

**Abstract Title Page**  
*Not included in page count.*

**Title:** Engaging high school students in advanced math and science courses for success in college: Is Advanced Placement the answer?

**Author(s):** Thomas Kelley-Kemple, Amy Proger, and Melissa Roderick

## **Abstract Body**

*Limit 4 pages single spaced.*

### **Background / Context:**

*Description of prior research and its intellectual context.*

Today, one of the most resounding national imperatives is to increase the number of students in our nation's public schools taking advanced math and science courses. There is widespread recognition that, as a country, we have fallen short in educating our youth to be leaders in a global economy. Moreover, many have argued that increasing the number of student taking advanced math and science courses will lead to concomitant increases in the number of students entering college, completing bachelor's degrees, and going on to careers that command high wages.

In order to increase the number of students engaged in advanced math and science courses, states and school districts have turned to the College Board's Advanced Placement program. Once reserved for the academic elite, in recent decades schools have expanded AP courses to students from a range of achievement backgrounds. Yet, we know very little about the extent to which students benefit from taking these courses. Without being able to randomize students to AP courses, it is difficult to make causal inferences about the effect of taking AP courses on college outcomes. Much of the existing research on AP overlooks this key estimation problem. For example, many studies of the effects of AP course-taking on college outcomes use multivariate regression with a limited set of controls for student demographic and achievement characteristics (Duffy, 2010; Hargrove, Godin, and Dodd, 2008; Keng and Dodd, 2008; Morgan and Klaric, 2007; Morgan and Ramist, 1998). These studies produce biased estimates of the effect of taking AP courses on college outcomes because they omit key variables, such as motivation. This omitted variables problem cannot be avoided without randomization of students to AP courses. However, innovative approaches, such as instrumental variables, can approximate randomization. We know of no research to date that takes this approach.

### **Purpose / Objective / Research Question / Focus of Study:**

*Description of the focus of the research.*

The current study provides an in-depth look at Advanced Placement (AP) math and science course-taking in one school district, the Chicago Public Schools (CPS). Using quasi-experimental methods, this study examines the college outcomes of students who take AP math and science courses. Specifically, this study asks whether students who take AP math and science courses are more likely to enroll in four-year colleges, enroll in selective or very selective four-year colleges, and persist in college for two years.<sup>2</sup> Because there may be heterogeneous treatment effects, we also run separate analyses for lower- and higher-achieving students.

### **Setting:**

*Description of the research location.*

---

<sup>2</sup> In our analysis, we grouped four-year colleges into four separate groups based on Barron's ratings: nonselective, somewhat selective, selective, and very selective. This top category, very selective, combines Barron's two top categories ("most competitive" and "highly competitive").

Chicago has the third largest school system in the country, with 122 high schools, approximately 409,000 students, and an operating budget of \$5.3 billion.<sup>3</sup> In Chicago, the expansion of AP course-taking has been rapid; the percent of graduates taking one or more AP course rose from 25 to 42 percent between 2002 and 2007. Graduates have been consistently most likely to take AP social science courses, followed by AP English courses. In 2007, 23 percent of graduates took one or more AP social science course and 18 percent of graduates took one or more AP English course. Graduates were less likely to take AP science and math courses; 13 percent of graduates took one or more AP science course and 12 percent of graduates took one or more AP math course (see Figure 1, Appendix B).

### **Population / Participants / Subjects:**

*Description of the participants in the study: who, how many, key features, or characteristics.*

This study focuses on the 36,548 students who graduated from a Chicago public high school between 2005 and 2007.<sup>4</sup> Of these graduates, 12 percent are white, 47 percent are African-American, 35 percent are Latino, and 6 percent are Asian; 59 percent are female. Over one-third (37 percent) of graduates took an AP course at some point in high school, with 10 percent taking one or more AP math course and 12 percent taking one or more AP science course. White and Asian graduates are overrepresented among graduates who took AP math and science courses, while Black and Latino graduates are underrepresented. Females are slightly underrepresented among AP math course-takers, and slightly overrepresented among AP science course-takers. Graduates who took AP math and science courses were much higher achieving than those who took no AP courses, and slightly higher achieving than those who took a minimum of one AP course in any subject. These descriptive statistics are presented in Table 1, Appendix B.

### **Intervention / Program / Practice:**

*Description of the intervention, program, or practice, including details of administration and duration.*

The College Board created the Advanced Placement program in 1955 as a small advanced standing program intended to give an academically select group of students the opportunity to place out of introductory college courses by demonstrating proficiency while in high school (Lichten, 2000). By the 1980s and 1990s, the AP program had become a staple of the suburban American high school. More recently, there has been a massive investment of resources in expanding AP course-taking in urban and rural areas, as school districts and states have begun to recognize the importance of taking AP courses to college admissions. The Chicago Public Schools (CPS) has been at the forefront of this movement, rapidly increasing the number of students engaged in AP courses over the past decade. The percent of graduates taking one or more AP course rose from 25 to 42 percent between 2002 and 2007.

Currently, the College Board administers 35 exams in a variety of subject areas. While the College Board does not provide a prescribed curriculum for the corresponding AP course, it does require schools to submit course syllabi and complete course audits to receive the “AP” designation. These course audits are intended to ensure consistency of course standards across

---

<sup>3</sup> These numbers are the most recent available, from the 2009-2010 school year. For more information, see [http://www.cps.edu/About\\_CPS/At-a-glance/Pages/Stats\\_and\\_facts.aspx](http://www.cps.edu/About_CPS/At-a-glance/Pages/Stats_and_facts.aspx).

<sup>4</sup> Students who attend charter school or alternative schools, or who participated in special education, are not included in the sample.

high schools. The math and science exams currently offered by the College Board include: Calculus, Statistics, Environmental Science, Biology, Chemistry, and Physics.

### **Research Design:**

*Description of the research design.*

In the current study, we use a combination of propensity scores and instrumental variables to address the selection problem. First, we separately model the propensity for taking AP math and science in schools where many students took these courses. Then, using these coefficients, we simulate the propensity for taking AP math and science for students in schools where few students have the opportunity to take these courses because of administrative decisions about course offerings. A key condition for instrumental variables to be valid is that differences in exposure to AP math and science courses are only related to the outcomes of interest through the treatment. This condition would be violated if students who attend schools that offer AP math and science courses are systematically different from students who attend schools that do not offer these courses in ways that are related to college outcomes. However, we find that there is significant overlap in respect to school-wide GPAs and ACT scores, and we account for marginal differences within the model.

### **Data Collection and Analysis:**

*Description of the methods for collecting and analyzing data.*

This study uses administrative data from the Chicago Public Schools, archived by the Consortium on Chicago School Research at the University of Chicago. The current study uses data on students' backgrounds, test scores, and course-taking patterns, as well as school compositional data. As a part of the state accountability system, all students take the PLAN in the 10<sup>th</sup> grade and the ACT in the 11<sup>th</sup> grade. In order to identify whether graduates enroll in college in the fall after graduation, the kinds of colleges they attend, and their two-year persistence rates, this study uses data from the National Student Clearinghouse (NSC). NSC is a non-profit corporation that began in 1993 to assist higher education institutions in verifying enrollment and degree completion. In 2004, NSC expanded its services to high school districts through its new program, "Success Outcomes." CPS is the first major urban school district to participate in this program and produce reports on its graduates. Currently, NSC's enrollment verification program covers 92 percent of postsecondary enrollment in the United States.

Data is analyzed using the combined propensity score and instrumental variable approach described above. First, we estimate the probability of taking an AP math or science course for students at schools that have high incidences of offering them, conditional on students' subject-specific 10<sup>th</sup> grade GPAs, PLAN scores, interactions between the two, and demographic information. Using the estimated model, we then simulate the propensity for taking AP math or science courses for students who attend schools that do not offer these courses, essentially simulating what would have happened if these students had gone to schools that offered AP math and science courses.

### **Findings / Results:**

*Description of the main findings with specific details.*

We find that AP math and science courses have moderate but significant effects on college outcomes. Taking either AP math or science is related to an increased likelihood of enrolling in a four-year college by 8 and 10 percentage points respectively. Moreover, students who take AP math are 7 percentage points more likely to attend a selective or very selective college; we did not find a similar association for students who take AP science. Finally, we find that taking either AP math or science is related to an improvement in two-year persistence at four-year colleges by 6 percentage points each. For AP math, this effect is completely explained by controlling for the selectivity of the college attended. However, the AP science effect remains even when controlling for the selectivity of the college attended.

To test whether these results were consistent across achievement groups, we repeated the analysis with subgroups of students, delineated on the basis of their access to different types of colleges.<sup>5</sup> For higher-achieving students, or those with access to a selective or very selective college, we find no relationship between taking AP math and four-year college enrollment, and a more moderate relationship between taking AP science and four-year college enrollment. For lower-achieving students, or those with access to a nonselective or somewhat selective college, the relationship between taking AP math or science and four-year college enrollment persists. Results for the other outcomes are presented in Table 3, Appendix B.

### **Conclusions:**

*Description of conclusions, recommendations, and limitations based on findings.*

Our findings suggest that taking AP math and science courses have significant positive effects on college outcomes. In previous work, we did not find large effects on college outcomes for taking an AP course, not specifying the subject area of the course. AP math and science may be unique because students are not required to take math or science during their senior year of high school. The fact that students are taking these courses could signal to colleges that they are more motivated and better candidates for admission. However, AP math and science may have different signaling mechanisms. While students who take either AP math or science are more likely to enroll in four-year colleges, only students who took AP math are more likely to enroll in selective or very selective four-year colleges than similar students who do not take AP science. It could be that almost all colleges look for students who took advanced math courses, while only colleges of engineering or with STEM majors look specifically to admit students with advanced science courses. We cannot test this hypothesis with the available data.

Given the low rates of AP math and science course-taking in CPS, it is heartening to see such positive effects for students who choose to take these more rigorous courses. However, these results should be interpreted with caution, given that our propensity score approach involves matching students on an observed set of covariates. While we believe our approach is superior to previous efforts to examine the effect of AP course-taking on college outcomes, it is still possible that there is a positive bias on the AP coefficient due to the omission of student motivation.

---

<sup>5</sup> We characterize students by the qualifications rubric developed by Roderick, Nagaoka, and Allensworth (2006), which identified the selectivity of colleges that students would likely have access to given their course performance (unweighted GPA in core classes), ACT scores, and involvement in AP and IB coursework.

## Appendices

*Not included in page count.*

### Appendix A. References

*References are to be in APA version 6 format.*

Duffy, W.R. (2010). Persistence and performance at a four-year university: The relationship with advanced coursework during high school. In P.M. Sadler, G. Sonnert, R.H. Tai, K. Klopfenstein (Eds.), *AP: A critical examination of the Advanced Placement Program* (pp. 139-163). Cambridge, MA: Harvard Education Press.

Hargove, L., Godin, D., & Dodd, B.G. (2008). *College Outcomes Comparisons by AP and Non-AP High School Experiences*. Research Report 2008-3. New York: The College Board.

Keng, L., & Dodd, B.G. (2008). *A Comparison of College Performances of AP and Non-AP Student Groups in 10 Subject Areas*. Research Report 2008-7. New York: The College Board.

Morgan, R., & Klaric, J. (2007). *AP Students in College: An Analysis of Five-Year Academic Careers*. Research Report 2007-4. New York: The College Board.

Morgan, R., & Ramist, L. (1998). *Advanced Placement Students in College: An Investigation of Course Grades at 21 Colleges*. Report No. SR-98-13. Princeton, NJ: Educational Testing Service.

Klopfenstein, K., & Thomas, M.K. (2006). The Link Between Advanced Placement Experience and Early College Success. Available from [https://www.utdallas.edu/research/tsp-erc/pdf/wp\\_klopfenstein\\_2006\\_link\\_advanced\\_placement.pdf](https://www.utdallas.edu/research/tsp-erc/pdf/wp_klopfenstein_2006_link_advanced_placement.pdf)

Lichten, W. (2000). Wither Advanced Placement? *Education Policy Analysis Archive*, 8.

Roderick, M., Nagaoka, J., & Allensworth, E. (2006). *From high school to the future: A first look at Chicago Public School graduates' college enrollment, college preparation, and graduation from four-year colleges*. Chicago: Consortium on Chicago School Research at the University of Chicago.

## Appendix B. Tables and Figures

Not included in page count.

Figure 1. Percent of Graduates Taking One or More AP Course, by Subject 2002-2007

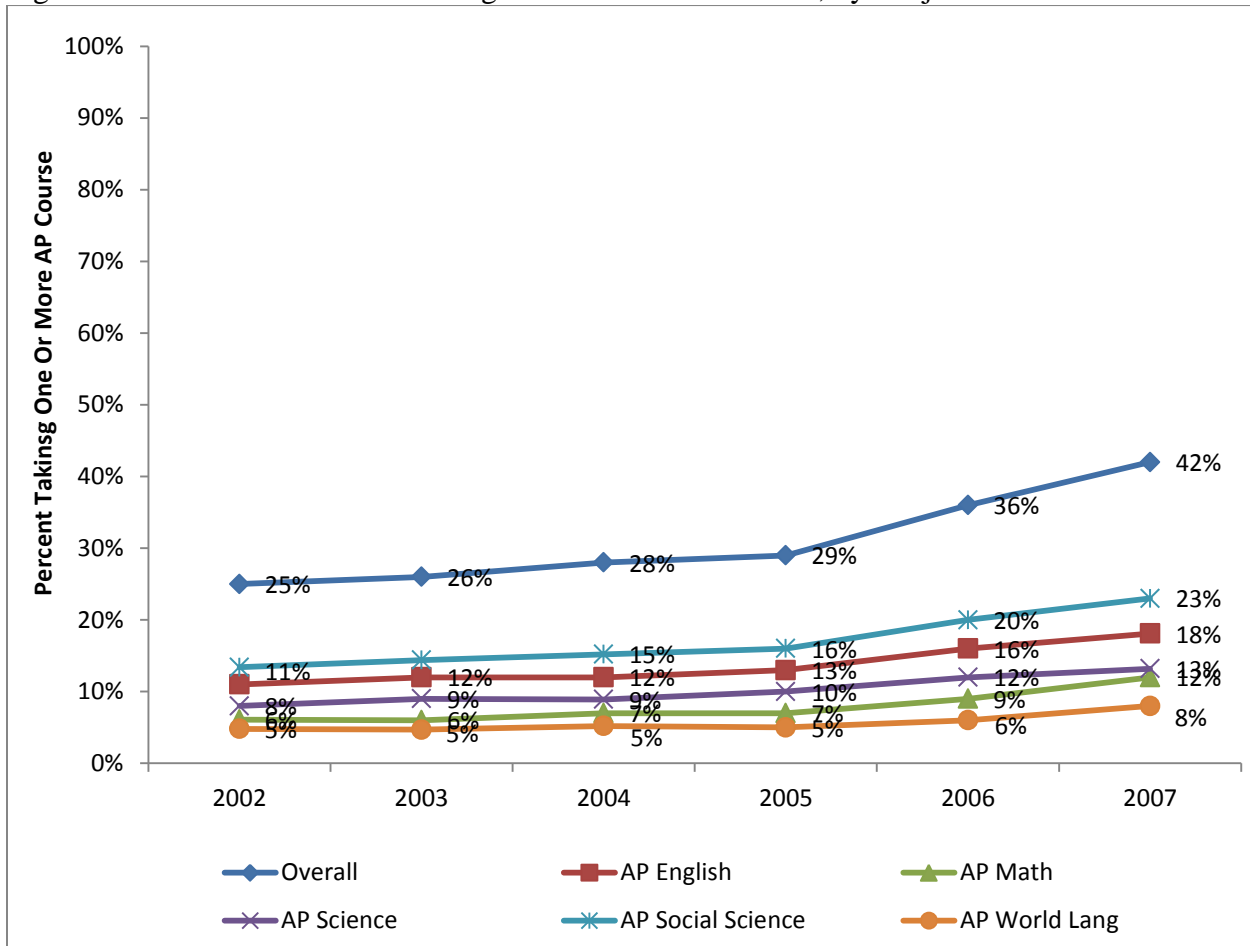


Table 1. Sample Descriptive Statistics

	Overall	No AP courses	1+AP course	1+ AP math course	1+ AP science course
<b>N</b>	36,548	23,187 (63%)	13,361 (37%)	3,638 (10%)	4,444 (12%)
<b>Race/ethnicity</b>					
White	12%	9%	18%	26%	20%
Black	47	52	38	26	34
Asian	6	4	11	21	18
Latino	35	35	33	27	28
<b>Gender</b>					
Female	59%	56%	64%	56%	63%
<b>Achievement</b>					
ACT Composite	18.2	16.6	20.8	23.4	22.0
ACT Math	17.9	16.4	20.3	23.7	21.8
ACT Science	18.4	17.1	20.6	22.9	21.8
<b>Mean Number of AP Courses</b>	0.83	0	2.27	3.54	3.12

Table 2. Results

	All Students	More Qualified Students	Less Qualified Students
<b><i>Attending a four-year college</i></b>			
AP Math	0.08*	0.05	0.09*
AP Science	0.11*	0.07*	0.08*
<b><i>Attending a more Selective four-year College</i></b>			
AP Math	0.08*	0.08*	0.03*
AP Science	0.01	0.05	0.00
<b><i>Persisting for two years in a four-year college</i></b>			
AP Math	0.06*	0.10*	0.03
AP Science	0.06*	0.08*	0.03

Note: All numbers are expressed as differences in predicted probability. \*  $p < .05$