEP and ACT and provided data on students who were part of the NAEP grade 12 sample during the 2012–2013 school year including their ACT data. The state-level NAEP-ACT linking study results can be found on the Governing Board's website. Although NAEP-ACT linking studies were performed using special samples of students in these two states (MI and TN), it is important to understand how national results on the two assessments are related to each other. The objective of the current study is to enable interpretation of the NAEP results in reference to the ACT score scale and the ACT college readiness benchmarks. This study also compares the newly identified potential benchmarks

[1] Governing Board preparedness research website: https://www.nagb.gov/focus-areas/reports/preparedness-research.html

[2] Massachusetts also participated in the state-level statistical linking research. However, the linking study conducted in MA was to connect NAEP and SAT, at the state level.

on NAEP to those established in the NAEP-SAT linking study, to evaluate the consistency in linking through different assessments.

In this report, we will describe the NAEP and ACT tests in reading and mathematics that were used for this study, discuss the linking methodology (and refer the interested readers to more technical references), and provide the results. A summary concludes this report.

Linking Assessments

The ACT Test

The ACT test is a U.S. college admission test measuring what students learn in high school to determine their academic readiness for college (https://www.act.org/content/act/en/products-and-services/the-act.html). The assessment contains four multiple-choice tests and an optional writing test that does not affect students' composite scores. Each multiple-choice test measures student achievement in one of the following four areas: English, mathematics, reading, and science. The testing time and number of items vary by subject. For ACT reading, students have 35 minutes to finish 40 multiple-choice questions. For ACT mathematics, students have 60 minutes to finish 60 multiple-choice questions. The ACT scores provide evidence about the knowledge and skills that students are likely to have in each of the four aforementioned areas. The distribution of item difficulties was selected so that the tests will effectively differentiate among students who vary widely in the level of achievement. A composite score is provided, which is calculated as the average of the four test scores. The individual test scores, as well as the composite score, range from 1 to 36 and are disseminated to students and schools directly. In this study, the ACT reading score was used to link with the NAEP reading assessment and the ACT mathematics score was used to link with the NAEP math assessment. The data set included the sample that participated in the 2013 NAEP grade 12 reading and mathematics assessments and had also taken the ACT by June 2013.

The ACT test is designed to assess a student's academic achievement in high school, especially with respect to college readiness. To help students translate test scores into clear indicators of their current levels of college readiness, ACT provides college readiness benchmarks reflecting the minimum ACT scores required for students to have a reasonable chance of success in credit-bearing college courses. Using data from ACT's Research Services, including the Course Placement Service and Prediction Service, ACT derived their college readiness benchmarks to reflect the ACT score associated with a 50% chance of earning a B or higher (and approximately a 75% chance of earning a C or higher) in a related first-year college course at a typical postsecondary institution (including two-year and four-year colleges; ACT, 2013). The ACT reading benchmark is a 22 on the ACT reading test and is derived based on course success in social science courses (ACT Technical Manual, Table 8.4). The ACT mathematics benchmark is a 22 on the ACT mathematics test and is derived based on course success in college algebra (ACT Technical Manual, Table 8.4). These two benchmarks were used in this study.

The National Assessment of Educational Progress (NAEP)

The NAEP assessment is based on broad frameworks developed by the National Assessment Governing Board and measures what U.S. students know and can do in various subjects across the nation, states, and in some urban districts. NAEP is the only nationally representative assessment of 4th, 8th, and 12th grade students in public and private schools in the U.S. in a variety of academic subjects. Subjects such as reading, mathematics, and science are also assessed at the state- and large urban district-level, particularly in grades 4 and 8. Samples of schools and students are selected from a sampling frame in order to produce results that are nationally representative and also representative of participating states and urban districts. Selected students had 50 minutes[3] to complete the cognitive items (i.e., test questions) contained in the NAEP test booklets that were randomly assigned to them. The number and type of items in each booklet vary by subject and by grade. For grade 12 reading, each booklet contains two blocks of about 10 items each. For grade 12 mathematics, each booklet contains two blocks of about 15 items each. A mix of multiple-choice (MC) and constructed-response (CR) items is administered and blocks are systematically paired across booklets (i.e., matrix sampling design).

NAEP reports assessment results reflecting student performance in two ways: average scores on the NAEP subject scale and percentages of students attaining NAEP achievement levels. The three NAEP achievement levels—*NAEP Basic*, *NAEP Proficient*, and *NAEP Advanced*—describe what students should know and be able to do. In particular, the *NAEP Proficient* achievement level is a benchmark for solid academic performance (i.e., students reaching this level have demonstrated competency over challenging subject matter; https://nagb.gov/focus-areas/NAEP-achievement-levels.html). For grade 12 reading, the NAEP performance is reported on a 0–500 scale, and the *NAEP Proficient* achievement level cut score is 302. For grade 12 mathematics, the NAEP results are reported on a 0–300 scale, and the *NAEP Proficient* achievement level cut score is 176.

By law, no student or school results are estimated or reported using the NAEP assessment. Instead, the main objective of NAEP is to report on the achievement of policy-relevant population groups, estimated directly using marginal estimation latent regression methods. For linking studies involving NAEP, this requires that the relationship between NAEP and other measures (e.g., the ACT) be directly estimated using this latent regression methodology, since there are no appropriate student-level NAEP scores available. In the methodology section we will discuss some of the steps required to complete this part of the research. For a comprehensive description of NAEP estimation procedures, interested readers are referred to Mislevy, Beaton, Kaplan, and Sheehan (1992).

Linking

When linking scales of different assessments, construct similarity between the two assessments plays an important role in determining the degree of linkage that can be achieved (Dorans, 2004). Typically, a content alignment precedes statistical alignment to assess the extent to which the instruments were designed to measure the same or different constructs. It serves as the foundation for most of the preparedness research, especially for the statistical relationship studies. The content alignment studies between the NAEP and ACT reading and mathematics assessments were

[3] The NAEP reading and mathematics assessments transitioned to a digital delivery platform in 2017. Under the digitally-based assessment (DBA) design, each selected student took two blocks of cognitive items, each with 30 minutes of allotted testing time, making the total testing time 60 minutes.

conducted by ACT in 2009, under subtask 4.3 of contract ED-06-CO-0098 with the National Assessment Governing Board. The studies found similar content in the 2009 NAEP and ACT, and the content overlap was more extensive in mathematics than in reading (https://www.nagb.gov/content/nagb/assets/documents/what-we-do/preparedness-research/content-alignment/ACT-NAEP_Math_and_Reading_Content_Comparison.pdf).

In addition, statistical indices such as correlations between the two sets of scale scores to be linked are also needed when determining the most appropriate type of linking method. In the current study, two types of test score links are considered: concordance and projection. *Concordance* occurs when scores are linked across tests built to different specifications, measure similar constructs, and are administered to similar populations (Holland & Dorans, 2006). A generally accepted minimum correlation for concordance is $r = 0.866$ (Dorans, 1999; Dorans & Walker, 2007), which corresponds to a 50 percent reduction in uncertainty (Dorans, 1999). *Projection* addresses assessments constructed around different conceptions of students' competence, or around the same conceptions but with tasks that differ in format or content (Mislevy, 1992). Neither concordance nor projection is a perfect prediction, but concordance in general assumes and requires a much stronger relationship than projection. Additionally, concordant scores have matched distributions (Dorans, 2004) and are provided in the form of a concordance table, while for projection there is usually no simple "one-to-one" correspondence tables generated. In the case of the NAEP-ACT linking study, a moderately strong relationship was expected based on experience with past studies, and linking the two assessments with projection appeared to be more appropriate. We elaborate further on this in subsequent sections.

Methodology

In this section we discuss the data and the linking methodology. The purpose is to give readers some insight into the procedures followed and therefore the opportunity to evaluate the results within the context of this NAEP-ACT linking study.

Data

The NAEP-ACT linking study used data from students attending public schools who were sampled and assessed in the NAEP 12th grade reading or mathematics in 2013 and had also taken the ACT test by June 2013.

NAEP Samples

From late January through early March of 2013, the NAEP assessments in reading and mathematics were administered to samples of 12th grade students that were representative of the nation. Whereas grade 12 NAEP assessments in reading and mathematics are in general administered to only nationally representative samples, 13 states (Arkansas, Connecticut, Florida, Idaho, Illinois, Iowa, Massachusetts, Michigan, New Hampshire, New Jersey, South Dakota, Tennessee, and West Virginia) volunteered to participate in a twelfth-grade state pilot program in 2013. As a result, larger samples of students from public schools in each of the 13 pilot states (roughly 2,600 students per subject) were drawn and augmented the nationally-representative samples of public school students. Overall, approximately 44,300 twelfth-grade public school students were assessed in NAEP reading and 44,900 twelfth-grade public school students were assessed in NAEP

mathematics in 2013. Sampling weights were used to ensure appropriate representation of the larger state samples in national-level analyses.

ACT Scores

For each student in the ACT data set, scores were available from one or more ACT administrations, which included separate scores for English, mathematics, reading, and science. The scale scores for each section, as well as the composite score, range from 1 to 36 in 1-point increments. The reading and mathematics scores from each student's highest ACT composite score were used in this study because these were the ACT scores most likely considered in college admissions. English and science scores were not used in this study.

Matching NAEP and ACT Test Takers

The process of matching ACT scores to NAEP participants was carried out through an agreement between the National Assessment Governing Board and the National Center for Education Statistics (NCES) to have NAEP contractors Westat and ETS conduct the preparedness research work. A data sharing agreement was established between all parties including ACT. This agreement involved the NAEP contractors working with ACT to match the needed ACT scores for students in the NAEP samples. A process for matching the student records was developed to protect students' identity. Confidentiality of ACT scores was assured through the assignment of a pseudo ID for students taking the ACT and using that pseudo ID as a way to transfer ACT scores from ACT to ETS. Similarly, the pseudo ID was appended to NAEP files by Westat, which then provided that file to ETS. Via the pseudo ID, ETS matched ACT scores to NAEP files without requiring access to any personally identifiable information (PII) data from ACT. The final student data were limited to questionnaire responses, ACT scores, and the pseudo ID. The NAEP scores were matched at a rate of 41% for the weighted reading sample and 42% for the weighted mathematics sample, resulting in 19,900 students for reading and 20,300 students for mathematics. These match rates are lower than the national ACT participation rate of approximately 54% of high school graduates in 2013. Table 1 provides weighted[4] percentages by gender and race/ethnicity for the matched sample and overall match rates.

Table 1. Weighted percentages by gender and race of the matched samples

	Reading							
	White	*Black*	*Hispanic*	*Asian*	*American Indian /Alaskan Native*	*Pacific Islander*	*2+ races*	***Total*[2]**
Male	30%	7%	5%	2%	#[1]	#	1%	**46%**
Female	33%	9%	7%	2%	#	#	1%	**54%**
***Total*[2]**	**63%**	**16%**	**13%**	**5%**	**1%**	**#**	**2%**	**100%**
						Overall Match Rate		**41%**

[4] For all NAEP assessments, sample weights are applied at the student level to ensure the representativeness of the jurisdictions from which they are selected. For more information on NAEP assessment weighting procedures, refer to https://nces.ed.gov/nationsreportcard/tdw/weighting/.

Mathematics								
	White	*Black*	*Hispanic*	*Asian*	*American Indian /Alaskan Native*	*Pacific Islander*	*2+ races*	***Total*[2]**
Male	29%	7%	5%	2%	1%	#	1%	**45%**
Female	34%	9%	7%	3%	1%	#	1%	**55%**
***Total*[2]**	**63%**	**16%**	**13%**	**5%**	**1%**	**#**	**2%**	**100%**
							Overall Match Rate	**42%**

NOTES: [1]# Rounds to zero.
[2] Detail may not sum to totals because of rounding.

Identification and Removal of Outliers

Given the fact that the two assessments to be linked have different purposes, reporting goals, and stakes, an outlier analysis is in order. For instance, if there are participants who scored very high on a higher stakes test (i.e., the ACT test) and very low on a lower stakes test (i.e., NAEP), the low performance can be reasonably attributed to motivation rather than performance level. Such cases would be considered 'outliers' and removed from further analysis. An initial examination of the joint distribution of NAEP and ACT revealed very few potential outlier cases. After this cursory inspection, standardized residuals from robust regression (Huber, 1973) were used to identify approximately 0.8% of cases in reading and approximately 0.7% of cases in mathematics (cases with absolute standardized residuals greater than 3 were considered outliers and removed). These outliers were excluded from the final linking sample and were not used in subsequent analyses.

Analysis Approach

After preparatory data identification, matching, merging, and data reconciliation, the linking analyses were conducted. The current study was designed to pursue five specific analysis questions:

1) What are the correlations between the grade 12 NAEP and ACT scores in reading and mathematics?

2) What scores on the grade 12 NAEP reading and mathematics scales correspond to the ACT college readiness benchmarks?

3) What are the average grade 12 NAEP reading and mathematics scores and Inter Quartile Range (i.e., the difference between the 75th and 25th percentiles) or IQR for students below, at, and at or above the ACT college readiness benchmarks?

4) What scores on the ACT reading and mathematics scales correspond to the grade 12 *NAEP Proficient* cut scores in reading and mathematics?

5) What are the average ACT reading and mathematics scores and IQRs for students below, at, and at or above the *NAEP Proficient* cut scores?

We describe pertinent methodological details about the analyses followed by the results of the analyses in the final section. The key steps of the analyses are (a) estimating the correlation between NAEP and ACT, which includes use of the aforementioned latent regression methodology,

(b) determining the appropriate methodology for linking based on those correlations, and (c) applying procedures to effectively estimate the linking functions.

Estimating Correlations between NAEP and ACT

The main objective of NAEP is to report on the achievement of policy-relevant population subgroups, estimated directly using the latent regression estimation method. A satisfactory treatment of the latent regression methodology is outside the scope of this report and the interested reader is referred to Mislevy, Beaton, Kaplan, and Sheehan (1992). The basic notion is that NAEP measures constructs that are represented on item response theory based latent scales, which are not measured reliably at the student level. However, pertinent data from students in specified groups of interest can be pooled to estimate reliable scores at the group level. To unbiasedly estimate a subgroup's proficiency on NAEP, the subgroup membership needs to be specified in the latent regression model. This means that to correctly estimate the correlation between NAEP and ACT scores, a separate latent regression model was defined to include the relationship between NAEP and ACT in the estimation process. Again, readers interested in learning details of the NAEP latent regression estimation process are referred to Mislevy et al. (1992).

In this study, the ACT scores were included as linear main and interaction effects[5] in the latent regression model. The model included three interaction terms: ACT × gender, ACT × race/ethnicity, and ACT × gender × race/ethnicity. The estimation results indicated that the true score correlation between NAEP and ACT was 0.75 for reading and 0.87 for mathematics. While the correlation for mathematics met the minimum requirement for concordance (Dorans, 2004), the correlation for reading was only moderately strong, suggesting that there was enough uncertainty in the relationship that a direct one-to-one correspondence of scale score points was not advisable.

To elaborate on that observation and, as briefly introduced earlier, different classes of statistical relationships can be established between various tests, and the distinctions correspond to the extent to which the tests are similar with respect to the constructs measured, populations, and measurement characteristics of the tests (Feuer, Holland, Green, Bertenthal, & Hemphill, 1999; Holland & Dorans, 2006). In this study, two types of statistical linking were originally considered: concordance and projection. Concordance establishes a score linkage between two tests by matching the corresponding score distributions. The claims that can be made based on concordance are also commensurately strong. Essentially, the claim is made that a score *X* on NAEP exactly corresponds to a score *Y* on ACT and vice versa, when both scales are continuous. Projection is a less stringent type of correspondence in which scores on one test are related, typically via a linear or nonlinear regression, to a conditional distribution of scores on the other test. Projection relationships are not symmetric, and do not result in matched distributions between the two assessments or a one-to-one correspondence. Projection analyses support claims like "A score of *X* on NAEP corresponds to a proportion *p* of students attaining the benchmark score of *Y* or higher on ACT". Subsequently, a choice for *p* has to be made, where a more conservative claim requires a higher *p*. This means that if one wants to have a very high degree of confidence that students at a certain NAEP score pass the benchmark, then a relatively high *p* has to be set. Consequently, a relatively high NAEP score level is identified, and likely, the percentage of students who actually

[5] The ACT scores were included as independent variables in the latent regression, and the measurement error associated with the ACT scores were not accounted for in the estimation by this model.

pass the benchmark is under-estimated. The reverse is true when a lower degree of confidence is acceptable.

The relationship between NAEP and ACT mathematics (r=0.87) just met the minimum correlation requirement of 0.866 for concordance (Dorans, 1999; Dorans & Walker, 2007), but the relationship between NAEP and ACT reading (r =0.75) was not sufficiently strong to support concordance. Additionally, a technically sound concordance linking requests the two assessments to have similar testing population (Holland and Dorans, 2006), which was likely not met as NAEP is a low-stakes survey assessment and ACT is a high-stakes college admission test. Therefore, projection was selected for both mathematics and reading in this study.

Typically a smoothing process is applied in order to produce more accurate probability distributions, particularly when the underlying population distribution of test scores may contain irregularities (Moses & Liu, 2011), for example due to a non-continuous nature of the scale. For the current study, a bivariate loglinear smoothing (Holland & Thayer, 2000) was applied to the joint NAEP-ACT distributions[6]. Based on the smoothed joint distributions between NAEP and ACT, projection tables containing conditional cumulative distributions of NAEP proficiencies for ACT scores were created. The range of possible NAEP scores below, at, and at or above the ACT college readiness benchmark (22 on the ACT reading scale and 22 on the ACT mathematics scale) were estimated and, subsequently, for each subject area the projected conditional distributions were used to identify the NAEP scale scores associated with the ACT benchmarks for a selected p. We discuss the results of the linking study in the following section.

Results

ACT college readiness benchmarks projected on the NAEP scale

The second and the third analysis questions ask what scores on the NAEP reading and mathematics scales correspond to the ACT college readiness benchmarks. In other words, what would be the scale score on NAEP that corresponds most reasonably to an established benchmark of academic preparedness for college?

Table 2 provides descriptive statistics to provide an initial sense of where the ACT benchmark is likely located on the NAEP scales as well as some distributional properties as context for these results. The average scores and percentile estimates for students below, at, and at or above the ACT benchmarks are spread out. Note that the mean *at* the benchmark is not necessarily the same as the NAEP score equivalent for the benchmark, but rather a characterization of the students at this level. Also note that these results are based on the proficiency estimates from the latent regression model including the relationship between NAEP and ACT.

[6] As part of the loglinear smoothing procedure for reading, we preserved the first 3 moments for the NAEP distribution, 5 moments for the ACT distribution, and 4 cross-moments. For mathematics, we preserved the first 4 moments for the NAEP distribution, 5 moments for the ACT distribution, and 4 cross-moments. These loglinear smoothing models mostly resulted in the smallest value of the Akaike Information Criterion (AIC) statistic (Moses & von Davier, 2006), although model complexity and sample size were also taken into consideration.

Table 2: Descriptive NAEP statistics for students below, at, and at or above the ACT college readiness benchmarks

Subject	ACT Benchmark	Percentage	Mean	SD	Percentile		IQR[1]
					25th	*75th*	
Reading	*Below*	53%	276	28	257	295	38
	At	6%	299	24	283	315	32
	At or Above	47%	319	28	300	338	38
Mathematics	*Below*	55%	142	22	127	157	30
	At	5%	168	15	158	178	20
	At or Above	45%	188	21	173	201	28

NOTES: [1]IQR is the Inter Quartile Range or the difference between the 75th and 25th percentiles.

A graphical representation of the relationship between NAEP scores and the proportion of students meeting the ACT benchmark helps illustrate the process of identifying the NAEP scale scores that most reasonably corresponds to the ACT benchmarks. Figures 1 and 2 show the relationship based on statistical projection for students at the respective benchmarks. The black curved line shows the proportion of students meeting the ACT college readiness benchmark for score levels on NAEP. Colored vertical lines indicate where the NAEP performance standards are located. Finally, and as mentioned previously, a proportion level has to be chosen commensurate with the confidence required to indicate whether students have passed the benchmark or not. A red dotted line shows the NAEP score above which students are more likely to have reached the benchmark than not (i.e., the conditional proportion *p* is set at 0.50). For context, a secondary, light orange line indicates when the conditional proportion *p* is set at 0.80, indicating a relatively high level of confidence that students have attained the ACT college readiness benchmark.

From Figure 1, it can be deduced that 301 is the location on the NAEP reading scale where students have a 0.50 probability of meeting the ACT reading benchmark. Note that 301 is only 1 point below the *NAEP Proficient* achievement level cut score for NAEP reading at grade 12. Figure 2 shows that the corresponding location on the NAEP mathematics scale is 167, about 9 points below the *NAEP Proficient* achievement level cut score for NAEP mathematics at grade 12.

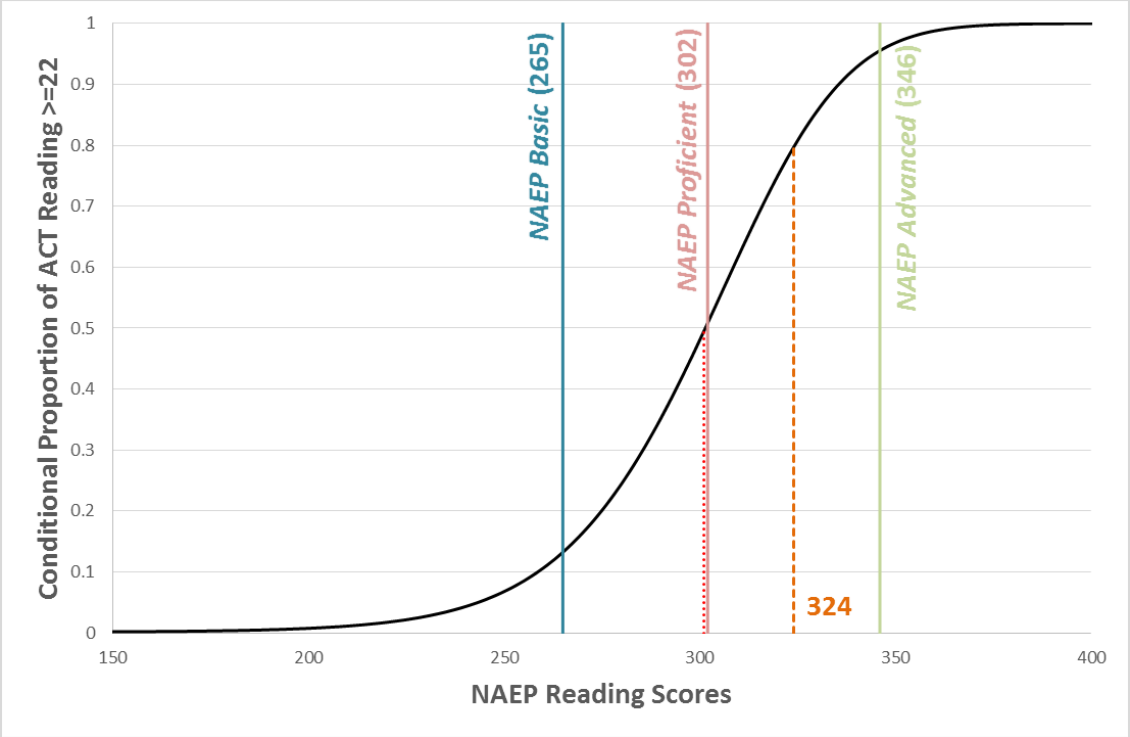

Figure 1: Proportion of students meeting the ACT reading college readiness benchmark of 22 for NAEP reading scores

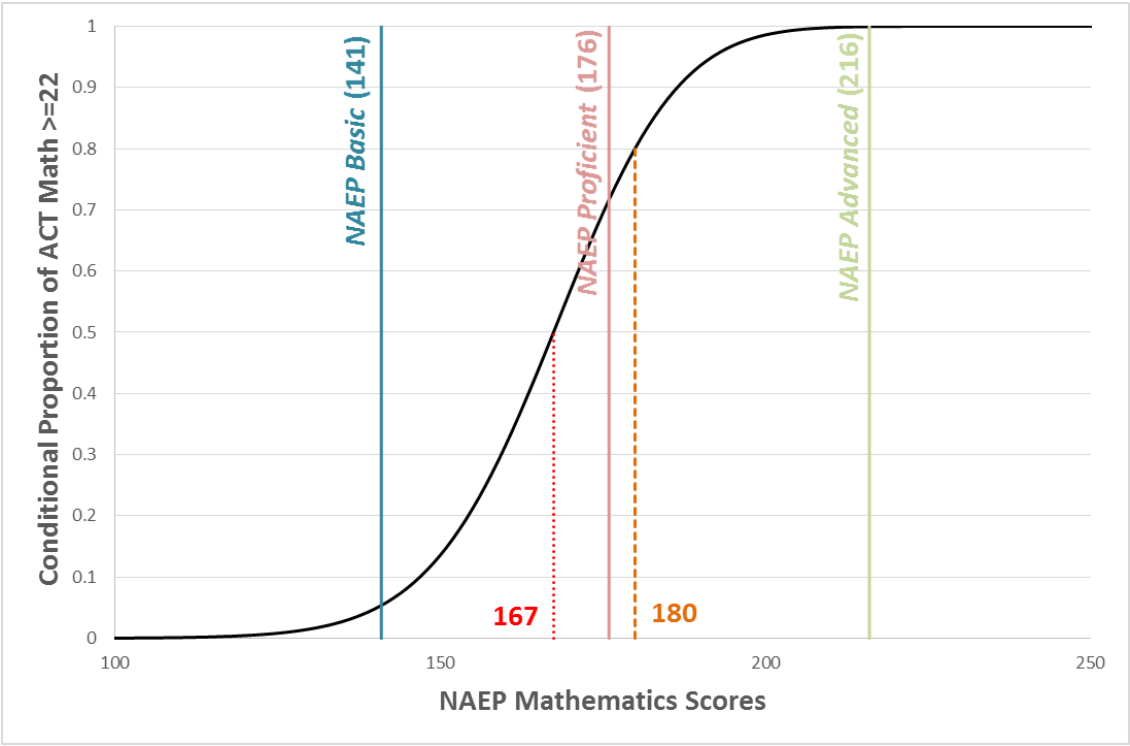

Figure 2: Proportion of students meeting the ACT mathematics college readiness benchmark of 22 for NAEP mathematics scores

Sensitivity Analysis

An important tool for evaluating statistical links between tests is sensitivity analysis, which is intended to examine the extent to which the linking relationship is invariant across key student groups, such as gender and race/ethnicity groups. These analyses require a minimum sample size[7] in order to produce reliable comparisons. For the final linking samples, both gender groups met that criterion. For the race/ethnicity groups, White, Black, Hispanic, and Asian student subgroups met the criterion. Separate linking functions were established for these subgroups.

The comparison results showed some variation across the six identified subgroups for reading but much less so for mathematics. For reading, the linking functions for Male, Female, White, and Asian student subgroups were close to the overall linking function, and the linking functions for Black and Hispanic students were slightly lower than the overall linking function. For mathematics, the linking functions for Male, Female, and White student subgroups were very close to the overall linking function, the linking function for Asian student subgroup was slightly higher than the overall linking function, and the linking functions for Black and Hispanic student subgroups were slightly lower. Thus, the location on the NAEP scale that corresponds to a 0.50 probability of meeting the ACT college readiness benchmark potentially varies by subgroup. However, it should be emphasized that some subgroups considered here had much smaller sample sizes than the overall linking sample, and therefore the difference observed between the linking functions might be due to a greater sampling variance and should be interpreted with great caution.

Impact

Given that potential NAEP benchmarks have been identified, it is important to show what percentage of students at the national level are deemed to have a reasonable probability (i.e., the probability set at 0.50) of meeting the ACT college readiness benchmarks in grade 12 across various student subgroups. Table 3 provides those percentages, based on the potential benchmarks identified on the NAEP scales, as well as the ACT college readiness benchmarks. Table 3 indicates that between 45 and 46 percent of students met the newly identified potential benchmarks on NAEP, but the results differ across subgroups. The percentages of students meeting the ACT college readiness benchmarks are similar to those meeting the NAEP potential benchmarks. No significance testing has been conducted to compare these percentages and, therefore, no comparative statements will be made.

[7] The minimum was set at 500 as a rule of thumb, based on the idea that there is at least one observation below -3 and above +3 standard deviations (in a standard normal distribution) in expectation.

Table 3: Percentage of the final linking samples that have a reasonable probability of meeting the ACT college readiness benchmarks based on the potential NAEP benchmarks, compared to the actual percentage of the same sample meeting the ACT reading benchmark of 22 and ACT mathematics benchmark of 22.

	Reading		Mathematics	
Student Group	**NAEP ≥ 301**	**ACT ≥ 22**	**NAEP ≥ 167**	**ACT ≥ 22**
Total	46%	47%	45%	47%
Male	42%	46%	49%	51%
Female	49%	48%	41%	44%
White	56%	58%	54%	56%
Black	13%	19%	12%	17%
Hispanic	34%	29%	29%	32%
Asian	54%	55%	70%	74%

NAEP *Proficient* cut scores projected on the ACT scale

To conduct the complementary analyses, we identified the point on the ACT scale that corresponds most closely to the NAEP *Proficient* cut score, essentially reversing the direction of the linking relative to the previous analyses. Table 4 provides descriptive statistics on the ACT reading and mathematics scores for students below, at, and at or above the grade 12 *NAEP Proficient* cut score. The grade 12 *NAEP Proficient* achievement level cut score was set at 302 for reading and 176 for mathematics.

Table 4: Descriptive ACT statistics for students below, at, and at or above the grade 12 NAEP Proficient level.

Subject	***NAEP Proficient***	**Mean**	**Percentage**	**SD**	**Percentile**		**IQR[1]**
					25th	***75th***	
Reading	*Below*	18	55%	5	15	21	6
	At	22	1%	4	18	24	6
	At or Above	26	45%	5	22	29	7
Mathematics	*Below*	18	65%	3	15	20	5
	At	23	1%	3	21	25	4
	At or Above	27	35%	4	24	28	4

NOTES: [1]IQR is the Inter Quartile Range or the difference between the 75th and 25th percentiles.

Following the same methodology of statistical projection (see Figures 3 and 4) we identified an ACT reading score of 22.41, rounding to 22, and a mathematics score of 23.38, rounding to 23, as cut points. Students attaining these newly identified cut points on ACT reading and mathematics have a reasonable chance (p=0.50) to meet the corresponding *NAEP Proficient* achievement levels.

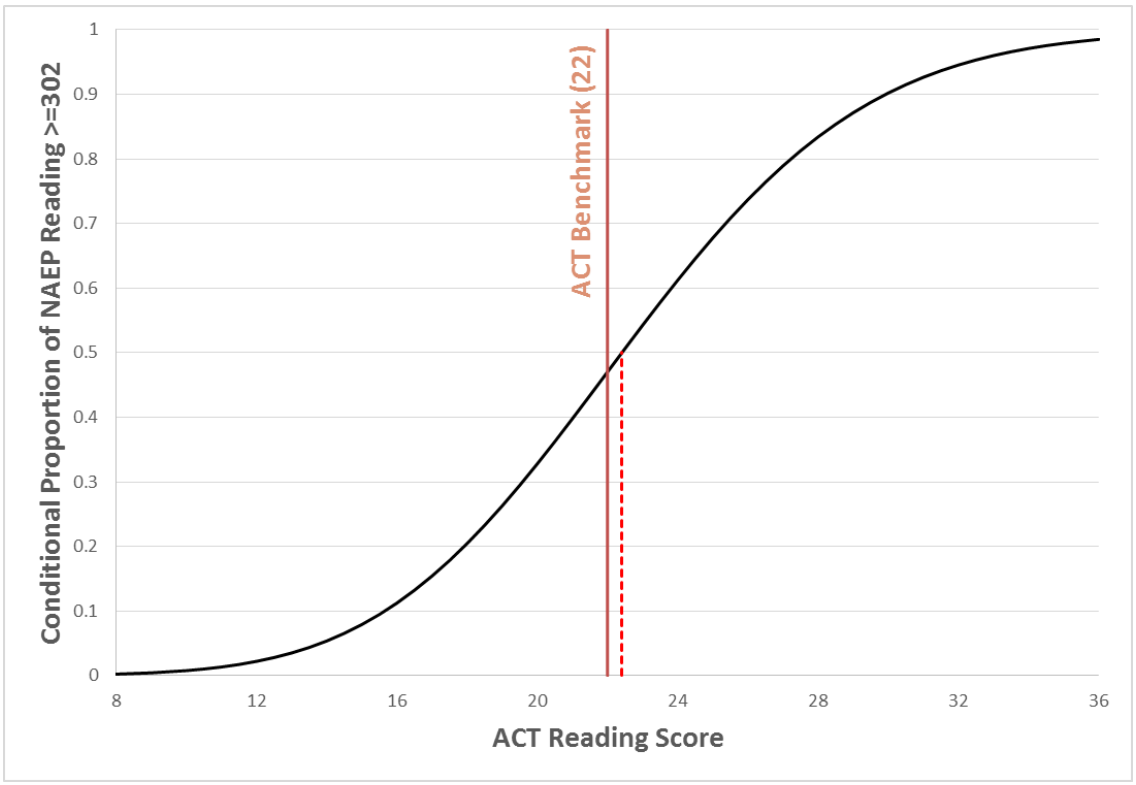

Figure 3: Proportion of students meeting the NAEP reading Proficient achievement level of 302 for ACT reading scores

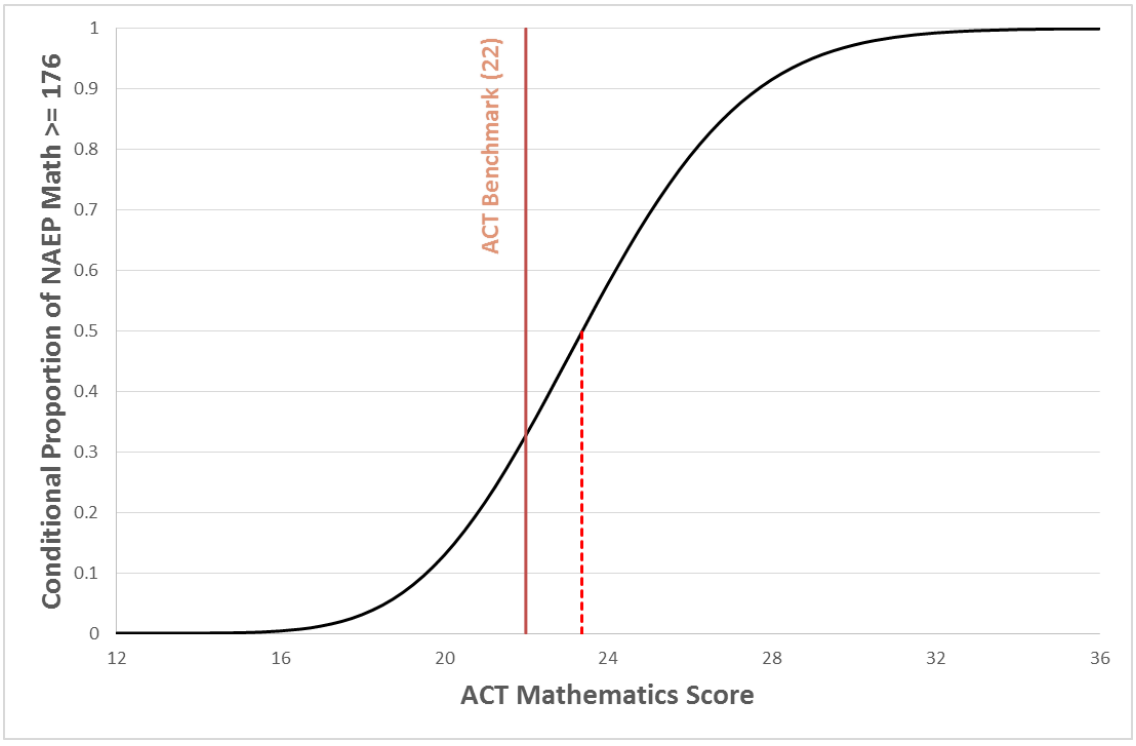

Figure 4*: Proportion of students meeting the NAEP mathematics Proficient achievement level of 176 for ACT mathematics scores*

Summary and Discussion

The objective of the study was to statistically relate NAEP and ACT assessments and use that relationship to identify a reference point or range on the NAEP 12th grade reading and mathematics scales reasonably associated with the ACT college readiness benchmarks for reading and mathematics. Identifying such points would potentially allow NAEP to report on the percentage of students at the 12th grade who are likely to achieve the ACT college readiness benchmarks associated with success in first-year college courses at typical post-secondary institutions. In this study, various statistical techniques, including latent regression, smoothing, and statistical projection were used to establish the relationship and identify potential benchmarks on the NAEP scales that could form the basis for reporting preparedness at grade 12 (see Figures 1 and 2 for examples of how the markers were determined).

In addition, we identified the point on the ACT scale that corresponds most closely to the *NAEP Proficient* achievement level cut score, for grade 12 reading and mathematics, in order to explore the relationship between the two measures in the reverse direction (see Figures 3 and 4 for the linking results).

A key finding was that the relationship between the two scales is moderately strong, meaning that the kind of relationship statements that can be made need to be presented in notions of probability rather than one-to-one relationships[8]. This is not surprising because the instruments are not intended to measure the exact same construct and the test taking populations could be different due to the nature of the two tests. However, it does make interpretation somewhat more challenging. The results showed that the ACT college readiness benchmarks and the *NAEP Proficient* achievement level cut scores correspond well to each other for reading in both linking directions, but they differed slightly for mathematics. In particular, the reading *NAEP Proficient* achievement level cut score of 302 could form a reasonable basis for reporting on meeting the ACT college readiness benchmarks and therefore potentially academic preparedness for college at grade 12. However, the mathematics counterpart is 167 on the NAEP scale, about 9 points lower than the *NAEP Proficient* achievement level cut score for grade 12 mathematics. Going the other direction, the projection of the *NAEP Proficient* reading cut score on the ACT scale coincides with the existing ACT college readiness benchmark for reading, and is about 1 point higher than the ACT benchmark for mathematics.

The current NAEP-ACT linking study is closely related to the statistical linking study that connected NAEP and SAT on the national level (Moran et al., 2012). The national NAEP-SAT linking study used data from students who were sampled and assessed in NAEP 12th grade reading or mathematics in 2009 and had also taken SAT by June 2009. Based on the national linking sample, the correlation between scores on the two reading scales was 0.74, and the correlation was 0.91 between the two

[8] A concordance analysis was tried to locate the scale score points on the NAEP scale that would associate with the ACT benchmarks. Due to the sparseness of the ACT scale (i.e., 1 to 36 versus NAEP's 0-500 or 0-300 scale), the concordance relationship is not one-to-one. The ACT benchmark of 22 on reading corresponds to a score range of 300 to 304 and an average of 302 on NAEP reading (coincides with the *NAEP Proficient* achievement level on reading). The ACT benchmark of 22 on mathematics corresponds to a score range of 167 to 171 and an average of 169 on NAEP mathematics.

mathematics scales. These numbers are very close to the correlations calculated in the current study (i.e., 0.75 for reading, and 0.87 for mathematics). The projection results obtained from the national NAEP-SAT linking study (see Table 1 of Moran et al., 2012, $p = 0.5$) indicated that a NAEP reading scale score of 302 and a NAEP mathematics scale score of 164 could potentially be used as the thresholds on the NAEP scales to indicate academic preparedness for college. These reference points also correspond well with the newly identified thresholds on the NAEP scales through this NAEP-ACT linking study.

Important limitations must be kept in mind when interpreting the results from the current linking study. The correlation between the NAEP and ACT scores is moderately high, indicating considerable variance associated with the relationship between the two assessments. As a consequence, a statistical linking methodology was selected to express the ACT college readiness benchmarks on the NAEP scales. Such a relationship is not symmetric, and the two linked scales do not correspond to each other on a one-on-one level. Besides, the statistical relationship established between NAEP and ACT is not invariant across major population subgroups. Additional investigation and longitudinal studies are needed to evaluate the validity and meaningfulness of the identified benchmark points on NAEP as indicators of students being academically prepared for college.

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