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An In-Depth Exploration of SAT® Math Scores for Use in College Course Placement

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Abstract

This study examines the value of SAT Math scores for predicting first-year college math course performance, beyond HSGPA, and across colleges and universities of varying selectivity. Findings demonstrate that SAT Math scores are a highly useful tool for course placement, above and beyond HS grades, and that the validity of scores hold across institutional selectivity segments and regardless of when the SAT was taken in high school. Using data from 152,829 students attending 54 higher education institutions, differential validity, placement accuracy, probability of success, and differential prediction analyses were conducted. Results indicated that all SAT Math score relationships with math course grades were positive, .50 or higher, demonstrating strong relationships. Moreover, the incremental validity of SAT scores beyond that of HSGPA alone was .10, a 20% increase. Additional analyses indicated that the admission selectivity did not differentially impact the relationship between SAT scores and math course grades. Findings from this study show that SAT Math scores are a highly predictive tool to ensure that students are prepared for first-year math coursework and to identify students who may need additional support to be successful.

Introduction

When covid appeared in the U.S. in spring of 2020, it upset both instructional and grading practices across all levels of education (American Association of Collegiate Registrars and Admission Officers, 2020; Camara, 2024). One significant educational consequence of the pandemic was documented learning loss due to school closures, manifested in lower test scores, particularly for students attending low income and high minority schools and districts (Fahle et al., 2024, Lewis & Kuhfeld, 2023; Piers et al., 2021; Sattem et al., 2022). Notably, however, while standardized test scores were falling post-pandemic, both high school and college grades were increasing (Allen et al., 2020; Edwards et al., 2023; Fahle et al., 2024; National Center for Education Statistics, 2024; Supriya et al., 2021; Sanchez & Moore, 2022; Tillinghast et al., 2023; Westrick et al., 2024).

Two additional related consequences of the pandemic were 1) the inability of students to take standardized admission tests when and where they desired, and 2) the movement toward test-optional admissions by higher education institutions. Students' inability to take admission tests due to covid initially drove the trend toward test-optional admissions, however, test-optional and test-blind admission policies persisted well beyond the pandemic. Some of the more-selective higher education institutions have recently reinstated test score requirements for admission (Camara, 2024).

In this environment, colleges and universities had less insight into student preparedness at the precise moment when preparedness was on the decline. This placed some renewed focus on placement tests so that institutions could better understand incoming student knowledge and skills in Math and English to best enable their success (Bickerstaff et al., 2021; Carvell et al., 2024; Hill & Needy, 2021). This focus warrants a more in depth analysis of SAT Math scores as tools for college course placement decisions and presents the opportunity to answer an important question about whether the time between when a student last took the SAT through the time when they are entering college could diminish the predictive value of those scores (versus a placement test upon arrival on campus).[1] On average, high school students who take the SAT a second time (or after taking the PSAT) score higher on the later administration, which can be attributed to academic growth as they progressed through high school between test administrations (Kim et al., 2018). However, if students did not have the opportunity to test at a later date, this growth would not be reflected in their older SAT scores. The core question for this study is, for SAT Math scores, are older scores underestimating students' actual developed math abilities, and consequently these students would be placed into lower-level math courses because their older scores did not reflect their true capabilities? This report aims to document the utility and value of SAT Math scores for placement into college math courses, as outlined in the "Intended Uses and Interpretations" section in the *SAT Technical Manual* (2017, 2024). Analyses will be parsed by different math courses, across institutions of differing selectivity, and across differences in the length of time between when a student takes the SAT in high school and when they take their first college math course.

[1] The use of older test scores for math placement purposes has been explored at the school district level (Schweig et al., 2021) if not at the college level.

College Readiness and Math Course Performance Measures

Data and Methods

Sample

The study sample was based on 152,829 students attending 54 four-year higher education institutions. Inclusion in the sample required that the institutions had math course grade data from the first semester of students' first year of college for four academic years: 2018-2019, 2020-2021, 2021-2022, and 2022-2023.[2] As student populations may have changed within institutions over time, we conducted checks for consistency across multiple measures. We calculated the correlations between institutional means across academic years to see if institutions had changed their standing relative to other institutions. The correlations ranged between .92 and .98 for admission rates, .94 to .97 for SAT Total score, .86 to .91 for HSGPA, indicating relative stability. Within institutions, we calculated standardized mean differences (*d*; Cohen, 1988) for mean SAT scores, HSGPA, and math course grades between the 2018 and 2022 cohorts. Whereas SAT scores declined (d=-0.23 for SAT Total and SAT Math scores), HSGPAs rose (d=0.23), and math grades increased slightly (d=0.06). This is consistent with other recent research on college grades and test score trends during this time period (Westrick et al., 2024)

To categorize institutions by admission selectivity, we first calculated the mean admission rate for each institution across the four academic years. We then classified institutions (*k*) as more-selective if they admitted no more than 50% of applicants (k=14, n=58,123), and less-selective if they admitted more than 50% of applicants (k=40, n=94,706). We included students whose most recent SAT score came from their junior year or the first half of their senior year of high school.[3] To ensure adequate sample sizes, we restricted first-semester undergraduate math courses to those that fell under four categories: calculus, pre-calculus, algebra, and statistics.

Measures

The high school measures of academic readiness include SAT scores and self-reported HSGPA. SAT Reading and Writing (RW) and Math scores were reported on a 200-to-800-point scale, and SAT total scores were reported on a 400-to-1600-point scale. Students' self-reported HSGPA was obtained from the SAT Questionnaire when they registered for the SAT and is reported on a 13-point interval scale, ranging from 0.00 (F) to 4.33 (A+). Participating undergraduate institutions reported math course grades on a 12-point interval scale, ranging from 0.00 (F) to 4.00 (A), or a 13-point interval scale, ranging from 0.00 (F) to 4.33 (A+). For this study, we dichotomized math course grades at 3.00, or a course grade of B. We classified students earning a course grade of B or higher as successful (doing well) and students earning a course grade below a B as unsuccessful. We decided upon this grade

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[2] The 2019-2020 academic year was excluded as most institutions did not report student outcomes due the COVID-19 pandemic.

[3] In our preliminary analyses, we sought to include students whose most recent SAT scores came from any term in high school. However, we found that less than one percent of the original sample had a most-recent SAT score from before their junior year, and less than four percent had a most-recent score from the second half of their senior year. As these small subsamples were divided across 54 institutions, we had very few institutions with at least 15 students in either of these test timeframes, making analyses impractical.

point based on past research that found that students with first-year GPAs below 3.00 are less likely than other students to persist to the fourth year, pull their fourth-year cumulative GPA above 3.00, and graduate within four years (Westrick et al., 2023).

Table 1 contains the descriptive statistics for the students in the overall sample and broken out by institutional admission selectivity. Overall, we see that the students in the study were well above the national averages for SAT scores (mean SAT total score = 1225) and HSGPA (3.77). Students at the more-selective institutions not only had higher mean SAT scores and HSGPAs than those of the students at the less-selective institutions, but they also had a higher mean math course grade, 3.17 versus 2.79 for the students at the less-selective institutions. Overall, the mean math course grade was 2.93, slightly below a 3.00 or B grade.

Table 1: Descriptive Statistics, Means (Standard Deviations), Overall and by Institution Admission Selectivity

Measure	Overall (*k*=54, *n*=152,829)	Less-Selective (*k*=40, *n*=94,706)	More-Selective (*k*=14, *n*=58,123)
SAT Math	617 (99)	583 (92)	670 (85)
SAT	1225 (171)	1166 (162)	1322 (140)
HSGPA	3.77 (0.44)	3.67 (0.47)	3.93 (0.32)
Math Course Grade	2.93 (1.12)	2.79 (1.21)	3.17 (0.90)

Note. *k*=number of institutions, *n*=number of students.

Table 2 contains the descriptive statistics for the overall sample broken out by the four general math courses. Calculus was the most common first math course, with 51% of the total sample. Next was algebra (21%), followed by statistics (16%), and then pre-calculus (12%). Students who enrolled in calculus courses had the highest, and students enrolled in algebra courses had the lowest, mean SAT scores and HSGPAs. The highest mean math course grade was for statistics (3.08), followed by calculus (3.01), pre-calculus (2.85), and then algebra (2.67).

Table 2: Descriptive Statistics, Means (Standard Deviations), by First Math Course and Overall

Measure	Calculus n=78,048	Pre-Calculus n=18,237	Algebra n=32,298	Statistics n=24,246	Overall n=152,829
SAT Math	670 (82)	577 (63)	528 (69)	591 (98)	617 (99)
SAT	1311 (144)	1163 (120)	1079 (130)	1190 (170)	1225 (171)
HSGPA	3.89 (0.37)	3.74 (0.43)	3.53 (0.48)	3.73 (0.45)	3.77 (0.44)
Course Grade	3.01 (1.02)	2.85 (1.16)	2.67 (1.27)	3.08 (1.11)	2.93 (1.12)

Table 3 contains the descriptive statistics for students broken out by institutional admission selectivity and then by first math course. A clear difference between the students at the less- and more-selective institutions was the distribution of students across the four math courses. At the less-selective institutions, only 42% of the students enrolled in calculus courses and 30% of the students enrolled in algebra courses, but at the more-selective institutions 66% of the students enrolled in calculus courses and only 7% enrolled in algebra courses. Across admission selectivity levels, enrollment percentages in statistics (16%,16%) and pre-calculus (12%, 11%) courses were nearly identical. Additional descriptive statistics broken out by when students last took the SAT can be found in Appendix A.

Before moving on to the analyses, Figures 1, 2, and 3 show the mean math course grades for students broken out by SAT Math score bands. As there were so few students with scores between 200 and 290, we combined the students between 200 and 390 as our lowest score band. The remaining score bands were 400 to 490, 500 to 590, 600 to 690, and 700 to 800. As SAT Math score bands increased, the math course grades increased in a stairstep fashion. For the overall results shown in Figure 1, the mean math course grades were 1.73, 2.20, 2.71, 3.08, and 3.38 for the 200-390, 400-490, 500-590, 600-690, and 700-800 score bands, respectively. Figure 2 shows the results broken out by institution admission selectivity levels, and Figure 3 shows the results disaggregated by when students last took the SAT. In both Figures 2 and 3, we see the same stairstep pattern or clear linear relationship seen in the overall results.

Table 3: Descriptive Statistics by First Math Course and Admission Selectivity

Less-Selective					
Measure	Calculus n=39,617	Pre-Calculus n=11,766	Algebra n=28,339	Statistics n=14,984	Total n=94,706
SAT Math	641 (80)	571 (64)	520 (65)	561 (94)	583 (92)
SAT	1258 (142)	1148 (120)	1061 (123)	1133 (166)	1166 (162)
HSGPA	3.81 (0.41)	3.66 (0.45)	3.50 (0.49)	3.64 (0.48)	3.67 (0.47)
Course Grade	2.91 (1.12)	2.73 (1.22)	2.60 (1.30)	2.87 (1.23)	2.79 (1.21)

More-Selective					
Measure	Calculus n=38,431	Pre-Calculus n=6,471	Algebra n=3,959	Statistics n=9,262	Total n=58,123
SAT Math	700 (73)	586 (61)	587 (63)	641(83)	670 (85)
SAT	1365 (125)	1190 (114)	1206 (104)	1283 (131)	1322 (140)
HSGPA	3.97 (0.30)	3.90 (0.35)	3.73 (0.35)	3.88 (0.33)	3.93 (0.32)
Course Grade	3.13 (0.90)	3.07 (0.98)	3.12 (0.95)	3.43 (0.77)	3.17 (0.90)

Figure 1: Average Math Course Grade by SAT Math Score Bands

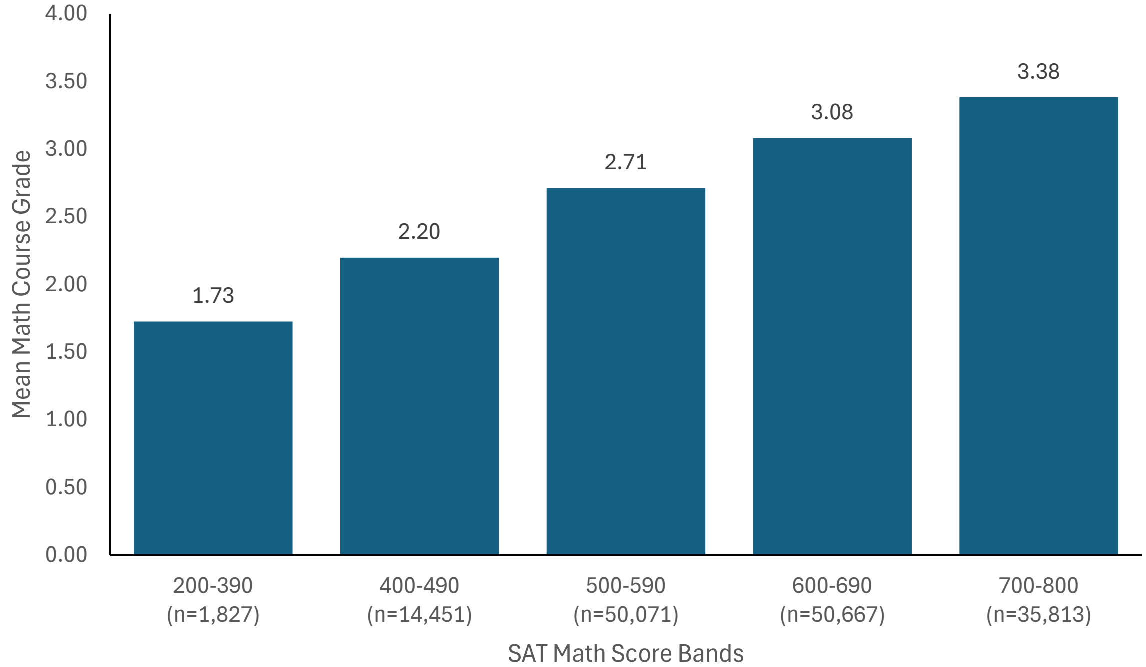


Figure 2: Average Math Course Grade by SAT Math Score Bands and Admission Selectivity

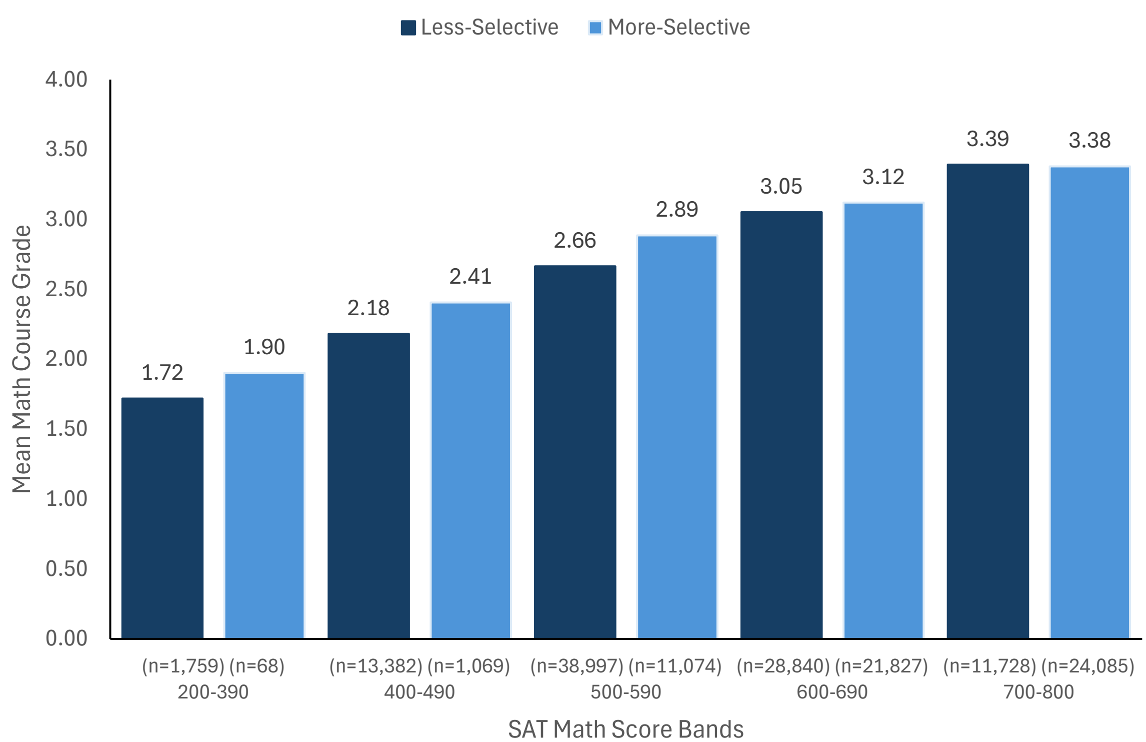
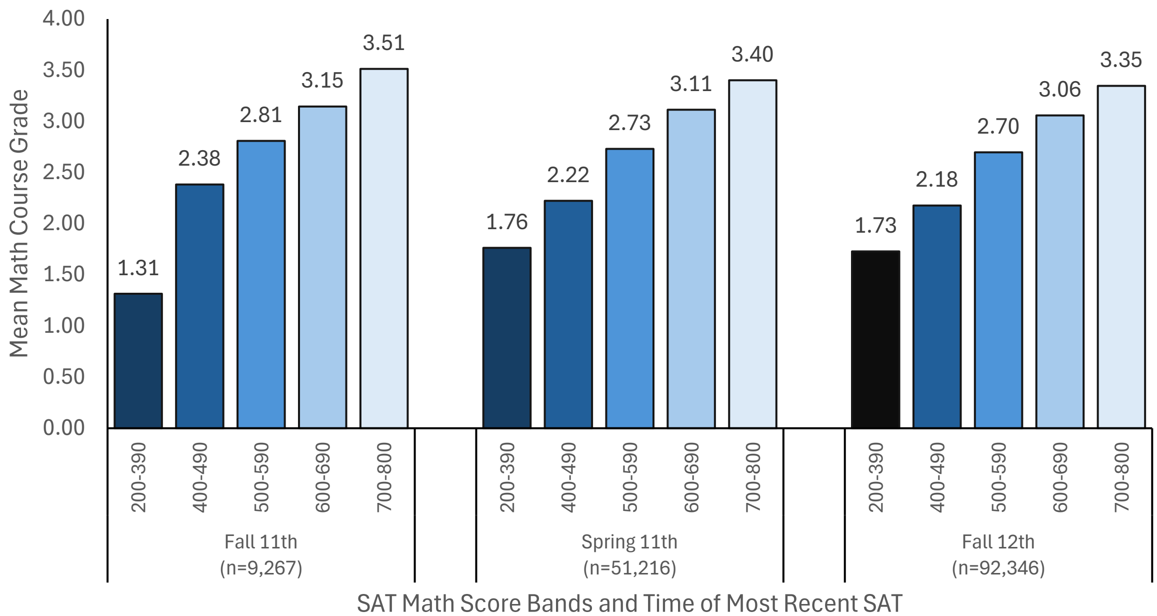
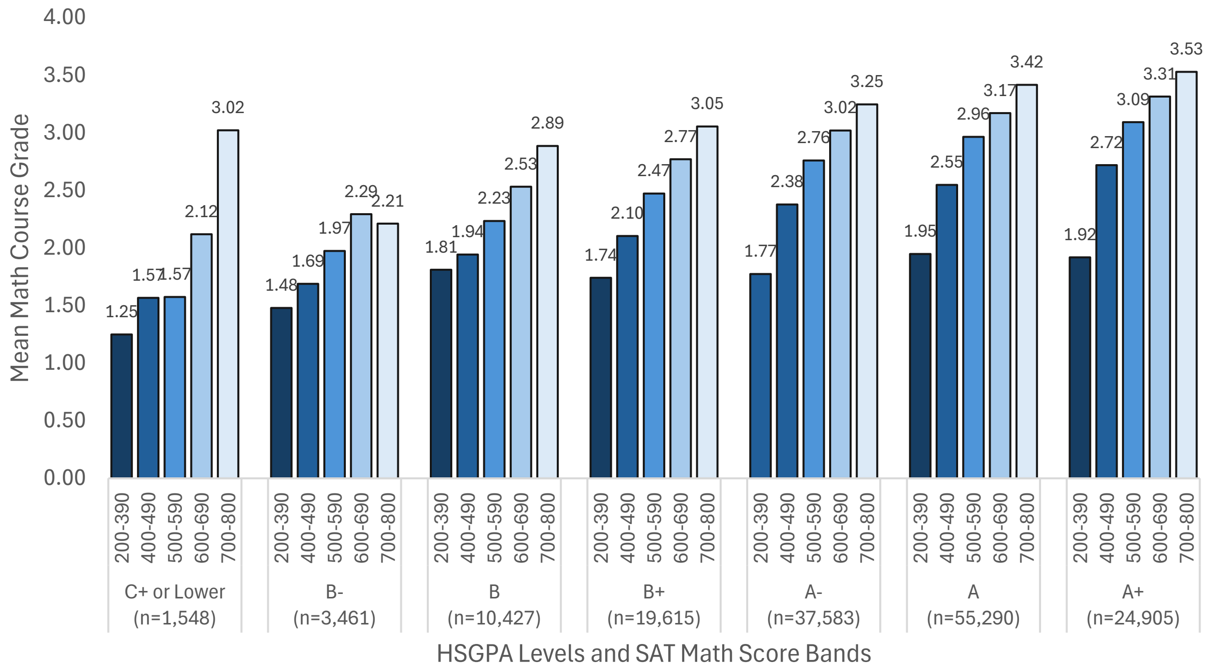


Figure 3: Average Math Course Grade by SAT Math Score Bands and Time of Most Recent SAT



Lastly, we present the mean math course grades within SAT Math score bands within HSGPA letter grades in Figure 4. Within each HSGPA letter grade, we see that the mean math course grades increase in a stairstep fashion as the SAT Math score bands increase. For example, among the students in the A+ HSGPA category, students in the SAT Math score bands 200-390, 400-490, 500-590, 600-690, and 700-800 had mean course grades of 1.92, 2.72. 3.09, 3.31, and 3.53, respectively. If SAT Math scores did not add any information beyond that of HSGPA, we would see the same mean course grades across the SAT Math score bands within each letter grade. However, we see that SAT Math scores clearly add value beyond HSGPA, which is further shown in the correlational analyses below.

Figure 4: Average Math Course Grade by SAT Math Score Bands and within HSGPA Levels



Analyses

Differential Validity

We conducted correlational analyses at the institution level, weighted by the institutional sample size, and then pooled those together for the entire sample to obtain estimated averages. Inclusion required that institutions have at least 15 students. Correlations were corrected for multivariate range restriction (Lawley, 1943) using the 2018, 2020, 2021, and 2022 graduating high school seniors who took the SAT as the reference population.

Accuracy Rates

We next identified the students with SAT Math scores in the bottom 10% within each math course at the institution level. We "flagged" these students as being at risk of not achieving a course grade of B or higher.[4] Within each math course at each institution, we then added in the outcome data for our measure of success, a course grade of B or higher, so that we had a 2x2 table: flagged students who did not earn a course grade of B or higher, the true negatives; unflagged students who earned a course grade of B or higher, the true positives; flagged students who earned a course grade of B or higher, the false negatives; and the unflagged students who did not earn a course grade of B or

[4] Institutions may choose to provide the flagged students with academic support to lessen their chances of being unsuccessful in the course. While we flagged the bottom 10% of students, institutions may choose to flag a higher or lower percentage of students depending on the resources available for academic support. Institutional data on whether students were flagged or if academic support was made available to students was not available for this study.

higher, the false positives. By adding the true negatives and the true positives and then dividing the sum by the total number of students in the course, we obtained the accuracy rate (AR).

Probability of Success

To examine the effect of the timeframe in which students last took the SAT on their math course outcomes, we subdivided students into three categories based on their most recent SAT Math scores. Students who last tested in the first half of their junior year of high school (between August 1 and December 31) were placed in the Fall 11th category. Students who last tested in the second half of their junior year of high school (between January 1 and June 30) were placed in the Spring 11th category. Students who last tested in the first half of their senior year of high school (between August 1 and December 31) were placed in the Fall 12th category.[5] We then conducted logistic regression analyses to estimate students' probabilities of earning a course grade of B or higher within their math course within their institution for each of the three subgroupings. We conducted logistic regression analyses for grades earned in any math course, and then again for calculus, pre-calculus, algebra, and statistics. Results were calculated at the institution level, weighted by institution sample size, and then aggregated to get estimated mean probabilities of success across the SAT Math score scale.

Differential Prediction

Lastly, we conducted differential prediction analyses based on the time of students' most recent SAT score. We first ran linear regression analyses using SAT Math scores to predict math course grades within each institution, and then we calculated the residuals—actual math course grades minus predicted math course grades—for individual students. Next, average residuals were calculated by subgroup (if $n \geq 15$) across all institutions. A negative mean residual indicates that SAT Math scores overestimate math course grades for students within the subgroup, on average. A positive mean residual indicates that SAT Math scores underestimate math course grades for students within the subgroup, on average. We conducted these analyses first for any math course and then for each of the four math courses. Inclusion in the analyses required at least 15 students within the math course within the institution.

Results

Differential Validity

Table 4 contains the adjusted (and raw) correlations found for SAT Math score relationships with any math course, overall and then by institutional admission selectivity levels. Overall, the adjusted correlation between SAT Math scores and math course grades was .52, higher than the correlation between HSGPA and math course grades (.49). Moreover, the incremental validity of SAT scores beyond that of HSGPA alone was .10, a 20% increase. Similar results were found after segmenting the institutions by admission selectivity levels, with the correlations slightly lower at the less-selective institutions and slightly higher at the more-selective institutions. However, the 95% confidence intervals for the adjusted correlations for the less- and more-selective institutions overlapped,

[5] Note that the SAT was not administered in the month of July during these years.

indicating that the admission selectivity did not moderate the relationships between the predictors and math course grades.

Table 5 contains the results found for the different math courses overall and then broken out by admission selectivity levels. All the SAT Math score relationships with math course grades were positive and at or above .50, indicating strong relationships.[6] The 95% confidence intervals for the adjusted correlations for the less- and more-selective institutions overlapped in all but one instance (Calculus, HSGPA), indicating that the admission selectivity generally did not moderate the relationships between SAT scores and math course grades.

Overall, SAT Math scores had the strongest relationship with calculus course grades, with a correlation of .61, and the weakest (though still strong) relationship with statistics courses, with a correlation of .53. Note, however, that the overall SAT Math and statistics course grade correlation of .53 exceeds the SAT Math correlation with any math correlation of .52 in Table 4. This is because the students in the four math courses have different SAT Math score ranges but very similar grade ranges (see the means and standard deviations in Tables 2 and 3). Though there is overlap in their SAT scores, there is even more overlap in their course grades.[7] Similar results were found after segmenting the institutions by admission selectivity. At the less-selective institutions, the adjusted correlations for the four types of math courses ranged from .50 to .59 (versus .49 in Table 4), and at the more-selective institutions the adjusted correlations ranged from .57 to .63 (versus .56 in Table 4). Across courses and institution types, the SAT Math score correlations with course grades exceeded or equaled those for HSGPA, and the incremental validity of the SAT beyond that of HSGPA alone range from 20% to 35%.

[6] The adjusted correlations are classified into three levels of predictive strength: strong, moderate, and weak. Strong correlations are defined as correlations with values of 0.50 or higher, moderate correlations are between 0.50 and 0.3, and weak correlations are 0.29 or lower. This classification is based on the work of Cohen, J. (1988).

[7] Though it is beyond the scope of the current study, Cohen (1988) provides methods to examine the degree of overlap in distributions for different groups on common measures.

Table 4: Adjusted (Raw) Correlations for SAT Scores and HSGPA with Any Math Course Grade

Institution Type	*k*	*n*	**SAT Math**	SAT	HSGPA	SAT+HSGPA	IV
Overall	54	152,829	**.52 (.31)**	.53 (.32)	.49 (.25)	.59 (.38)	.10
Less-Selective	40	94,706	**.49 (.30)**	.50 (.31)	.49 (.30)	.57 (.39)	.08
More-Selective	14	58,123	**.56 (.33)**	.57 (.34)	.48 (.18)	.61(.37)	.13

Note. *k*=number of institutions, *n*=number of students, IV=incremental validity beyond that of HSGPA alone.

Table 5: Adjusted (Raw) Correlations for SAT Scores and HSGPA with Math Course Grades

Math Course	Institution Type	*k*	*n*	**SAT Math**	SAT	HSGPA	SAT+HSGPA	IV
Calculus	Overall	52	78,024	**.61 (.36)**	.61 (.36)	.52 (.22)	.66 (.41)	.14
	Less-Selective	38	39,593	**.59 (.35)**	.59 (.36)	.55 (.28)	.66 (.42)	.11
	More-Selective	14	38,431	**.63 (.36)**	.63 (.37)	.50 (.16)	.67 (.39)	.17
Pre-Calculus	Overall	28	18,199	**.57 (.27)**	.58 (.28)	.52 (.24)	.64 (.36)	.12
	Less-Selective	23	11,738	**.56 (.26)**	.57 (.27)	.53 (.27)	.64 (.38)	.11
	More-Selective	5	6,461	**.59 (.29)**	.59 (.30)	.51 (.19)	.64 (.34)	.13
Algebra	Overall	25	32,281	**.55 (.27)**	.55 (.28)	.53 (.30)	.62 (.39)	.09
	Less-Selective	23	28,322	**.54 (.27)**	.55 (.28)	.52 (.31)	.62 (.39)	.10
	More-Selective	2	3,959	**.57 (.27)**	.57 (.28)	.55 (.25)	.64 (.35)	.09
Statistics	Overall	40	24,172	**.53 (.33)**	.54 (.34)	.51 (.28)	.61 (.40)	.10
	Less-Selective	28	14,919	**.50 (.31)**	.52 (.33)	.50 (.32)	.59 (.41)	.09
	More-Selective	12	9,253	**.58 (.35)**	.59 (.36)	.53 (.23)	.65 (.40)	.12

Note. *k*=number of institutions, *n*=number of students, IV=incremental validity beyond that of HSGPA alone.

Accuracy Rates

Table 6 contains the accuracy rates for each of the four types of math courses across all institutions and segmented by admission selectivity. As noted earlier, the bottom 10% of students within each type of math course within each institution were flagged as being at risk of not earning a course grade of B or higher. The remaining 90% of students were unflagged. The accuracy rate is the percentage of students who were flagged and did not earn a course grade of B or higher (true negatives) combined with the percentage of students who were not flagged and earned a course grade of B or higher (true positives). Accuracy rates were consistently higher at the more-selective institutions (74% total) than they were at the less-selective institutions (65% total) across all four types of math courses, with an overall accuracy rate of 68% across all courses at all institutions. Accuracy rates were highest for statistics courses, followed by calculus. Overall, the accuracy rates were lowest for algebra courses.

Table 6. Accuracy Rates, Overall and by Institutional Admission selectivity

Course	Overall	Less-Selective	More-Selective
Calculus	70%	67%	72%
Pre-Calculus	66%	63%	71%
Algebra	62%	61%	72%
Statistics	73%	68%	82%
Total	68%	65%	74%

Probability of Success

Turning next to the role of *when* students most recently took the SAT on their performance in math courses, results from the logistic regression are presented in Figures 5 through 8. The definition of success in each math course was earning a grade of B or higher. Figure 5 illustrates students' mean probabilities of success (y-axis) given their SAT Math scores (x-axis) overall and by institutional admission selectivity levels. The solid red probability curve represents the mean results for the 54 institutions overall. The dotted blue probability curve represents the mean results for the 40 less-selective institutions, and the orange dashed curve represents the mean results for the 14 more-selective institutions. The light blue and yellow boxes overlaying the figure represent the middle 90% of student scores at the less-selective (440 to 750) and more-selective (530 to 790) institutions, respectively (and green represents the overlap of the two ranges). Note that all along the SAT Math score scale that the probabilities of success for students at the more-selective institutions were lower than the probabilities for students at the less-selective institutions. For example, a student with an SAT Math score of 600 at a more-selective institution had an estimated probability of .60, or a 60% chance, of earning a math course grade of B or higher, but a student with the same SAT Math score of 600 at a less-selective institution had an estimated probability of .67, or a 67% chance of earning a math course grade of B or higher.

Figure 5: Probability of Earning a Grade of B or Higher in Any Math Course given SAT Math Score, Overall and by Admission Selectivity

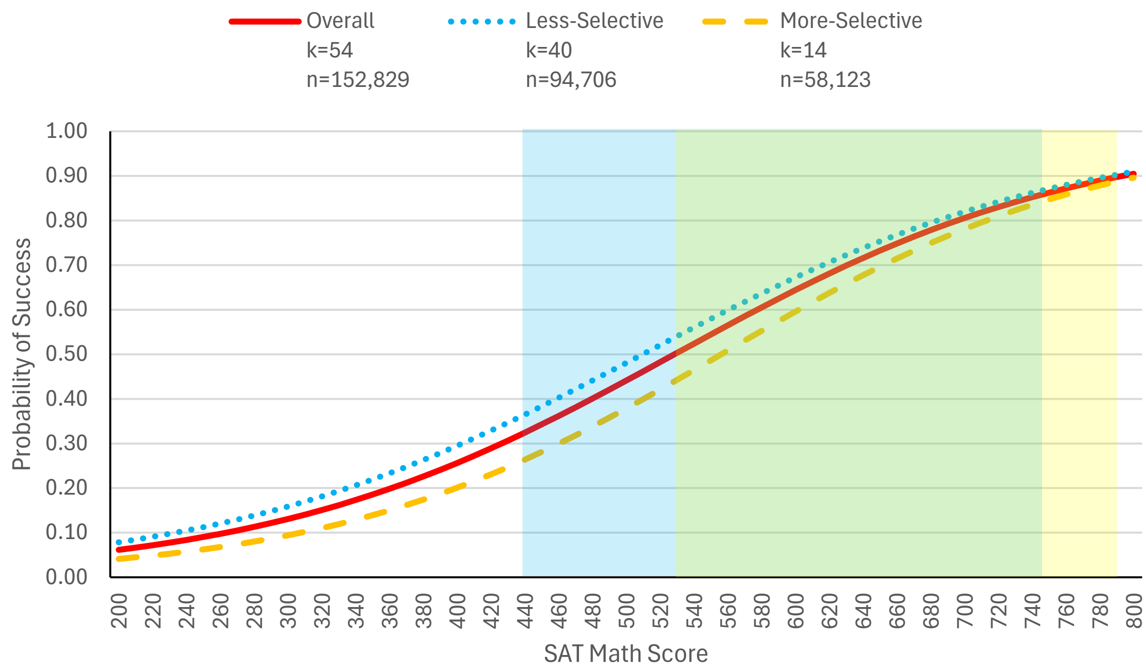


Figure 6 shows the probability curves for the two most common math courses, calculus and statistics, segmented by admission selectivity levels. Note that the differences between the courses were larger than those between admission selectivity levels within courses. For example, students in calculus at more-selective institutions with an SAT Math score of 600 had a 47% chance of earning a grade of B or higher, but students in statistics courses at more-selective institutions had an 82% chance of earning a grade of B or higher, a substantial difference. In contrast, students in calculus at less-selective institutions with an SAT Math score of 600 had a 57% chance of earning a grade of B or higher, higher than that for students in calculus at the more-selective institutions, but the gap is much smaller than the gap between the calculus and statistics students at the more-selective institutions.

Figure 6: Probability of Earning a Grade of B or Higher in Calculus and Statistics Courses given SAT Math Score, by Admission Selectivity

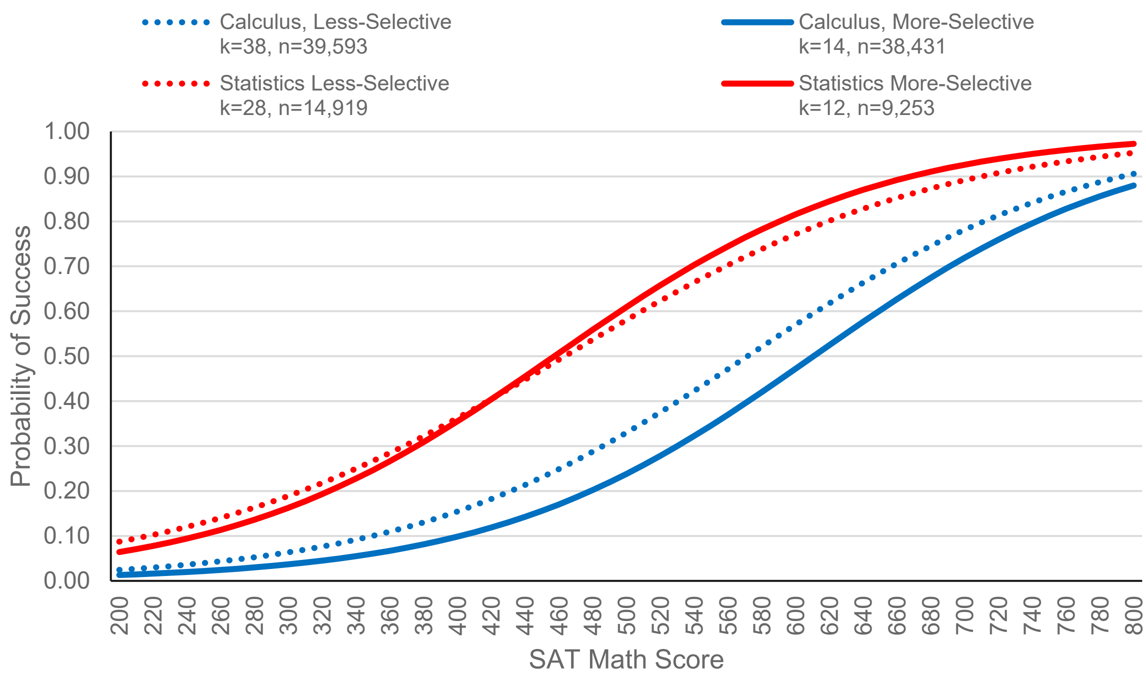
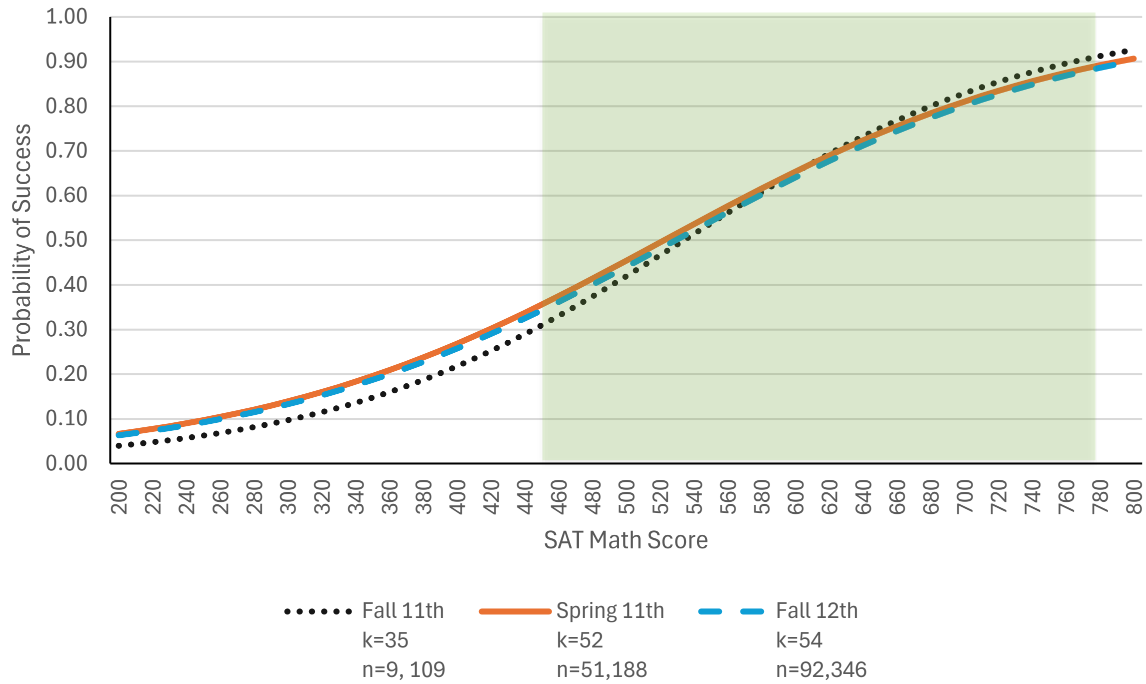


Figure 7 illustrates students' mean probabilities of success given their SAT Math scores by students' most recent SAT scores across all math courses and institutions. The smallest subgroup consisted of students whose most recent SAT score came from the first half of their junior year, Fall 11th (n=9,109), and the results for that subgroup are represented by the dotted black probability curve. Students with SAT scores from the second half of their junior year, Spring 11th (n=51,188) made up the second largest subgroup, and the results for that subgroup are represented by the solid orange probability curve. The majority of students had SAT scores from the first half of their senior year, Fall 12th (n=92,346), and the results for that subgroup are represented by the dashed blue probability curve. Note that the number of institutions in each subgroup varied as many institutions did not have at least 15 students in each subgroup despite aggregating data across four academic years.[8]

[8] As a check, we restricted our analyses to the 35 institutions that had at least 15 students within each timing subgroup, but the results Spring 11th and Fall 12th subgroups were nearly identical to those presented in this report.

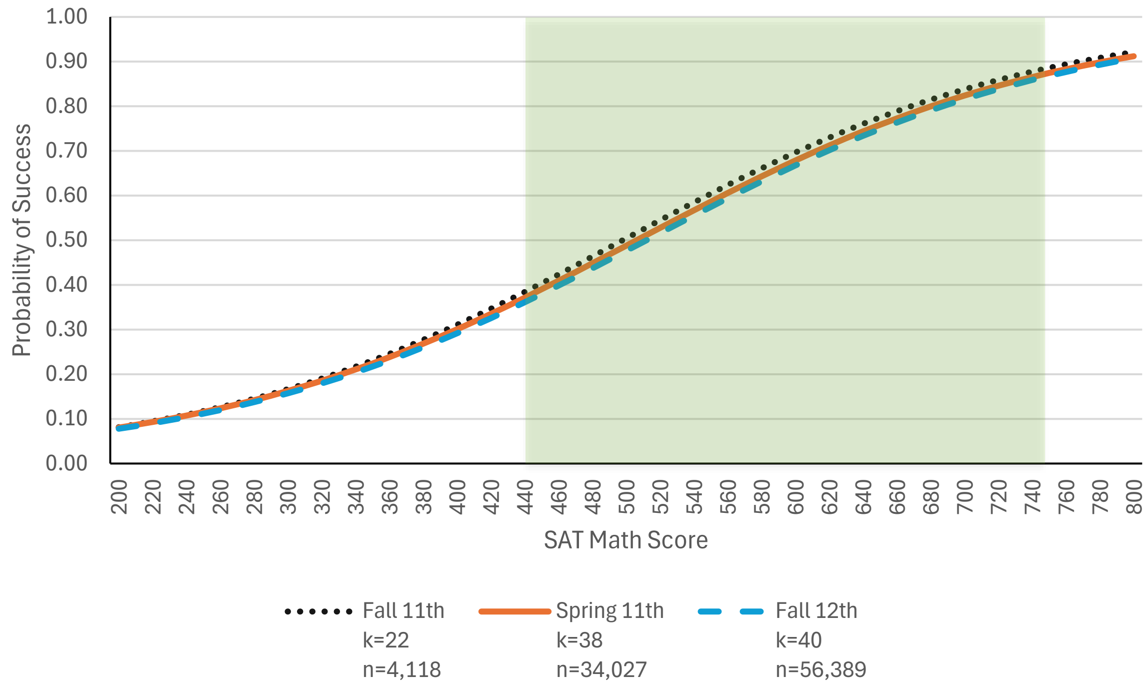
Figure 7: Probability of Earning a Grade of B or Higher in Any Math Course given SAT Math Score, by Most Recent SAT



In general, the probability curves were quite similar. As the Fall 12th subgroup made up 60% of the total study sample, the curve for that subgroup was essentially the same as the curve for the overall sample, so the curve for the overall sample is not shown. The middle 90% of students overall fell between 450 and 780 on the SAT Math score scale, the area shaded in light green. Given the range of observed SAT Math scores, there were minor differences in estimated probabilities across the SAT Math score scale. For example, at the median (50th percentile) SAT Math score for the total sample, 610, the probabilities of success for students in the Fall 11th, Spring 11th, and Fall 12th subgroups were .67, .67, and .66, respectively. However, the Fall 11th subgroup had probabilities that were slightly lower at the lower end and slightly higher at the upper end of the SAT Math score scale, but the middle 90% of scores differed slightly among the three subgroups: 490 to 800 for Fall 11th, 460 to 780 for Spring 11th, and 450 to 780 for Fall 12th.

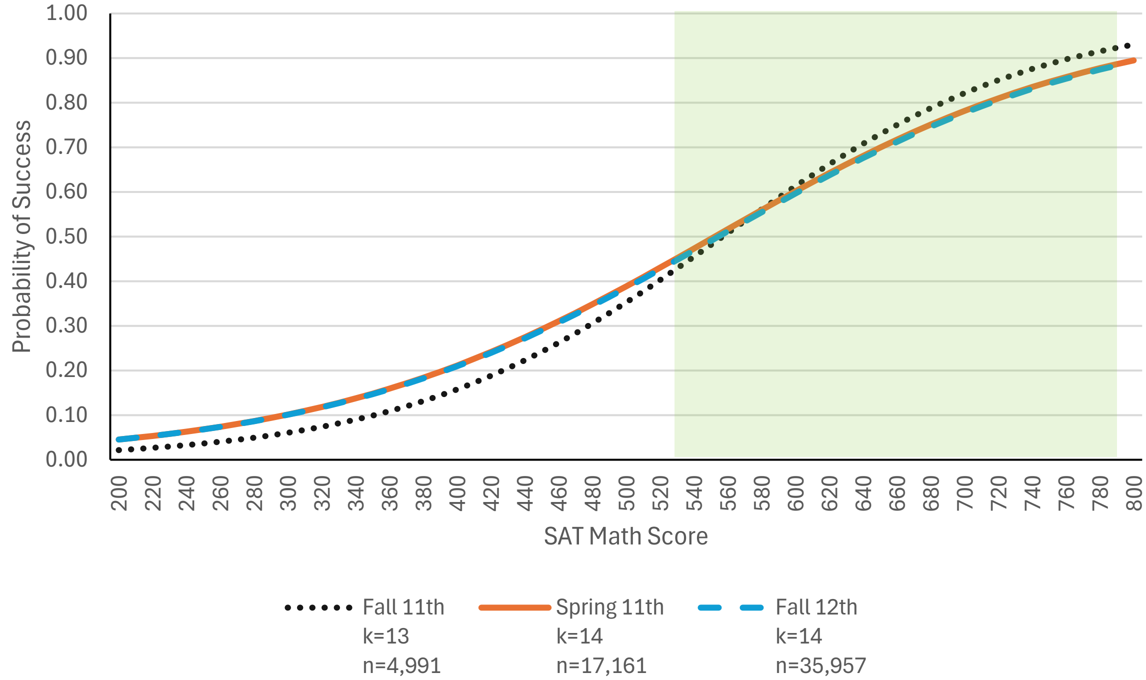
Figures 8 and 9 show the probability curves for each timing subgroup at less-selective institutions and more-selective institutions, respectively. In Figure 8, at the less-selective institutions, the probability curves were nearly identical for the three subgroups. Ninety percent of the students had SAT Math scores between 440 and 750, shaded in light green, and across that score range the largest difference in estimated probabilities for the subgroups was .03.

Figure 8: Probability of Earning a Grade of B or Higher in Any Math Course given SAT Math Score at Less-Selective Institutions, by Most Recent SAT



In Figure 9, we can see at the more-selective institutions that the probability curve for the Fall 11th subgroup differed somewhat from the curves for the two other subgroups, indicating lower estimated probabilities of success for Fall 11th students at the lower end of the SAT Math score scale and higher estimated probabilities of success at the upper end of the score scale. However, 90% of the students at the more-selective institutions had SAT Math scores between 530 and 790, and that the middle 90% of the Fall 11th students at these institutions had SAT Math scores between 540 and 800. Between these score points, the estimated mean probabilities never differed more than .04, with the Fall 11th students having slightly higher estimated probabilities at the upper end of the SAT Math score scale.

Figure 9: Probability of Earning a Grade of B or Higher in Any Math Course given SAT Math Score at More-Selective Institutions, by Most Recent SAT



Estimated probabilities of success varied across the four math courses, but in most cases the differences between the three student subgroups within each course-level analysis were minor, quite similar to those found in the analyses above conducted for any math course.[9]

Differential Prediction

For the differential prediction analyses we conducted linear regression analyses at each institution to obtain predicted math course grades at each SAT Math score point and then calculated the residuals (actual math course grade minus predicted math course grade) for each student. Mean residuals were calculated for the Fall 11th, Spring 11th, and Fall 12th subgroups across all institutions and again by institutional admission selectivity levels. Figure 9 illustrates the results, with the residuals for each of the three SAT timing categories overall (blue bars), at the less-selective institutions (gold/yellow bars), and more-selective institutions (green bars). Regardless of admission selectivity level, the math course grades for students in the Fall 11th subgroup were underpredicted by .09 to .11 points on the 4-point grading scale, and the math course grades for students in the Spring 11th subgroup were underpredicted by .01 to .03 points. The math course grades for students in the Fall 12th subgroup, the largest subgroup, were

[9] Larger differences were seen for some of the analyses conducted at the more-selective institutions where they number of institutions with sufficient sample sizes were few, particularly for algebra (*k*=2) and pre-calculus (*k*=5). Schmidt and Hunter (2015) noted that eight studies is a small number for a meta-analysis, and we believe results based on even fewer studies should be interpreted with care.

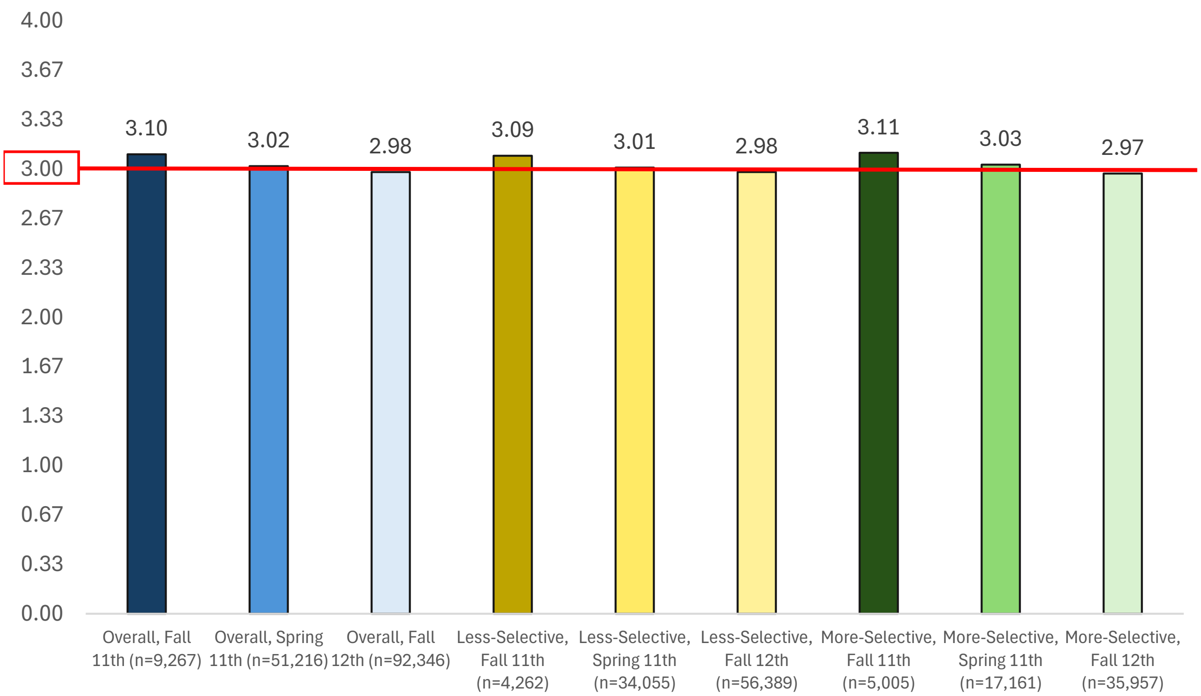
overpredicted by .02 to .03 points. Results by each of the four math courses are presented in the appendix (Table A5).

Table 7: Over- and Underprediction of Grades in Any Math Course by Most Recent SAT Administration and Institution Type

Timing	Overall		Less-Selective		More-Selective	
	n	Residual	*n*	Residual	*n*	Residual
Fall 11th	9,267	0.10	4,262	0.09	5,005	0.11
Spring 11th	51,216	0.02	34,055	0.01	17,161	0.03
Fall 12th	92,346	-0.02	56,389	-0.02	35,957	-0.03

Table 7 shows the pattern across SAT timing categories for both less- and more-selective institutions, and notably none of the mean residuals approached a meaningful difference of 0.33, and neither did any of the gaps between subgroups within the institutional categories. For example, the difference between the residuals for students in Fall 11th and students in Fall 12th at more-selective institutions was only 0.14. Figure 10 puts the results into a more realistic context, showing what the mean math course grades would be for students who had been predicted to earn a math course grade of 3.00, a letter grade of B, for students in each of the three timing categories across all institutions and again disaggregated by admission selectivity levels.

Figure 10: Actual Mean Math Course Grades for Students Predicted to Earn a Grade of B (3.00)



Discussion

The results of this study provide valuable insights on the utility of SAT Math scores for math course placement at colleges and universities. Results from the differential validity analyses signaled that all the SAT Math score relationships with math course grades were positive, .50 or higher, indicating strong relationships. Moreover, SAT Math score relationships with math course grades were in most instances greater than the HSGPA relationships with math course grades, and in every instance the SAT added incremental validity beyond that of HSGPA alone. Additionally, the 95% confidence intervals for the adjusted correlations for the less- and more-selective institutions overlapped, indicating that the admission selectivity did not moderate the relationships between SAT scores and math course grades.

The placement accuracy analyses yielded a 68% accuracy rate overall, meaning that more than two-thirds of the students identified as being expected to earn or not earn a math course grade of B or higher were correctly identified based on the SAT Math scores. The criterion of earning a grade of B or higher and the 10% flagging rate used in this study are not universal standards for defining success or identifying students who may not be successful in a course, but they do serve as useful tools for demonstrating the utility of SAT Math scores for predicting student success and identifying students at risk, much as a FYGPA of B or higher helps us identify students' chances of graduating within four years (Westrick et al., 2023). Institutions define success in their own ways, and the amount of resources institutions have to support students vary, which may determine the percentage of students they identify as being at risk and who may need academic support in their first undergraduate math course.

For the probability of success analyses, we defined success as earning a math course grade of B or higher, a 3.00 on a 0.00 to 4.00 scale. In all the analyses across math courses and institution types, as SAT Math scores increased, so did students' probability of success. Probabilities did differ across math courses, notably between calculus and statistics courses, but differences across institutional admission selectivity were minimal. As always, results vary across institutions, so the average results presented in this study may differ from what individual institutions find in their own analyses, but these types of analyses are valuable in that institutions may conduct similar analyses to help them identify which students may be at risk for poor math performance and in need of academic support.

The possible concern regarding the weakened utility of older SAT Math scores for placement into first-semester math courses (versus scores upon arrival on campus) helped shape this study, and the results of this study suggest that any underestimation of math course performance for students with SAT scores from the first half of their junior year of high school was quite minimal. Math course grades for Fall 11th SAT Math scores were underestimated, on average (across 54 institutions), by only 0.10 on a 0.00 to 4.00 scale.

Conclusion

In closing, the results of this in-depth placement validity study show the utility of SAT Math scores as predictors of students' grades in four types of math courses: calculus, pre-calculus, algebra, and statistics. Institutions can feel confident using SAT Math scores to help place students into math courses and identify students who may benefit from academic support in their first undergraduate math courses and in order to be successful in early STEM major coursework. Finally, the results suggest that the time when students completed the SAT in high school has little impact on students' academic performance in their first undergraduate math courses, indicating that a math placement exam administered as a student arrives on campus and is adjusting to college may not be necessary if the student has an SAT Math score on record.

Colleges and universities interested in studying SAT score relationships (and other measures such as HSGPA) with course grades for placement can continue to use the College Board's free online service for higher education institutions and systems (Admitted Class Evaluation Service, ACES) to conduct campus or system-specific validity studies that meet their particular institutional needs.

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Appendices:

Appendix Table A1. Adjusted (Raw) Correlations with Calculus Course Grades

Institution Type	Timing	*k*	*n*	**SAT Math**	SAT	HSGPA	SAT+HSGPA	IV
Overall		52	78,024	**.61 (.36)**	.61 (.36)	.52 (.22)	.66 (.41)	.14
Less-Selective		38	39,593	**.59 (.35)**	.59 (.36)	.55 (.28)	.66 (.42)	.11
More-Selective		14	38,431	**.63 (.36)**	.63 (.37)	.50 (.16)	.67 (.39)	.17
Overall	Fall 11th	28	5,769	**.60 (.34)**	.61 (.36)	.53 (.21)	.67 (.40)	.14
	Spring 11th	46	26,675	**.60 (.35)**	.61 (.36)	.53 (.23)	.67 (.41)	.14
	Fall 12th	47	45,356	**.60 (.35)**	.61 (.36)	.51 (.21)	.66 (.40)	.15
Less-Selective	Fall 11th	16	2,020	**.56 (.32)**	.57 (.35)	.54 (.25)	.65 (.41)	.11
	Spring 11th	32	14,708	**.58 (.34)**	.59 (.35)	.55 (.29)	.66 (.42)	.11
	Fall 12th	33	22,662	**.59 (.35)**	.59 (.36)	.54 (.27)	.65 (.42)	.11
More-Selective	Fall 11th	12	3,749	**.62 (.36)**	.63 (.37)	.53 (.19)	.68 (.40)	.15
	Spring 11th	14	11,967	**.62 (.36)**	.63 (.37)	.51 (.17)	.67 (.39)	.16
	Fall 12th	14	22,694	**.62 (.36)**	.63 (.36)	.49 (.15)	.66 (.39)	.17

Appendix Table A2. Adjusted (Raw) Correlations with Pre-Calculus Course Grades

Institution Type	Timing	*k*	*n*	**SAT Math**	SAT	HSGPA	SAT+HSGPA	IV
Overall		28	18,199	**.57 (.27)**	.58 (.28)	.52 (.24)	.64 (.36)	.12
Less-Selective		23	11,738	**.56 (.26)**	.57 (.27)	.53 (.27)	.64 (.38)	.11
More-Selective		5	6,461	**.59 (.29)**	.59 (.30)	.51 (.19)	.64 (.34)	.13
Overall	Fall 11th	12	835	**.58 (.31)**	.59 (.34)	.56 (.26)	.69 (.42)	.13
	Spring 11th	25	5,876	**.56 (.27)**	.57 (.28)	.54 (.27)	.65 (.38)	.11
	Fall 12th	28	11,412	**.58 (.28)**	.58 (.28)	.51 (.23)	.64 (.36)	.13
Less-Selective	Fall 11th	9	420	**.56 (.29)**	.58 (.34)	.55 (.32)	.69 (.45)	.14
	Spring 11th	21	4,253	**.56 (.26)**	.57 (.27)	.54 (.29)	.65 (.39)	.11
	Fall 12th	23	7,003	**.56 (.27)**	.57 (.27)	.52 (.26)	.63 (.37)	.11
More-Selective	Fall 11th	3	415	**.60 (.32)**	.60 (.33)	.56 (.21)	.69 (.39)	.13
	Spring 11th	4	1,623	**.56 (.29)**	.57 (.29)	.52 (.22)	.63 (.35)	.11
	Fall 12th	5	4,409	**.59 (.29)**	.60 (.30)	.50 (.19)	.65 (.34)	.15

Appendix Table A3. Adjusted (Raw) Correlations with Algebra Course Grades

Institution Type	Timing	*k*	*n*	**SAT Math**	SAT	HSGPA	SAT+HSGPA	IV
Overall		25	32,281	**.55 (.27)**	.55 (28)	.53 (.30)	.62 (.39)	.09
Less-Selective		23	28,322	**.54 (.27)**	.55 (.28)	.52 (.31)	.62 (.39)	.10
More-Selective		2	3,959	**.57 (.27)**	.57 (.28)	.55 (.25)	.64 (.35)	.09
Overall	Fall 11th	10	1,155	**.59 (.34)**	.61 (.37)	.57 (.34)	.68 (.47)	.11
	Spring 11th	24	10,434	**.53 (.27)**	.54 (.28)	.51 (.29)	.61 (.38)	.10
	Fall 12th	25	20,614	**.55 (.27)**	.55 (.28)	.53 (.30)	.63 (.39)	.10
Less-Selective	Fall 11th	9	1,024	**.59 (.34)**	.61 (.38)	.56 (.34)	.68 (.47)	.12
	Spring 11th	22	9,478	**.53 (.26)**	.54 (.28)	.51 (.29)	.61 (.38)	.10
	Fall 12th	23	17,746	**.54 (.27)**	.55 (.28)	.53 (.31)	.62 (.39)	.09
More-Selective	Fall 11th	1	131	**.59 (.27)**	.60 (.28)	.65 (.33)	.72 (.41)	.07
	Spring 11th	2	956	**.57 (.30)**	.57 (.30)	.56 (.27)	.65 (.38)	.09
	Fall 12th	2	2,868	**.57 (.27)**	.57 (.27)	.54 (.23)	.64 (.34)	.10

Appendix Table A4. Adjusted (Raw) Correlations with Statistics Course Grades

Institution Type	Timing	*k*	*n*	**SAT Math**	SAT	HSGPA	SAT+HSGPA	IV
Overall		40	24,172	**.53 (.33)**	.54 (.34)	.51 (.28)	.61 (.40)	.10
Less-Selective		28	14,919	**.50 (.31)**	.52 (.33)	.50 (.32)	.59 (.41)	.09
More-Selective		12	9,253	**.58 (.35)**	.59 (.36)	.53 (.23)	.65 (.40)	.12
Overall	Fall 11th	18	1,149	**.55 (.35)**	.59 (.40)	.51 (.28)	.67 (.48)	.16
	Spring 11th	33	8,033	**.51 (.32)**	.53 (.34)	.52 (.30)	.61 (.42)	.09
	Fall 12th	36	14,787	**.53 (.32)**	.55 (.34)	.50 (.26)	.60 (.40)	.10
Less-Selective	Fall 11th	11	498	**.45 (.24)**	.52 (.32)	.53 (.35)	.64 (.45)	.11
	Spring 11th	23	5,452	**.50 (.32)**	.51 (.34)	.52 (.33)	.60 (.42)	.08
	Fall 12th	26	8,831	**.50 (.31)**	.52 (.33)	.48 (.30)	.58 (.40)	.10
More-Selective	Fall 11th	7	651	**.62 (.43)**	.65 (.47)	.51 (.24)	.70 (.50)	.19
	Spring 11th	10	2,581	**.55 (.33)**	.56 (.34)	.54 (.24)	.64 (.40)	.10
	Fall 12th	10	5,956	**.58 (.34)**	.59 (.35)	.52 (.21)	.65 (.39)	.13

Appendix Table A5. Over- and Underprediction of Specific Math Course Grades by Timing

		Calculus		Pre-Calculus		Algebra		Statistics	
Institution Type	Timing	*n*	Residual	*n*	Residual	*n*	Residual	*n*	Residual
Overall	Fall 11th	5,893	0.13	886	0.08	1,224	0.05	1,264	0.06
	Spring 11th	26,738	0.02	5,912	0.02	10,449	0.00	8,117	0.02
	Fall 12th	45,417	-0.03	11,439	-0.02	20,625	0.00	14,865	-0.02
Less-Selective	Fall 11th	2,123	0.13	469	0.11	1,089	0.04	581	0.09
	Spring 11th	14,771	0.03	4,277	0.02	9,493	-0.01	5,514	0.00
	Fall 12th	22,723	-0.03	7,020	-0.02	17,757	0.00	8,889	-0.01
More-Selective	Fall 11th	3,770	0.13	417	0.04	135	0.06	683	0.04
	Spring 11th	11,967	0.02	1,635	0.03	956	0.01	2,603	0.05
	Fall 12th	22,694	-0.03	4,419	-0.01	2,868	-0.01	5,976	-0.03