

Comparison of AP Math Participation and Performance among California and Nationwide Students

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Received April 12, 2024; Revised October 1, 2024; Accepted November 12, 2024

Abstract

In recent years, with the release of a new controversial math framework, there have been widespread concerns over how to reduce achievement gaps between demographics and increase the accessibility of math education in California. This study served to improve our understanding of the math proficiency of California high school students, by comparing California and nationwide data on the AP math exams. A secondary analysis of College Board AP test data and U.S. Census data from the year 2020 found that California students were more likely to participate in AP math exams. However, performance on these exams was below the nationwide standards for students in historically low-performing demographic groups. Additionally, a comparison between math AP exam data and the three most popular humanities AP exams showed that the gaps between demographics were larger in math than in humanities. Overall, the analysis suggested that more educational support needs to be provided specifically for California's large Hispanic demographic and in the subject of math. This research holds significance in helping education policy makers determine what is being done well and what issues still need to be addressed in the California education system.

Keywords: Math education, College Board, California, High school, AP exam

1. Introduction

Math education equity is a more relevant issue now than ever before (Vithal et al., 2024). It is imperative for equity to be incorporated into the education system under parameters of equal opportunities and access to higher education, regardless of background (Santos et al., 2020). However, the goal of equity had resulted in many controversial changes in the math education system within the last decade. In 2014, the San Francisco Unified School District made the contentious decision of delaying Algebra I until the ninth grade for all students (Huffaker et al., 2023). Even more recently, the College Board offered the new AP Precalculus course in an attempt to provide more students with the opportunity for rigorous math education in high school. And the new policies of the California Mathematics Framework sparked many concerns over whether California's math education system is headed in the right direction (Conrad, 2023).

All these changes have the underlying intention of reducing the gaps in math performance and access to math education between different demographic groups. However, it is especially important that this is achieved by improving the performance of struggling groups, rather than diminishing the performance of historically more successful groups. After all, math proficiency has a highly significant effect on future earnings, even when controlling for college attainment, and the significance of this effect has increased by 6% per year (Dougherty, 2003). Due to the evident benefits of strong math skills in the workforce, educators need to make informed decisions that are ultimately beneficial to the math education system. And this is only possible by obtaining a better understanding of what these achievement gaps actually are, which is the central focus of this study.

Many past studies examined demographic patterns on a national scale. Earlier research found a far higher percentage of Asian students earning their highest math course credit in calculus compared to any other racial group. Additionally, this percentage was almost twice as high for White students than for Black or Hispanic students (National Center for Education Statistics, 2013). And more recently, the American Council on Education found that American Indian, Black, Hispanic and Pacific Islander students were less likely to meet national math/reading standards and take rigorous coursework for college credit during high school compared to White students, despite reporting similar expectations of pursuing a bachelor's degree (Taylor et al., 2020). However, there has been limited research comparing AP exam participation and performance among students in different racial groups.

This study served to compare participation and performance data on the AP exams among students in different racial groups and to compare the participation and performance data on the AP math exams (i.e. AP Calculus AB, AP Calculus BC, and AP Statistics) between students from California and the rest of the U.S. through a secondary data analysis. Contextualizing California math education with the nation as a whole provided a better understanding of the specific problems that California is facing. The choice of California in particular was motivated by the sheer size of the California education system, its historically poor ranking in math education in comparison to other states (Guthrie et al., 1991), as well as recent California education reforms, notably the new California Mathematics Framework. Additionally, the choice to focus on AP exam data was made to evaluate the preparedness of California students for higher STEM education, which is the ultimate goal of math education in high school. Studies have found a high correlation between passing scores on AP exams and college success, even when controlling for other metrics of high school academic performance (Mattern et al., 2009).

The following research questions were investigated: How does AP math participation and performance vary between California and nationwide students and between different demographic groups? How do demographic inequalities in participation and performance on AP math exams compare with that of AP exams in humanities?

Several hypotheses were formulated to address these research questions. It was expected that the patterns between racial groups would match the findings of past studies, with Asian participation and performance being the highest, Black and Hispanic being the lowest, and the White demographic somewhere in between. Additionally, it was hypothesized that when compared with the rest of the nation, California students would have similar participation rates on AP exams but lower pass rates, especially for minority groups. And finally, it was believed that achievement gaps between racial groups would be larger for math exams compared to humanities exams.

These hypotheses can be justified by past research. California had been historically below average on performance in the National Assessment of Educational Progress (Guthrie et al., 1991). Furthermore, California has the most segregated school system for Hispanics, with 58% of Hispanic students attending intensely segregated schools (Orfield et al., 2019). Racial school segregation has been found to be strongly associated with the magnitude of achievement gaps and their growth from 3rd grade up to eighth grade (Reardon et al., 2019), and this pattern is expected to continue as these students enter high school. Also, past studies have found persistent racial/ethnic inequality in the attainment of STEM degrees not found in other fields (Riegle-Crumb et al., 2019).

Ultimately, the importance of investigating these research questions is so that there exists a clear picture of the current state of California math education. As a result, more informed decisions can be made to improve the availability and quality of education for California students, leading to greater future prospects of success in the professional workforce.

2. Materials and Methods

Demographic data for the AP exams was obtained from College Board, while teenage (15-19 y.o.) population data was obtained from the U.S. Census Bureau, both datasets from the year 2020. Unfortunately, the College Board has removed the data from its archive and has not released any new AP data associated with racial information since 2021. The U.S. Census did not provide Asian teenage data, so it was linearly extrapolated using the under-18 population data.

For each demographic and AP exam, the number of students who participated and the number who passed (scoring 3 or higher) were extracted from the data set. This was done for California, and then the California data was subtracted

from the data of the entire country to get the values for the rest of the nation. Participation rates were found by dividing the number of participants on a specific AP exam by the total teenage population for each demographic. Pass rates were found by simply dividing the number of students scoring 3 or higher by the total number of participants.

Then, the percent differences between California and the rest of the nation were found, with the nationwide rate being the initial value. Also, calibrated participation rates for all demographic groups were calculated by dividing by the corresponding White participation rate (calibrated White participation rate is always 1). This was done in order to more conveniently make comparisons between racial groups.

Finally, a one-sample proportion Z-test was performed to confirm the significance of our results for each California-nation pair of participation or pass rates. Denote the California rate as the sample proportion p , and the nationwide rate as the population proportion P . Also let n be the sample size, which for participation rates is the California teenage population for a specific demographic, and for pass rates is the number of California participants on the AP exam for a specific demographic. For all the data, np and $n(1-p)$ were both at least 10, so it could be assumed that the sample proportion followed a roughly normal distribution. This allowed for the calculation of Z-scores using the following equation:

$$Z = \frac{p-P}{\sqrt{\frac{P(1-P)}{n}}}$$

The Z-score represents the number of standard deviations that the California proportion differs from the nationwide proportion by.

The p-values were found by computing the area under the standard normal distribution either to the right or to the left of Z , depending on if Z was positive or negative. The p-value represents the probability that the California rate being higher or lower than the nationwide rate was due to random chance. Prior to the data analysis, it was determined that a difference between the California and nationwide rates was significant if $p\text{-value} < 0.05$.

Calculations were done through Google Sheets and graphs of the results were generated using the Python Matplotlib library.

3. Results

The analysis is divided into 4 tables showing participation rates on math AP exams, participation rates on humanities AP exams, pass rates on math AP exams, and pass rates on humanities AP exams respectively. Each table contains the participation/pass rates for each demographic group and each relevant AP exam. And all tables include both the state of California (CA) and nationwide (US, excluding California).

Additionally, every table has a column for the percent difference, to show the degree to which the California rate is greater than or less than the nationwide rate. For tables 1 and 2 which show participation rates, the rightmost two columns contain the calibrated participation rates. For tables 3 and 4 which show pass rates, the rightmost two columns contain the Z-scores and p-values of the proportion tests. Note that for tables 1 and 2, showing precise Z-scores and p-values is unnecessary since $p\text{-value} \ll 0.001$ for all the data.

The previous Materials and Methods section details how all values in the tables were obtained.

Table 1. Participation Rates for AP Math Exams

AP Calc. AB	# of students (US)	# of students (CA)	Participation rate (US)	Participation rate (CA)	% difference	Calibrated rate (US)	Calibrated rate (CA)
Black	10109	774	0.00336	0.00534	59%	0.3	0.34
Hispanic	28969	12808	0.00582	0.00995	71%	0.52	0.63
White	123880	10668	0.01117	0.01574	41%	1	1
Asian	32069	15509	0.02292	0.05376	135%	2.05	3.41
AP Calc. BC							
Black	2587	240	0.00086	0.00166	92%	0.19	0.22
Hispanic	8701	3238	0.00175	0.00252	44%	0.39	0.33

White	49770	5208	0.00449	0.00769	71%	1	1
Asian	25980	9594	0.01857	0.03326	79%	4.14	4.33
AP Statistics							
Black	6625	494	0.00221	0.00341	55%	0.28	0.29
Hispanic	19467	7241	0.00391	0.00562	44%	0.49	0.48
White	88560	7933	0.00799	0.01171	47%	1	1
Asian	24959	10241	0.01784	0.03549	99%	2.23	3.03

Table 2. Participation Rates for AP Humanities Exams

AP US Hist.	# of students (US)	# of students (CA)	Participation rate (US)	Participation rate (CA)	% difference	Calibrated rate (US)	Calibrated rate (CA)
Black	29158	1905	0.0097	0.0131	36%	0.49	0.45
Hispanic	68650	26879	0.0138	0.0209	51%	0.7	0.72
White	217946	19757	0.0197	0.0292	48%	1	1
Asian	45755	17109	0.0327	0.0593	81%	1.66	2.03
AP Eng. Lang.							
Black	34486	2487	0.0115	0.0172	50%	0.53	0.5
Hispanic	77632	34098	0.0156	0.0265	70%	0.72	0.77
White	241206	23364	0.0218	0.0345	58%	1	1
Asian	47595	19536	0.0341	0.0677	99%	1.56	1.96
AP Gov.							
Black	16848	1139	0.0056	0.0079	40%	0.44	0.43
Hispanic	42494	17522	0.0085	0.0136	60%	0.67	0.74
White	140317	12472	0.0127	0.0184	45%	1	1
Asian	27279	11155	0.0195	0.0389	98%	1.54	2.1

Table 3. Pass Rates for AP Math Exams

AP Calc. AB	# passing students (US)	# passing students (CA)	Pass rate (US)	Pass rate (CA)	% difference	Z-score	p-value
Black	4220	318	0.417	0.411	-1.58%	-0.37	0.35
Hispanic	13393	5206	0.462	0.406	-12.08%	-12.68	<< 0.001
White	77019	7134	0.622	0.669	7.56%	10.01	<< 0.001
Asian	22673	11814	0.707	0.762	7.74%	14.98	<< 0.001
AP Calc. BC							
Black	1744	162	0.674	0.675	0.13%	0.03	0.49
Hispanic	6209	2127	0.714	0.657	-7.95%	-7.14	<< 0.001
White	39571	4396	0.795	0.844	6.16%	8.76	<< 0.001
Asian	22600	8559	0.869	0.892	2.55%	6.47	<< 0.001
AP Statistics							
Black	2214	164	0.334	0.332	-0.66%	-0.1	0.46
Hispanic	7803	2590	0.401	0.358	-10.76%	-7.49	<< 0.001
White	53831	5224	0.608	0.659	8.34%	9.24	<< 0.001
Asian	18493	7561	0.741	0.738	-0.35%	-0.61	0.27

Table 4. Pass Rates for AP Humanities Exams

AP US Hist.	# passing students (US)	# passing students (CA)	Pass rate (US)	Pass rate (CA)	% difference	Z-score	p-value
Black	10046	791	0.344	0.415	20.52%	6.49	<< 0.001
Hispanic	29250	11243	0.426	0.418	-1.83%	-2.58	0.005
White	138516	13930	0.636	0.705	10.94%	20.3	<< 0.001
Asian	33484	12670	0.732	0.741	1.19%	2.58	0.005
AP Eng. Lang.							
Black	13510	1135	0.392	0.456	16.49%	6.6	<< 0.001
Hispanic	36131	16614	0.465	0.487	4.69%	8.08	<< 0.001
White	162531	17219	0.674	0.737	9.37%	20.59	<< 0.001
Asian	35428	14781	0.744	0.757	1.64%	3.92	<< 0.001
AP Gov.							
Black	6356	422	0.377	0.371	-1.79%	-0.47	0.32
Hispanic	18859	6850	0.444	0.391	-11.91%	-14.09	<< 0.001
White	87007	8468	0.621	0.679	9.50%	13.55	<< 0.001
Asian	18919	7536	0.694	0.676	-2.59%	-4.12	<< 0.001

The following two figures provide a graphical representation of the participation and pass rates found in the previous tables. In particular, they clearly present the relationship between the different demographic groups.

4. Discussion

4.1. Participation Rates

The study found significantly higher participation rates for California students compared to the rest of the nation, no matter the demographic or AP exam. The least significant increase was 36% for Black students taking AP U.S. History, while the most significant was 135% for Asian students taking AP Calculus AB. This was very surprising; such a large increase in nationwide participation rates in all categories was not expected. Possible explanations may include differing educational policies in California which promote high schoolers to take these exams, or an overall more competitive, high-pressure educational environment. However, more research is needed to determine if this pattern of high ambition among California students is consistent in other aspects of education as well.

Another interesting observation is that the participation increase from nationwide to California was generally higher for math subjects than humanities subjects. This potentially indicates that California students place more value on higher math education than high school students from the rest of the nation as a whole.

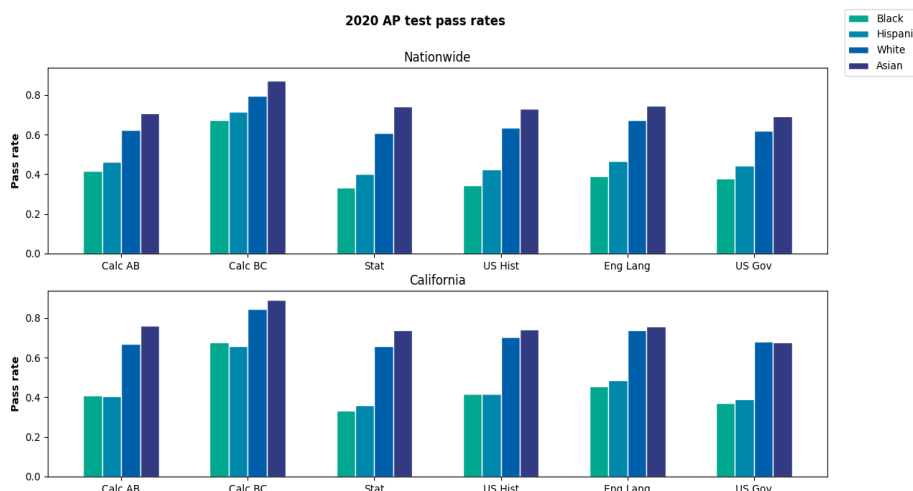


Figure 1. Participation Rates by Racial Groups

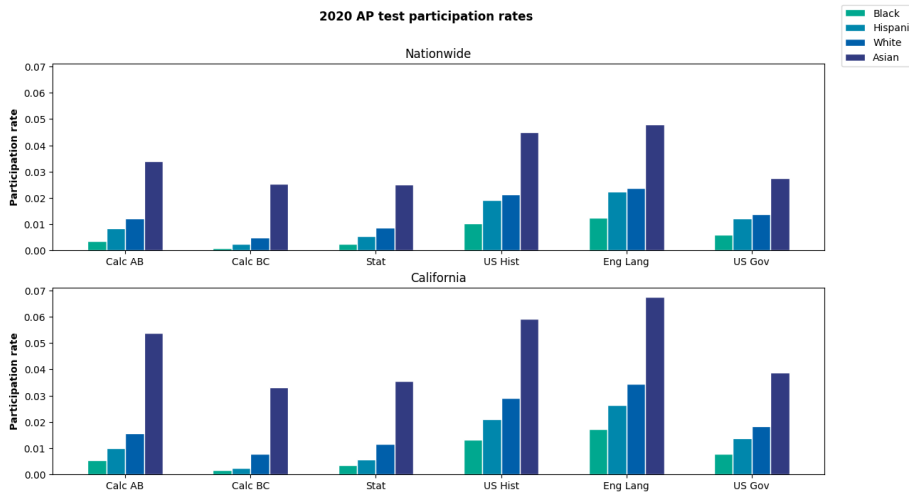


Figure 2. Pass Rates by Racial Groups

that the gaps between racial groups were larger in math than humanities. Using the White demographic as a baseline, the Asian participation rates were roughly twice as high for humanities AP exams but over three times as high for math AP exams. The gap between White and Black/Hispanic groups was larger for math AP exams as well. In humanities subjects, the participation rate of Blacks was between 40% and 50% that of Whites and for Hispanics it was between 70% and 80%. But for math subjects, the participation rates of Blacks and Hispanics relative to Whites were less than 35% and 65%, respectively. Therefore, educational inequity is an even more pressing issue in math and needs to be further prioritized.

4.2. Pass Rates

Examining pass rates for the math AP exams, the White and Asian demographics in California were ahead of the rest of the nation, having on average 7% higher pass rates; the only exception was Asians in AP Statistics, as the comparison test for this category did not lead to statistical significance. There was no significance for any of the Black pass rate comparisons either, so it can be concluded that Black proficiency on math AP exams was the same for California as for the rest of the nation. And most significantly, the Hispanic pass rates in California were on average 10% lower than nationwide.

Therefore, our hypothesis was partially supported. Based on historical performances on other math examinations such as the NAEP, lower pass rates in California compared to nationwide for all demographics was expected. In reality, this was only the case for the Hispanic group; no difference was found for Blacks, and the pass rates for Whites and Asians were in fact higher for California. This indicates that the Hispanic demographic in California is struggling the most while the other demographics are at or above the national standard. As Hispanic students also make up the largest racial group within California, this sheds light on California’s consistently poor NAEP performance. Ultimately, for California to make the most significant progress in the math education of its millions of students, more needs to be done to provide educational support for its largest demographic.

For the relationship between racial groups, the pattern was consistent no matter the AP exam. There was always a very large drop of at least 0.2 in the pass rate going from Asian/White to the minority groups of Hispanic/Black. Although there were a few exceptions, in general the Asian pass rates were slightly higher than White pass rates and Hispanic pass rates were slightly higher than Black pass rates. This is consistent with past studies; the large gap between Black/Hispanic and White/Asian had always been present. For example, a study using 2015 NAEP data found that Black and Hispanic students were twice as likely to be in the lowest achievement level compared to White students (Taylor et al., 2020).

Now comparing racial groups, all AP exams followed the same trend of the Asian demographic having the highest participation rate, followed by White, Hispanic, and Black. This mostly matches patterns found in past research, although a slightly larger gap between Hispanic and White participation rates was expected.

The data also supported the hypothesis

To compare math and humanities, the difference in the California and nationwide pass rate was evaluated within each racial group. For Blacks, there was no difference for all math subjects, while the pass rate for AP U.S. History and AP English Language were 21% and 16% higher in California than the rest of the nation. With the exception of AP English Language, Hispanics performed worse in California than nationwide, and this performance decrease was more significant for math subjects. And relative pass rates in math were slightly lower than in humanities for Whites but slightly higher than in humanities for Asians. Thus, it was found that in general, California students excelled less in math APs than in humanities.

5. Conclusion

In summary, through an analysis of 2020 AP math exam data, it has been confirmed both in California and nationwide that the Asian demographic has the highest participation and pass rates, followed by White, then Hispanic, and finally Black. Contrary to what was hypothesized, the participation rates of California students far exceeded nationwide participation rates in all cases. Though as expected, pass rates in California were lower than nationwide for historically underperforming demographic groups, and demographic gaps were more significant for math than humanities.

These results have several implications useful for California educators and policymakers to consider. Most importantly, greater emphasis needs to be placed on improving the quality of math education for California's struggling demographic groups. For instance, funding could be increased for schools in poorer neighborhoods, which typically have larger Black or Hispanic populations. Furthermore, as shown by the disparity between math and humanities AP exams, more encouragement can be provided for these groups to pursue interests in STEM fields.

However, there were some limitations to the study that need to be recognized. First of all, Asian participation rates were likely inaccurate due to estimation uncertainty, but nonetheless it was clear that they would be higher than all the other demographics. Additionally, regarding the comparisons between math and humanities courses—due to the small sample size of different types of AP exams, such observations cannot be considered definitive, but should be viewed as a starting point for further research.

As a whole, this study contributes to the body of knowledge for helping educators determine what is done well and what still needs to be addressed in the education system, for both California and the nation as the whole.

Acknowledgment

This paper would not have been possible without the support of my mentor Yan Liu.

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