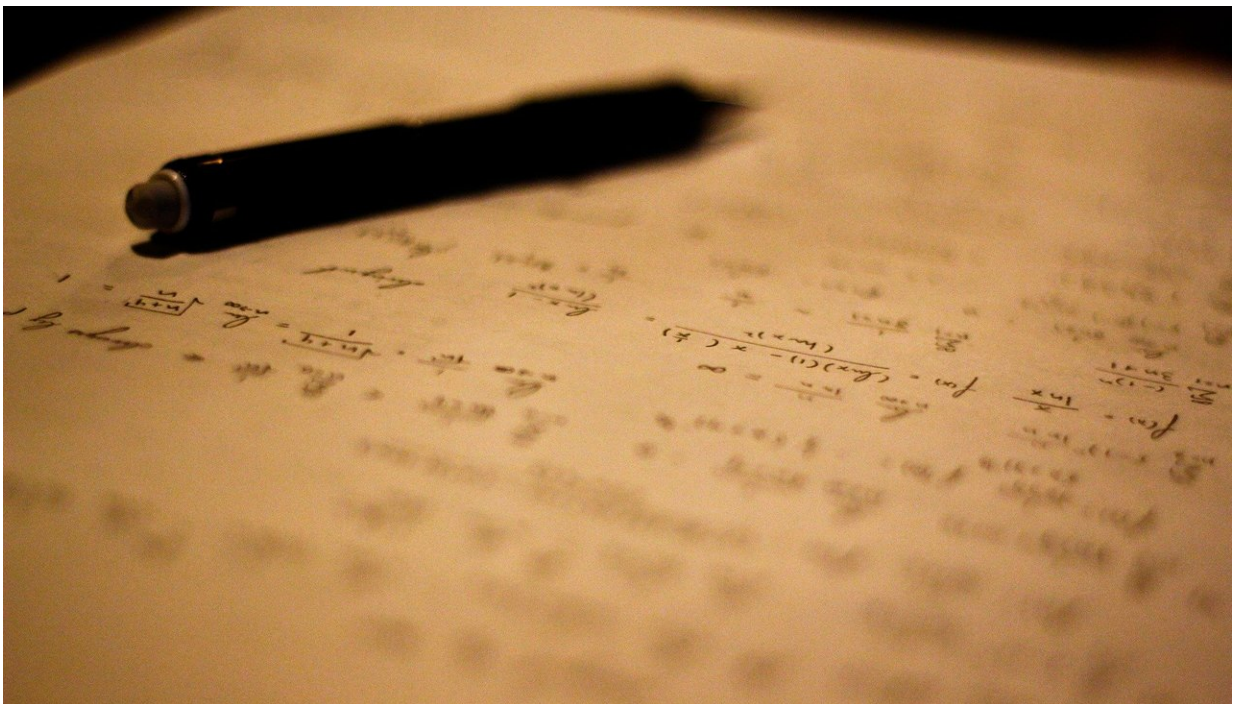


# Study finds that mastering prerequisites—not taking calculus in high school—better predicts success in college

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Calculus.

The word alone is enough strike terror into the hearts of even the most accomplished students, but for those who break out in cold sweats at the

thought of differentiation rules and integral tables, Philip Sadler and Gerhard Sonnert are here to offer some hope.

Contrary to widely-held opinion, taking high school calculus isn't necessary for success later in college calculus—what's more important is mastering the prerequisites, algebra, geometry, and trigonometry—that lead to calculus. That's according to a study of more than 6,000 college freshmen at 133 colleges carried out by the Science Education Department of the Harvard Smithsonian Center for Astrophysics, led by Sadler, the Frances W. Wright Senior Lecturer on Astronomy, and by Sonnert, a Research Associate. In addition, the survey finds that weaker math students who choose to take calculus in high school actually get the most benefit from the class. The study is described in a May 2018 paper published in the *Journal for Research in Mathematics Education*.

"We study the transition from high school to college, and on one side of that there are college professors who say calculus is really a college subject, but on the other side there are [high school teachers](#) who say calculus is really helpful for their students, and the ones who want to be scientists and engineers get a lot out of it," Sadler said. "We wanted to see if we could settle that argument—which is more important, the math that prepares you for calculus or a first run-through when you're in high school followed by a more serious course in college?"

The study's results, Sadler said, provided a clear answer -a firmer grip on the subjects that led up to calculus had twice the impact of taking the subject in high school. And of those who did take calculus in high school, it was the weakest students who got the most from the class.

To get those findings, Sadler and Sonnert, designed a study that asked thousands of college freshmen to report not only demographic information, but their educational history, background and mathematics training.

"They fill out the detailed survey at the beginning of the semester...and there's a field on the last page where the faculty member can put their grade," Sonnert said. "Then the professors remove the first page with the [student](#)'s name and we get their final grade and all the self-reported information."

"We looked at how students did in college calculus...and tried to figure out what the predictive influence of taking a calculus course in high school was versus mastering those pre-calculus subjects," Sadler said. "So, we looked at how those students did in algebra, geometry, and pre-calculus subjects like trigonometry, as well as their SAT and ACT scores, and we combined those into one factor.

That gave us a composite measure of how much they know of the math that's preparatory for calculus," he continued. "Then we looked at the students who had taken the subject in high school and built a statistical model to separate the two."

While it's difficult to pin down an exact reason for why weaker students who took calculus in high school get the most out of it, Sadler suggested that part of the difference may be chalked up to the educational environment of high school calculus.

A high school class, he said, might have just 15 or 20 students, each of whom likely receives constant support from their teacher and homework assignments are turned in daily.

"In some ways, the high school class is probably better supported," Sadler said. "In high school, if you are not doing your work, there is an interim grade that goes home to your parents (so intervention happens when you need it.)"

By the time they arrive in college, however, students might be one of

several hundred in a lecture hall, and their only opportunity for one-on-one contact with the professor comes during office hours. In some cases, attending sections and even completing problem sets is optional, so unless students make an effort to seek out tutoring help, it's easy to fall behind.

"Even Harvard students run into this—they have trouble with learning how to be an independent learner," Sadler said. "But one other difference is that in college the professor just assumes you know all the prerequisites, and if you don't, or you're not really solid in them, then what do you do? They won't go back and cover the things that you may be missing like a teacher can do in high school."

Another reason weaker math students take more from a high school calculus class, Sadler and Sonnert suggested, may be similar—though they may not receive top marks, the high school class gives them a chance to bone up on the basics, so by the time they get to college those students have a stronger mathematical foundation on which to build.

"To some extent, it's like learning a foreign language," Sonnert said. "The more you're exposed to it, the more you do it every day, the more sentences you say, the better your sentences are. So, there may be this practice effect and facility with it that only comes in a college class."

Ultimately, Sadler said, the study's findings don't suggest that students should drop high school calculus altogether, but rather shows that success in the subject—whether in high school or college—comes more from having a strong foundation. That foundation starts early and every year of great math teaching, even as far back as Algebra I in eighth grade, contributes to math proficiency that pays off in college.

"The one thing the paper says is if your background is strong, if you really know your algebra, geometry and pre-calculus, you're going to do

well in college calculus," Sadler said. "You don't need a high school calculus course. That was a surprise. There is no reason that those new to calculus should not take the course in college, in spite of half the students in class having taken it in high [school](#)."

"There are always these kinds of arguments in education, where people have very strong views based primarily on personal experience, and we specialize in investigating those views," Sadler said. "As it turns out, in this case, the professors are more right than [high school](#) teachers, because how well students did in courses before calculus makes the biggest difference in their [college calculus](#) grade. But, the heavy-lifting is done by those math teachers whose efforts lay the foundation for later student success."

Provided by Harvard University

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