Updated College Enrollment Benchmarks for the Grade 12 NAEP Mathematics Assessment

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Executive Summary

There is a growing interest in ensuring that students are prepared for college and a career when they finish high school. Yet, at least regarding college preparedness, there is reason for concern. According to results from the National Assessment of Educational Progress (NAEP) in 2019, only 37 percent of the 12th-grade students who took mathematics and reading assessments met the college preparedness benchmark determined in prior research by National Assessment Governing Board (NAGB; Fields, 2014) where preparedness for college was defined as being ready to enroll in postsecondary education without remedial coursework and succeed in entry-level, credit-bearing college courses (Fields, 2014). Among those who enter college, remedial coursetaking is prevalent. According to transcript data from the Beginning Postsecondary Students Longitudinal Study, among a cohort of students who entered a 4-year college in the 2003–04 school year, remedial coursetaking rates were 39 percent for public 4-year institutions and 68 percent for public 2-year institutions (Chen, 2016).

Studies have shown that at the high school level, the most frequently noted college preparedness indicators are attendance, grade point average (GPA), and test scores, including high school exit exams and college entrance exams (Allensworth & Easton, 2007; Mishook et al., 2012). However, it is difficult to use these indicators to determine students' preparedness level because they do not share a common metric and only a select number of students take these assessments. Therefore, there is a need for policymakers and the public to assess benchmarks from a common metric applicable across the nation.

NAEP is often described as the "gold standard" for assessing what students know and can do in grades 4, 8 and 12. A significant change occurred in 2001 when NAEP began to report its results not only in scale score points but by achievement levels as well. NAGB, which is responsible for NAEP policy, defines three levels of achievement: *NAEP Basic*, *NAEP Proficient*, and *NAEP Advanced*. Since their inception, the achievement levels have been controversial, and several evaluations, including those by the National Academy of Education and the National Academy of Sciences, have raised questions about their validity with the specific criticism that they were established without predictive evidence (National Academies of Sciences, Engineering, and Medicine, 2017). In response to this criticism, for over a decade NAGB carried out a series of studies to determine whether grade 12 mathematics and reading could be used to predict college preparedness. Using longitudinal data from Florida, NAGB found that both NAEP mathematics and reading scores were good predictors of first-year college performance, defined as a GPA of 2.67 (B-) or better. However, the studies were limited, given that the data came from a single state and students who attended out-of-state or nonpublic colleges in Florida could not be followed (Fields, 2014). Nevertheless, using the results from the study, NAGB suggested preparedness cut points on the grade 12 reading and mathematics assessment scales of 302 for reading and 163 for mathematics.

To alleviate the limitations of NAGB's Florida studies, NCES commissioned a series of studies (Ogut, Bohrnstedt, & Broer, 2019; 2021) to test whether the relationship between NAEP mathematics performance and postsecondary enrollment holds at the national level. These studies used imputed NAEP scores for the full HSLS:09 sample based on data from a subsample of students in the High School Longitudinal Study of 2009 (HSLS:09) who also participated in the NAEP 2013 mathematics assessment. The results showed that grade 12 NAEP mathematics scores can be used to predict students' preparedness for college admissions, enrollment in college, enrollment without remedial coursetaking, the selectivity of the colleges enrolled in, the selection of a STEM major, and persistence in college. Since at the time of their study, neither data collection included any postsecondary information about college performance, Ogut, Bohrnstedt, and Broer (2019; 2021) were unable to examine any postsecondary outcomes, such as college GPA.

The purpose of the current study is to extend the analyses from the prediction of college enrollment alone to the prediction of college enrollment as well as additional postsecondary outcomes, given that such data have since been collected. Outcomes include remedial coursetaking based on transcript data and first-year GPA. Replicating NAGB, we first defined college preparedness as enrolling in a 2- or 4-year college without remedial coursetaking and acquiring a first-year college GPA of 2.7 or higher. However, we also provide a definition of college preparedness that omits remedial coursetaking and argue that remedial coursetaking could be reconsidered as a criterion to for college preparedness if students meet the requirement to achieve a GPA of 2.7 or higher by the end of their first year in college.

Key findings

Overall, the results show that NAEP grade 12 mathematics achievement explained a considerable amount of the variation in the college preparedness outcome: about 30 percent of the total variance by itself and 44 percent of the variance with the addition of covariates (race/ethnicity, gender, GPA, high school algebra scores, test scores, and parental education).

When translated into probabilities, the results show that the probability of enrolling in a 2- or 4-year college without remedial coursework and with a first-year GPA of at least 2.7 increased from 26 percent for students performing at the *NAEP Basic* level to 58 percent at the *NAEP Proficient* level and 87 percent at the *NAEP Advanced* level. The probability at NAGB's college preparedness indicator (a score of 163 or greater on the grade 12 mathematics assessment) was 45 percent. (See Figure 1.)

When college preparedness is defined without remedial coursetaking as a criterion, i.e., when it is defined as enrolling in 2- or 4-year college with a first-year GPA of 2.7 or higher, the college preparedness rates at each NAEP achievement level were higher than under the college preparedness definition that included remedial coursetaking as a criterion (See Figure 2). The *NAEP Basic* level corresponded to a 49 percent rate of being college prepared, and the rate increased to 73 percent and 90 percent at the *Proficient* and *Advanced* levels, respectively. A

student at NAGB's college preparedness cut point had a 65 percent chance of being college prepared.

Across student subgroups, including gender, race/ethnicity, and parental education, the probability of enrolling in college and earning a first-year GPA of 2.7 or greater increases as performance moves from the *NAEP Basic* to the *NAEP Advanced* levels. Female students and Black students had higher probabilities of being college prepared compared to their male and non-Black peers at each NAEP achievement level. Also, at each NAEP achievement level, students whose parents graduated from college and had an advanced degree had a higher probability of being college prepared than did students whose parents had less than a college degree.

The findings from the study, first to examine the relationship between NAEP achievement and college preparedness using nationally representative data, provide strong evidence of the predictive validity of NAEP for a set of important outcomes related to college preparedness. This concerns not only the predictive validity of NAEP in general but also of the NAEP achievement levels.

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Background

There is a growing interest in ensuring that students are prepared for college and a career when they finish high school. Yet the nation's students do not appear to be well prepared. According to the National Assessment of Educational Progress (NAEP), in 2019 only 37 percent of 12th-grade students who took mathematics and reading assessments scored at or above the indicator for college preparedness;[1] that is, they were ready to take and succeed in entry-level, college credit-bearing courses. Among college entrants, remedial coursetaking is prevalent. According to transcript data from the National Center for Education Statistics (NCES) Beginning Postsecondary Students Longitudinal Study, among a cohort of students who entered a 4-year college in the 2003–04 school year, remedial coursetaking rates were 39 percent for public 4-year institutions and 68 percent for public 2-year institutions (Chen, 2016).

In 2009, the U.S. Department of Education announced the Race to the Top (RTT) grant program to encourage and reward innovation in K-12 education. Within this grant, the State Reform Conditions Criteria for standards and assessments required states to adopt college- and career-ready proficiency standards. Similarly, the Common Core State Standards aimed to ensure all students graduate from high school ready to succeed in college and in their careers. While this is all well and good, these standards require a measure that can accurately determine and track college preparedness. The focus of the current study is to demonstrate that NAEP can serve this purpose.

Studies have shown that at the high school level, the most frequently noted college preparedness indicators are attendance, grade point average (GPA), and test scores. Missing no more than 10 percent of school days per grade level is shown to be associated with being on track for high school graduation (Allensworth & Easton, 2007). Maintaining a GPA of 3.0 or higher or passing high school exit exams or college entrance exams is also shown to be correlated with college entrance and successfully completing credit-bearing, entry-level college courses (Mishook et al., 2012). However, it is difficult, if not impossible, to use these indicators to determine the preparedness level of the nation's students in general. The SAT and ACT use benchmarks that are indicative of performance in college, but only a select number of students take these assessments. Moreover, an increasing number of colleges have switched from the SAT/ACT being mandatory for admissions to being optional.[2] Therefore, policymakers and the public need access to benchmarks using a common metric that can be used across the nation.

As the "gold standard" for assessing what students know and can do in grade 12, NAEP is the perfect candidate to establish college preparedness benchmarks. For over a decade, the

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[1] See https://www.nationsreportcard.gov/highlights/mathematics/2019/g12/.

[2] See https://edsource.org/updates/harvard-university-wont-require-sat-act-through-2026 and https://admissions.wisc.edu/act_sat_faq/.

National Assessment Governing Board (NAGB) carried out a series of studies to study college preparedness in the context of NAEP. In a recent study that used longitudinal data from the state of Florida, the results show that grade 12 NAEP mathematics performance could be used to predict college preparedness, where preparedness was defined as a 2.67 (B-) or better GPA at the end of the first year of college. The NAEP preparedness cut point established by that study was 163 on the grade 12 mathematics assessment. However, as important as that study is, it is limited by the fact that the data came from just a single state, and students who attended out-of-state or nonpublic colleges in Florida could not be followed (Fields, 2014).

To alleviate the limitations of the NAGB Florida study, NCES commissioned two studies (Ogut, Bohrnstedt, & Broer 2019; 2021) that used data from a subsample of about 3,470 students in the High School Longitudinal Study of 2009 (HSLS:09) who were also selected to participate in the NAEP 2013 mathematics assessment. This overlap in samples made it possible to test whether the relationship between NAEP performance and selected measures of postsecondary success holds at the national level. Using the estimated relationship between NAEP scale scores and HSLS:09 variables, including HSLS:09 grade 9 and 11 algebra assessment scores, Ogut, Bohrnstedt, and Broer (2019) imputed NAEP scale scores for the full HSLS:09 sample. These imputed NAEP scale scores were then used to explore their relationship to postsecondary outcomes.

Ogut, Bohrnstedt, and Broer (2019) used data from the HSLS:09 2013 update, which covered college enrollment plans immediately after high school graduation. Ogut, Bohrnstedt, and Broer (2021) used data from the HSLS:09 second follow-up (which collected information 3 years after graduation from high school) to show that grade 12 NAEP can be used to predict students' preparedness for college admissions, enrollment in college, enrollment without remedial coursetaking, the selectivity of colleges enrolled in, the selection of a STEM major, and persistence in college. Since the HSLS:09 second follow-up data collection did not include any postsecondary information about college performance, Ogut, Bohrnstedt, and Broer (2019, 2021) were not able to include college GPA, which is needed to calculate NAGB's measure of first-year college preparedness.

In 2020, HSLS:09 released postsecondary transcripts and student records. The purpose of the current study is to determine how college preparedness measures that include college GPA relate to NAEP achievement levels (as well as to the NAEP preparedness indicator) in order to provide critical validity evidence for NAEP's achievement levels as well as contribute to the discussion about appropriate national benchmarks for tracking the college preparedness of the nation's students.

Study goals and research questions

This study has two main goals. The first is to examine the relationship between NAEP performance and college preparedness defined in a few different ways, taking into account enrollment in a 2- or 4-year college, remedial coursetaking, and first-year GPA. The second is

to compare the performance of NAEP grade 12 mathematics to SAT mathematics in predicting first-year college GPA. Given that the SAT historically has been the test most used for college admission decisions, a finding that NAEP does as well in the prediction of first-year GPA for groups of students would further boost its validity as a predictor of college preparedness.

To address these goals, the study examines the following two research questions:

Research Question 1: What is the relationship between performance on the grade 12 NAEP mathematics assessment and college preparedness?

- Does this relationship vary by gender, race/ethnicity, and socioeconomic status (SES)?
- What is the probability of preparedness for students scoring at the *NAEP Advanced*, *Proficient*, and *Basic* levels on the grade 12 mathematics assessment?
- What is the probability of preparedness for students scoring at NAEP's college and career preparedness indicator point on the grade 12 mathematics assessment?
- What is the probability of preparedness for students performing below the *NAEP Basic* level on the grade 12 mathematics assessment?

Research Question 2: How do NAEP grade 12 mathematics and SAT mathematics compare in the prediction of first-year college GPA?

- Does this relationship vary by race/ethnicity?

Methods

Data

The study utilizes two datasets: (a) the special overlap sample of about 3,470 students who participated in the HSLS:09 base-year collection and who took the 2013 grade 12 NAEP mathematics assessment; and (b) all HSLS:09 students for whom imputed NAEP scores could be computed following a methodology first investigated by Ogut, Bohrnstedt, and Broer (2015).

The HSLS:09 base-year collection took place in the 2009–10 school year with a randomly selected sample of all fall-term 9th-graders enrolled in over 900 public and private high schools. Students took an algebra assessment and an online survey. The first follow-up of HSLS:09 took place in the spring of 2012 when most sample members were in the spring semester of the 11th grade.

The study also collected high school transcripts for all students who remained in the sample in 2013; the transcripts included ACT and/or SAT scores if students took either or both of these assessments. In addition, between June 1 and January 31, 2014, all students (or their parents) who had participated in the baseline and first follow-up studies were surveyed in the HSLS:09

2013 update to determine their enrollment plans. In the second wave of data collection, which occurred 3 years after high school graduation in 2016, information was collected on students' postsecondary enrollment, remedial coursetaking, and persistence. In 2020, HSLS:09 released postsecondary transcripts that included courses taken and grades earned through the spring of 2018.

Data from the base year, first follow-up, second follow-up, and postsecondary transcript follow-up of HSLS:09 are used to examine the study's two research questions.

Outcome

There is one major outcome to be examined: college enrollment with and without remediation, as reported by institutions, with a first-year GPA of 2.7 or higher. Remedial coursetaking information comes from students' postsecondary transcripts, and first-year college GPA was computed using the postsecondary transcripts. To mimic NAEP's definition of college preparedness, the data were pooled across 4-year and 2-year college enrollment to create an ordered variable with four levels:

- not enrolled;
- enrolled in a less-than-2-year college;
- enrolled in a 2- or 4-year college with remedial coursetaking and a first-year college GPA of less than 2.7; and
- enrolled in a 2- or 4-year college without remedial coursetaking and with a first-year GPA of 2.7 or higher.

We use three different definitions of college preparedness in this report:

- enrolled without remediation;
- enrolled without remediation with a first-year college GPA or 2.7 or higher; and
- enrolled in a 2-or 4-year college with a first-year college GPA or 2.7 or higher.

With the second definition, we aimed to assess the change in the probability of college preparedness in relation to the change in the rigor of the definition of college preparedness, specifically the addition of first-year college GPA. The third definition examines a definition of college preparedness that omits remedial coursetaking as a criterion and differentiates between students who attended a 2- or 4-year college with a first-year GPA of less than 2.7, and those who attend a 2- or 4-year college with a first-year GPA of 2.7 or higher.

Analysis

The Twenty NAEP plausible value scale scores are imputed for students in the dataset, as described in Ogut, Bohrnstedt, and Broer (2015). In addition to the variables used in Ogut,

Bohrnstedt, and Broer,[3] high school GPA, first-year postsecondary GPA, college enrollment, and remedial coursetaking are included as predictors in the imputation model since they are not part of the NAEP population structure model and an analysis involving such variables would otherwise be biased.

To examine the relationship between NAEP and college preparedness (RQ 1), ordered logistic regression was used where outcomes increase consecutively as a continuous latent variable[4] and are modeled as

$$y_i^* = \beta_1 x_i + \varepsilon_i$$

(1)

where y_i^* is the unobserved continuous measure of college preparedness and its values determine what the observed ordered outcomes are. The term, x_i, is the NAEP plausible values. The four ordered outcomes are defined by

$$y_i = j \text{ if } \alpha_{j-1} < y_i^* \le \alpha_j, j = 1, 2, 3, 4$$

(2)

where $\alpha_0 = -\infty$ and $\alpha_4 = \infty$, and the analytic model takes the form

$$Pr(y_i = j) = \frac{e^{\alpha_j - \beta_1 x_i + \varepsilon_i}}{\left(1 + e^{\alpha_j - \beta_1 x_i + \varepsilon_i}\right)} - \frac{e^{\alpha_{j-1} - \beta_1 x_i + \varepsilon_i}}{\left(1 + e^{\alpha_{j-1} - \beta_1 x_i + \varepsilon_i}\right)}$$

(3)

where x_i is NAEP grade 12 mathematics performance.

We also use results from this form of regression model to compute the probabilities of college preparedness at different NAEP proficiency cut points, for students performing below NAEP *Basic*, and for the NAGB grade 12 mathematics college preparedness indicator of 163.

To compare NAEP grade 12 mathematics and SAT mathematics in the prediction of first-year college GPA (RQ 2), we use regression models of the following form:

$$Y_i = \beta_1 x_i + \beta_2 HSGPA_i + \varepsilon_i$$

(4)

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[3] The imputation model used in Ogut, Bohrnstedt, and Broer (2015) includes HSLS:09 algebra scores at grades 9 and 11, race/ethnicity, sex, parental education, receipt of special education services, and whether the first language learned is English.

[4] We tested the assumptions of order using a multinomial logistic regression instead of ordered logistic regression. The results are very similar for both models. We present the results from ordered logistic regression in the body of the report as the preferred estimates but also report results from multinomial logistic regression in the appendixes.

where Y_i is the first-year college GPA, x_i represents NAEP or SAT mathematics performance, and $HSGPA_i$ is the high school GPA. These models are also run separately for major racial/ethnic groups.

Results

Imputing plausible values

As discussed in the Analysis section, the first step in examining the relationship between NAEP achievement and postsecondary outcomes was to impute NAEP scores for the full HSLS:09 population (Table 1). The results show that the variance explained in the NAEP achievement score by the predicator variables we used is 87.1 percent.

Table 1. Results from marginal maximum likelihood regression imputation model predicting NAEP performance

Variable	Model 1	
Constant	-7.691 (5.503)	***
Algebra, grade 11	1.709 (0.114)	***
Algebra, grade 9	0.915 (0.083)	***
Black	-6.938 (2.909)	*
Hispanic	-4.343 (2.395)	
Asian	1.688 (3.321)	
Other race	-2.108 (3.323)	
Male	6.621 (1.731)	***
Parent college graduate	0.334 (1.532)	
High school GPA	7.963 (1.636)	***
College preparedness	1.272 (0.781)	
Pseudo R^2	0.871	

***$p < .001$, **$p < .01$, *$p < .05$.
SOURCE: U.S. Department of Education, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), High School Longitudinal Study of 2009 (HSLS:09).

Using the results from this model, 20 plausible values were created, as described in Ogut, Bohrnstedt, and Broer (2015), and used in the analyses that follow.

Descriptive statistics for the analytic sample

Table 2 displays the characteristics of the analytic sample. White students accounted for the majority of the analytic sample (54 percent). Hispanic students accounted for 21 percent, and Black and Asian American students made up 13 percent and 4 percent of the sample, respectively. Thirty-seven percent of the students had a parent who was a college graduate, and 51 percent came from families with an annual income higher than $55,000 (in 2009 dollars). The average high school and first-year college GPAs were 2.69 and 2.99, respectively.

Table 2. Characteristics of the analytic sample

Variable	Mean	SD	Min	Max
White	0.54	0.50	0	1
Black	0.12	0.33	0	1
Hispanic	0.21	0.41	0	1
Asian	0.04	0.19	0	1
Other race	0.09	0.28	0	1
Male	0.50	0.50	0	1
Parent college graduate	0.38	0.48	0	1
Income higher than 55K	0.52	0.50	0	1
Algebra, grade 11	50.84	10.02	24.96	84.91
Algebra, grade 9	50.81	9.90	24.32	82.19
High school GPA	2.69	0.82	0	4
First-year college GPA	2.99	0.63	0.5	4

NOTE: N = 1,690 for all variables except first-year college GPA (N = 8,670). A comparison of the analytic sample with the 2013 NAEP operational sample is shown in Table A-1 in appendix A.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

After finishing high school, 32 percent of the analytic sample had not enrolled in college (Table 3). About 3 percent were enrolled in less-than-2-year programs, 27 percent were enrolled either in 2- or 4-year programs with remediation and a first-year college GPA of more than 2.7, or without remediation but with a first-year college GPA of less than 2.7, or both with remediation and a first-year college GPA of less than 2.7. The remaining 38 percent were enrolled in 2- or 4-year colleges without remediation and had a first-year GPA of at least 2.7.

Table 3. College enrollment status of the analytic sample

Variable	Proportion
Not enrolled	0.32
Less than 2-year	0.03
2- or 4-year with remediation or GPA < 2.7	0.27
2- or 4-year without remediation and GPA ≥ 2.7	0.38

NOTE: N = 11,690.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

When broken down by race/ethnicity and gender, the results show some differences in enrollment patterns (Table 4). Female, Asian American, and White students were the most likely to be enrolled in a 2- or 4-year college without remediation and to earn a first-year GPA of at least 2.7. Finally, Black and Hispanic students were the most likely not to be enrolled or, if they were, to take remedial courses or have a first-year GPA of less than 2.7.

Table 4. College enrollment status for the analytic sample, by race/ethnicity and gender

Group	Not Enrolled	Less than 2-year	2- or 4-year with remediation or GPA < 2.7	2- or 4-year without remediation and GPA ≥ 2.7
White	0.29	0.02	0.24	0.45
Black	0.41	0.04	0.31	0.24
Hispanic	0.38	0.04	0.30	0.29
Asian	0.19	0.01	0.25	0.55
Other race	0.36	0.06	0.29	0.29
Female	0.27	0.04	0.27	0.42
Male	0.38	0.03	0.26	0.33

SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

Predicting college preparedness

The ordered logistic regression models described earlier (Equation number 3) were used to examine the relationship between NAEP achievement and enrollment in college without remediation. In addition to NAEP achievement, the models use other demographic variables to test whether the relationships between grade 12 NAEP mathematics and postsecondary outcomes hold when they are included. Table 5 displays the results from these analyses.

In Model 1, NAEP achievement by itself explained 30 percent of the total variance in college preparedness. The addition of race/ethnicity, gender and GPA, algebra scores, and parental education across Models 2 through 5 increased the variance explained to 44 percent. In

Model 5, significant results are observed for all variables except grade 9 algebra and the Asian indicator variable.

Table 5. Logistic regression model results for predicting college enrollment without remediation

Variables	Model 1		Model 2		Model 3		Model 4		Model 5	
NAEP achievement	0.039 (0.001)	***	0.04 (0.001)	***	0.023 (0.002)	***	0.012 (0.003)	***	0.012 (0.003)	***
GPA					1.452 (0.071)	***	1.439 (0.07)	***	1.415 (0.07)	***
Algebra, grade 11							0.034 (0.008)	***	0.031 (0.008)	***
Algebra, grade 9							0.011 (0.006)		0.008 (0.006)	
Black			0.29 (0.103)	**	0.505 (0.109)	***	0.472 (0.106)	***	0.506 (0.106)	***
Hispanic			0.062 (0.095)		0.321 (0.103)	**	0.285 (0.102)	**	0.391 (0.102)	***
Asian			-0.067 (0.146)		0.067 (0.141)		0.036 (0.142)		0.029 (0.14)	
Other race			-0.16 (0.089)		0.033 (0.086)		0.007 (0.086)		0.038 (0.087)	
Male					-0.263 (0.063)	***	-0.228 (0.063)	***	-0.243 (0.063)	***
Parent college graduate									0.501 (-0.057)	***
Cutoff 1: No college	4.855 (0.204)	***	5.027 (0.206)	***	6.208 (0.219)	***	6.832 (0.234)	***	6.654 (0.233)	***
Cutoff 2: Less than 2-year	5.034 (0.211)	***	5.207 (0.213)	***	6.42 (0.225)	***	7.045 (0.241)	***	6.87 (0.241)	***
Cutoff 3: 2- or 4-year with remediation or GPA of less than 2.7	6.53 (0.224)	***	6.707 (0.225)	***	8.169 (0.242)	***	8.808 (0.258)	***	8.652 (0.259)	***
Pseudo R^2	0.299		0.301		0.422		0.427		0.436	
N	11,690		11,690		11,690		11,690		11,690	

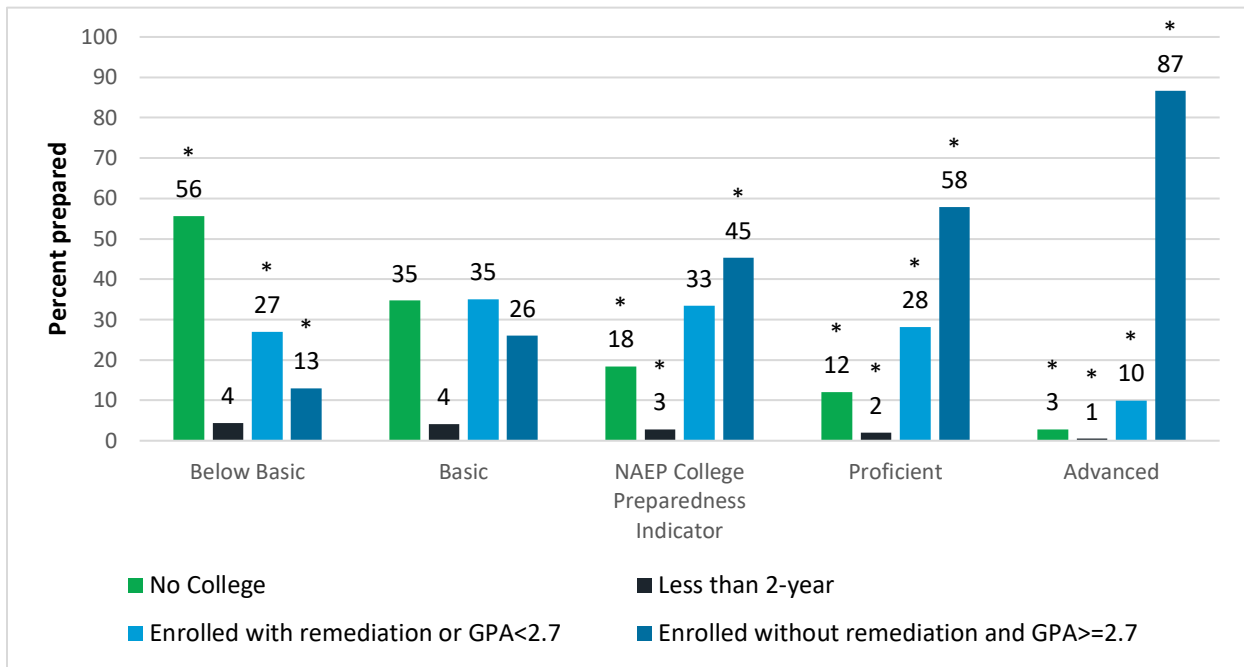***$p < .001$, **$p < .01$, *$p < .05$.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

The results from Model 1 were then used to estimate the predicted probabilities associated with the NAEP achievement levels and college preparedness. The percentages shown in

Figure 1 show the probabilities for performance at the *NAEP Basic*, *NAEP Proficient,* and *NAEP Advanced* achievement levels as well as at the NAEP college preparedness indicator. For students scoring below the *NAEP Basic* cut score, the average achievement score was used to compute the corresponding percentages.

As seen in Figure 1, the probability of enrolling in a 2- or 4-year college without remediation and achieving a first-year GPA of at least 2.7 increased from 26 percent for performance at the *NAEP Basic* level to 87 percent at the *NAEP Advanced* level.[5] Somewhat surprisingly, even the typical student scoring below *NAEP Basic* had a 13 percent probability of enrolling in college without remediation and earning a first-year GPA of 2.7 or higher. The probability of this outcome for those scoring at the NAEP college preparedness benchmark of 163 was 45 percent. The increase in probability associated with the *NAEP Proficient* level was 13 percentage point higher than that of the NAEP college preparedness benchmark. Results using multinomial logistic regression models that make no assumption about the ordering of the dependent variables are presented in Figure A-1 in appendix A.

Figure 1. NAEP probability benchmarks for college preparedness, by NAEP achievement level and NAEP's college preparedness indicator

*Significantly different from the *NAEP Basic* achievement level.
NOTE: *N* = 11,700.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

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[5] The probabilities for the NAEP achievement levels are computed just at the cut-off points and are not cumulative. That is, the probability for college preparedness, for example, for students at the *NAEP Basic* level would be between 26 and 58 percent, depending on their NAEP scores.

To assess the change in probability of college preparedness in relation to the change in the rigor of the definition of college preparedness, we present results for four definitions of college preparedness in Figure 2. The top panel shows the percentages of enrollment in a 2- or 4-year college among all students regardless of whether they took remedial coursework. The second panel presents the probability of enrollment with the addition of the remedial coursetaking criterion, the third panel shows the probability of enrollment with both remedial coursetaking status and first-year college GPA as additional criteria, and the bottom panel shows the probability of enrollment with just first-year college GPA as the additional condition.

Students who performed at the *NAEP Proficient* cut point had an 86 percent probability of enrolling in a 2- or 4-year college (top panel). When college preparedness is defined as enrolling without taking remedial courses, 75 percent of the students at the *NAEP Proficient* cut point were prepared (second panel). When we define college preparedness as enrollment in a 2- or 4-year college without remediation and with a first-year college GPA of 2.7 or higher, 58 percent of students at the *NAEP Proficient* cut point were prepared (third panel). NAGB's college preparedness indicator point corresponded to a 45 percent probability of enrollment in a 2-or 4-year college without remediation and with a first-year GPA of 2.7 or higher. In the bottom panel, we examine a definition of college preparedness that omits remedial coursetaking as a criterion and differentiates between students who did not go to college, students who attended a less-than 2-year college, and students who attended a 2- or 4-year college with a first-year GPA of less than 2.7 and those with a first-year GPA of 2.7 or higher. Under this definition, college preparedness rates at each NAEP achievement level were higher than under the college preparedness definition that included remedial coursetaking as a criterion. The *NAEP Basic* level corresponded to a 49 percent rate of being college prepared, and the rate increased to 73 percent and 90 percent at the *Proficient* and *Advanced* levels, respectively. A student at NAGB's college preparedness cut point had a 65 percent chance of being college prepared.

Figure 2. NAEP probability benchmarks for various definitions of college preparedness, by NAEP achievement level and the NAEP college preparedness indicator

Enrollment in a 2- or 4-year college

See notes at end of figure.

Enrollment in a 2-or 4-year college by remedial coursetaking status

Enrollment in a 2-or 4-year college by remedial coursetaking status and first-year college GPA

Percent prepared

	Below Basic	Basic	NAEP College Preparedness Indicator	Proficient	Advanced
No College	56 *	35	18 *	12 *	3 *
Less than 2-year	4	4	3 *	2 *	1 *
Enrolled with remediation or GPA<2.7	27 *	35	33	28 *	10 *
Enrolled without remediation and GPA>=2.7	13 *	26	45 *	58 *	87 *

Legend:
- No College
- Less than 2-year
- Enrolled with remediation or GPA<2.7
- Enrolled without remediation and GPA>=2.7
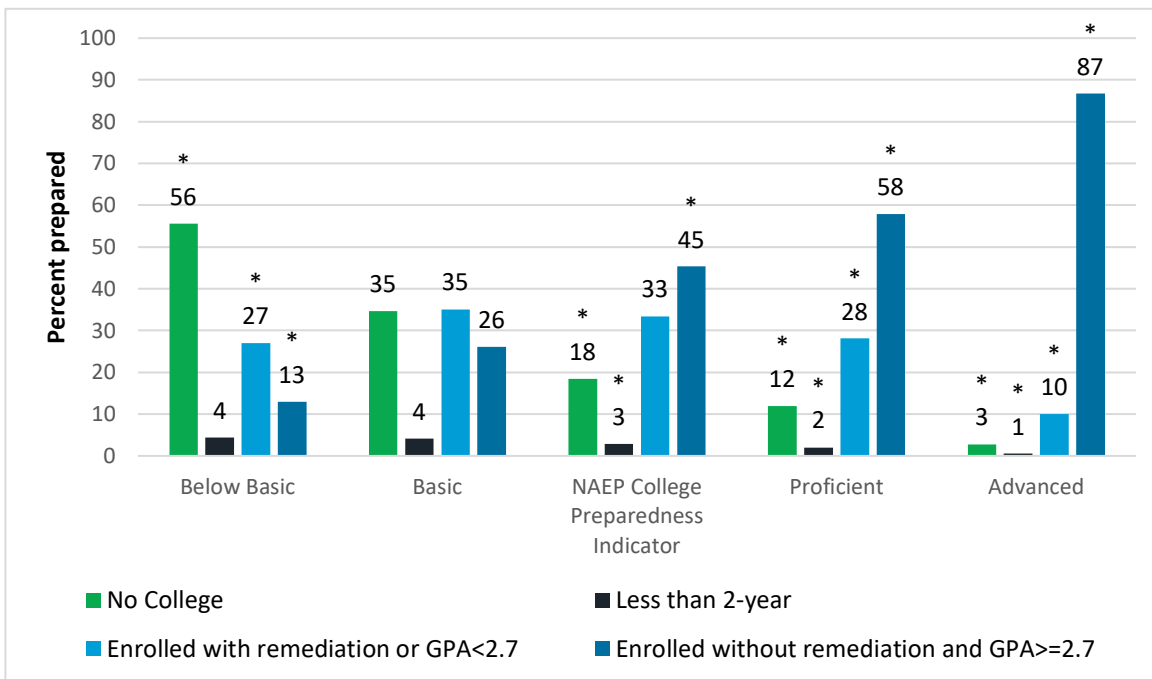
See notes at end of figure.

Enrollment in a 2-or 4-year college by first-year college GPA
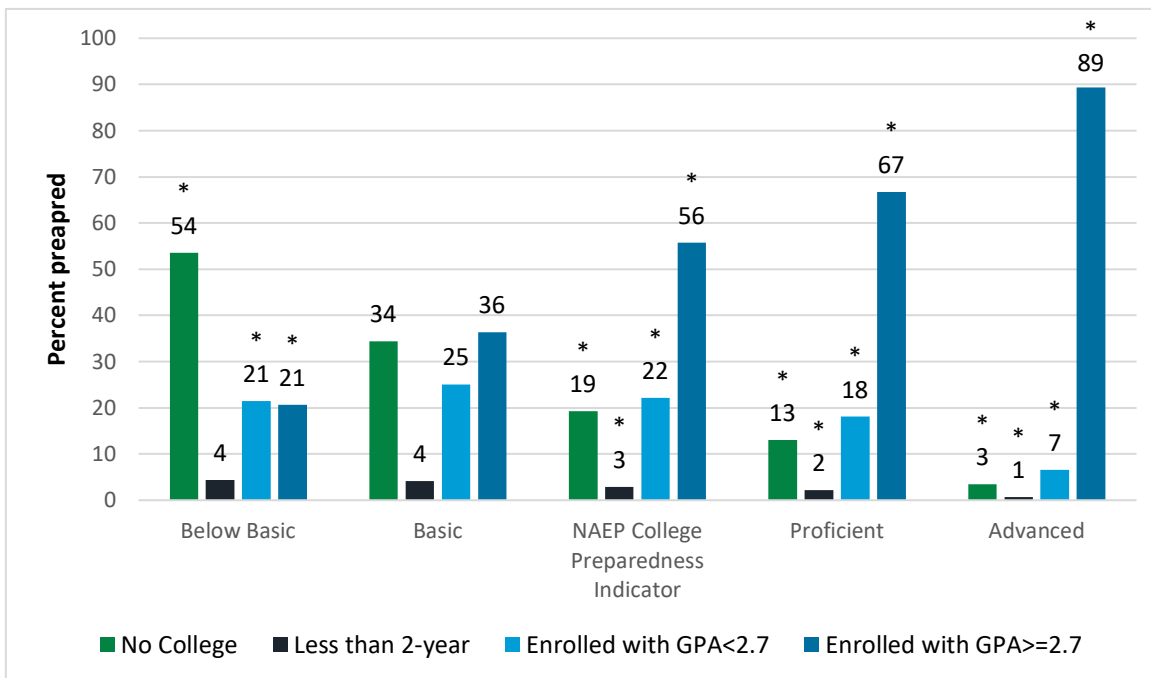
Percent preapred

	Below Basic	Basic	NAEP College Preparedness Indicator	Proficient	Advanced
No College	54 *	34	19 *	13 *	3 *
Less than 2-year	4	4	3 *	2 *	1 *
Enrolled with GPA<2.7	21 *	25	22 *	18 *	7 *
Enrolled with GPA>=2.7	21 *	36	56 *	67 *	89 *

Legend:
- No College
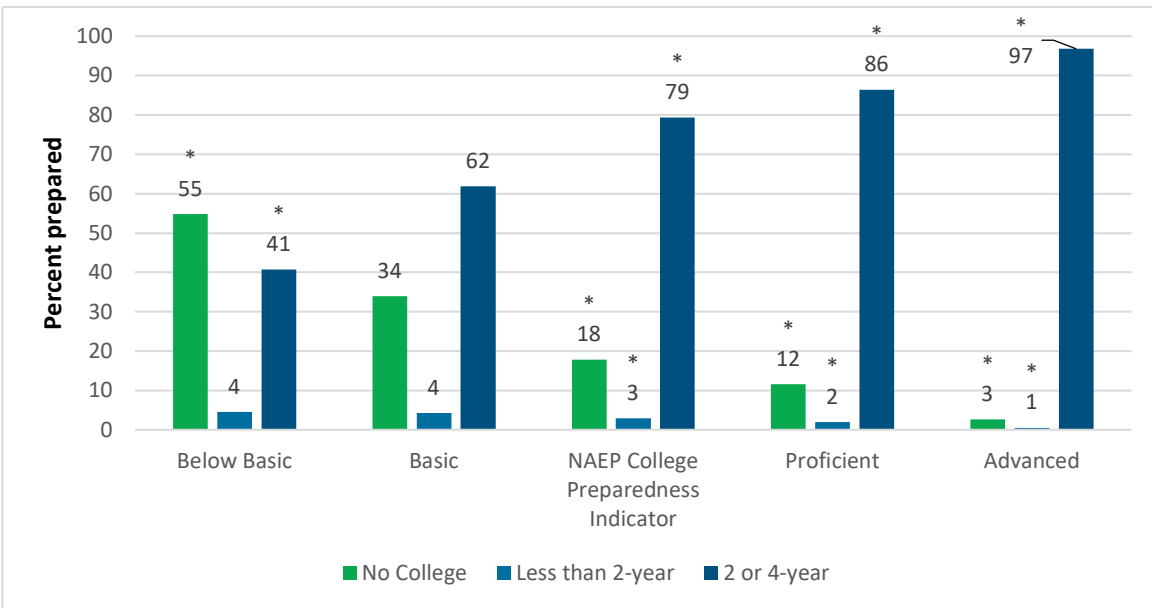- Less than 2-year
- Enrolled with GPA<2.7
- Enrolled with GPA>=2.7

*Significantly different from the NAEP Basic achievement level.
NOTE: N = 11,700.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).
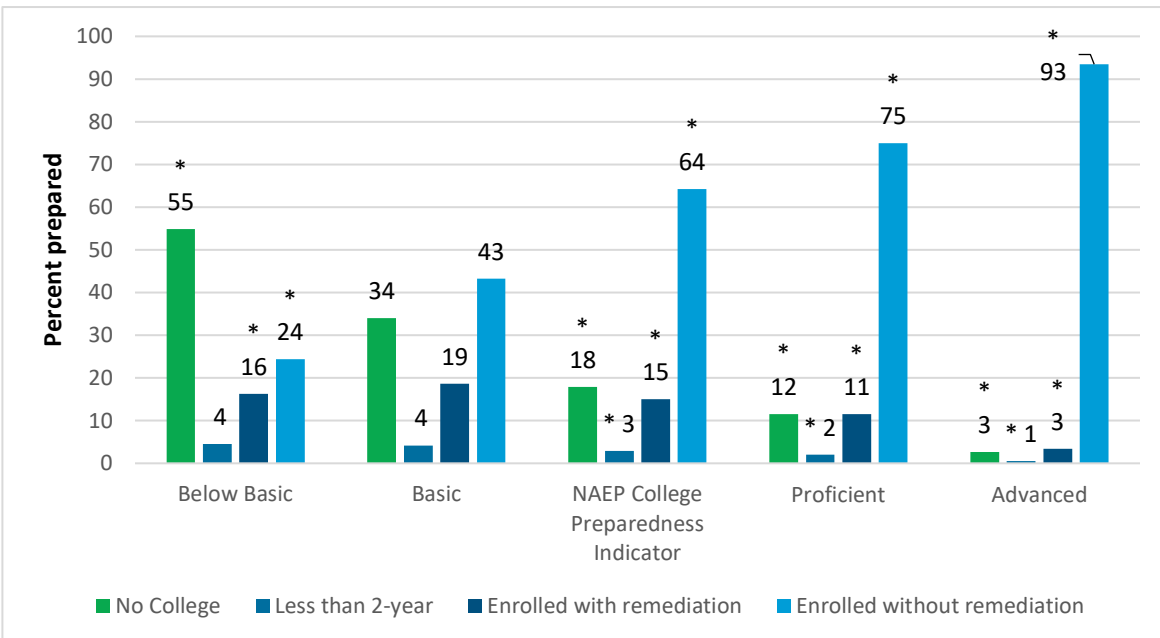
Subgroup analyses

Figure 3 displays the probabilities of college preparedness generated from separate ordered logistic regression analyses for the subgroups of interest. In this figure, we display the results for college preparedness defined as enrolling in a 2- or 4-year college and having a first-year college GPA of 2.7 or higher as our preferred metric.[6] Across all subgroups, the probability of enrolling in a 2- or 4-year college and earning a GPA of 2.7 or higher by the end of the first year of college was higher for performance at the *NAEP Advanced* level than at the *NAEP Basic* level. Note that female students and Black students had higher probabilities of being college prepared than their counterparts at each NAEP achievement level. Also, at each NAEP achievement level, students whose parents graduated from college had higher probabilities of being college prepared than students whose parents had less than a college education. Results from multinomial logistic regression models where no assumption is made about the ordering of the dependent variable are presented in figures A-1 and A-2 in appendix A.

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[6] Results obtained using a more stringent definition of college preparedness that also takes remediation into account are presented in figure A-2 in appendix A.

Figure 3. Probability of college enrollment by first year college GPA status, by NAEP achievement level, gender, race/ethnicity, and parental education
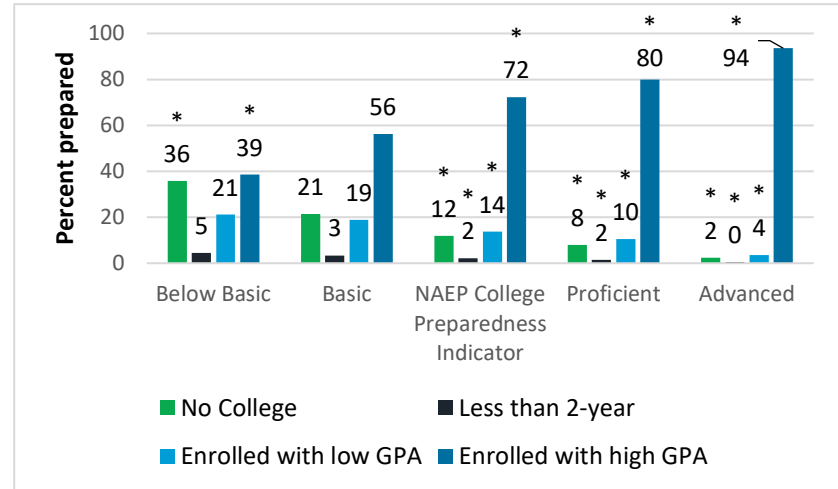
Male

Female

See notes at the end of the figure.
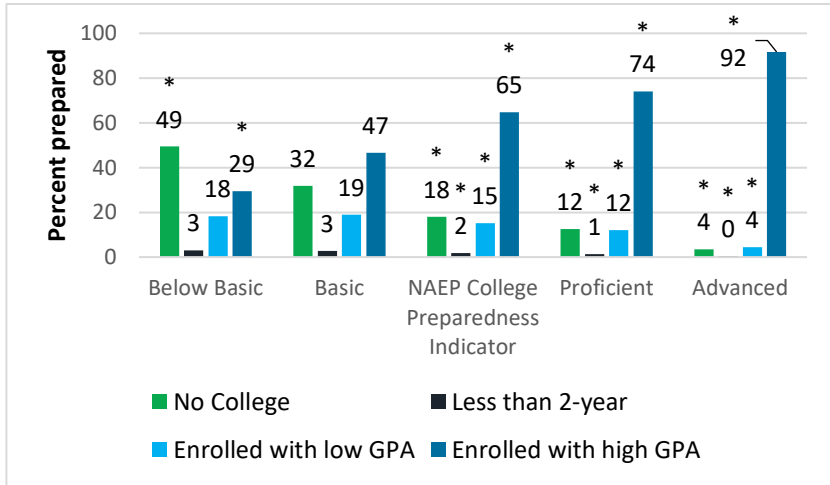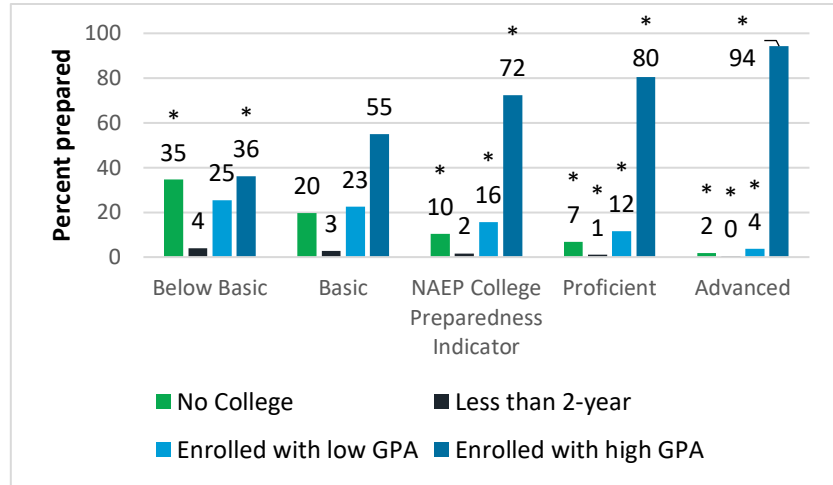
White

Black
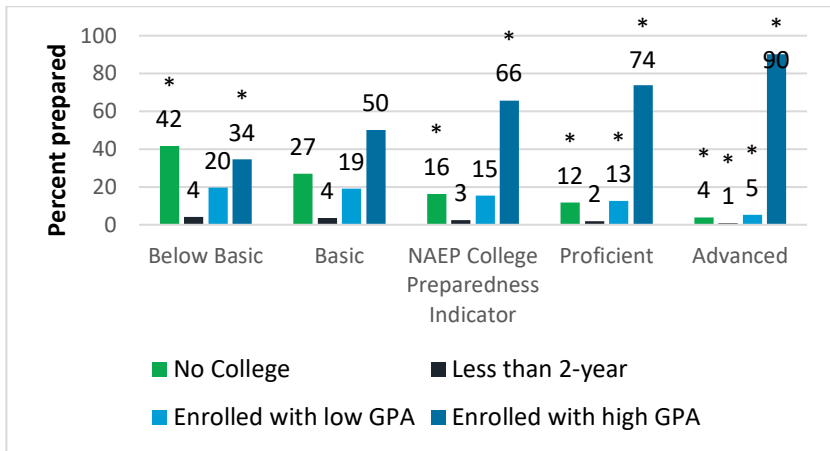
Hispanic
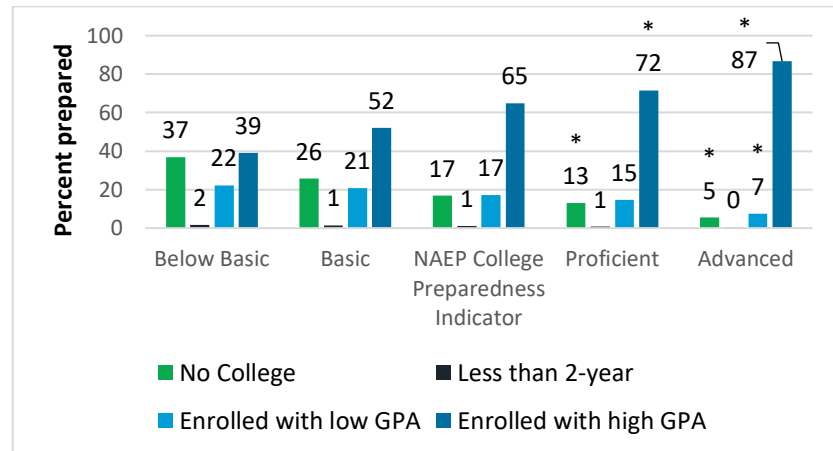
Asian

See notes at the end of the figure.
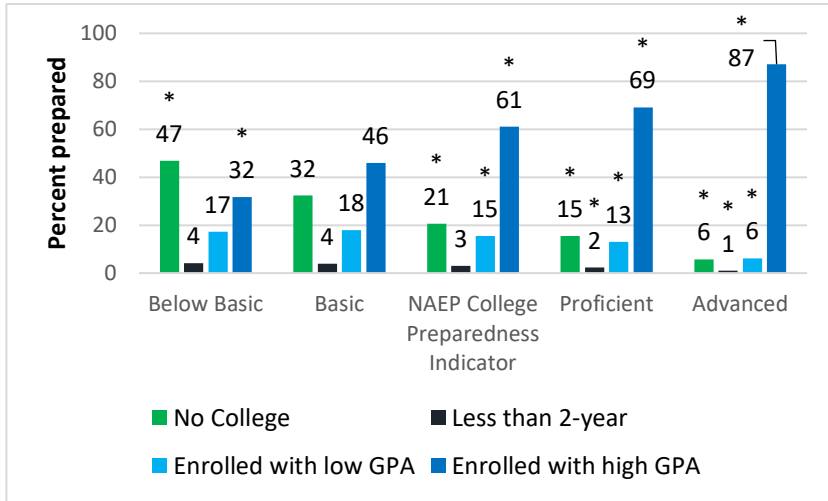
Parental education less than college
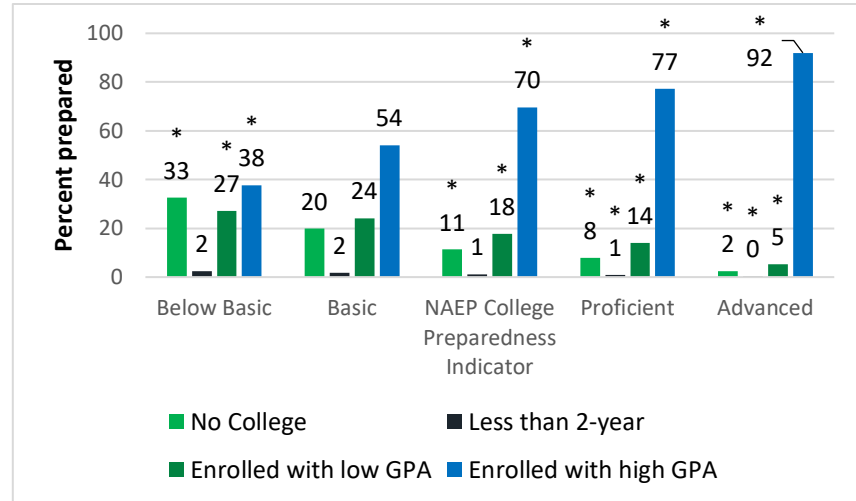
Parental education college or higher

*Significantly different from the reference group (male, White, or parental education less than college).

NOTE: N's are 5,650, 6,050, 6,760, 1,130, 1,740, 970, 6,250, and 5,450.

SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).
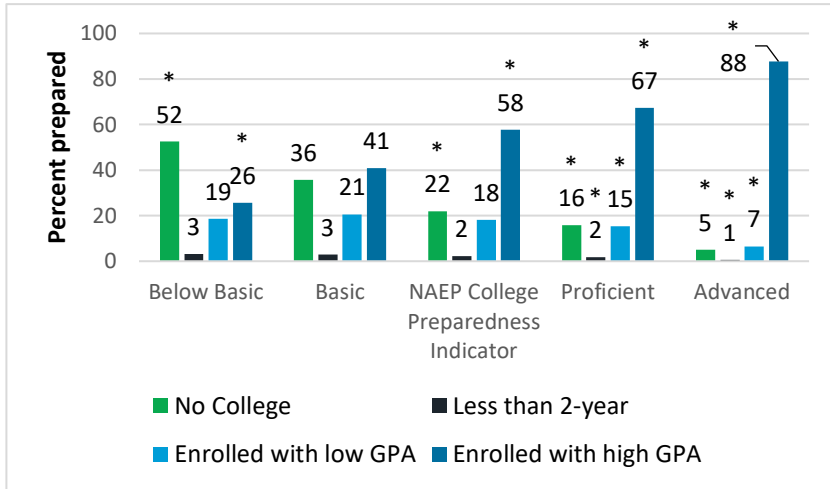
Comparing NAEP and SAT mathematics

As a further validity check on the utility of NAEP as a predictor of college preparedness, we examined how the NAEP and SAT mathematics assessments compare in prediction of first-year college GPA, taking into account high school GPA. Table 6 displays the average high school GPA and first year college GPA for all students as well as student groups. The average high school GPA for student groups ranges from 2.74 (Black) to 3.27 (Asian) with an overall mean of 3.11. The pattern was similar for first year college GPA with a low of 2.74 for Black students and a high of 3.12 both for White and Asian students.

Table 6. Average high school GPA and first year college GPA by student groups

Group	Variable	Mean	SE
Overall	First-year college GPA	3.03	0.01
	High school GPA	3.11	0.01
White	First-year college GPA	3.12	0.01
	High school GPA	3.24	0.01
Black	First-year college GPA	2.74	0.03
	High school GPA	2.74	0.03
Hispanic	First-year college GPA	2.92	0.04
	High school GPA	2.91	0.03
Asian	First-year college GPA	3.12	0.03
	High school GPA	3.27	0.04
Other	First-year college GPA	2.95	0.04
	High school GPA	3.00	0.04

SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

To compare NAEP and SAT in prediction of first-year college GPA, we first examined pairwise correlations among NAEP achievement, SAT scores, high school GPA, and first-year college GPA for all students as well as for racial/ethnic groups separately. Across all groups, high school GPA had the highest correlation with first-year college GPA. NAEP achievement and SAT math scores had similar but lower correlations with first-year college GPA. The correlations between NAEP mathematics achievement and first-year college GPA were between 0.27 (Asian students) and 0.31 to .33 (White, Black, and Other students), compared with 0.35 for all students (Table 8). The correlations between SAT mathematics and first-year college GPA were of similar magnitudes, between 0.29 (Hispanic) and 0.33 (White).

Table 7. Correlations between NAEP mathematics, SAT mathematics, high school GPA, and first-year college GPA by student groups

Group	Variable	First-year college GPA	NAEP math	SAT math
Overall	First-year college GPA	1		
	NAEP math	0.35	1	
	SAT math	0.36	0.71	1
	High school GPA	0.53	0.55	0.54
White	First-year college GPA	1		
	NAEP math	0.32	1	
	SAT math	0.33	0.68	1
	High school GPA	0.54	0.50	0.50
Black	First-year college GPA	1		
	NAEP math	0.31	1	
	SAT math	0.27	0.56	1
	High school GPA	0.39	0.51	0.44
Hispanic	First-year college GPA	1		
	NAEP math	0.27	1	
	SAT math	0.29	0.66	1
	High school GPA	0.42	0.51	0.45
Asian	First-year college GPA	1		
	NAEP math	0.27	1	
	SAT math	0.31	0.70	1
	High school GPA	0.44	0.51	0.51
Other	First-year college GPA	1		
	NAEP math	0.31	1	
	SAT math	0.31	0.70	1
	High school GPA	0.49	0.54	0.50

SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

Next, we ran a series of regression analyses where first-year college GPA is predicted by NAEP or SAT mathematics alone as well as in combination with high school GPA. We first examined the relationship between first-year college GPA and NAEP or SAT mathematics for all students. We report the results from four models, first with NAEP or SAT mathematics as the only predictor (Models 1 and 2) and then with high school GPA as an additional predictor (Models 3 and 4) (Table 9). When examined alone, NAEP and SAT mathematics explain about 13 percent of the total variance in first-year college GPA. When high school GPA is added to NAEP or SAT mathematics (Models 3 and 4), the variance explained increases to about 28 percent. One interesting result to note is the importance of high school GPA. In the base model, high school GPA alone already explains 28 percent of the variance in first-year college GPA.

Table 8. Predicting freshman GPA using NAEP and SAT mathematics performance

Variable	Base		Model 1		Model 2		Model 3		Model 4	
NAEP			0.007	***			0.002	***		
			(0.000)				(0.000)			
High school GPA	0.553	***					0.498	***	0.489	***
	(0.019)						(0.024)		(0.022)	
SAT					0.002	***			0.001	***
					(0.000)				(0.000)	
Constant	1.31	***	1.852	***	1.971	***	1.161	***	1.181	***
	(0.064)		(0.071)		(0.053)		(0.069)		(0.063)	
R^2	0.276		0.125		0.132		0.282		0.28	
N	8880		8880		8880		8880		8880	

***$p < .001$, **$p < .01$, *$p < .05$.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

We then ran the same models for each student racial/ethnic group separately. Tables 9–12 display the results for White, Black, Hispanic, and Asian students, respectively. For White students, the variance explained in first-year college GPA is similar to that in the overall model in Table 8. For the other subgroups, the variance explained is smaller. To look for any indication of a disproportionate relationship between NAEP or SAT and first-year college GPA for different student groups, we compared the coefficients across results in tables 9–12. These results do not suggest any disproportionate relationship between SAT and first-year college GPA. However, the coefficient between NAEP and first-year college GPA is slightly smaller for Asian American students than for students in any of the other three racial/ethnic groups. While the difference is small, interaction analyses (Table 13) reveal that the relationship between NAEP performance and first-year GPA is significantly lower for Asian American students than for White students. But given the small difference between the coefficients (0.002 for White students vs. 0.001 for Asian American students), the substantive implications are negligible.

When high school GPA was added as a predictor (in Models 3 and 4), we observed a different pattern of relationships by race/ethnicity subgroups. In particular, the coefficients associated

with the relationship between high school GPA and college GPA for Black, Hispanic, and Asian students were substantially lower than those for White students. For example, in Model 3, which examines the relationship between NAEP, high school GPA, and college GPA, the coefficients associated with high school GPA were 0.56 for White students, 0.30 for Black students, 0.41 for Hispanic students, and 0.39 for Asian Americans. A similar pattern was observed for Model 4, which examines the relationship between SAT mathematics, high school GPA, and college GPA, where the coefficients, respectively, were 0.55, 0.32, 0.40, and 0.37 for all groups combined shown in Table 7. That is, the difference in variance explained in college GPA when examining the results by subgroup appear not to be due to differences in the relationship between NAEP and college GPA by subgroup nor between SAT mathematics and college GPA by subgroup, but rather that the relationships of high school GPA and college first-year GAP vary substantially by subgroup in the presence of NAEP and the SAT. Importantly, high school GPA appears to be a substantially better predictor (taking into account NAEP or SAT scores) for White students than for the other subgroups. Notably, the association is weakest for Black students.

These analyses provide further evidence for the validity of NAEP as a predictor of college preparedness. As the analyses have demonstrated, grade 12 NAEP mathematics along with high school GPA predicts college preparedness, as defined by NAGB, as well as does the SAT in combination with high school GPA.

Table 9. Comparing NAEP and SAT mathematics scores in predicting freshman GPA: White students

Variable	Base		Model 1		Model 2		Model 3		Model 4	
NAEP			0.007	***			0.002	***		
			(0.000)				(0.000)			
High school GPA	0.601	***					0.562	***	0.554	***
	(0.024)						(0.028)		(0.027)	
SAT					0.002	***			0.001	***
					(0.000)				(0.000)	
Constant	1.17	***	1.943	***	2.057		1.036	***	1.05	***
	(0.0837)		(0.073)		(0.060)	***	(0.084)		(0.082)	
R^2	0.291		0.103		0.111		0.295		0.297	
N	5260		5260		5260		5260		5260	

***$p < .001$, **$p < .01$, *$p < .05$.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

Table 10. Comparing NAEP and SAT mathematics scores in predicting freshman GPA: Black students

Variable	Base		Model 1		Model 2		Model 3		Model 4	
NAEP			0.006	***			0.003	*		
			(0.001)				(0.002)			
High school GPA	0.374	***					0.301	***	0.322	***
	(0.053)						(0.059)		(0.067)	
SAT					0.002	***			0.001	
					(0.000)				(0)	
Constant	1.714	***	1.823	***	1.969	***	1.467	***	1.504	***
	(0.157)		(0.199)		(0.173)		(0.204)		(0.173)	
R2	0.15		0.095		0.073		0.168		0.163	
N	810		810		810		810		810	

***p < .001, **p < .01, *p < .05.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

Table 11. Comparing NAEP and SAT mathematics scores in predicting freshman GPA: Hispanic students

Variable	Base		Model 1		Model 2		Model 3		Model 4	
NAEP			0.006	***			0.002			
			(0.001)				-0.002			
High school GPA	0.461	***					0.411	***	0.398	***
	(0.051)						(0.071)		(0.067)	
SAT					0.002	***			0.001	*
					(0.000)				(0.000)	
Constant	1.581	***	2.04	***	2.059	***	1.393	***	1.389	***
	(0.157)		(0.244)		(0.164)		(0.210)		(0.162)	
R^2	0.179		0.074		0.086		0.189		0.192	
N	1090		1090		1090		1090		1090	

***p < .001, **p < .01, *p < .05.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

Table 12. Comparing NAEP and SAT mathematics scores in predicting freshman GPA: Asian students

Variable	Base		Model 1		Model 2		Model 3		Model 4	
NAEP			0.005	***			0.001			
			(0.001)				-0.001			
High school GPA	0.425	***					0.392	***	0.365	***
	(0.042)						(0.049)		(0.050)	
SAT					0.001	***			0.001	*
					(0.000)				(0.000)	
Constant	1.732	***	2.253	***	2.333	***	1.614	***	1.62	***
	(0.146)		(0.200)		(0.161)		(0.172)		(0.151)	
R^2	0.191		0.072		0.098		0.196		0.202	
N	890		890		890		890		890	

***$p < .001$, **$p < .01$, *$p < .05$.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

Table 13. Results from interaction models predicting freshman GPA using NAEP mathematics performance

Variables	Model 1		Model 2	
NAEP	0.007 (0.000)	***	0.002 (0.000)	***
GPA			0.49 (0.024)	***
Black	-0.12 (0.21)		0.092 (0.21)	
Hispanic	0.097 (0.245)		0.118 (0.236)	
Asian	0.31 (0.216)		0.302 (0.173)	
Other	-0.07 (0.228)		0.069 (0.205)	
Black*NAEP	-0.001 (0.001)		-0.001 (0.001)	
Hispanic*NAEP	-0.001 (0.001)		-0.001 (0.001)	
Asian*NAEP	-0.002 (0.001)		-0.002 (0.001)	*
Other*NAEP	0 (0.001)		-0.001 (0.001)	
Constant	1.943 (0.073)	***	1.152 (0.079)	***
R^2	0.138		0.285	
N	8880		8880	

***$p < .001$, **$p < .01$, *$p < .05$.

SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

Summary and Discussion

There is an increasing focus on ensuring that students are prepared for college when they graduate from high school. As the "gold standard" for measuring what students know and can do, NAEP can potentially inform educators and policymakers on whether the nation's schools have adequately prepared students for college by the time they reach 12th grade. There have been several studies that have examined the relationship between NAEP achievement and college admission at the national level and postsecondary entry at the state level (Ogut, Bohrnstedt, & Broer, 2019; Fields, 2014). However, the current study is the first to examine the relationship between NAEP achievement and college preparedness using nationally representative data that include college GPA data. Furthermore, it does so by using preparedness as defined by NAGB—entry into postsecondary education without remedial coursework and end-of-first-year GPA of 2.7 or higher—as well as an alternative preparedness indicator that excludes the requirement for no remedial coursetaking. The results show that NAEP explains a considerable amount of the variance (about 30 percent) in college preparedness.

When translated into probabilities of enrollment, the results show that the *NAEP Basic* level corresponded to a 49 percent probability of being college prepared, defined as enrolling in a 2- or 4-year college and having a first-year GPA of 2.7 or higher, whereas the probability for students at the *NAEP Proficient* and *NAEP Advanced* levels were 73 and 90 percent, respectively. The probability of being college prepared for those at the NAEP college preparedness benchmark was 65 percent.

Research shows that postsecondary enrollment depends on a number of factors, including academic skills measured by GPA or college entrance exams, noncognitive skills, and the availability of information about college systems (Roderic, Nagaoka, & Coca 2009). Other factors include students' desire to go to college, SES, the availability of financial aid, parental education, peer effects, and high school involvement (Cartledge et al., 2015; Hossler & Gallagher, 1987; Darolia & Koedel 2018; McDonough & Antonio, 1996; Roderick, Nagaoka, & Coca, 2009). NAEP is a measure of academic skills and, therefore, the results of this study only reflect the association between college preparedness and academic achievement, without taking into account any of the other potentially important factors related to success in college. Given this, perhaps it should not be surprising that NAEP by itself did not explain a large amount of the variation in postsecondary outcomes examined in the study. The same is true, however, for SAT mathematics.

An examination of the relationships between NAEP and the various outcomes by subgroup showed differences, but not always as expected. At a given NAEP achievement level, Black students had a higher probability of being college prepared than White or Hispanic students. Likewise, female students had higher probabilities of being college prepared than male

students and students with higher SES had a higher probability of being college prepared than those with lower SES when using parental education as the measure of SES. These results might be indicative of different student groups choosing majors with varying entry requirements and relying heavily on math achievement as the independent variable, as we do, might not be picking up these potential differences.

The results from this study that show different probabilities for postsecondary outcomes by subgroup do not necessarily suggest that students from different backgrounds are favored or being discriminated against. The results are mostly in line with the literature and reinforce the idea that academic skills, as reflected by NAEP achievement, are only one of the factors affecting the probability of college preparedness; other factors include SES, financial aid, and students' educational aspirations (Cartledge et al., 2015; Darolia & Koedel, 2018; Roderick, Nagaoka, & Coca, 2009). The differences in any of these factors across student groups could lead to varying probabilities of college preparedness.

Taken together, the findings from the study provide strong evidence of the predictive validity of NAEP for a set of important outcomes related to college preparedness. This concerns not only the predictive validity of NAEP in general but also of the NAEP achievement levels. However, the evidence for NAGB's college preparedness indicator does not appear to be as strong when using NAGB own definition of college preparedness which includes the absence of any remedial coursetaking in college. When college preparedness is defined as entry into a 2- or 4-year college without remedial coursetaking and having a first-year college GPA of 2.7 or higher, the indicator corresponds to a 45 percent probability of preparedness. But when the definition is updated to remove remedial coursetaking and focus on enrolling in a 2 or 4-year college and earning a first-year college GPA of at least 2.7, the probability of preparedness associated with the indicator increases to 65 percent.

Importantly, NAGB could use the results of this study to identify alternative college preparedness cut points on the NAEP scale (such as a 50 percent, 66 percent, or 75 percent chance of a positive outcome) and consider including *NAEP Basic* and *NAEP Proficient* cut points in college preparedness reporting, which would enhance their meaning for grade 12 mathematics and contribute to their acceptance, given the predictive validity information furnished by this study. With our preferred definition of college preparedness—which requires a college GPA of 2.7 but does not require the absence of remedial coursetaking—NAGB's current preparedness indicator (at 65 percent) is very close to the above-mentioned 66 percent probability benchmark, while *NAEP Basic* (at 49 percent) is close to the 50 percent benchmark and *NAEP Proficient* (at 73 percent) is close to the 75 percent probability benchmark.
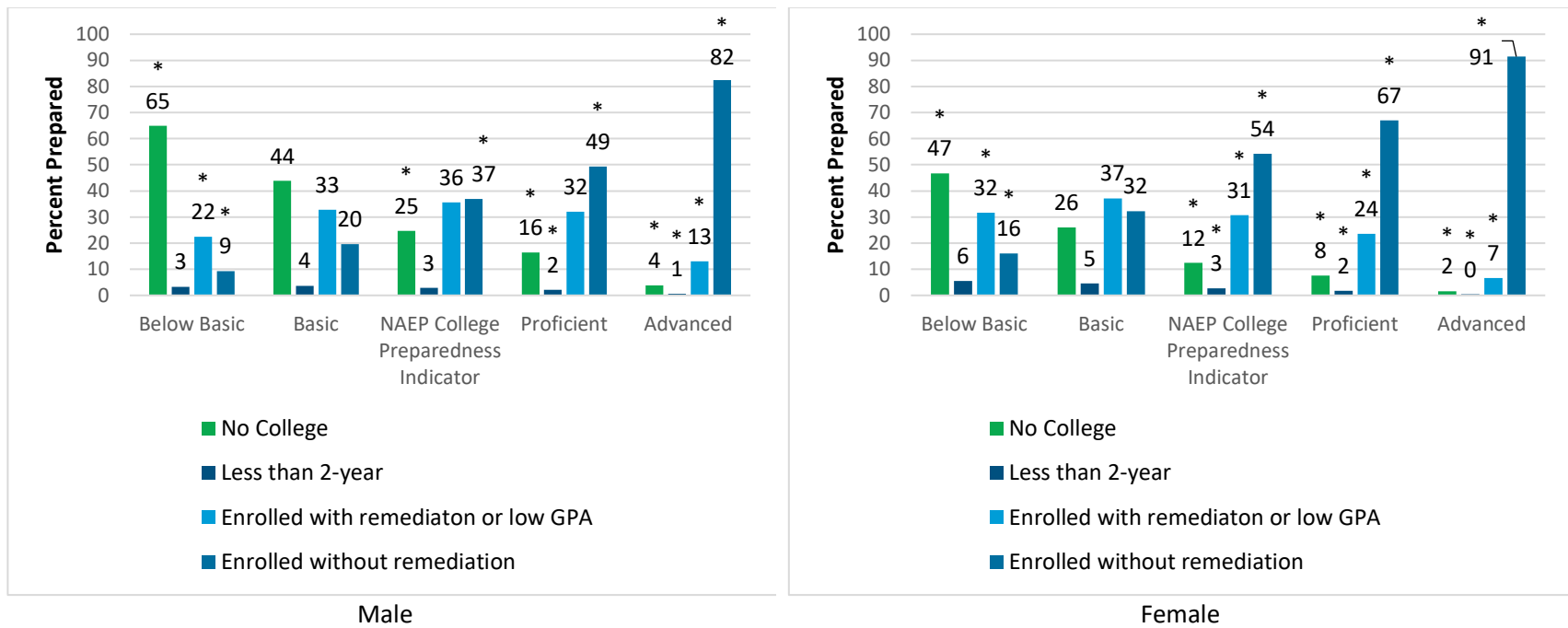
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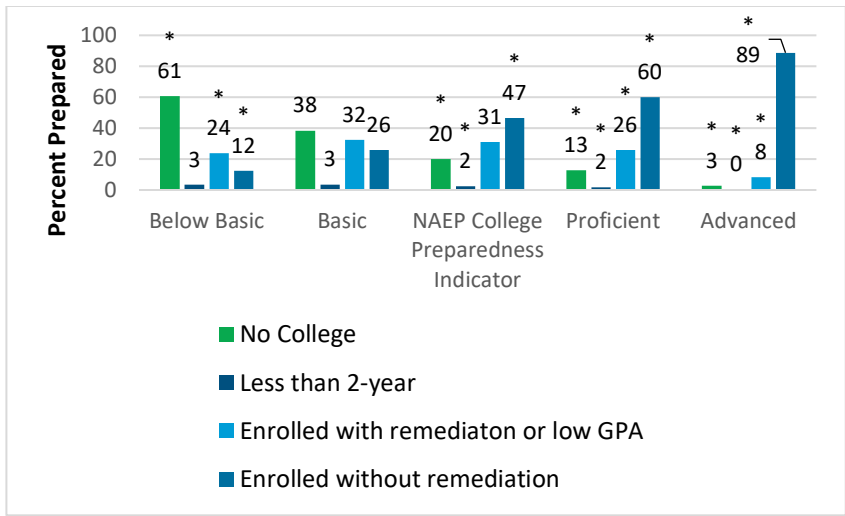
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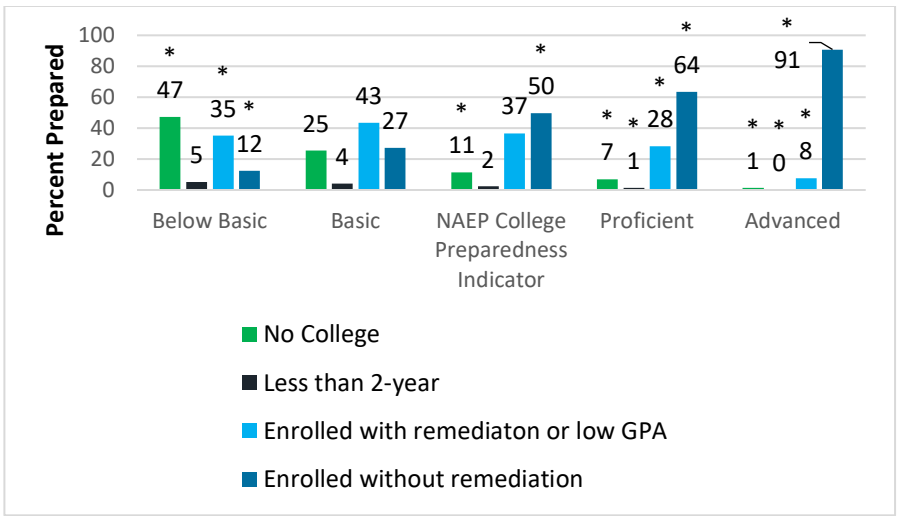
Appendix A

Figure A-1. Probabilities of college enrollment without remediation by first year college GPA status, by NAEP achievement level, gender, race/ethnicity, and parental education
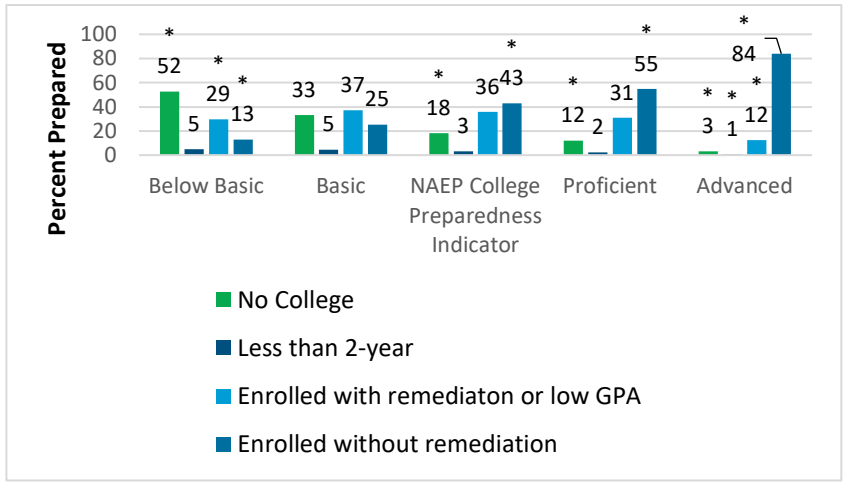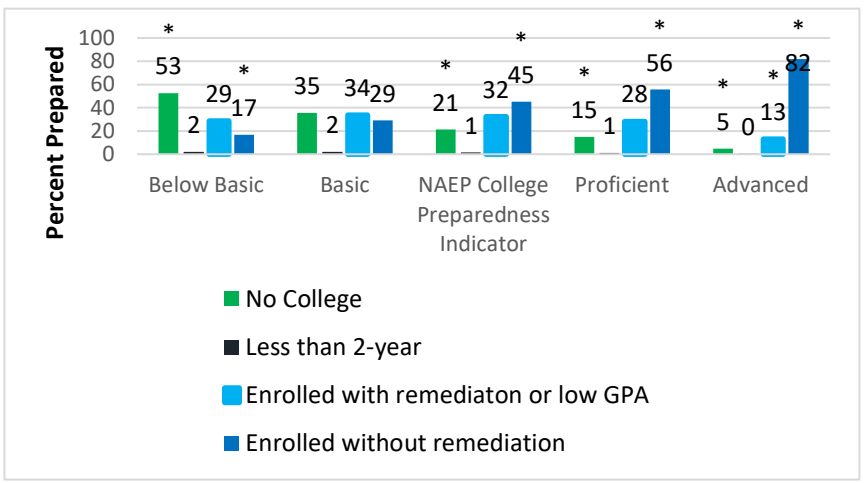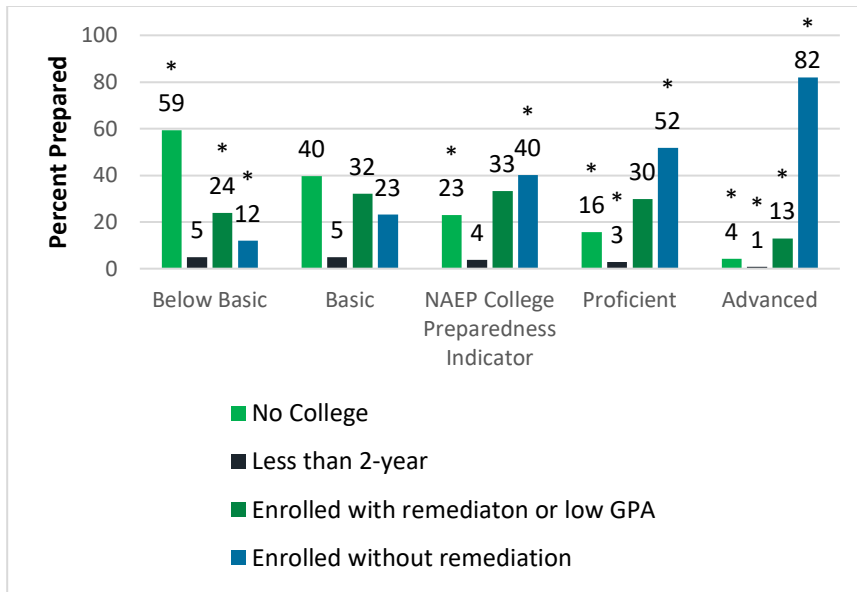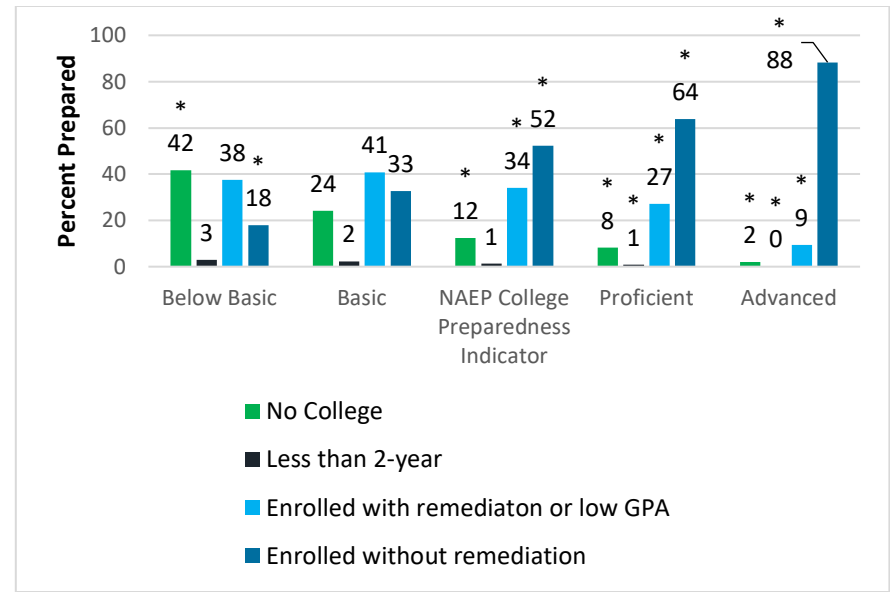

See notes at the end of the figure.

White

Hispanic

Black

Asian

See notes at the end of the figure.

Left chart — Parental education less than college

Percent Prepared (y-axis)

Below Basic: No College 59*, Less than 2-year 5, Enrolled with remediation or low GPA 24*, Enrolled without remediation 12*

Basic: No College 40, Less than 2-year 5, Enrolled with remediation or low GPA 32, Enrolled without remediation 23

NAEP College Preparedness Indicator: No College 23*, Less than 2-year 4, Enrolled with remediation or low GPA 33, Enrolled without remediation 40*

Proficient: No College 16*, Less than 2-year 3*, Enrolled with remediation or low GPA 30, Enrolled without remediation 52*

Advanced: No College 4*, Less than 2-year 1*, Enrolled with remediation or low GPA 13, Enrolled without remediation 82*

Legend:
- No College
- Less than 2-year
- Enrolled with remediaton or low GPA
- Enrolled without remediation

Parental education less than college

Right chart — Parental education college or higher

Percent Prepared (y-axis)

Below Basic: No College 42*, Less than 2-year 3, Enrolled with remediation or low GPA 38*, Enrolled without remediation 18

Basic: No College 24, Less than 2-year 2, Enrolled with remediation or low GPA 41, Enrolled without remediation 33

NAEP College Preparedness Indicator: No College 12*, Less than 2-year 1, Enrolled with remediation or low GPA 34*, Enrolled without remediation 52*

Proficient: No College 8*, Less than 2-year 1*, Enrolled with remediation or low GPA 27*, Enrolled without remediation 64*

Advanced: No College 2*, Less than 2-year 0*, Enrolled with remediation or low GPA 9*, Enrolled without remediation 88*

Legend:
- No College
- Less than 2-year
- Enrolled with remediaton or low GPA
- Enrolled without remediation

Parental education college or higher

*Significantly different from the reference group (male, White, or parental education less than college).
NOTE: N's are 5,650, 6,050, 6,760, 1,130, 1,740, 960, 6,250, and 5,450.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

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Results from multinomial logistic regression

To test the assumption about the order used in the college enrollment outcome variable, we conducted multinomial logistic regression analyses that do not impose any order on the outcome variable. With a four-alternative model (no less-than-2-year college, 2- or 4-year college with remediation, 2- or 4-year college without remediation and GPA less than 2.7, and 2-or 4-year college without remediation and GPA higher than 2.7), the analytic model takes the form

$$Pr(y_i = j) = \frac{e^{\alpha_j - \beta_1 x_i + \varepsilon_i}}{(1 + e^{\alpha_j - \beta_1 x_i + \varepsilon_i})}$$

(5)

where x_i is the NAEP grade 12 mathematics performance and y_j is the enrollment outcome.

Table A-1 displays the results from the marginal maximum likelihood (MML) regression model that was estimated to impute NAEP scale scores.

Table A-1. Result from marginal maximum likelihood regression imputation model predicting NAEP performance

Variable	Model 1	
Constant	-7.808	***
	(5.685)	
Algebra, grade 11	1.711	***
	(0.116)	
Algebra, grade 9	0.905	***
	(0.086)	
Black	-6.977	*
	(2.935)	
Hispanic	-4.201	
	-2.431	
Asian	1.566	
	-3.268	
Other race	-1.839	
	-3.262	
Male	6.448	***
	(1.747)	
Parent college graduate	0.258	
	-1.601	
High school GPA	-0.074	
	-1.676	
2- or 4-year with remediation	7.978	***
	(1.663)	
2- or 4-year without remediation and GPA < 2.7	2.134	
	-2.821	
2- or 4-year without remediation and GPA ≥ 2.7	7.135	*
	(2.845)	
Pseudo R2	0.875	

***$p < .001$, **$p < .01$, *$p < .05$.
SOURCE: U.S. Department of Education, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), High School Longitudinal Study of 2009 (HSLS:09).

After running the multinomial logistic regression models, we estimated the probability of different outcomes at NAEP achievement levels. Figure A-2 shows the probability for performance at the *NAEP Basic, NAEP Proficient,* and *NAEP Advanced* achievement levels as well as at the NAEP college preparedness indicator. For students scoring below the *NAEP Basic* cut score, their average achievement score was used to compute the corresponding percentages.

The results show that the probability of enrolling in a 2- or 4-year college without remediation and achieving a first-year GPA of at least 2.7 increased from 26 percent for performance at the *NAEP Basic* level to 84 percent for performance at the *NAEP Advanced* level. The probability of this outcome for those scoring at the NAEP college preparedness benchmark of 163 was 47 percent. These results are very similar to those from the ordered logistic regression reported in the main body of the report.

Figure A-2. Probability of college enrollment without remediation by first year college status, by NAEP achievement level and NAEP's college preparedness indicator
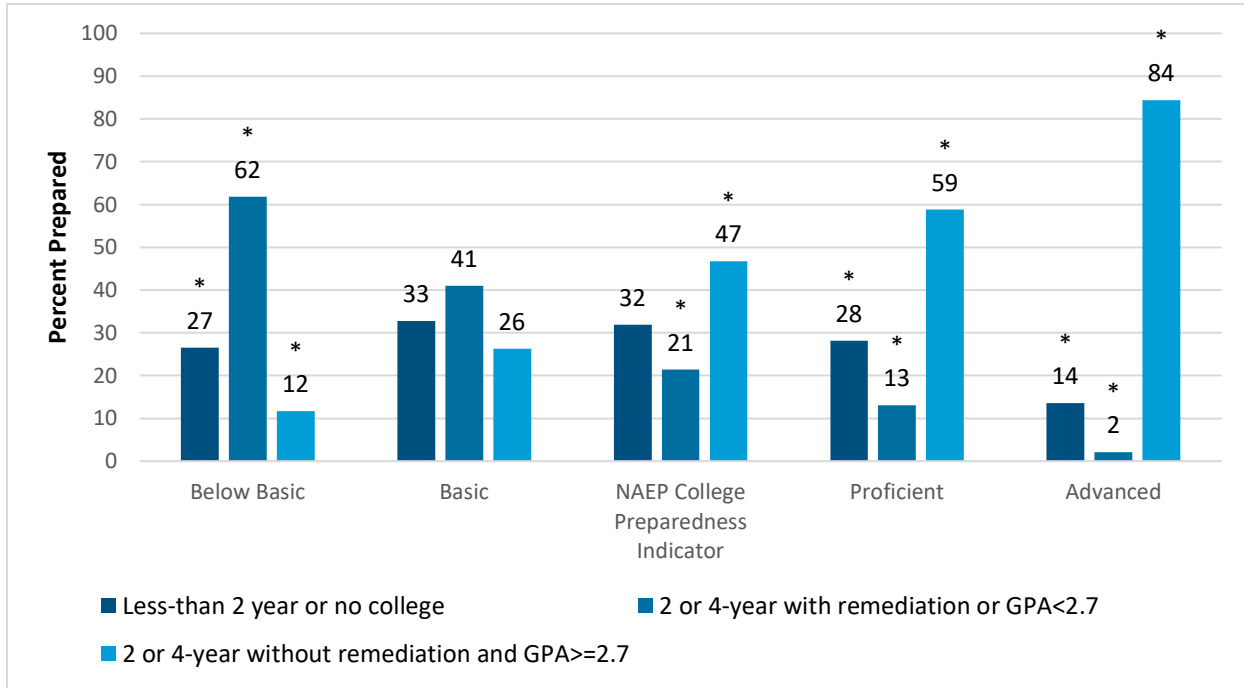
*Significantly different from the NAEP Basic achievement level.
NOTE: N = 11,700.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

Figure A-3 displays the probability of college preparedness generated from separate multinomial logistic regression models for the subgroups of interest. Similar to the results from the ordered logistic regression models, using NAEP's definition of preparedness, female students and Black students had a higher probability of college preparedness than their peers at each NAEP achievement level. Also, at each NAEP achievement level, students whose parents graduated from college or had an advanced degree had a higher probability of college preparedness than students whose parents had less than a college education.

Figure A-3. Probability of college enrollment without remediation by first year college GPA status, by NAEP achievement level, gender, race/ethnicity, and parental education
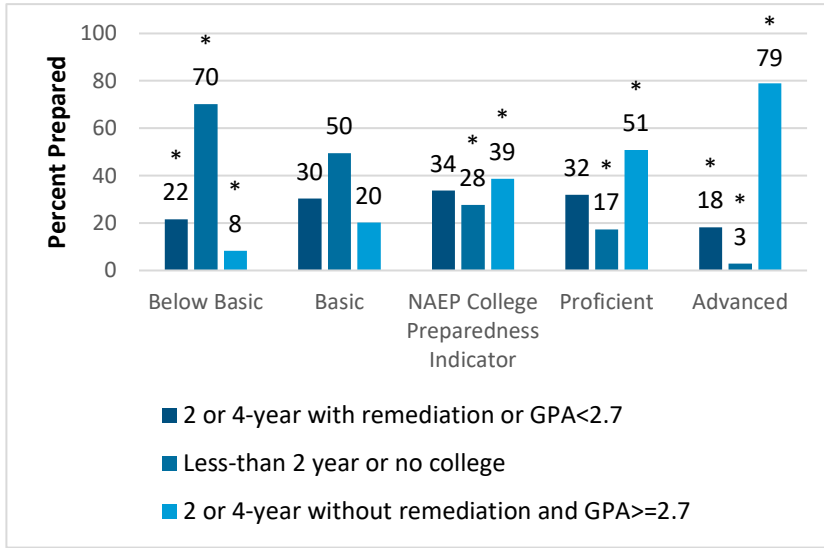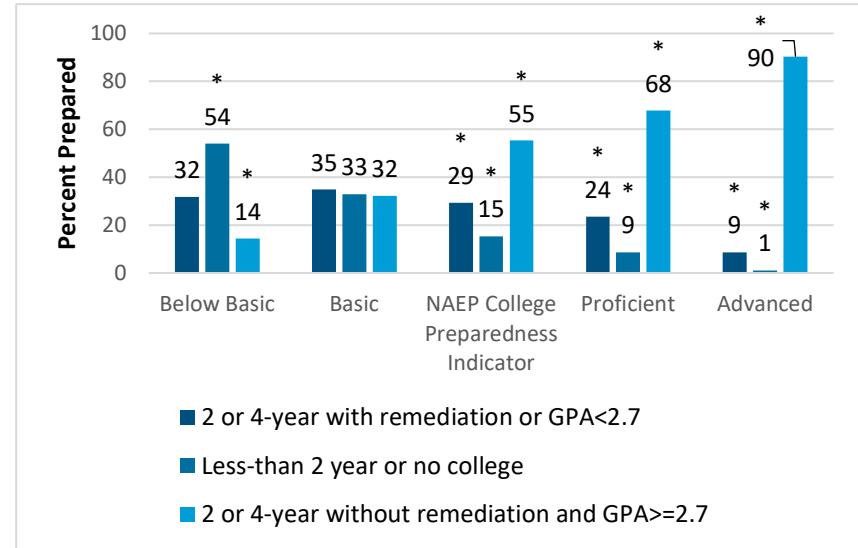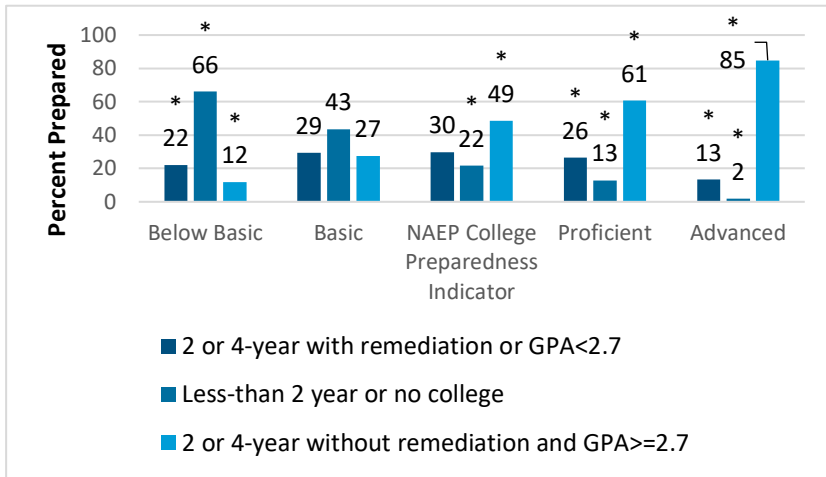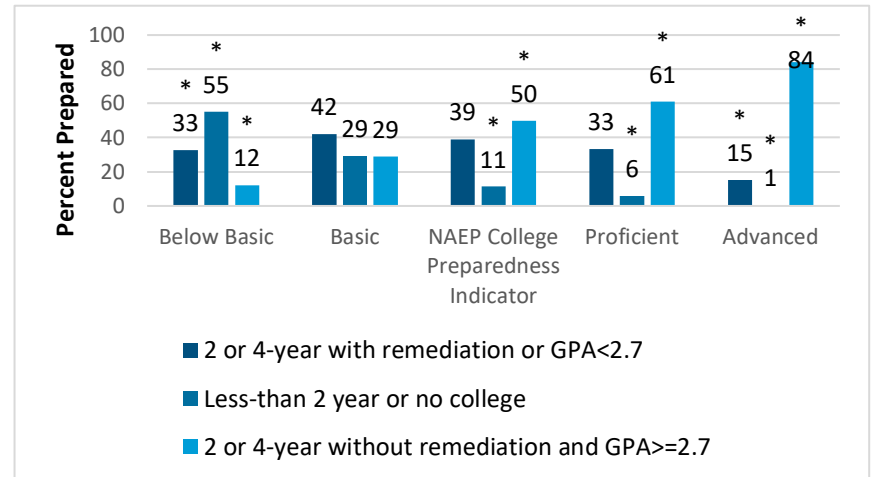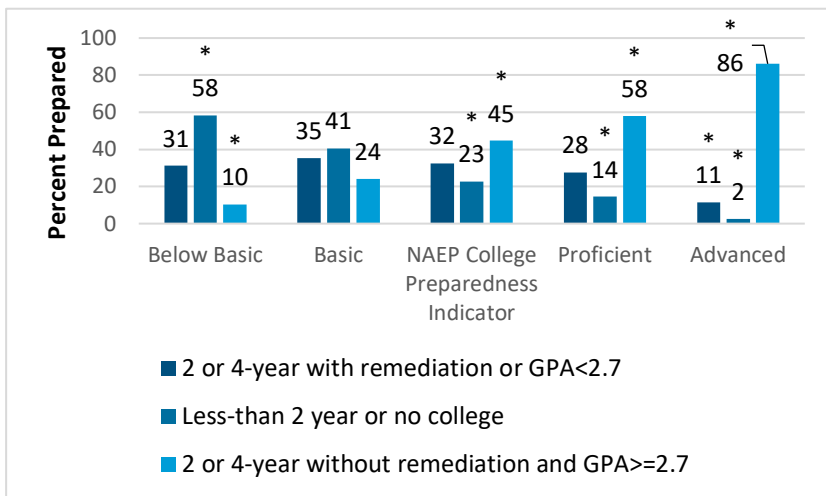

Male

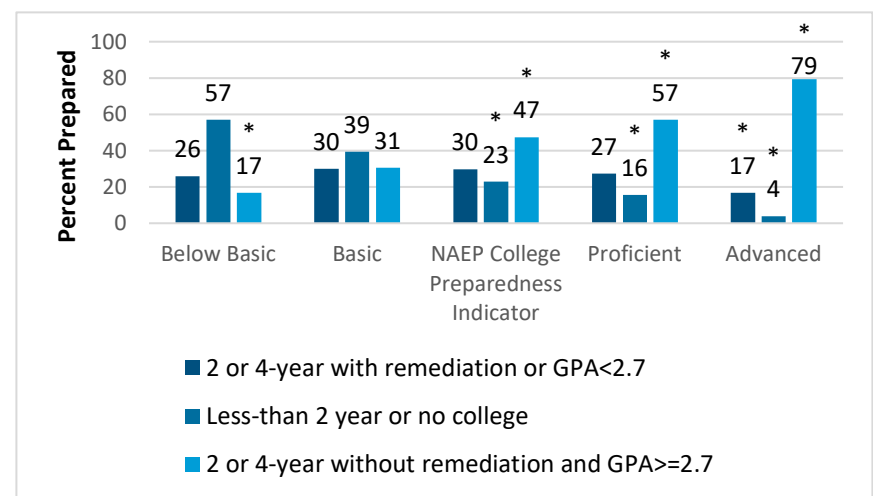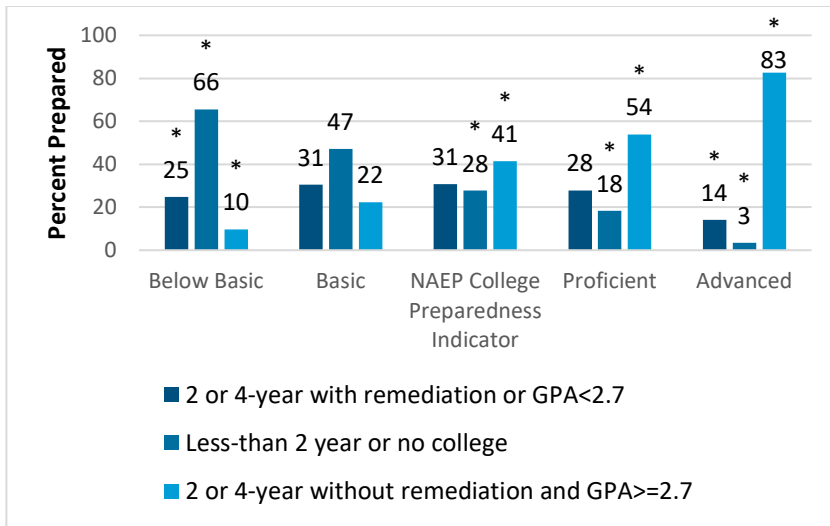Female

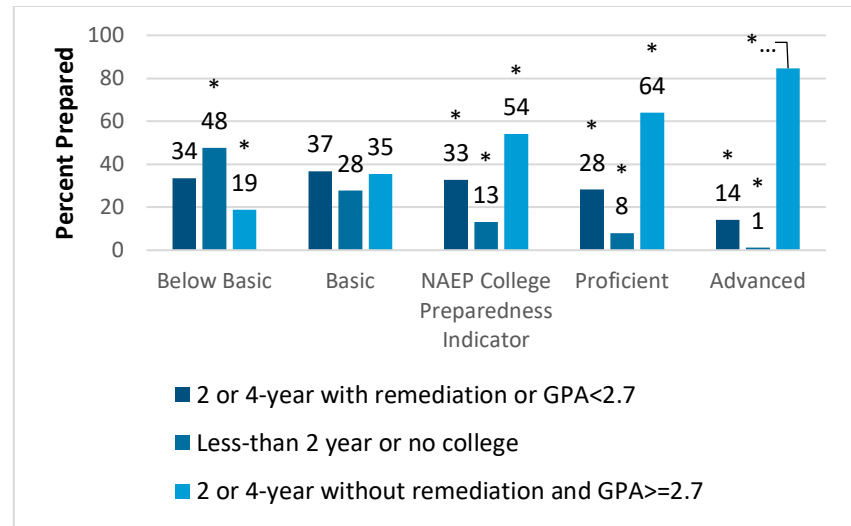See notes at the end of the figure.

White

Black

Hispanic

Asian

See notes at the end of the figure.

Parental education less than college

Parental education college or higher

#Rounds to zero.
*Significantly different from the reference group (male, White, or parental education less than college).
NOTE: N's are 5,650, 6,050, 6,760, 1,130, 1,740, 960, 6,250, and 5,450.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09).

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