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AP® STEM Participation and Postsecondary STEM Outcomes: Focus on Underrepresented Minority, First-Generation, and Female Students

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Executive Summary

Projections by the President's Council of Advisors on Science and Technology (2012) point to a need for approximately one million more STEM professionals than the U.S. will be able to produce considering the current rate of STEM postsecondary degree completions (Executive Office of the President of the United States, 2012). Do Advanced Placement® (AP®) courses in STEM complement the desire for more students completing STEM majors? In this study we ask if participation and performance in Advanced Placement STEM Exams in high school is predictive of a student's performance in STEM courses in the first year of college and the likelihood that a student will graduate with a STEM major, particularly for traditionally underrepresented populations in STEM fields—first-generation, underrepresented minority, and female students. We find that AP STEM examinees had 7% higher first-year STEM grades and a 13% higher probability of STEM major completion than matched non-AP STEM peers. Nearly all of these positive results held for first-generation, underrepresented minority, and female students.

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Introduction

In their 2014 digest, the National Science Foundation cautiously commended the U.S. for holding a preeminent international position in science and engineering, while also warning that the world leadership role is becoming readily challenged by other nations (National Science Foundation, 2014). Well-documented trends have reported domestic students' declining interest in Science, Technology, Engineering, and Mathematics (STEM) majors, especially among students in traditionally underrepresented groups—such as females, underrepresented minority students, and students from low-socioeconomic backgrounds (National Science Board, 2010). Even for students who indicate interest in STEM fields in high school, postsecondary outcomes, such as performance in STEM courses, major persistence, and graduation in the field are declining (Bettinger, 2010). In fact, the U.S. has one of the lowest ratios of STEM to non-STEM bachelor's degree completers in the world (National Science Foundation, 2014). National statistics demonstrate that students are not entering college prepared to succeed in STEM fields and that more needs to be done to promote graduation in these important areas.

The Bureau of Labor Statistics (Vilorio, 2014) projected that between 2012 and 2022 careers in STEM fields will grow to more than nine million, representing an increase of about one million jobs over the 2012 employment levels. According to the U.S. Congress Joint Economic Committee, the U.S. will have great difficulty filling open STEM positions because not enough students are completing degrees and pursuing careers in the STEM field to meet the demand. If the number of students who are completing college with a STEM major does not increase, the U.S. will slip further behind competing nations in the global economy (Vilorio, 2014). A mismatch between the number of open STEM positions and candidates with the skills and experience to fill them could have grave consequences for the United States beyond a slipping international ranking. Kanwar (2010) and Suzuki and Collins (2009) note that maintaining basic societal needs such as housing, communications, and economic sustenance will be a challenge for 21st-century scientists.

Traditionally Underrepresented Populations in STEM Fields

The recent paradigm shift in the global economy requires a STEM workforce that is well educated and well trained (Pearson, 2005). As the Committee on Science, Technology, Engineering and Math Education (CoSTEM) noted, improvements in STEM education and a match between open STEM positions and number of STEM educated workers is possible only if underrepresented groups—females, minorities, and first-generation students—become proportionally represented in STEM education (The White House, 2013). It is also important to support the retention of all college students who initially demonstrate interest in a STEM field. Unfortunately, women, minorities, and students from low-income backgrounds have been shown to leave STEM majors at higher rates than their counterparts (Anderson & Kim, 2006; Hill, Corbett, & Rose, 2010; Griffith, 2010; Shaw & Barbuti, 2010), which translates to women and minorities not being sufficiently represented in the STEM workforce. Women make up almost half of the total workforce and, while their representation in STEM occupations has increased since the 1970s, they still compose less than 24% of the STEM workforce (Beede et al., 2011). Similarly, in 2011, about 71% of the STEM occupations were occupied by whites; however, only 67% of the workforce was white. Asians held 15% of the STEM jobs as compared to 6% of the jobs overall (Landivar, 2013). In order to diversify the STEM workforce, the first step is ensuring that all women and minorities interested in pursuing STEM majors have the high school preparation to do so.

Rigorous Coursework and STEM Career Interest

A component of CoSTEM's strategy to improve postsecondary STEM outcomes is increasing the rigor of P–12 STEM education. Participation in AP® STEM courses and exams is aligned with that objective as there is a documented relationship between participation in AP in high school and positive postsecondary STEM outcomes. Using a national sample of high school students Tai, Liu, Almarode, and Fan (2010) found a "strong positive effect associated with AP Program participation [measured by AP Exam taking] in mathematics and science" and the likelihood of completing a life and physical science-related bachelor's degree (Tai et al., p. 114). Similarly, Ackerman, Kanfer, and Calderwood (2013) found that the most important predictors of STEM major persistence in a sample of first year undergraduate students at Georgia Institute of Technology was earning credit for AP Calculus and successfully completing three or more AP Exams in STEM areas while in high school. While these studies do not support causal claims about the role of AP course and exam participation on STEM major choice compared to students who do not participate in AP, they identify a general pattern that students who complete a STEM major tend to have taken and performed well on AP STEM exams. Quasi-experimental work examining the impact of earning various AP Exam scores on choice of STEM found among identical students who both took AP Exams, earning an AP STEM score of 5 versus a score of 4 increased the probability that the student would major in that STEM AP subject by 3.4% (Avery, Gurantz, Hurwitz, & Smith, 2017).

In tangential lines of research, others have found further evidence to support a positive relationship between AP Exam participation and positive postsecondary STEM outcomes. Shaw and Barbuti (2010) compared a student's intended major in high school with their declared major at the beginning of the third year of college and found that the majority of students who indicated in high school that they planned to pursue a physical science or math major, and then went on to pursue that major once in college, took three or more AP Exams. Mattern, Shaw, and Ewing (2011) found that students who took an AP Exam in a given subject area were more likely to declare a college major in a related field, especially in the fields of biological sciences, computer science, physical sciences, and math.

While prior research has considered the effects of AP STEM exam taking on postsecondary STEM outcomes, these studies have not explicitly focused on the extent to which there may be a differential relationship between AP STEM exam taking and postsecondary STEM outcomes when considering underrepresented minority, first-generation, and female students. Morgan and Klaric (2007) touched on the question of subgroup differences by looking at the percentage of students majoring in a related STEM content area by AP STEM exam participation separately for gender and underrepresented minority groups. Descriptive results from their study showed that the proportion of students who graduated with a STEM major was higher for both race and gender subgroups for students who had taken an AP STEM exam when compared with students of the same race and gender who did not complete an AP STEM exam. These results are supportive of AP STEM exams, but there is a need for more rigorous exploration into the ways in which AP STEM exam taking affects the postsecondary STEM outcomes of underrepresented groups—first-generation, underrepresented minority, and female students. The AP Program has expanded to serve more underrepresented students than ever before and, as Tai et al. noted in their previously cited study on the effects of AP on STEM major completion, "The[se] recent initiatives to provide AP courses to previously underserved constituencies, namely minorities and all levels of socioeconomic status, make it necessary that we now look at the impact on the multiple subgroups" (p.116). It is also important to focus on underrepresented groups because the future of a prosperous STEM workforce in the U.S. lies in the successful incorporation of currently underrepresented populations (The White House, 2013).

Research Purpose

The current research will contribute to the existing body of literature in three ways. First, this study will expand upon the descriptive results presented by Morgan and Klaric (2007) by examining the relationship between AP STEM exam taking and postsecondary STEM outcomes within underrepresented subgroups, taking into account nonrandom assignment by matching AP STEM exam takers to students who did not take any AP STEM exams to approximate a random sample. In this way, we improve upon Morgan and Klaric's descriptive results by better isolating the unique effects of AP STEM participation and performance on postsecondary STEM outcomes beyond the impact of background and demographic characteristics. We also improve upon Morgan and Klaric by considering first-generation students as a subgroup, where they only focused on gender and race. Second, previous studies that have found a relationship between AP Exam taking and postsecondary STEM outcomes have failed to account for prior motivation to major in STEM.[1] Research has not isolated the effect of AP participation on STEM major completion above and beyond a student's motivation to major in STEM prior to the AP course. Given that most students participate in AP STEM courses in the 11th and 12th grades, in this study we account for motivation by including a variable in the match that indicates the field a student intended to major in when in 10th grade. Finally, this study uses both AP STEM exam taking and AP

[1] The NSF-funded AP Science Impact Study being conducted by Long, Conger, and McGhee randomly assigns students to AP Biology and AP Chemistry courses, thereby addressing the motivation factor not incuded in prior work; however, the study does not investigate outcomes examined in the present research study. This research is still in progress, see https://evans.uw.edu/policy-impact/ap-science-impact-study for updates on the study findings.

STEM exam performance to understand how each is related to a student's STEM grades in the first year of college and to the likelihood of completing a STEM major. This approach will allow us to understand if the benefits of taking an AP STEM exam are a function of AP Exam score, or if all students who take AP STEM exams benefit from the experience.

Methods

Data Sources

Two sources of data are used for this study. The first comes from a database created by the College Board. The College Board partners with four-year institutions to collect student transcript data. The data set used includes data from 43 institutions that provided student information for six years (2007 through 2013).[2] These data were matched to the respective College Board cohort file, which contains AP, SAT®, and PSAT/NMSQT® scores, self-reported high school grade point average, and demographic information for students who graduated from high school in 2007.

Sample 1. The data used for Sample 1 was restricted to students who have valid PSAT/NMSQT scores in all three sections, and have nonmissing data on gender, ethnicity, parental education, and their planned college major as reported in 10th grade.[3] Students were also required to have graduated from a four-year college within six years and have had a valid major declared at the time of graduation. Both students who had participated in at least one AP STEM exam and students who had never participated in an AP STEM exam were included in the file (*N* = 17,268). Next the study file was matched using the Godfrey Exact Match method (Godfrey, 2016) where students are exact matched on categorical variables and nearest neighbor matched on continuous variables. The file was split by AP STEM exam takers and non-AP STEM peers. All AP STEM exam takers were matched to one or more students who did not take any AP STEM exams using a two-step process. First, 10th-grade students were exact matched on gender, race, and motivation to major in STEM. We also exact matched on highest level of parental education using coarsened category matching. Proximity matching was used to match on students' PSAT/NMSQT mathematics scores, PSAT/NMSQT reading scores, and PSAT/NMSQT writing scores. In order to be matched, students had to be within two score points in each section. Final matched samples were matched one to one without replacement, minimizing differences between the matches while optimizing the number of matches by allowing for some negligible differences in PSAT/NMSQT scores. There were 9,584 students in the AP STEM exam taker file. Of these, 4,739 students did not have a match in the non-AP STEM group and were dropped

[2] For more details about the research effort and the sample, see Kobrin, Patterson, Shaw, Mattern, & Barbuti (2008) where the collection effort for 2006 Cohort is explained. The same steps were taken in collecting data for the 2007 Cohort.

[3] If a student indicated that they were undecided in their major in 10th grade, the field was coded as missing.

from the sample. The final matched sample for the all AP Exam takers included 9,690 students with 4,845 AP STEM exam takers and 4,845 non-AP STEM peers.

Sample 2. Sample 2 consisted of matched pairs of AP and non-AP students from Sample 1 restricted to those AP students scoring a 1 or 2 on any AP STEM exam. The sample size was 4,648 with 2,324 AP STEM exam takers whose highest score was either a 1 or 2 on any AP STEM exam and 2,324 matched students who did not take any AP STEM exams.

Sample 3. Sample 3 consisted of matched pairs of AP and non-AP students from Sample 1 restricted to those AP students scoring a 3, 4, or 5 on an AP STEM exam. The sample size was 5,042 with 2,521 AP STEM exam takers whose highest score was either 3, 4, or 5 on any AP STEM exam and 2,521 matched students who did not take any AP STEM exams.

Measures

PSAT/NMSQT Performance. PSAT/NMSQT scores were obtained from official College Board records. The students in this study took the old version of the PSAT/NMSQT that was last administered in October 2014 and consisted of three sections: Critical Reading (scale 20–80), Writing (scale 20–80), and Math (scale 20–80).

Gender. Students were asked to report their gender on the SAT Questionnaire. Students were asked to select between “Male” and “Female.” Students who did not provide a response were excluded from analysis.

Race/Ethnicity. Students reported one race/ethnicity that they most identify with on the SAT Questionnaire. The final variable was dichotomized into “STEM nonminority,” which includes white and Asian students, and “STEM underrepresented minority,” which includes American Indian or Alaska Native; Black or African American; Mexican or Mexican American; Puerto Rican; Other Hispanic, Latino, or Latin American; Native American; Pacific Islander; and Other. Students who did not provide a response were excluded from analysis.

First-Generation Status. Students were asked to select their mother’s highest level of education and their father’s highest level of education separately on the SAT Questionnaire from the following options: grade school, some high school, high school diploma, business school, some college, associate degree, bachelor’s degree, some graduate education, or graduate degree. The mother and father education variables were combined to make one highest level of parental education variable. First-generation students were defined as students whose parents’ combined highest education completed was a high school diploma. Students whose parents’ combined highest education was associate degree, bachelor’s degree, or graduate degree were coded as not first-generation students. Students who did not provide a response were excluded from analysis.

Motivation to Major in STEM. Students were asked to indicate what area they intended to major in once in college on the 10th-grade PSAT/NMSQT Questionnaire. Responses were coded and a dichotomous variable indicating that either the student intended to major in

STEM in college or the student did not intend to major in STEM in college. Response options that were coded as motivated to major in STEM included: agriculture, architecture, biological and biomedical sciences, computer and information sciences, engineering, engineering technologies/technicians, mathematics and statistics, and physical sciences.

First Year STEM Grade Point Average. A first year grade point average (FYGPA) in STEM courses was calculated for each student. To calculate STEM FYGPA, courses were coded as either STEM or non-STEM. To be considered a STEM course, the course had to be nonremedial and in the content area of biology, calculus, chemistry, computer science, environmental science, mathematics, physics, or statistics. For each student, we calculated the product of the credits attempted in each nonremedial STEM course in the first year of college and the course grade earned, summed this total for all the courses, and then divided the sum by the total number of credits attempted in STEM courses in the first year.

STEM Major at Graduation. All students were coded as graduating with either a STEM major or a non-STEM major. In order to be coded as a STEM major at graduation, a student would have majored in one of the following fields: agriculture, architecture, biology, chemistry, engineering, engineering technologies, mathematics, physics, or chemical technology.

AP STEM Exam Taker. An AP STEM exam taker is a student who took one or more of the following AP Exams: AP Biology, AP Calculus AB, AP Calculus BC, AP Chemistry, AP Computer Science A, AP Computer Science AB[4], AP Environmental Science, AP Physics B[5], AP Physics C: Mechanics, AP Physics C: Electricity & Magnetism, and AP Statistics. Students who did not take any of these AP Exams were coded as non-AP STEM peers. It is worth noting that some students take an AP course but do not take the corresponding AP Exam; therefore, the non-AP Exam group may include students who were exposed to AP.

AP Exam Performance. AP Exam scores are criterion referenced and range from 1 to 5. A score of 1 represents “No recommendation for college credit”; 2 represents “Possibly qualified for college credit”; 3 represents “Qualified for college credit”; 4 represents “Well-qualified for college credit”; and 5 represents “Extremely well-qualified for college credit.” Many postsecondary institutions award college credit to students who score a three or higher on an AP Exam. Thus, for the purposes of the analyses in this study, AP Exam success was operationalized as a score of 3 or higher on an AP Exam.

Analyses

Prior to analyzing the data, three sets of descriptive analyses were run to assess the quality of the matches. First, we examined the match of the entire group of AP STEM exam takers in Sample 1 to the group of students who did not take any AP STEM exams. Then we

[4] The AP Computer Science AB Exam was discontinued following the May 2009 exam administration.

[5] In fall 2014, Physics B was replaced by two new algebra-based physics courses: AP Physics 1 and AP Physics 2.

compared the match results for the subsample of AP students who scored a 1 or 2 on their AP STEM exams and students who scored a 3 or higher on at least one AP Exam with their respective peers who did not take any AP STEM exams. If the matches were successful, we would expect the descriptive characteristics for the AP STEM exam takers and non-AP STEM peers to match perfectly on the categorical variables and to be within two points on the PSAT/NMSQT scores.

Once establishing quality matches, we conducted the main analyses of the study. The first set of analyses compared the entire group of AP STEM exam takers to their matched non-AP STEM peers with respect to STEM FYGPAs and STEM major completion. For STEM FYGPAs we used an independent samples t-test to examine whether there was a statistically significant difference in achievement between groups, while for STEM major completion we used a chi-square test. Next, we were interested in understanding if the relationship between AP STEM exam participation and STEM college outcomes depended on student AP STEM exam score. Thus, we separated our total sample into two groups, students whose highest score on all AP STEM exams was less than or equal to 2, and students whose highest score on one or more AP STEM exams was at least a 3. For example, a student who scored a 2 on an AP Biology Exam and a 3 on an AP Chemistry Exam would be placed in the group of students whose highest score on one or more AP STEM exams was at least a 3.

As the focus of this study is on the relationship between AP STEM exam participation and success and positive postsecondary STEM outcomes for traditionally underrepresented populations—underrepresented minority, first-generation, and female students—we also looked at the differences in STEM FYGPAs and graduation for underrepresented minority, first-generation, and female students separately for the overall AP STEM exam takers and non-AP STEM peers, as well as the two different AP STEM exam score subgroups and their respective non-AP STEM peers. This allowed us to examine if the relationships between AP STEM exam participation and performance and postsecondary STEM outcomes were different when considering these traditionally underrepresented subgroups.

Results

Assessing Match Quality

To assess the quality of the match, we compared the sample characteristics of AP STEM students and non-AP STEM peers before and after the match. The comparison of sample demographic statistics of the prematched sample and the postmatched sample are presented in Table 1, which indicates that all categorical variables were matched exactly and the PSAT/NMSQT scores were within two score points of each other. The results from this quality check indicate that the matching process was successful.

Tables 2 and 3 present the matched descriptive statistics of AP STEM exam takers whose highest AP STEM exam score was either a 1 or a 2 and their matched peers who did not take an AP STEM exam, and AP STEM exam takers who received an AP STEM exam score of either a 3, 4, or 5 on any of their AP STEM exams and their matched peers who did not take an AP STEM exam, respectively. The counts and proportions presented in both tables suggest that this match was also successful and that the samples can be used for this analysis.

Table 1: Sample Characteristics Prematch and Postmatch

		Prematched Sample (*n* = 17,268)				**Postmatched Sample (*n* = 9,690)**			
		AP (any score)		**Non-AP**		**AP (any score)**		**Non-AP**	
		#	**%**	**#**	**%**	**#**	**%**	**#**	**%**
Gender	Female	5,128	53.51%	4,792	62.36%	3,001	61.94%	3,001	61.94%
	Male	4,456	46.49%	2,892	37.64%	1,844	38.06%	1,844	38.06%
Ethnicity	Underrepresented Minority	1,308	13.65%	1,315	17.11%	603	12.45%	603	12.45%
	White/Asian	8,276	86.35%	6,369	82.89%	4,242	87.55%	4,242	87.55%
Parental Education	First-Generation	1,638	17.09%	1,648	21.45%	867	17.89%	867	17.89%
	Not First-Generation	7,946	82.91%	6,036	78.55%	3,978	82.11%	3,978	82.10%
STEM Interest	Interest in STEM Major	302	3.15%	209	2.72%	42	0.87%	42	0.87%
	No Interest in STEM Major	9,282	96.85%	7,475	97.28%	4,803	99.13%	4,803	99.13%
PSAT/ NMSQT Scores	Math	9,584	56.3%	7,684	49.6%	4,845	52.7%	4,845	52.3%
	Reading	9,584	52.1%	7,684	48.4%	4,845	50.2%	4,845	50.1%
	Writing	9,584	55.7%	7,684	51.6%	4,845	53.3%	4,845	53.3%

Table 2: Postmatch Characteristics of AP STEM Exam Takers Scoring a 1 or 2 and Non-AP STEM Peers

		AP 1–2; Postmatched Sample (*n* = 4,648)			
		AP (1-2) (*n* = 2,324)		**Non-AP (*n* = 2,324)**	
		#	**%**	**#**	**%**
Gender	Female	1,542	66.35%	1,542	66.35%
	Male	782	33.65%	782	33.65%

Ethnicity	Underrepresented Minority	412	17.73%	412	17.73%
	White/Asian	1,912	82.27%	1,912	82.27%
Parental Education	First-Generation	526	22.63%	526	22.63%
	Not First-Generation	1,798	77.37%	1,798	77.37%
STEM Interest	Interest in STEM Major	14	0.60%	14	0.60%
	No Interest in STEM Major	2,310	99.40%	2,310	99.40%
PSAT/NMSQT Scores	Math	2,324	50.2%	2,324	49.9%
	Reading	2,324	48.1%	2,324	48.1%
	Writing	2,324	51.2%	2,324	51.2%

Table 3: Postmatch Characteristics of AP STEM Exam Takers Scoring a 3, 4, or 5 and Non-AP STEM Peers

		AP 3–5; Postmatched Sample (*n* = 5,042)			
		AP (3–5)		**Non-AP**	
		(*n* = 2,521)		**(*n* = 2,521)**	
		#	**%**	**#**	**%**
Gender	Female	1,459	57.87%	1,459	57.87%
	Male	1,062	42.13%	1,062	42.13%
Ethnicity	Underrepresented Minority	191	7.58%	191	7.58%
	White/Asian	2,330	92.42%	2,330	92.42%
Parental Education	First-Generation	341	13.53%	341	13.53%
	Not First-Generation	2,180	86.47%	2,180	86.47%
STEM Interest	Interest in STEM Major	28	1.11%	28	1.11%
	No Interest in STEM Major	2,493	98.89%	2,493	98.89%
PSAT/NMSQT Scores	Math	2,521	55.0%	2,521	54.5%
	Reading	2,521	52.1%	2,521	52.0%
	Writing	2,521	55.3%	2,521	55.3%

Comparing Differences in STEM FYGPA

Figure 1 demonstrates that students who took an AP STEM exam in high school earned higher STEM FYGPAs, on average, than their matched peers who never took an AP STEM exam (3.05 and 2.85, respectively). To further understand if this relationship is dependent on AP Exam score, we separately compared the STEM FYGPAs of AP STEM exam takers whose highest AP STEM Exam score was either a 1 or a 2 and AP STEM exam takers who received an AP STEM exam score of 3, 4, or 5 on at least one AP STEM exam to their corresponding matched peers who did not take any AP STEM exams. Figure 2 shows that students who took an AP STEM exam and scored a 1 or 2 earned higher STEM FYGPAs, on average, than did their matched peers who did not take an AP STEM exam (2.86 and 2.77, respectively). Similarly, Figure 3 shows that students who took an AP STEM exam and scored a 3, 4, or 5 on at least one exam earned higher STEM FYGPAs, on average, than did their matched peers who did not take an AP STEM exam (3.21 and 2.92, respectively). These results indicate that at both high and low ends of the score scale, students who took an AP STEM exam, regardless of score, had higher STEM FYGPAs, on average, than matched students who did not take an AP STEM exam; however, differences were larger for higher-performing students. AP STEM examinees scoring a 3 or higher earned 10% higher grades than non-AP STEM peers, while AP examinees scoring a 1 or 2 earned 3% higher grades than non-AP STEM peers

Figure 1: STEM FYGPAs of AP STEM exam takers and matched non-AP STEM peers

	STEM FYGPA
No AP (*N* = 4,845)	2.85
AP (*N* = 4,845)	3.05

Note: Differences between No-AP and AP groups are statistically significant at 0.001 level.

Figure 2: STEM FYGPAs of AP STEM exam takers scoring a 1 or 2 and matched non-AP STEM peers

	STEM FYGPA
No AP (*N* = 2,324)	2.77
AP (*N* = 2,324)	2.86

Note: Differences between No-AP and AP groups are statistically significant at 0.001 level.

Figure 3: STEM FYGPAs of AP STEM exam takers scoring a 3, 4, or 5 and matched non-AP STEM peers

	STEM FYGPA
No AP (*N* = 2,521)	*2.92*
AP (*N* = 2,521)	*3.21*

Note: Differences between No-AP and AP groups are statistically significant at 0.001 level.

Given that increasing STEM major completion rates for underrepresented students is a primary goal of current STEM initiatives, we investigated whether the relationship between AP STEM exam taking and performance and STEM FYGPA persisted within gender, race/ethnicity, and first-generation status. Figure 4 shows that for all three subgroup comparisons, AP STEM exam takers earn higher STEM FYGPAs, on average, than their peers who do not take any AP STEM exams. The differences are statistically significant at the 0.001 level in all cases. When disaggregating analyses by AP Exam performance, Figure 5 shows that all subgroups of students who took an AP STEM exam and scored either a 1 or a 2 earned higher STEM FYGPAs, on average, than their matched peers. While underrepresented minority and first-generation students who took an AP STEM exam did have higher average STEM FYGPAs than students who did not complete any AP STEM exams, the difference between their average STEM FYGPAs was not statistically significant. Focusing on the high scoring students, Figure 6 shows that all subgroups of students who took an AP STEM exam and scored a 3, 4, or 5 earned statically significantly higher STEM FYGPAs, on average, than their matched peers who did not take any AP STEM exams.

Figure 4: STEM FYGPAs of AP STEM exam takers and matched non-AP STEM peers by gender, race/ethnicity, and first-generation status

		STEM FYGPA
Female (*N* = 3,001)	No AP	2.89
	AP	3.07
Male (*N* = 1,844)	No AP	2.79
	AP	3.00
Underrepresented Minority (*N* = 603)	No AP	2.58
	AP	2.78

White/Asian (*N* = 4,242)	No AP	2.89
	AP	3.08
First-Generation (*N* = 867)	No AP	2.72
	AP	2.90
Not First-Generation (*N* = 3,978)	No AP	2.88
	AP	3.08

Note: Differences between No-AP and AP groups are statistically significant at 0.001 level.

Figure 5: STEM FYGPAs of AP STEM exam takers scoring a 1 or 2 and matched non-AP STEM peers by gender, race/ethnicity, and first-generation status

		STEM FYGPA
Female (*N* = 1,542)	No AP	2.81
	AP	2.88
Male (*N* = 782)	No AP	2.71
	AP	2.82
Underrepresented Minority (*N* = 412)	No AP	2.54
	AP	2.64
White/Asian (*N* = 1,912)	No AP	2.83
	AP	2.91
First-Generation (*N* = 526)	No AP	2.68
	AP	2.76
Not First-Generation (*N* = 1,798)	No AP	2.80
	AP	2.89

Note: Differences between No-AP and AP groups are statistically significant at 0.05 level for all groups except underrepresented minority and first-generation students.

Figure 6: STEM FYGPAs of AP STEM exam takers scoring a 3, 4, or 5 and matched non-AP STEM peers by gender, race/ethnicity, and first-generation status

		STEM FYGPA
Female (*N* = 1,459)	No AP	2.97
	AP	3.27

Male (N = 1,062)	No AP	2.85
	AP	3.14
Underrepresented Minority (*N* = 191)	No AP	2.65
	AP	3.07
White/Asian (*N* = 2,330)	No AP	2.94
	AP	3.23
First-Generation (*N* = 341)	No AP	2.78
	AP	3.11
Not First-Generation (*N* = 2,180)	No AP	2.94
	AP	3.23

Note: Differences between No-AP and AP groups are statistically significant at 0.001 level.

Comparing Differences in STEM Major Completion

To understand if students who take an AP Exam in a STEM subject are more likely to complete a STEM major, we first compared the proportion of all AP STEM exam takers graduating with a STEM major to the proportion of their matched non-AP STEM peers graduating with a STEM major. Figure 7 shows that roughly double the proportion of students who took an AP STEM exam in high school graduated with a major in a STEM field than non-AP STEM matched peers (27% and 14%, respectively).[6] We further investigated if this relationship held across AP STEM exam scores. Figure 8 shows that students scoring a 1 or 2 on an AP STEM exam still graduated with a STEM major at a higher rate than their matched non-AP STEM peers (18% and 12%, respectively) and, as Figure 9 shows, students who scored a 3, 4, or 5 graduated with a STEM major at an even higher rate than their matched non-AP STEM peers (35% and 16%, respectively). As with STEM FYGPA, these results indicate that students who take an AP STEM exam in high school are more likely to complete a STEM major at both high and low ends of the score scale.

Figure 7: Proportion of students graduating with a STEM major for AP STEM exam takers and matched non-AP STEM peers

	STEM FYGPA
No AP (*N* = 4,845)	14%
AP (*N* = 4,845)	27%

Note: Differences between No-AP and AP groups are statistically significant at 0.001 level.

[6] See Appendix Tables A4–A6 for information on the means, standard deviations, and significance tests associated with results presented in this section.

Figure 8: Proportion of students graduating with a STEM major for AP STEM exam takers earning a 1 or 2 and matched non-AP STEM peers

	STEM FYGPA
No AP (*N* = 2,324)	12%
AP (*N* = 2,324)	18%

Note: Differences between No-AP and AP groups are statistically significant at 0.001 level.

Figure 9: Proportion of students graduating with a STEM major for AP STEM exam takers scoring a 3, 4, or 5 and matched non-AP STEM peers

	STEM FYGPA
No AP (*N* = 2,521)	16%
AP (*N* = 2,521)	35%

Note: Differences between No-AP and AP groups are statistically significant at 0.001 level.

As with the analysis on STEM FYGPA, we split our sample by male and female students, underrepresented minorities and White/Asian students, and first-generation and not first-generation students and conducted the same analysis within these subgroups. Figure 10 shows that for all three subgroup comparisons, AP STEM exam takers graduated with a STEM major at a higher rate than their matched non-AP STEM peers. The differences are statistically significant at the 0.001 level in all cases.

Figure 10: Proportion of students graduating with a STEM major for AP STEM exam takers and matched non-AP STEM peers by gender, race/ethnicity, and first-generation status

Female (*N* = 3,001)	No AP	10%
	AP	21%
Male (*N* = 1,844)	No AP	21%
	AP	37%
Underrepresented Minority (*N* = 603)	No AP	12%
	AP	22%

White/Asian (*N* = 4,242)	No AP	14%
	AP	27%
First-Generation (*N* = 867)	No AP	15%
	AP	23%
Not First-Generation (*N* = 3,978)	No AP	14%
	AP	27%

Note: Differences between No-AP and AP groups are statistically significant at 0.001 level.

When separating the subgroups by AP Exam performance, the trend remains. Figures 11 and 12 show that all subgroups of students who participated in an AP STEM exam graduated with a STEM major at a higher rate than their matched non-AP STEM peers. All of the subgroup differences in Figures 11 and 12 are statistically significant.

Figure 11: Proportion of students graduating with a STEM major for AP STEM exam takers scoring a 1 or 2 and matched non-AP STEM peers by gender, race/ethnicity, and first-generation status

Female (*N* = 1,542)	No AP	8%
	AP	13%
Male (*N* = 782)	No AP	21%
	AP	27%
Underrepresented Minority (*N* = 412)	No AP	10%
	AP	17%
White/Asian (*N* = 1,912)	No AP	13%
	AP	18%
First-Generation (*N* = 526)	No AP	13%
	AP	18%
Not First-Generation (*N* = 1,798)	No AP	12%
	AP	18%

Note: Differences between No-AP and AP groups are statistically significant at 0.05 level.

Figure 12: Proportion of students graduating with a STEM major for AP STEM exam takers scoring a 3, 4, or 5 and matched non-AP STEM peers by gender, race/ethnicity, and first-generation status

Female (*N* = 1,459)	No AP	12%
	AP	29%
Male (*N* = 1,062)	No AP	22%
	AP	44%
Underrepresented Minority (*N* = 191)	No AP	17%
	AP	32%
White/Asian (*N* = 2,330)	No AP	16%
	AP	35%
First-Generation (*N* = 341)	No AP	18%
	AP	32%
Not First-Generation (*N* = 2,180)	No AP	16%
	AP	35%

Note: Differences between No-AP and AP groups are statistically significant at 0.001 level.

Limitations

In the absence of a randomized design, students in this study were matched on observable traits to create balanced samples in an effort to remove to the extent possible selection bias from analyses. While matching students allows us to make claims about relationships, this approach does not replace a randomized control trial, where casual inferences are appropriate. Additionally, we matched students primarily on observable traits, with one observable trait, 10th-grade interest in pursuing a STEM major, used as a proxy for STEM major motivation (which is not readily observed). However, there are other unobservable traits, such as grit and confidence that may play a role in students' performance in STEM postsecondary courses and their likelihood to graduate with a STEM major. There are also sample limitations as only students who enrolled at four-year institutions and had available data on all variables needed for the match were included in the sample. Students were also required to have a declared major at graduation. Students with missing data or no major reported at graduation were removed from the sample. While the samples in our study are large, they are not inclusive of all high school students in the U.S. and may not be representative.

Discussion

The national focus on STEM education, coupled with the growing disparity between the demographic makeup of the United States and that of the STEM workforce makes the critical examination of factors related to students' postsecondary performance in STEM courses and students graduating with a STEM degree imperative. Previous research has identified rigorous high school coursework and academic preparation as key predictors of students declaring and persisting in a STEM major (Ackerman et al., 2013). Similarly, research has demonstrated that one of the factors that contributes to high attrition in STEM majors is poor academic performance in first year STEM courses as compared to other courses students take (Chen, 2013). The current study demonstrates that taking AP STEM exams in high school is favorably related to student performance in STEM courses in the first year of college and to the likelihood that a student graduates with a STEM major, above and beyond student first-generation and underrepresented minority status, prior academic achievement, and interest in STEM majors. These relationships persist when examined within AP performance category. That is, students who scored a 1 or a 2 on an AP STEM exam earned 3% higher STEM FYGPAs and had a 6% higher likelihood of graduating with a STEM major than their matched peers. Similarly, students who scored a 3, 4, or 5 on an AP STEM exam had 10% higher grades and a 19% greater likelihood of graduating with a STEM major than did their matched peers. These results suggest that taking an AP STEM exam favorably influences STEM postsecondary outcomes regardless of whether a student is successful on the AP STEM exam.

When examining the relationship between AP STEM exam taking and positive postsecondary STEM outcomes for subgroups of students that are currently underrepresented in both STEM majors and STEM careers—underrepresented minority, first-generation, and female students—we find that the positive relationships remain and are generally as strong as in the full sample. Minority and first-generation students who take AP STEM exams and score a 1 or 2 have earned about 3% higher STEM FYGPAs than their matched subgroup counterparts who do not take any AP STEM exams, but the differences in grades are not statistically significant in either case. However, when comparing STEM major completion rates for underrepresented minority, first-generation, and female students, the underrepresented subgroups are on average 10% more likely to complete a STEM major than their peers who do not take any AP STEM exams. The completion rate differences are significant in all cases regardless of AP STEM exam score. Underrepresented students benefit from taking the AP STEM exam in terms of STEM major completion regardless of AP STEM exam performance, and they benefit in terms of first year STEM grades if they score a 3 or higher on an AP STEM exam. Considering the need for an additional million STEM-trained professionals, as well as the desire to diversity STEM fields, the results presented show that student participation in AP STEM courses in high school is an important tool in closing the gap between the number of STEM positions and those available to fill them.

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Appendix

Table A1: STEM FYGPAs of AP STEM Exam Takers and Matched Non-AP STEM Peers

STEM FYGPA	*N*	AP		*N*	No AP		
		Mean	SD		Mean	SD	Diff
Overall	4,845	3.05	0.74	4,845	2.85	0.83	0.20***
Female	3,001	3.07	0.74	3,001	2.89	0.83	0.18***
Male	1,844	3.00	0.74	1,844	2.79	0.82	0.21***
Minority	603	2.78	0.84	603	2.58	0.94	0.20***
White/Asian	4,242	3.08	0.72	4,242	2.89	0.80	0.19***
First-Generation	867	2.90	0.78	867	2.72	0.87	0.18***
Not First-Generation	3,978	3.08	0.73	3,978	2.88	0.82	0.20***

Note: *** indicates significance at the <.001 level, ** indicates significance at the <.01 level, * indicates significance at the <.05 level.

Table A2: STEM FYGPAs of AP STEM Exam Takers Scoring a 1 or 2 and Matched Non-AP STEM Peers

STEM FYGPA	*N*	AP		*N*	No AP		
		Mean	SD		Mean	SD	Diff
Overall	2,324	2.86	0.78	2,324	2.77	0.85	0.09***
Female	1,542	2.88	0.78	782	2.81	0.85	0.07*
Male	782	2.82	0.78	1,542	2.71	0.83	0.11**
Minority	412	2.64	0.85	412	2.54	0.94	0.10
White/Asian	1,912	2.91	0.76	1,912	2.83	0.82	0.08***
First-Generation	526	2.76	0.80	526	2.68	0.88	0.08
Not First-Generation	1,798	2.89	0.77	1,798	2.80	0.83	0.09**

Note: *** indicates significance at the <.001 level, ** indicates significance at the <.01 level, * indicates significance at the <.05 level.

Table A3: STEM FYGPAs of AP STEM Exam Takers Scoring a 3, 4, or 5 and Matched Non-AP STEM Peers

STEM FYGPA	*N*	AP		*N*	No AP		
		Mean	SD		Mean	SD	Diff
Overall	2,521	3.21	0.66	2,521	2.92	0.80	-0.30***
Female	1,459	3.27	0.63	1,459	2.97	0.81	0.30***
Male	1,062	3.14	0.69	1,062	2.85	0.80	0.29***
Minority	191	3.07	0.71	191	2.65	0.94	0.42***
White/Asian	2,330	3.23	0.66	2,330	2.94	0.79	0.29***
First-Generation	341	3.11	0.69	341	2.78	0.85	0.33***
Not First-Generation	2,180	3.23	0.66	2,180	2.94	0.80	0.29***

Note: *** indicates significance at the <.001 level, ** indicates significance at the <.01 level, * indicates significance at the <.05 level.

Table A4: STEM Major Completion Rates of AP STEM Exam Takers and Matched Non-AP STEM Peers

STEM FYGPA	N	AP		N	No AP		
		Mean	SD		Mean	SD	Diff
Overall	4,845	0.27	0.44	4,845	0.14	0.35	0.13***
Female	3,001	0.21	0.41	3,001	0.10	0.30	0.11***
Male	1,844	0.37	0.48	1,844	0.21	0.41	0.16***
Minority	603	0.22	0.41	603	0.12	0.33	0.10***
White/Asian	4,242	0.27	0.45	4,242	0.14	0.35	0.13***
First-Generation	867	0.23	0.42	867	0.15	0.35	0.08***
Not First-Generation	3,978	0.27	0.45	3,978	0.14	0.35	0.13***

Note: *** indicates significance at the <.001 level, ** indicates significance at the <.01 level, * indicates significance at the <.05 level.

Table A5: STEM Major Completion Rates of AP STEM Exam Takers Scoring a 1 or 2 and Matched Non-AP STEM Peers

STEM FYGPA	N	AP		N	No AP		
		Mean	SD		Mean	SD	Diff
Overall	2,324	0.18	0.38	2,324	0.12	0.33	0.06***
Female	1,542	0.13	0.34	1,542	0.08	0.27	0.05***
Male	782	0.27	0.44	782	0.21	0.41	0.06**
Minority	412	0.17	0.37	412	0.10	0.30	0.07**
White/Asian	1,912	0.18	0.39	1,912	0.13	0.33	0.05***
First-Generation	526	0.18	0.38	526	0.13	0.33	0.05*
Not First-Generation	1,798	0.18	0.38	1,798	0.12	0.33	0.06***

Note: *** indicates significance at the <.001 level, ** indicates significance at the <.01 level, * indicates significance at the <.05 level.

Table A6: STEM Major Completion Rates of AP STEM Exam Takers Scoring a 3, 4, or 5 and Matched Non-AP STEM Peers

STEM FYGPA	*N*	AP		*N*	No AP		
		Mean	SD		Mean	SD	Diff
Overall	2,521	0.35	0.48	2,521	0.16	0.37	0.19***
Female	1,459	0.29	0.45	1,459	0.12	0.32	0.17***
Male	1,062	0.44	0.50	1,062	0.22	0.41	0.22***
Minority	191	0.32	0.47	191	0.17	0.38	0.15***
White/Asian	2,330	0.35	0.48	2,330	0.16	0.36	0.19***
First-Generation	341	0.32	0.47	341	0.18	0.39	0.14***
Not First-Generation	2,180	0.35	0.48	2,180	0.16	0.36	0.19***

Note: *** indicates significance at the <.001 level, ** indicates significance at the <.01 level, * indicates significance at the <.05 level.