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Evaluation of the IMPACTS Computer Science Presentations

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Abstract

Recent computer science enrollments have shown positive trends. However, these trends are not evenly distributed by gender and race. Efforts to recruit underrepresented students should focus on providing information that demystifies the field of computer science. This paper reports on such an effort to inform underrepresented high school students about the field and its diversity. The results suggest that increasing awareness in an enjoyable format can increase student interest in pursuing computer science. These results can provide guidance about ways to encourage students to take high school computer science classes as motivation and preparation for college-level computer science.

1. Background

From the mid-part to the end of the last decade, the number of computer science bachelor degree graduates dropped by about one-third from a high of 59,000 in 2004 to a low of 38,000 in 2009 (National Center for Education Statistics, 2012b) (see Figure 1). This is the second time in the past 30 years that the number of computer science graduates reached a peak and then dropped significantly. The previous peak was 42,000 in 1986 followed by a 40% drop in graduates over a nine-year period to 25,000. These peaks seem to correspond to significant computing trends. The growth to the first peak occurred during the dawn of the personal computer revolution, marked by the start of Apple in 1976. The growth to the second peak occurred during the explosion of the Internet, marked by the initial public offering of Netscape in 1995.

In the most recent statistics from the National Center for Education Statistics, the number of computer science graduates halted the downward trend and showed an increase in 2010 to almost 40,000 (National Center for Education Statistics, 2012b). Likewise, the 2010–11 annual Taulbee survey, which tracks computer science enrollment trends at PhD-granting institutions, shows a three-year increase in the number of computer science graduates (Zweben & Bizot, 2012). It remains to be seen whether the current increases will continue or it is simply a minor peak that will either level off or reverse directions and continue the long-term declines in computer science graduates.

One indicator that the turnaround will continue comes from data about the number of high school students taking the AP computer science exam (College Board, 2012). Since AP computer science courses serve as a conduit for inspiring students to major in computer science (Margolis & Fisher, 2002), the trends in AP test takers are likely to be reflected in college graduate trends four to five years later, given the typical length of time between AP tests and completing a college degree. The number of AP Computer Science A test takers reached a peak in 2001, three years before the peak and subsequent decline in computer science majors (see Figure 2). The number of AP Computer Science A test takers reached a trough in 2005 and has increased by 84% through 2012. This upward trend in AP test takers starting in 2006 seems to suggest that the uptick in computer science graduates will continue for the foreseeable future.

These trends in total computer science majors and AP test takers are not evenly reflected across gender and racial groups. The overall trend in the number of female computer science graduates and AP test takers has the same general pattern as the number of male computer science graduates and AP test takers. However, the percentage of computer science degrees awarded to women has steadily declined from a high of 37% in 1985 to 18% in 2010. Similarly, the percentage of female AP test takers was at a peak of 20% in 1997 and dropped to just under 16% in 2003.

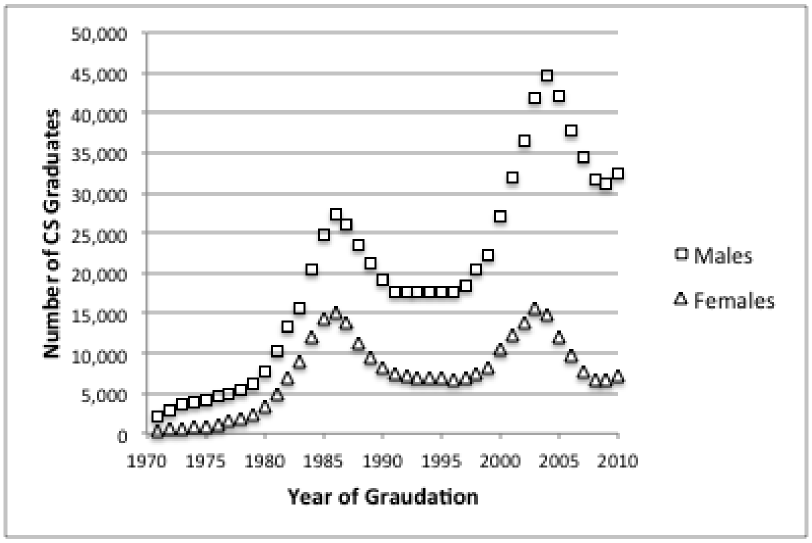

Figure 1: Forty-Year Trend in Computer Science Graduates

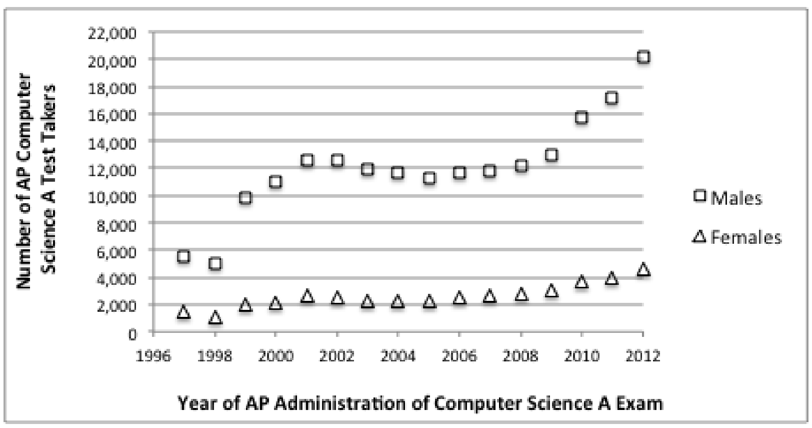

Figure 2: Sixteen-Year Trend in AP Computer Science A Test Takers

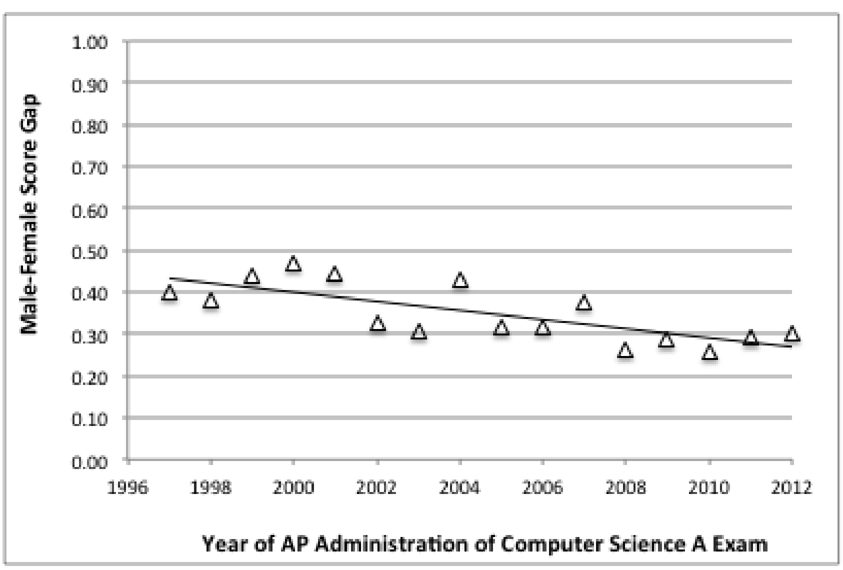

Figure 3: Sixteen-Year Trend in Gender AP Computer Science A Score Gap

The percentage of female AP test takers has since been on an upward trend to just under 19% in 2012, representing a near-recovery to the peak of 1997. In addition, the caliber and preparation of female AP test takers has been on the rise as the gap between male and female AP test scores has steadily declined from a high of almost half a point in 2000 to less than one-third of point in 2012 (see Figure 3). If the upward trend in both the percentage of female AP test takers and the performance of female AP test takers is reflected in future computer science majors, the percentage of female graduates should begin to trend upward.

The overall trend for the number of black and Hispanic computer science graduates has the same general pattern as the number of Caucasian computer science graduates (National Center for Education Statistics, 2012a) (see Figure 4). Like the overall trend in computer science enrollments, the number of black and Hispanic computer scientists has shown an increase in 2010. But, unlike the declining percentage of women, the percentage of black and Hispanic computer science graduates has steadily increased since 1992 when the U.S. Department of Education began tracking bachelor degrees by race. The percentage of black computer science graduates has increased by about one-third (8.7% to 11.5%) and is close to the percentage of black citizens in the overall population in 2010 (12.3%, U.S. Census Bureau, 2011). The percentage of Hispanic computer science graduates has doubled (3.7% to 7.4%), but is still less than two-thirds of the percentage of the Hispanic citizens in the overall population in 2010 (12.5%, U.S. Census Bureau, 2011).

The number of black and Hispanic AP Computer Science A test takers has also been steadily increasing since 1997. The number of black AP test takers has more than tripled, and the number of Hispanic test takers has seen a nearly six-fold increase during that timeframe (see Figure 5). However, even with the increase, the percentage of black AP test takers has remained stable between 4% and 5% of the AP test takers, well below the representation of black computer science graduates. On the other hand, the percentage of Hispanic AP test takers has increased during that same time period (from 4.3% to 7.7%), consistent with the percentage of Hispanic computer science graduates.

Although the number and percent of black and Hispanic AP test takers has steadily increased, the gap between black/Hispanic AP scores and Caucasian scores has hovered around 1.3 points for black students and around 0.9 for Hispanic students (see Figure 6). Given the increasing trend in black and Hispanic AP Computer Science Test A takers it is likely that the trend in computer science graduates will continue to rise. On the other hand, the disparity in preparation between Caucasian students and the black and Hispanic students, as measured by the AP test score gap, may mitigate the transition of black and Hispanic high school students into computer science majors.

2. Recruiting Underrepresented Computer Science Students

These promising trends in the number of AP Computer Science A test takers and the number of computer science graduates provide some optimism for overall growth in computer science graduates. However, much work needs to be done to increase the percentage of female and minority computer science graduates. While there has not been a great deal of research on the reasons for the racial gap in computer science graduates, there has been a great deal of research on the reasons for the gender gap in bachelor degrees in computer science.

Researchers have found that the main difference between boys and girls is not due to differences in attitudes toward technology (Meelissen, 2008). Instead, gender differences exist in the nature of technology use between boys and girls. Girls find computers more interesting when they are used for practical applications (Christensen, Knezek, & Overall, 2005; King, Bond, & Blandford, 2002). In contrast, computer instruction in both high school and college has tended to focus on the abstract fundamentals of computing, which is more appealing to boys (Margolis & Fisher, 2002). Computer scientists at Carnegie Mellon University have made progress at increasing the representation of women in computer science at Carnegie Mellon by making changes to the nature of instruction in their introductory courses. Faculty significantly changed the course assignments to highlight problem solving as a primary component and technical fluency as a secondary component (Margolis & Fisher, 2002).

In addition to changing the nature of the coursework in computer science, researchers have focused on the need to broaden the recruitment of students into computer science. Although boys tend to receive greater encouragement in the use of computers than girls, the effect of encouragement is stronger on girls (Meelissen, 2008). Therefore, it is important to begin the recruitment process early by encouraging girls to take computer science courses in high school (Margolis & Fisher, 2002). It is also valuable to recruit girls in groups, such as through sports teams, and to have girls recruit their peers.

In addition to recruiting students directly, it is valuable to educate counselors on how to encourage girls (Solomon, 2006). Counselors tend to steer

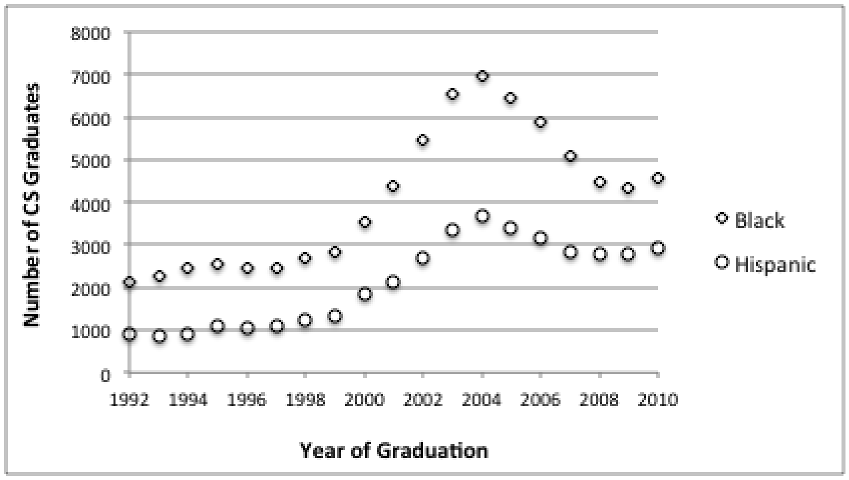

Figure 4: Nineteen-Year Trend in Computer Science Graduates

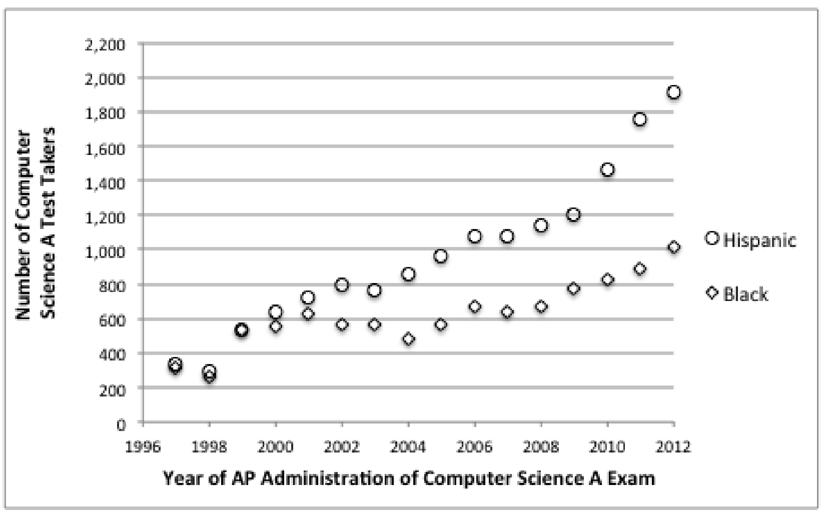

Figure 5: Sixteen-Year Trend in AP Computer Science A Test Takers

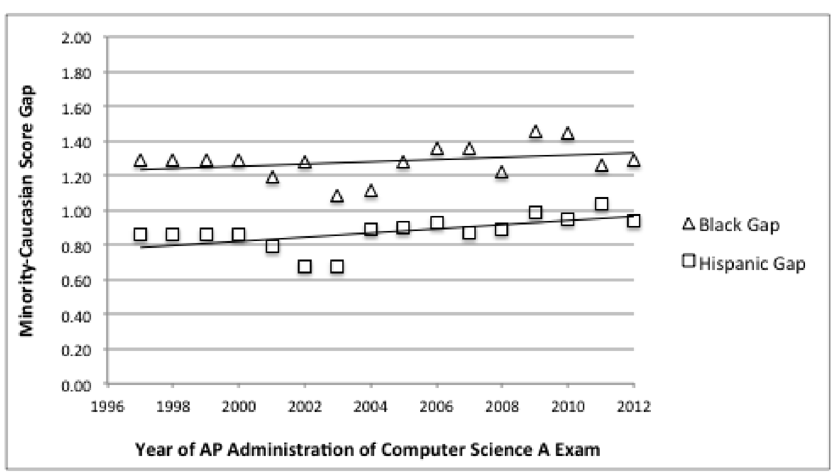

Figure 6: Sixteen-Year Trend in Racial AP Computer Science A Score Gap

students away from computer science if they do not have a strong math background (Babin, Grant, & Sawal, 2010). However, other computer science programs have been successful with students having only a basic understanding of algebra.

It is valuable to recruit students both through courses that may feed into computer science such as math or business classes as well as through classes that appeal more to girls, such as humanities (Margolis & Fisher, 2002). A recent Intel survey about teenagers' interest in engineering careers suggests that providing basic information about the field of computer science during these recruitment sessions can significantly increases students' interest in the field as a career (Intel, 2011). Therefore, it is important in the recruitment process to highlight the diversity of people in the field of computing, the types of problems that computer scientists work on, and the availability of computing jobs (Babin et al., 2010).

It is within this context that computer scientists at Loyola University Chicago, University of Illinois at Chicago, Illinois Institute of Technology, and University of Illinois at Urbana-Champaign undertook the IMPACTS initiative (Improving Metropolitan Participation to Accelerate Computing Throughput and Success) to educate Chicago-area high school students and teachers about the computing field and its diversity. The computer scientists developed a standardized set of presentation materials that could be used in a variety of contexts to present high school students with information about the field of computing. The program initially ran under the title IMPACTS and later adopted the title "Illinois Computes" for ongoing efforts of a similar nature[1].

The primary goals of the IMPACTS presentations were:

1. To provide an interesting and enjoyable learning experience.
2. To increase students' awareness of the computing field and its diversity.
3. To spark interest in the science of computing and challenges of problem solving.

The design of the components of the IMPACTS presentations were based somewhat on the Carnegie Mellon Road Show, which was developed by women computer science graduate students at Carnegie Mellon and used to encourage high school girls to pursue careers in computer science (Frieze, 2005; Frieze & Treat, 2006). Consistent with the structure of the Carnegie Mellon Roadshow, the IMPACTS presentations focused on demonstrating areas of computer science research, showing the diversity of people involved in computer science, identifying the availability of computer science jobs, and providing advice on preparing for a career in computer science. Below is a description of the IMPACTS presentation components that each presenter could customize based on his or her style, availability of time, and the needs of the target audience.
(see http://www.illinoiscomputes.org/hspresent)

What is computer science about? Presenters used Internet websites, YouTube videos, and presentation materials from various sources, including the pioneering Carnegie Mellon Roadshow, to demonstrate a wide variety of computing application areas such as Internet, email, speech recognition, cryptography, life-science computing, entertainment, web design, visualization techniques, and technologies to assist people with disabilities. In particular, a strong emphasis was generally placed on robotics videos, because they tend to be highly engaging. Additionally, presenters usually performed at least one entertaining magic trick based on computing concepts.

Who does computer science? Presenters demonstrated the diversity of people working in computer science through a pictorial quiz. The quiz came in the form of four web pages, each picturing four to six people representing computer scientists and non-computer scientists. The pictures of people who were not computer scientists were of public personalities who could potentially be recognizable to the students. The representative computer scientists included both males and females from a variety of races, and they were sometimes engaged in non-stereotypical activities. The CMU Roadshow was a key resource for many of the best pictures. The IMPACTS slide show included an even greater variety of computer scientists than the CMU Roadshow. The students were challenged to identify which people were not computer scientists.

Are there jobs for computer scientists? Presenters provided an overview of statistics about the availability of computer science jobs and typical salary levels for these jobs. The data came from the Bureau of Labor Statistics projections of job growth in computing and mathematical fields; from magazine articles that have rated computing-related jobs very highly based on availability, salary, and working conditions; and from national surveys showing decreased number of college students majoring in computing fields. The presenters also highlighted the tendency of the computing field to weather recessions well and to have growth outstripping any trends toward offshoring. The presentations were designed to help students appreciate the strong availability of well-paying computing career opportunities.

What can I do now? Presenters generally incorporated pointers about preparing for computing studies and careers in the overall presentation as well as during the question/answer period at the end. For example, they would note that computing can be studied at the college level without substantial prior experience, but that it is always good to seek out computing-related instruction in high school that goes beyond just using applications such as word processors and spreadsheets. Another important point was that given the interdisciplinary nature of the field, it would be very valuable to learn about any application area of interest. Students were also reassured that they don't have to be mathematics aficionados, since many areas of computer science are not mathematically oriented. Where applicable, the presenters also pointed out contests for high school students.

Although it is becoming more common for university STEM professionals to present to K–12 students and teachers, as in IMPACTS and the Carnegie Mellon Roadshow, research is needed on the effect of such presentations and the broader question of why students do or do not choose to study computer science (Holdren, Lander, & Varmus, 2010). In this paper, we undertake to evaluate the extent to which the IMPACTS presentations influence students' awareness of the field of computing and its diversity as well as the extent to which the presentations influence students' interest in pursuing a college major in computer science.

3. IMPACTS Presentations

Over a two-year period (2009–11), the IMPACTS project team contacted the business, computer science, or math teachers at 117 high schools in the Chicago area to offer to conduct the IMPACTS presentation at their school. Of the schools contacted, 52 accepted the offer. Of those, most invited the project team to present to classes of business, computer, and/or math students; a few invited the project team to present at career fairs. Seven IMPACTS presenters conducted 87 school visits and presentations at the 52 different schools around the Chicago area (see Table 1). The schools were almost evenly split between urban and suburban schools. There was also a mixture of public, private, and charter schools. These visits reached more than 6400 students.

Table 1. Distribution of School Visits and Students Reached

Region	High Schools	Visits	Students
Urban	27	50	4046
Suburban	25	37	2377
Total	52	87	6423

4. Instruments

Students participating in the evaluation completed a brief survey at the end of the presentations. The components of the survey evolved over the course of the two-year program. All of the versions of the survey asked students about their background, including gender, year in school, race, and self-reported science GPA. All of the surveys asked students about the extent to which the presentations influenced their interest in majoring in computer science. The students rated their interest on a five-point scale (interest has decreased a lot, interest has decreased a little, interest is about the same, interest has increased a little, interest has increased a lot). Students were asked on a five point scale about the extent to which the presentations increased their awareness of the computing field and its diversity: I gained a greater recognition of the diversity of people working in computing-related fields; I learned more about the kinds of computing-related work people do; and I learned more about availability of computing-related career opportunities.

After the IMPACTS team had settled on the components for the presentations, we added questions to the survey that asked students to rate each of the presentation components on a four-point scale (poor, fair, good, very good). The components of the presentation were: pictorial quiz on identifying computer scientists, statistics on job availability and salary, pointers on how to prepare for computing studies/careers, magic tricks, robotics videos, and visualization techniques.

In the second year of the program, we added two questions to the survey that asked students the extent to which the presentations increased their interest in taking a high school computer science course: take an introductory computer science course and take an AP computer science course. Students at one suburban school responded to these questions (n=96). The students rated their interest in taking each course on a five-point scale. We computed the higher level of change in interest between the two questions and analyzed the extent of change in students' interest in taking any high school science course.

5. Population

Five urban and two suburban schools agreed to administer the attitudinal surveys to the participating students at the end of the IMPACTS presentations. A total of 527 students completed the survey (8% of the total participants); 342 students were from urban schools and 185 were from suburban schools. All of these students participated in the presentations and surveys as part of their normal attendance in their business, computer, or mathematics class. Students from the urban schools were more likely to be black, female, and to report receiving lower grades in science than the suburban students (see details below). These characteristics represent individuals who are among the least represented in computer science.

Of the students who reported their gender, there were roughly equal numbers of boys and girls in the overall sample. There was a higher percentage of boys in the suburban schools and a higher percentage of girls in the urban schools (χ^2=5.10; p<0.05; see Table 2).

Table 2. Percentage of boys and girls by region

Region	N	Boys	Girls
Suburban	184	54%	46%
Urban	332	44%	56%
Total	516	48%	52%

Of the students who reported their racial background, more than half of the students were either Black or Hispanic, followed by Asian and Caucasian (see Table 3). There were a higher percentage of Asian, Caucasian, and Hispanic students in the suburban schools than the urban schools (χ^2=94.75; p<0.0001). Conversely, there were a higher percentage of black students in the urban schools than the suburban schools.

Table 3. Percentage of students from various racial backgrounds by region

Race	Suburban	Urban	Total
Asian	26%	15%	19%
Black	3%	39%	26%
Caucasian	27%	9%	15%
Hispanic	32%	26%	28%
Multiracial	8%	10%	10%
N	184	329	513

Of the students who reported the grades they usually get in science, a higher percentage of urban students reported receiving B's and C's in science than suburban students (X^2=20.32; p<0.01; see Table 4). Conversely, a higher percentage of suburban students reported receiving A's in science than urban students. Roughly the same percentage of students reported receiving D's and F's in science. Converting the letter grades into numerical GPA's, where F is 0 and A is 4, we computed the average GPA for urban and suburban students. Suburban students reported a higher average science GPA than urban students (F(1, 485) = 11.4, p < 0.001, d = 0.30), where d represents the effect size. The effect size is computed by dividing the mean difference by the standard deviation. An effect size of 0.20 is considered small, 0.50 is considered medium, and 0.80 is considered large. Therefore, an effect size of 0.30 is a small to medium effect.

Given the differences in gender, racial, and prior achievement distributions between urban and suburban schools, we examined differential effects of the presentations based on gender, race, prior achievement, and school region. In order for the presentations to contribute to attracting students from underrepresented populations, the presentations need to have an equivalent impact on urban students as they do for suburban students.

Table 4. Students self-reported science grades by region

Grade	Suburban	Urban	Total
A's	38%	21%	27%
B's	36%	43%	40%
C's	19%	28%	25%
D's/F's	7%	8%	8%
Avg. GPA	3.1	2.8	2.9
N	176	311	487

6. Results

We compared the student responses on the attitudinal questionnaire to the goals of IMPACTS presentations. The questions asked students the extent to which the presentations impacted their attitude towards the computing field. In general, students enjoyed the presentations. The extent to which students enjoyed the presentations predicted the extent to which the presentations increased their awareness of the computing field and its diversity. In turn, the extent to which students increased their awareness of the computing field predicted the extent to which they increased their interest in taking a computer science course in high school as well as majoring in computer science in college. Below is a detailed summary of students' responses for each of the goals.

Goal 1: To provide an interesting and enjoyable learning experience.

Overall, the results indicate that Goal 1 was achieved. Students found the presentations to be an interesting learning experience. The ratings of the presentation components ranged from 74% to 88% of the students rating them as Good to Very Good (see Table 5). Almost every student (95%) found at least one component of the presentations Good to Very Good.

The student ratings of the presentation components were aggregated in two ways. First, we averaged the ratings of all the components that each student experienced. This average score served as a measure of the students' enjoyment of the overall presentation. The mean rating for overall enjoyment of the presentation was 3.1 out of 4 with a standard deviation of 0.61. There were no demographic differences in students' enjoyment of the overall presentation.

Table 5: Student ratings of presentation components

Presentation Component	Poor/ Fair	Good/ Very Good
Robotics videos (n=227)	12%	88%
Visualization techniques (n=212)	18%	82%
Pictorial quiz on identifying computer scientists (n=237)	20%	80%
Magic tricks (n=209)	21%	79%
Statistics on job availability and salary (n=215)	26%	74%
Pointers on how to prepare for computing studies/careers (n=208)	26%	74%

Second, we computed the highest rating the students provided for any particular presentation component, which served as a measure of the extent to which students enjoyed at least one component of the program. The mean rating for the most enjoyable component was 3.7 out of 4 with a standard deviation of 0.61.

There were small demographic differences in the extent to which students enjoyed at least one component of the presentation. We conducted a multiple regression that included gender, race, region, and science GPA as independent variables. The regression was statistically significant ($F(5, 223) = 2.44$; $p < 0.05$), but only explained 5.2% of the variance. Black students ($t = 2.21$; $p < 0.05$; $\beta = 0.16$) and students who reported higher GPAs ($t = 2.46$; $p < 0.05$; $\beta = 0.19$) rated their most liked presentation component higher than students of other races and with lower GPAs. (Note: The β value indicates on a scale of 0 to 1 how much influence a given independent variable has on the dependent variable.)

Goal 2: To increase students' awareness of the computing field and its diversity

Overall, the results indicate that Goal 2 was achieved. Students felt that the presentations helped them gain a greater recognition of the diversity of computer scientists, the kinds of work that computer scientists do, and the availability of careers in computing-related fields (see Table 6). The three questions related to awareness of the computing field and its diversity were averaged together to create an overall measure of student awareness.

To examine the extent to which students' *awareness of the computing field and its diversity* was predicted by their perception of the presentations, we conducted a multiple regression analysis, controlling for region, gender, race, and science GPA. The overall model was statistically significant ($F(7, 218) = 9.97$; $p < 0.0001$), explaining 24% of the variance. The only statistically significant variable predicting the extent to which students increased their overall awareness was students' overall rating of the presentations ($t=5.02$, $p<0.0001$, $\beta=0.38$). In other words, the primary factor influencing the extent to which students increased their awareness of the computing field was the extent to which they enjoyed the presentations.

Table 6: Student ratings on their increased awareness of the computing field and its diversity

Awareness of computing field and its diversity	Disagree/ Strongly Disagree	Neutral	Agree/ Strongly Agree
I gained a greater recognition of the diversity of people working in computing-related fields. (n=434)	7%	30%	63%
I learned more about the kinds of computing-related work people do. (n=432)	4%	16%	70%
I learned more about availability of computing-related career opportunities. (n=427)	5%	25%	70%

Goal 3: To spark interest in the science of computing and challenges of problem solving

Overall, the results indicate that Goal 3 was achieved. The majority of students responding to the survey indicated that as a result of the presentations their interest in taking a computer science course in high school and majoring in computer science in college both increased.

Goal 3a: To spark interest in taking a high school computer science course

More than two-thirds of the students (70%) indicated that their interest in taking a high school computer science course increased, relative to a handful of students (3%) who indicated that their interest decreased. This provides a net increase of two-thirds of the students (67%) who increased their interest in taking a high school computer science.

To examine the extent to which students' *change in interest in taking a high school computer science course* was predicted by their increased awareness of the computing field and their perception of the presentations, we conducted a multiple regression analysis, controlling for gender, race, and prior background in science. Region was not included since only one suburban school responded to the question about interest in taking a high school computer science course. The overall model was statistically significant ($F(7, 86) = 3.50$; $p < 0.01$), explaining 22% of the variance. None of the demographic variables predicted the extent to which students increased their interest in taking a high school computer science course. The extent to which students increased their awareness of the computing field was the only factor that predicted the extent to which students increased their interest in taking a high school computer science course ($t = 3.37$; $p < 0.01$, $\beta = 0.37$). Thus, student enjoyment of the presentations increased awareness of the computing field, which in turn increased interest in taking a high school computer science class (see Figure 7).

Goal 3b: To spark interest in majoring in computer science in college

All of the students were asked about the extent to which their experience with the program changed their interest in majoring in computer science. More than half of the students (52%) indicated that their interest in majoring in computer science in college increased, relative to almost one-fifth of the students (17%) who indicated that their interest decreased. This provides a net increase of 35% of students who increased their interest in majoring in computer science in college.

To examine the extent to which students' *change in interest in majoring in computer science* was predicted by their increased awareness of the computing field and their perception of the presentations, we conducted a multiple regression analysis, controlling for region, gender, race, and prior background in science. The overall model was statistically significant ($F(8, 208) = 8.70$; $p < 0.0001$), explaining 26% of the variance. Students in urban settings ($t = 4.32$; $p < 0.001$, β=0.31) and students reporting higher science GPAs ($t = 2.92$; $p < 0.01$; $\beta = 0.21$) reported higher levels of change in interest.

After controlling for these statistically significant demographic variables, there were two programmatic variables that were statistically significant. The extent to which students increased their awareness of the computing field predicted the extent to which students increased their interest in majoring in computer science ($t = 4.81$, $p < 0.0001$, β=0.33). To a lesser degree, the extent to which students found at least one presentation component enjoyable predicted the extent to which they increased their interest in majoring in computer science ($t = 1.91$, $p = 0.057$, β=0.15). Thus, the extent to which students enjoyed the presentations influenced the extent to which they increased their awareness, which in turn influenced their interest in majoring in computer science (see Figure 7).

7. Conclusion

Although there has been a significant drop in the number of computer science graduates over the past decade, there are indicators that the field is rebounding in the growth of computer science graduates. However, it is important to reexamine how the field of computer science is presented to students as well as the types of experiences that computer science programs offer to students to ensure that the representation of computer scientists is broadened to include more women and minorities.

Prior research has indicated that providing students with information about the field of computer science may increase student interest in taking high school computer science classes and eventually majoring in computer science. The research presented here provides additional evidence that giving students a better awareness of the field of computing can serve to increase interest among all students, particularly women and minority students. These results can provide guidance to high school counselors and computer science teachers about ways to encourage students to take computer science classes in high school as a conduit to majoring in computer science.

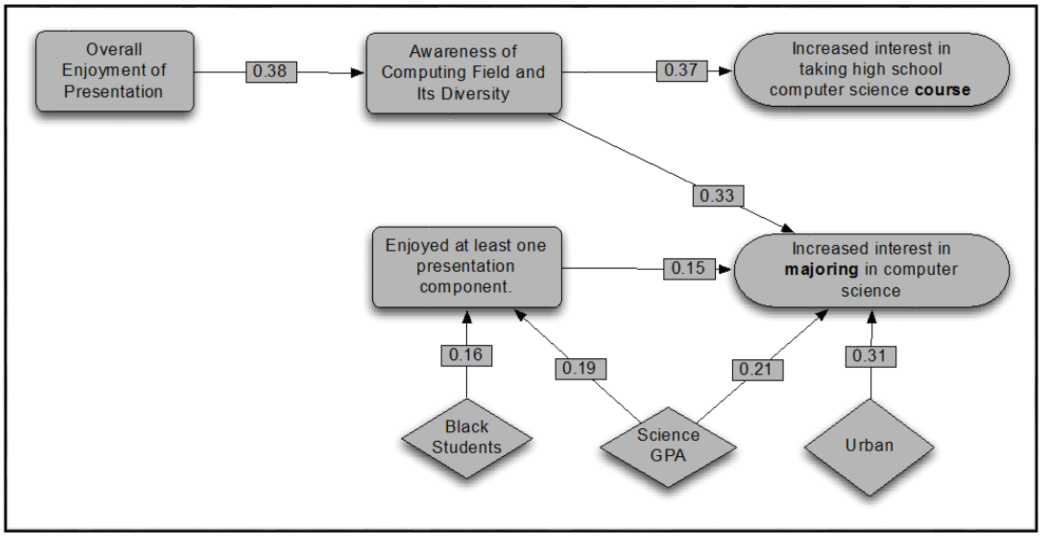

Figure 7: Path Diagram of Influence of IMPACTS Presentations on Student Interest

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[1] The Illinois Computes name was inspired by the Georgia Computes program (http://georgiacomputes.org). Georgia Computes has a strong emphasis on professional development for high school teachers, as does the Exploring Computer Science Program in Los Angeles (http://exploringcs.org). Related efforts are now underway in Chicago under the program name "Taste of Computing," with the hope of bringing a meaningful computer science introductory course to a greatly enlarged population of students.