Public School Students Left Behind: Contrasting the Trends in Public and Private School Computer Science Advanced Placement Participation

Kevin Freisen, Tim Sanders, and Jennifer S. Kay
Rowan University, freise29@students.rowan.edu, sander80@students.rowan.edu, kay@rowan.edu

Abstract - **Across the United States, interest in computer science as a major is down, as are the number of Bachelor's degrees in computer science. While there are obvious factors like the dot com bust that may explain much of our communal enrollment crash over the last few years, anecdotal reports also suggest that the No Child Left Behind act of 2001 (NCLB), and specifically the fact that computer science is not an area that students are tested on, may be a factor in the decreased presence of computer science at the high school level. But how can we empirically separate the effect of the dot com bust from that of NCLB given the proximity in time of the two events? This paper presents a first attempt to do so: recognizing the fact that private schools are exempt from NCLB, it seems appropriate to compare public school students with their private school counterparts. We present some initial results of our investigation focusing on our home state of New Jersey. This paper discusses these results and further directions of study.**

Index Terms – Advanced Placement, Computer Science Education, K-12 Education, No Child Left Behind.

INTRODUCTION

While there are some bright spots, the general state of computer science Education in North America is pretty grim. The total number of computer science related courses offered in high schools is on the decline, [1] and the picture is not much brighter at the college level. Overall Bachelor's Degree production in computer science has continued to drop at a fairly steady pace since 2004, though there are some indications that we may have hit bottom. [2]

This occurs at a time when we need more students learning about computer science – not fewer! There is general consensus that computational literacy is becoming more and more critical to the success of our students as they graduate. Furthermore, there are those who argue persuasively that a basic understanding of programming is also an essential part to computational literacy. [3]

Beyond concerns about literacy, our nation is in need of computer professionals. While programming jobs are expected to decline, the need for professionals trained in various fields of computer science is expected to grow much faster than the average for all occupations. Indeed, the U.S. Bureau of Labor Statistics projects that Computer Software Engineer will be one of the fastest growing professions in the nation. [4]

Many attribute the declines in computer science enrollments to the dot com bust. We also wonder whether the No Child Left Behind Act of 2001 (NCLB) [4] might be a significant factor. Could legislation intended to improve overall student performance actually be reducing their opportunities to study computer science at the high school level?

BACKGROUND AND RELATED WORK

The No Child Left Behind Act (NCLB) (formally referred to by the U.S. Department of Education as the Elementary and Secondary Education Act) [6] sets laudable goals for states to achieve: all students will "attain proficiency or better in reading/language arts and mathematics," "be taught by highly qualified teachers," "be educated in learning environments that are safe, drug free, and conducive to learning," and "will graduate from high school." [7] However NCLB has many critics who are concerned that the focus on language arts and mathematics has resulted in a decreased focus on all other subjects.

Changes have been reported in the arts education curriculum under NCLB. [8] It seems likely that computer science has been affected too; in a National Study of 349 school districts, the Center on Education Policy found that 78% of districts have changed their mathematics curriculum at the high school level to emphasize NCLB tested content and skills.[9] While the field of computer science is not mentioned specifically, there is definite cause to consider that NCLB may be responsible for cuts in computer science instruction. Anecdotally, NCLB's negative impact on computing education has been reported as early as the elementary school level. [10]

In March 2010 the US Department of Education put out "A Blueprint for Reform: The Reauthorization of the Elementary and Secondary Education Act." [11] The document does recognize that "students need a well-rounded education to contribute as citizens in our democracy and to thrive in a global economy – from literacy to mathematics, science, and technology to history, civics, foreign languages, the arts, financial literacy, and other subjects." Indeed there are provisions for grants to help states improve their STEM programs and other curricula. However, beyond English and Mathematics, only Science seems to be slated for intense

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scrutiny: "States and districts will collect and make public data relating to student academic achievement and growth in English language arts and mathematics, student academic achievement in science, and if states choose, student academic achievement and growth in other subjects, such as history."

The US is sorely in need of better standards for computer science education; *Running on Empty,* a 2010 report jointly sponsored by the Association for Computing Machinery and The Computer Science Teachers Association reports that "roughly two-thirds of the country have few computer science education standards for secondary school education…" [12] One might imagine that the added focus on science might have an impact on computer science education, but it seems unlikely given that "most states treat high school computer science courses as simply an elective and not part of a student's core education." [12]

ASSESSING THE IMPACT OF NO CHILD LEFT BEHIND

How can we empirically separate the effect of the dot com bust from that of NCLB given the proximity in time of the two events? This paper presents a first attempt to do so: recognizing the fact that private schools are exempt from NCLB, it seems appropriate to compare public school students with their private school counterparts.

The work presented here focuses on our home state of New Jersey. We used two sources for our data. The first, the New Jersey Department of Education's "New Jersey School Report Card" [13] is a source of detailed information about NJ Public Schools with data beginning in the 1994-1995 academic year. This provides, among other things, information not only on the number of public school students taking advanced placement exams in different subjects, but also on the number of students enrolled in AP courses at public schools. Our second data source, the College Board's Summary Reports, [14] provides data about Advanced Placement participation on a state-by-state basis beginning in 1997. This data includes information on public vs. non-public school participation.

TRENDS IN AP COMPUTER SCIENCE EXAM PARTICIPATION

We began our analysis by looking at the overall trends in the Computer Science Advanced Placement (AP) exams over the last several years. We considered both the Computer Science A exam (AP-CS-A), as well as the Computer Science AB exam (AP-CS-AB), which was discontinued in May 2009. [15] The College Board's decision to discontinue this exam was made in part because of a steady decline in annual student participation over the course of the 5 preceding years. [15] The College Board described the differences between the two exams as follows: "The AP CS A course emphasizes object-oriented design and problem solving and covers the topics listed in the Topic Outline. In addition to covering the material in AP CS A, AB students study formal analysis of algorithms (Big-Oh notation); advanced data structures, including two-dimensional arrays, linked lists (singly, doubly, circular), stacks, queues, trees, heaps, priority queues, sets, and maps; and more advanced algorithm development dealing with these advanced data structures." [16]

Looking at the trends in the AP-CS-A and AP-CS-AB exam participation, it is clear that there was a significant drop following the 2001 administration of the exam (see Figure 1). While the numbers for AP-CS-A increased dramatically in 2010, we believe that increase can probably be attributed to the discontinuation of the AP-CS-AB exam rather than a sudden spike in interest in AP-CS-A.

So how does the decline in computer science compare with other fields? We decided to take a look at the AP Calculus exams, AP-CALC-AB and AB-CALC-BC. Perhaps the trends are similar. As is evident in Figure 2, this is not the case.

Given the dramatic contrast between the trends in Computer Science and Calculus Advanced Placement participation, we felt it would be valuable to split out the public school data and see if the trends in the public and non-public schools have been similar, since only public schools are subject to NCLB. While we are not prepared to claim that these results conclusively place blame on NCLB, the data are certainly interesting. Figures 3 shows the trends for the Calculus AB exam split by school type. The popularity of Calculus AB seems to be on an upward trend. The slope of the public school participation graph is steeper than that of non-public, but there does not appear to be any sudden shift around 2001. The graphs for the Calculus BC exams are equally uninspiring. Due to space limitations, we are unable to include the graph in this paper, but interested readers may find it in an online appendix located at http://www.rowan.edu/~kay/fie2011

In contrast to the Calculus exams, the differences between public and non-public participation in the Computer Science A and Computer Science AB Advanced placement exams are quite dramatic as shown in Figures 4 and 5. Non-public school students do not seem to have seen much of a change in 2001 in either exam, but both exams saw a steep decline in public school participation beginning in 2001.

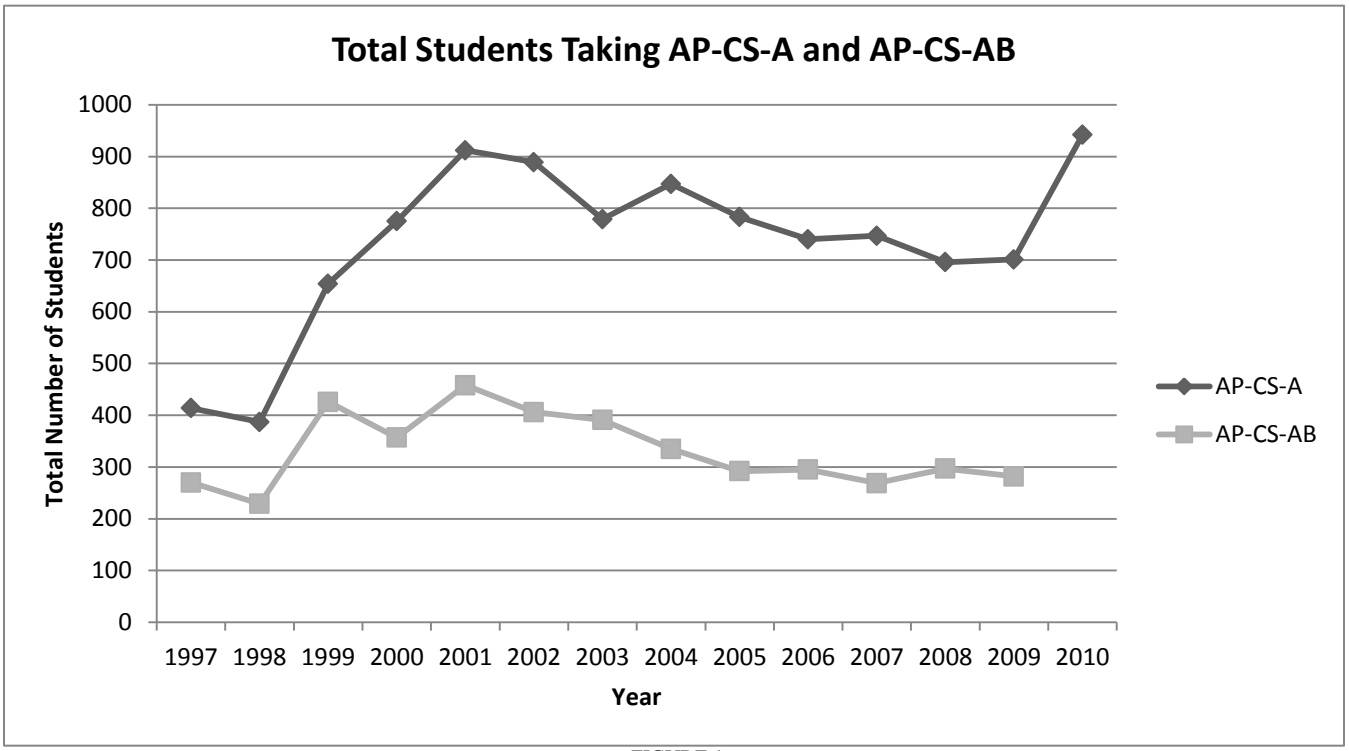

FIGURE 1

THE TOTAL NUMBER OF STUDENTS TAKING ADVANCED PLACEMENT EXAMS IN COMPUTER SCIENCE HAS BEEN FALLING SINCE 2001. WE BELIEVE THE SPIKE IN AP-CS-A IN 2010 IS THE RESULT OF THE FACT THAT THE AP-CS-AB EXAM WAS DISCONTINUED IN 2009 RATHER THAN A SUDDEN INCREASE IN INTEREST.

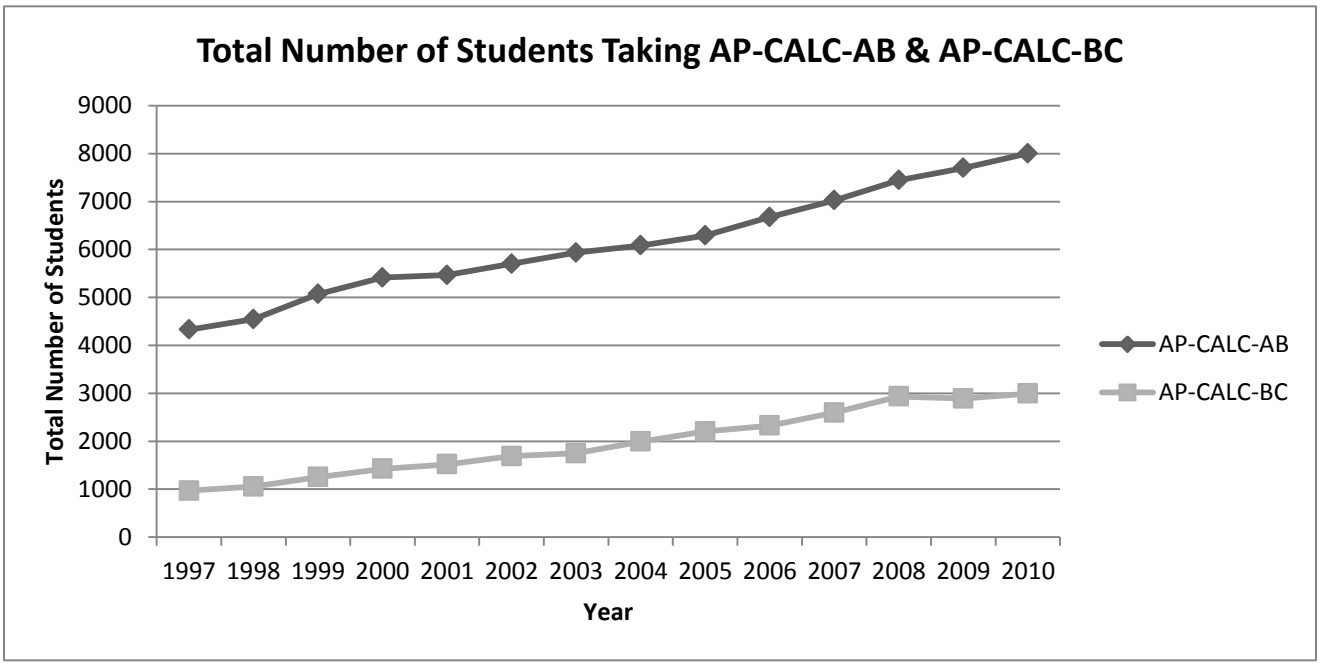

FIGURE 2

IN CONTRAST TO THE TRENDS WE SEE IN THE COMPUTER SCIENCE ADVANCED PLACEMENT EXAMS, THE TOTAL NUMBER OF STUDENTS TAKING ADVANCED PLACEMENT EXAMS IN CALCULUS HAS BEEN STEADILY INCREASING OVER THE YEARS. NOTE THAT THE VERTICAL SCALES ON THESE TWO FIGURES DIFFER SIGNIFICANTLY.

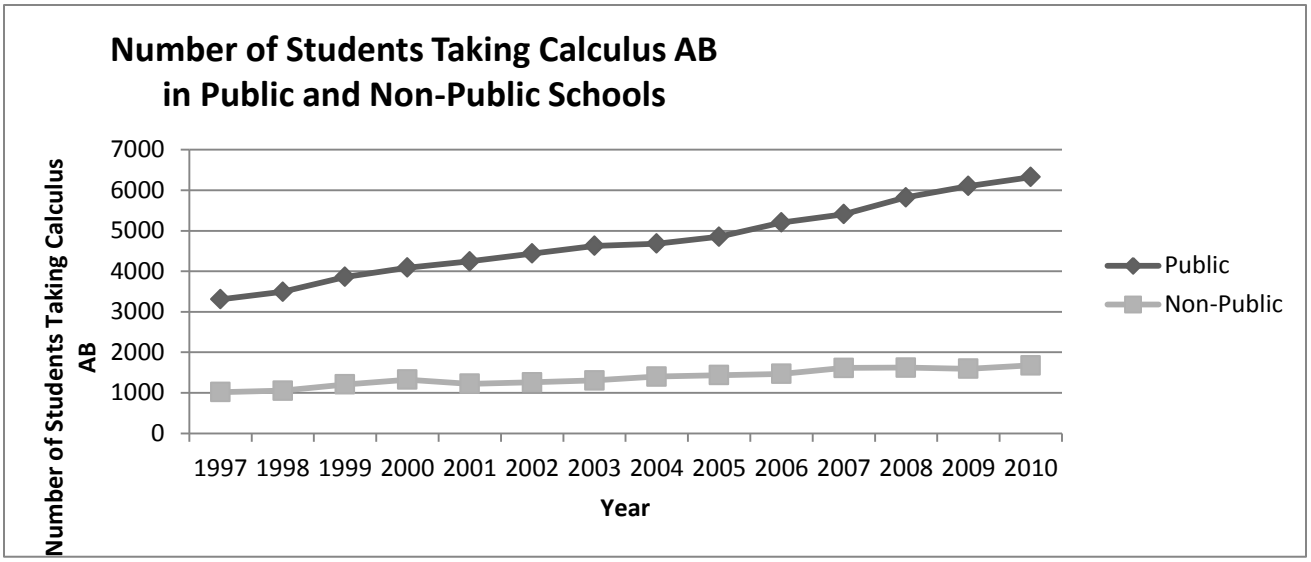

FIGURE 3

THE TRENDS IN BOTH PUBLIC AND NON-PUBLIC PARTICIPATION IN THE CALCULUS AB EXAM SEEM TO BE QUITE STEADY

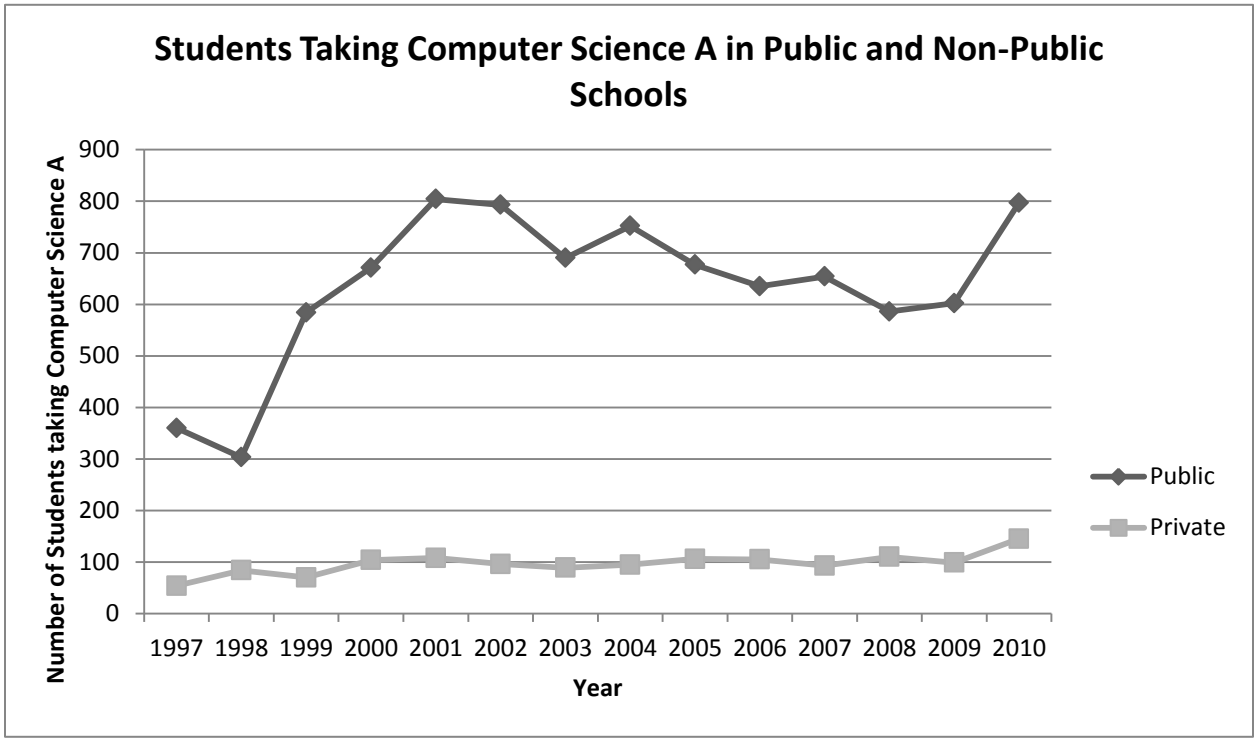

FIGURE 4

THE CONTRAST BETWEEN THE TREND IN PUBLIC AND NON-PUBLIC SCHOOLS FOR THE COMPUTER SCIENCE A ADVANCED PLACEMENT EXAM IS QUITE STRIKING. RECALL THAT THE FINAL DATA POINT FOR 2010 IS LIKELY THE RESULT OF THE CANCELATION OF THE AP-CS-AB IN 2009

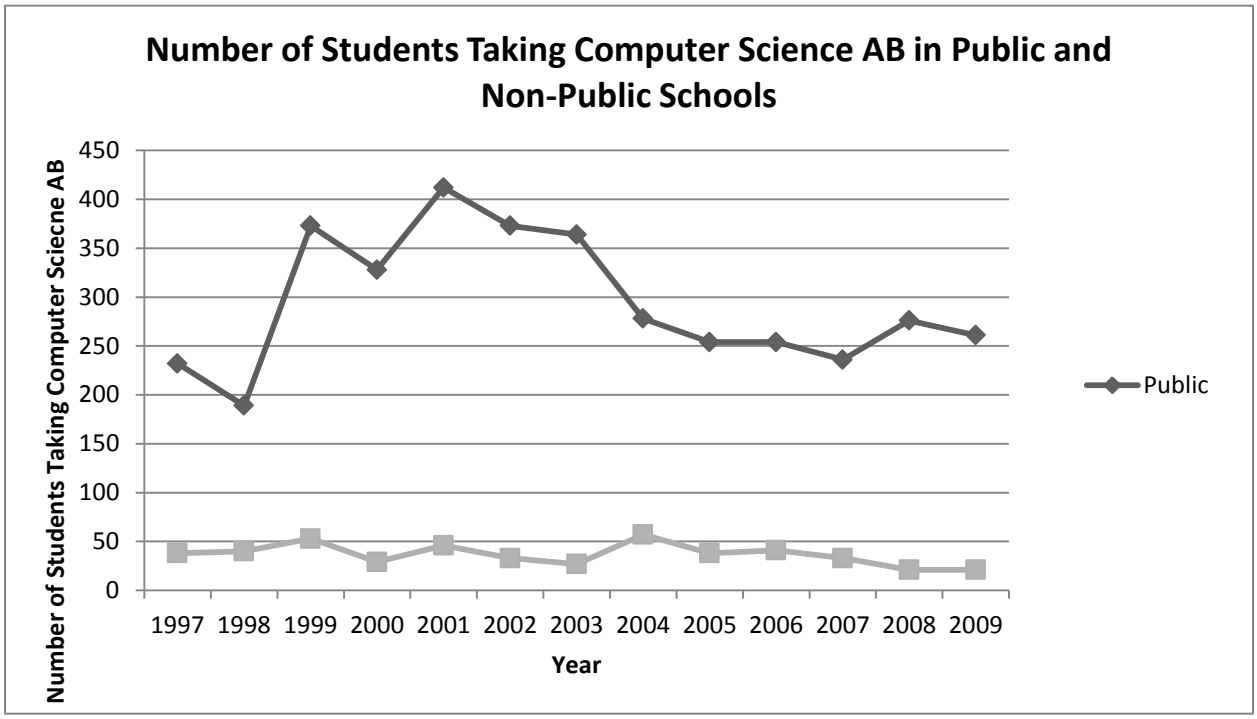

FIGURE 5
THE CONTRAST BETWEEN THE TREND IN PUBLIC AND NON-PUBLIC SCHOOLS FOR THE COMPUTER SCIENCE AB ADVANCED PLACEMENT EXAM PRIOR TO ITS CANCELATION SEEMS TO MIRROR THAT OF THE COMPUTER SCIENCE A EXAM.

THE EFFECT OF SOCIOECONOMIC STATUS ON COMPUTER SCIENCE ADVANCED PLACEMENT PARTICIPATION

The results presented to this point are based on data from the College Board. But we felt it would be interesting to look in more detail at the trends in the public schools and see whether this effect was solely one of socio-economic status. Fortunately the "New Jersey School Report Card" data [13] include a District Factor Group code for each school district in the state. District Factor Groups are updated every 10 years based on census data, and "represent an approximate measure of a community's relative socioeconomic status (SES.)" [17] District Factor Group Codes range from A (lowest) through J (highest).

Figure 6 splits out the participation in the Computer Science A exam by District Factor Group, showing the top two (J&I) along with the bottom two (B and A) . Note that in order to normalize the various graphs, each number is reported as a percentage of the total number of students in that group. As might be expected, the more affluent districts (J & I) seem to dominate the participation. It appears that whatever the cause of the 2001 AP Computer Science Crash, the more affluent districts were more strongly affected than the lesser ones. A complete graph showing all of the district factor groups can be found in the online appendix at http://www.rowan.edu/~kay/fie2011

DISCUSSION

The data presented lead to two categories of questions. The first class of questions are relatively straightforward and have well-defined answers. This class includes questions such as:

- Do other states show the same relationships between public and non-public schools for Computer Science and Calculus as NJ?
- Do advanced placement exams for other subjects not tested by NCLB show similar trends in NJ and/or across the nation?

The answers to these questions are in the data, just waiting to be mined, though much of the mining requires a bit of a brute force approach – each state has its own form of assessment and presentation of results. Nevertheless it is clear that there is a straightforward path to the answers.

After seeing such a shocking contrast between AP trends in computer science and calculus, we decided to take a look at the other AP exams within NJ and try and find some answers. We expected that subjects like art history, government and politics, and music theory might show similar trends to computer science. To our surprise, they did not. While there are several subjects that show dips around 2000 or 2001, none show as dramatic a contrast as computer science. A full set of these graphs can be seen in our on-line appendix at http://www.rowan.edu/~kay/fie2011

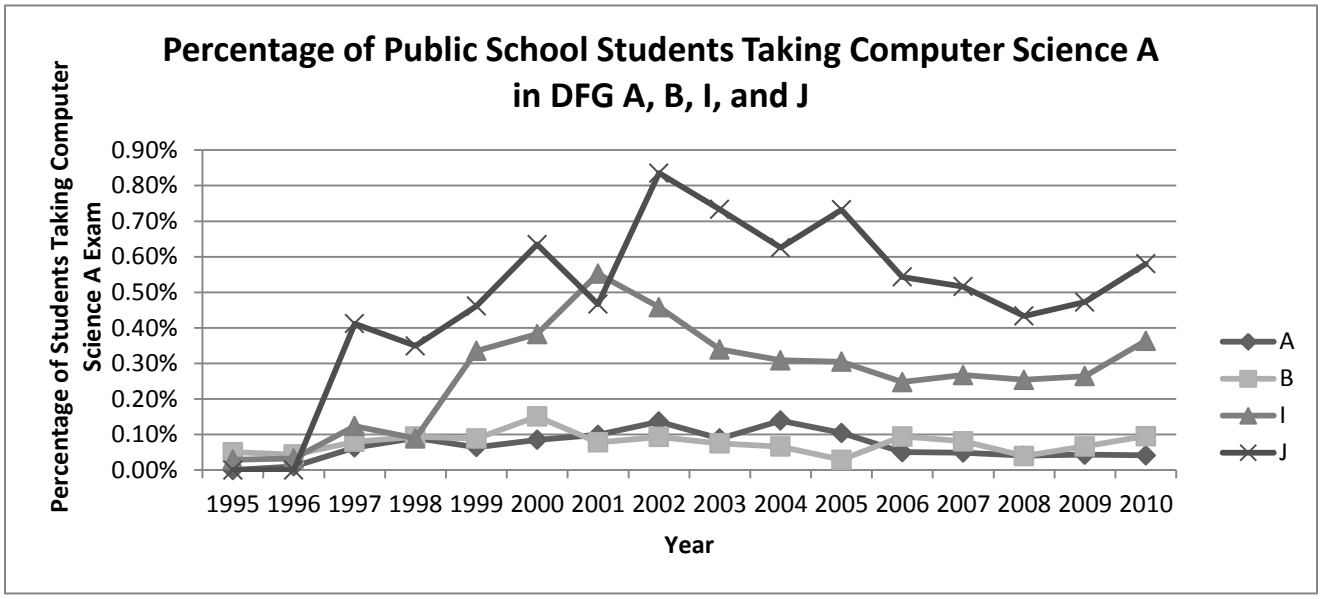

FIGURE 6

PUBLIC SCHOOL PARTICIPATION BY DISTRICT FACTOR GROUP. SHOWING THE TOP AND BOTTOM TWO DFGS.

Thus we arrive at the second, more difficult category of questions such as:

- Has NCLB had a significant effect on K-12 computer science offerings in NJ and across the country?
- Did the dot com bust have a significant effect on computer science offerings?
- What are the other factors that influence computer science education in America?

Despite the fact that our findings for the other AP exams do not show the same trends as computer science, the data shown in figures 4 and 5 remain compelling. However, the contrast with the other AP exam data leaves us searching for additional factors that contribute to the sad state of K-12 computer science in NJ and much of the country. How can we begin to approach these questions?

SEARCHING FOR ANSWERS

Computer science as a field faces many challenges, not least of which is its dismal reputation with America's youth who view computer science to be difficult, tedious, boring, irrelevant, and asocial. [18] [19] What is not clear is whether these poor perceptions of computer science are the result of insufficient exposure to computer science in schools, or are actually a factor in why schools and states fail to give computer science the attention it deserves.

The *Running on Empty* report [12] from ACM and CSTA mentioned above presents a plethora of problems with state and national computer science education policy that clearly affect secondary schools across the country. Three, however, stand out: first, the fact that computer science is not part of the "core" curriculum required for graduation in most states; next, the fact that most states do not have adequate (if any) computer science standards; and third, the fact that many states do not have certification programs for computer science teachers, and those that do are "deeply flawed."

Finally, while we certainly would not claim that the data presented above definitively shows a relationship between the NCLB legislation and Computer Science Advanced Placement Exam Participation, we do feel that further study of the effects of NCLB on computer science is warranted. We hope that this work will further the discussion of all of the reasons that computer science has lost popularity and help to begin work on a recovery.

REFERENCES

[1] Radev, D., and Levin, L. 2009. Engaging High School Students in Interdisciplinary Studies, *Computing Research News*, 21(4).

[2] Zweben, S. 2010. "Undergraduate CS Enrollment Continues Rising; Doctoral Production Drops," *Computing Research News*, 22(3), May 2010.

[3] Forte, A., and Guzdial, M. 2005. Motivation and Nonmajors in Computer Science: Identifying Discrete Audiences for Introductory Courses, *IEEE Transactions on Education*, 48(2), 2005, pp. 248-253.

[4] "Professional and Related Occupations," http://www.bls.gov/oco/oco1002.htm#comp, accessed April 2011.

[5] "The Elementary and Secondary Education Act (The No Child Left Behind Act of 2001)," http://www2.ed.gov/policy/elsec/leg/esea02/index.html, accessed June 2011.

[6] "No Child Left Behind – ED.gov," http://www2.ed.gov/nclb/landing.jhtml?src=ln, accessed June 2011.

[7] "Consolidated State Information," http://www2.ed.gov/admins/lead/account/consolidated/index.html, accessed June 2011.

[8] Spohn, Cydney, "Teacher Perspectives on No Child Left Behind and Arts Education: A Case Study", *Arts Education Policy Review*; Vol. 109, No. 4, March 2008.

[9] McMurrer, Jennifer, Choices, Changes, and Challenges: Curriculum and Instruction in the NCLB Era, Report from the Center on Education Policy, http://www.cep-dc.org/_data/n_0001/resources/live/07107%20Curriculum-WEB%20FINAL%207%2031%2007.pdf, accessed April 2009.

[10] Meier, Deborah, Kohn, Alfie, Darling-Hammond, Linda, Sizer, Theodore R., Wood, George, et al, *Many Children Left Behind: How the No Child Left Behind Act is Damaging Our Children and Our Schools*, Beacon Press, 2004.

[11] *A Blueprint for Reform: The Reauthorization of the Elementary and Secondary Education Act,* U.S. Department of Education, March 2010, http://www2.ed.gov/policy/elsec/leg/blueprint/blueprint.pdf

[12] "Running on Empty," http://csta.acm.org/runningonempty/fullreport.pdf Association for Computing Machinery and Computer Science Teachers Association, accessed April 2010.

[13] "New Jersey Department of Education | School Report Card", http://education.state.nj.us/rc/index.html, accessed April 2011.

[14] "AP Exam Grades: Summary Reports: 2009[sic]", http://www.collegeboard.com/student/testing/ap/exgrd_sum/2010.html, accessed April 2011.

[15] "AP Central – Important Announcement about AP Computer Science AB," http://apcentral.collegeboard.com/apc/public/courses/teachers_corner/195948.html, accessed April 2011.

[16] "AP Central – AP FAQs," http://apcentral.collegeboard.com/apc/Pageflows/FAQ/VwDetailFAQ.do?faqid=1163, accessed April 2011.

[17] "NJ Department of Education District Factor Groups (DFG) for School Districts," http://www.state.nj.us/education/finance/sf/dfg.shtml accessed April 2011.

[18] Guzdial, M. 2009. Education: Teaching computing to everyone. *Commun. ACM* 52, 5 (May. 2009), 31-33.

[19] Yardi, S. and Bruckman, A. 2007. What is computing?: bridging the gap between teenagers' perceptions and graduate students' experiences. In *Proceedings of the Third International Workshop on Computing Education Research* (Atlanta, Georgia, USA, September 15 - 16, 2007). ICER '07. ACM, New York, NY, 39-50.

AUTHOR INFORMATION

Kevin Freisen, Undergraduate Computer Science Student, Rowan University, freise29@students.rowan.edu

Tim Sanders, Computer Science Masters Student, Rowan University, sander80@students.rowan.edu

Jennifer Kay, Associate Professor, Computer Science Department, Rowan University, kay@rowan.edu