#### SHORT COMMUNICATION

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## K-12 CALCULATOR USAGE AND COLLEGE GRADES\*

ABSRTACT. We find that students in the big mathematics service courses at the Johns Hopkins University who were encouraged to use calculators in K-12 have somewhat lower grades than those who weren't.

KEY WORDS: calculators, college grades

### 1. INTRODUCTION

We teach our elementary mathematics courses Calculus I, II, III, and Linear Algebra, in fairly large multi-section courses. Calculators are certainly a big improvement over the slide rule and books of tables. However, none of the mathematical concepts and problem-solving skills we want to impart in these courses require the use of a calculator. Overuse of calculators, especially in the lower grades, might carry some risk with it. Students may not get the necessary feel for the number system needed to progress in mathematics. Many of our students want to use their calculators in our courses. We began to wonder if there were any connections between students' previous experience with calculators and their performance in our basic mathematics courses.

Students at Johns Hopkins University are all very good. Admission is highly competitive and a strong mathematics background is fairly universal. Many of our students have high scores on standardized tests in mathematics

<sup>\*</sup>This short communication, written by two university mathematicians, is published in ESM in the hope that it will start off a discussion among readers on several interesting issues. The authors of the paper state a difference in achievement in university mathematics courses related to the use of calculators in pre-university study of mathematics. It would be interesting to understand the reasons behind this fact. Why this difference in achievement? How is the mathematical thinking with calculators different from mathematical thinking without them? What are the non-calculator mathematics courses teaching that calculator courses don't and vice-versa? The mathematical knowledge and ways of thinking developed with calculators may not be very useful in succeeding in the mathematics courses offered at the university, but perhaps this knowledge is useful elsewhere. What is this knowledge and where could it be useful? ESM readers are welcome to express their opinions and proposals in commentary articles and Letters to the Editor. (Editor's note)



and many have advanced placement in Calculus. We formed the hypothesis that with this group of elite students their previous K-12 calculator experience would have no effect on their grades in their elementary mathematics courses.

# 2. The survey

We set out to test our hypothesis by giving a small survey to our students during their final exam. We asked a very simple question: "In K-12, calculator usage was (1) emphasized and encouraged, (2) was taught but not pushed, or (3) not much at all."

The survey was done in the fall of 2002. The courses surveyed were as follows: 110.105, Introduction to Calculus, our pre-calculus course; 110.106-7, Calculus I and II for Biological and Social Sciences; 110.108 Calculus I for Physical Sciences and Engineering; 110.201, Linear Algebra; 110.202, Calculus III, Calculus of Several Variables.

There were a total of 776 students who finished the surveyed courses with a grade. Of these, we had signed, complete surveys from 663 (85%). Of these 663 students we had mathematics SAT scores for 607 of them. As it was possible that mathematics SAT score was a key factor in determining grades, it was important to control for the effect of this variable in our analysis.

## 3. CONCLUSION

We combined the last two answers for the survey to create a binary categorical variable that, we feel, appropriately segregates the students into high calculator and low calculator emphasis groups. Thus each student had a 0 or a 1 for the variable CALC. It is 0 if they picked (1) in the survey (In K-12, calculator usage was emphasized and encouraged.) and 1 if they picked (2) or (3). (In K-12, calculator usage was not emphasized and encouraged.) The GRADE is the grade at the end of the course on the 4.0 scale (with B+ a 3.3, B- a 2.7, etc). MSAT is the students' mathematics SAT score.

Regression analysis led to the following fit to the data:

 $GRADE = CONSTANT + CALC \times .2046 + MSAT \times .0036.$ 

The *p*-value for MSAT is 0.0000 and the *p*-value for CALC is 0.01. The CALC *p*-value is significant. From this, it appears that calculators have an effect on grades. We proceed to quantify the magnitude of this effect.

We first note that CALC has the same effect on the grade that 57 points of the mathematics SAT has. This, of course, does not make the result

meaningful. It is the effect on grades that makes it meaningful. With plus and minus grades, a notch on the grade scale is, on average, 0.33. A notch on the grade scale is definitely meaningful to our students. Of our 607 students surveyed, 268 (44%) were self-declared that "In K-12, calculator usage was emphasized and encouraged." On average, their grades were 0.20 lower. One way to achieve this outcome is for 162 of these 268 students to have one grade notch lower. That is, 27% of all the students in the survey. Although there are other ways to achieve this numerical outcome, it is clear that our hypothesis was wrong.

Much to our surprise, we must conclude that there is a (negative) connection between our college mathematics grades at Johns Hopkins University and heavy calculator usage in K-12.

Calculators clearly have a place in the classroom but we suspect that they are sometimes misused.

### 4. DISCUSSION

Mathematics education research is not our area of research or expertise. This study should be considered a small pilot study. Our survey question was rather blunt. If our students are asked if calculator usage was encouraged and emphasized for 1 year or more (asked informally in class), then the number shoots way up over the 44% obtained here. From this we deduce that the students' interpretation of the question was one of pretty heavy calculator usage. A refinement of this question would be nice and give more insight into the results.

Johns Hopkins University is a rather limited universe. It would not be difficult to do similar studies at other places. Giving the survey with the final exam does guarantee a fairly captive audience. The majority of high school graduates now go on to college. Thus most K-12 programs are college preparatory by default. The success of mathematics programs in K-12 should be judged by how well students do in college. Grades are only one place to look. The first thing entering students get is a placement exam in mathematics. So, to a large extent, K-12 is preparing students for this placement test as the next step in their careers. Most college mathematics departments would be happy to put a series of questions about calculator usage on their placement test. The results would be interesting no matter how they fell.

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