

Women Who Choose Computer Science— What Really Matters

The Critical Role
of Encouragement
and Exposure

Editor's Note

Throughout this white paper we report findings about women's decision to pursue a "Computer Science" degree. For the high school model in this paper, our classification of students as interested in computer science included those who were interested in computer science and programming, as well as those who reported interest in related fields - specifically mathematics/statistics, engineering, and other computing-related disciplines (e.g., information systems, IT). This is because we felt that interest in any of these fields could lead to majoring in computer science.

Subsequent analyses have shown that excluding these additional subjects and only focusing on students who expressly were interested in computer science and programming produced similar results overall with a few differences, notably an increase in the importance of encouragement (amplifying what we have reported in this paper) and additional negative impact from concerns about grades.

Abstract

Google believes that a diverse workforce leads to better products for diverse users, and is especially committed to reversing the negative trends around women in Computer Science. To guide the company's outreach and investments in this space, Google conducted a study to identify and understand the factors that influence young women's decisions to pursue degrees in Computer Science. It identified encouragement and exposure as the leading factors influencing this critical choice and learned that anyone can help increase female participation in Computer Science, regardless of their technical abilities or background.

According to the National Science Board's "Science and Engineering Indicators for 2012," women make up only 26% of Computer Science and Mathematical Science professionals in the United States.¹ These numbers are even more stark when considering that while degree conferment for women in Science, Technology, Engineering and Mathematics (STEM) is trending upward, female participation in Computer Science, specifically, has declined to 18% from a 37% peak in the mid-1980s.²

In addition to issues related to workplace diversity, the lack of female participation in Computer Science exacerbates a pre-existing problem with labor supply shortages: the overall need for Computer Science professionals has severely outstripped the number of graduates entering the workforce.³ One approach to narrowing the supply gap is to increase the number of Computer Science graduates across the board. It then logically follows that growing female participation in the field can dramatically bolster those numbers. Because effective educational outreach requires a long-term approach and a solid understanding of the motivating factors involved, Google conducted a study to identify the critical exposures and experiences that influence a woman's decision to pursue a Computer Science degree.

Our study found that encouragement and exposure are key controllable indicators for whether or not young women decide to pursue a Computer Science degree. More specifically, the top four influencing factors are:

- 1 **Social Encouragement:** Positive reinforcement of Computer Science pursuits from family and peers.
- 2 **Self Perception:** An interest in puzzles and problem solving and a belief that those skills can be translated to a successful career.
- 3 **Academic Exposure:** The availability of, and opportunity to participate in, structured (e.g., graded studies) and unstructured (e.g., after-school programs) Computer Science coursework.
- 4 **Career Perception:** The familiarity with, and perception of, Computer Science as a career with diverse applications and a broad potential for positive societal impact.

The study also called to attention the limited role that uncontrollable factors play in influencing the pursuit of a Computer Science degree. We learned that the impact of factors like ethnicity, family income, parental occupation and objectively measured proficiency is far less when controlling for having familial and peer encouragement and a young woman's perception of her own proficiency.

1. Methodology

Despite the abundance of published studies on the topic, the question of what influences a young woman's decision to pursue Computer Science as a college major remained difficult to answer. The sheer volume of potential influencing factors and their possible interdependencies complicates selecting the most effective outreach strategies. However, we were able to design a study to help identify the most critical variables.

Developing the Study

We began by reviewing existing studies in order to:

- 1 Determine a comprehensive set of influencing factors.
- 2 Identify strengths and limitations in and incorporate best practices from previous studies.
- 3 Refine our study's hypothesis around influencing factors.

Our review resulted in 91 statistically relevant factors with the potential to influence a decision to pursue a Computer Science degree. The hypothesis was then further refined to assess the significance and rank order of the established background, rather than just ask what influences exist. The benefits of this refinement were twofold: it provided actionable information by identifying the top factors influencing women who chose to study Computer Science while also identifying which factors were statistically insignificant when accounting for all other variables.

To ensure a statistically relevant study with a high level of confidence (95% or better) and a small margin of error (5% or less), 1000 women and 600 men were surveyed in partnership with the research firm Applied Marketing Science, in accordance with the following:

- Respondents were geographically and academically diverse, from all available regions and colleges across the United States.

- 50% of respondents were pre-college (i.e., those in the process of deciding whether or not to pursue a Computer Science major) while 50% were attending or had recently graduated from college (i.e., those who had decided whether or not to pursue a Computer Science major).
- 50% of respondents were interested in (or currently studying) Computer Science or a related field and 50% were not.
- All 91 factors were tested concurrently to control for highly correlated variables.

To design the survey, three focus groups were polled. Each was presented with a combination of closed and open-ended questions.

The Analysis

Conflating correlation with causation is a frequent concern with statistical studies and identifying social predictors can be tricky. But while statistical analysis cannot always explain individual behavior, it can provide powerful insights into behavioral patterns (with varying levels of confidence). To control for related influences and fairly evaluate competing factors, the survey results were analyzed using *logit regression*—a form of statistical modeling used to predict binary outcomes. We used logit regression to rate the importance of factors in predicting Computer Science enrollment.

At a very high level, logit regression allows each factor to be evaluated independently to determine to what extent it contributes uniquely to the associated behavior. More specifically, it measures the strength of the relationship between dependent variables (pursuing a CS degree) and independent variables (e.g., the life experiences and opportunities that may lead to that decision). In this study, the analysis model was “factor X influences a young woman's decision to pursue a Computer Science degree” and each factor is scored using Pseudo-R²—a measure of fitness—to determine how well it fit the model for high school students (the “high school model”) and recent college graduates (the “college model”).

The study found most of the decision-making to pursue Computer Science occurs before a young woman begins college; once she enters college, application requirements and variable interdependence are so tightly coupled that the decision becomes less malleable (e.g., Computer Science courses correlate with degree pursuits because they are required to complete the degree coursework). As a result, the factors with the most influence are all associated with pre-college experiences. In fact, the high school model has a Pseudo-R² of 60.5% (the various influencing factors contribute to 60.5% of the decision)—an exceptionally high score that translates to reasonably accurate influence modeling.

2. Encouragement

Positive reinforcement of Computer Science pursuits and a personal belief that such a pursuit can be successful can both influence the interest of young women in Computer Science.

Social Encouragement

Social encouragement includes positive reinforcement from family and peers and, for the high school model, comprises 28.1% of the explainable factors influencing a young woman’s decision to pursue Computer Science. Encountering this encouragement in an extracurricular setting also has a large impact on participation in STEM in general because it fosters peer encouragement and places science in a social context. At the college level, the availability of scholarships (i.e., monetary encouragement) also contributes to the decision to pursue (or continue pursuing) a Computer Science degree.

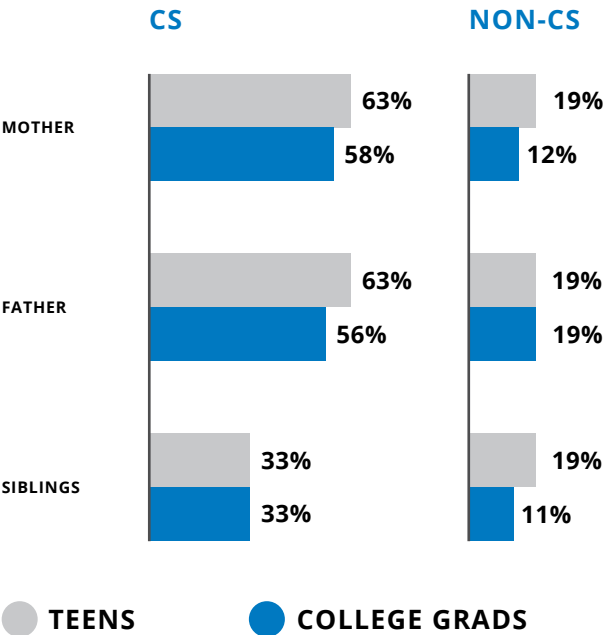
To further examine social encouragement in the high school model, peer encouragement (11%) is almost as important as familial support (17%). Moreover, for both the high school and the college model, parental occupation was statistically insignificant in deciding to pursue Computer Science when controlling for other variables. What matters most is encouragement, not whether this encouragement was from someone with technical expertise. This is particularly important given that young women are half as likely as young men to receive that encouragement (in any form).

Self Perception

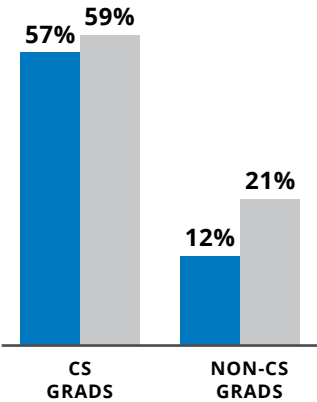
One interesting finding of the study is that a girl’s *interest* in and *perceptions* of her own proficiency in Mathematics and problem-solving significantly influence the decision to pursue a Computer Science degree. In the high school model, this perception comprises 17.1% of the explainable factors.

This positive self-perception translated to internal encouragement in the form of ongoing confidence in one’s abilities. This confidence may be reinforced by a love of Mathematics or a natural aptitude for technology, but the ultimate source is a passion for, and interest in, related concepts like puzzles, problem solving and tinkering.

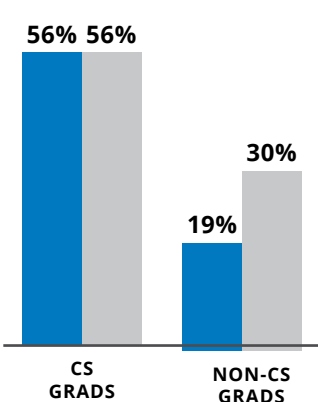
FAMILY-MEMBER
ENCOURAGED STUDY OF CS



MOTHERS
ENCOURAGED STUDY OF CS

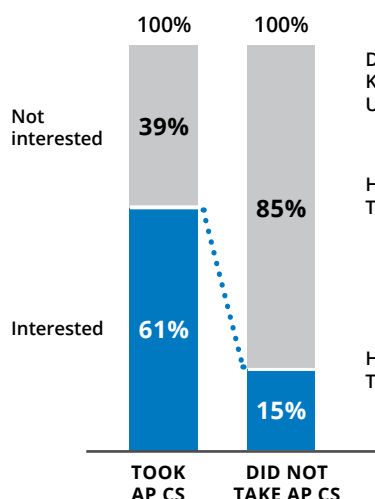


FATHERS
ENCOURAGED STUDY OF CS

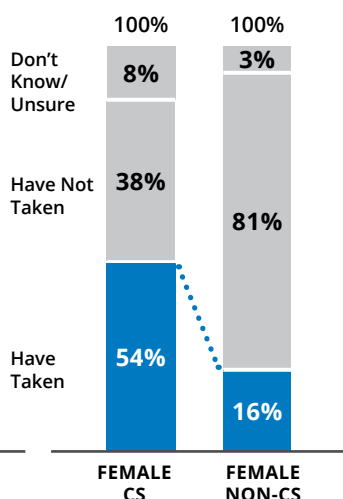


FEMALES MALES

CS INTEREST IN RELATION TO AP COURSEWORK PERCENT



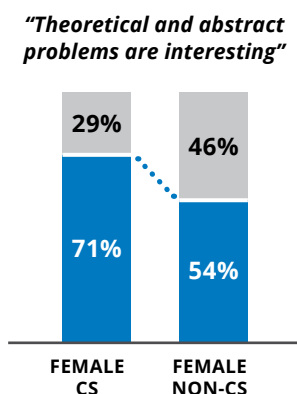
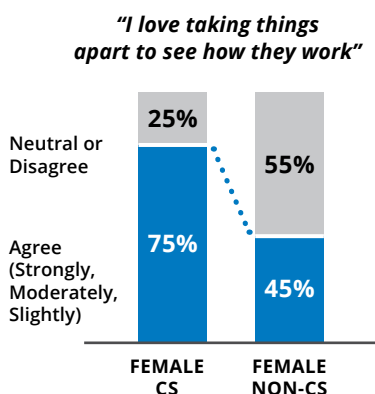
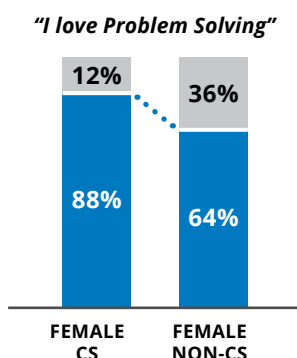
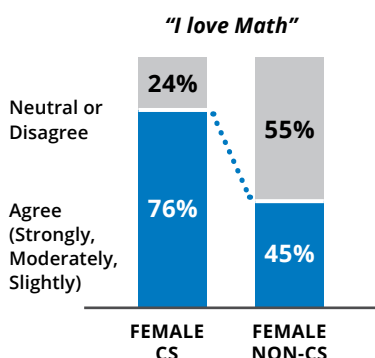
TOOK AP CS IN HIGH SCHOOL PERCENT OF COLLEGE GRADS



3. Exposure

Early exposure to Computer Science is important because familiarity with a subject can generate interest and curiosity while establishing a sense of competency. Moreover, even a basic understanding of Computer Science provides insight into viable career paths within the field and how those careers can be leveraged to achieve personal goals.

PERSONALITY PROFILE REGARDING MATH AND PROBLEM-SOLVING PERCENT AGREE



Academic Exposure

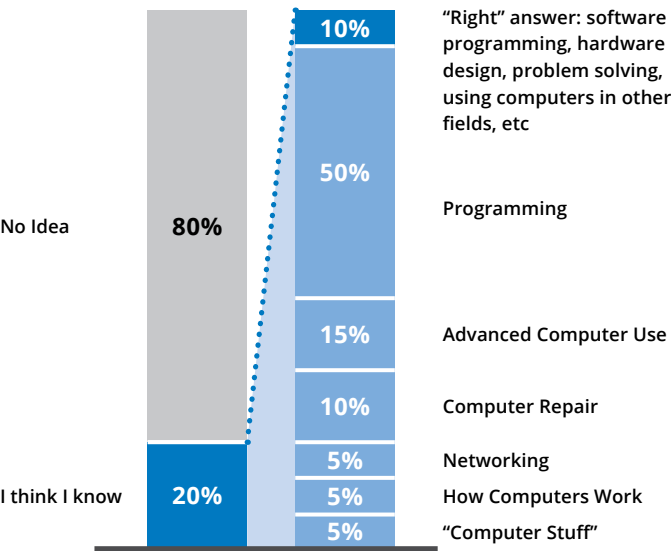
The ability to participate in Computer Science courses and activities accounts for 22.4% of the explainable factors influencing the decision to pursue a Computer Science degree. In general, those who had the opportunity to take the Advanced Placement (AP) Computer Science exam were 46% more likely to indicate interest in a Computer Science major. This is particularly true for women who are 38% more likely to pursue a Computer Science degree after having taken AP Computer Science in high school.

In addition to examining the influence of AP coursework specifically, the study controlled for varying high school curricula (e.g., no Computer Science classes, compulsory classes and elective classes) and the accessibility of extra-curricular programs (e.g., clubs and camps) and found that, regardless of *how* they were exposed, young women who had opportunities to engage in Computer Science coursework were more likely to consider a Computer Science degree than those without those opportunities.

The key takeaway is that the type of participation is statistically insignificant when measured against having been exposed at all. This is very much a case of "anything is better than nothing".

HIGH SCHOOL STUDENT’S IMPRESSION OF WHAT
COMPUTER SCIENCE MAJORS LEARN

PERCENT OF TOTAL (n=836)



Career Perception

At 27.5%, a young woman’s perception of Computer Science and its associated careers is the second most potent explainable factor influencing the pursuit of a Computer Science degree.

The negative potential associated with flawed or incomplete career perceptions is twofold: 1) not understanding Computer Science as a discipline makes an informed decision more difficult and, 2) a flawed perception of the discipline actively dissuades young women from considering it.

The end result is that young women unfamiliar with Computer Science and its broad applications have difficulty visualizing it outside the narrow scope often presented in popular media. They may be unable to perceive Computer Science as a career that fulfills both the academic passion (inventing, problem solving, exploration, etc.) and the intangible, social passions (helping people, conservation, medical breakthroughs, etc.) that make a profession personally rewarding.

WORD ASSOCIATE BY FEMALES FAMILIAR WITH COMPUTER SCIENCE

technology

programming

future

fun

interesting

exciting

money

challenging

information

innovative

computers

design

geek

innovation

boring

data

jobs

math

change

computer

hard

programs

apple

code

coding

difficult

internet

nerdy

smart

software

technical

changing

creative

engineering

microsoft

advancement

challenge

it

java

learning

work

applications

cool

current

everywhere

games

good

google

info

intelligence

interest

modern

nerd

new

programing

progress

science

secure

web

web

advance

advanced

advancements

apps

best

competitive

cuttingedge

detailed

easy

efficiency

electronics

expanding

fast

futuristic

gaming

WORD ASSOCIATE BY FEMALES UNFAMILIAR WITH COMPUTER SCIENCE

boring

technology

hard

difficult

computers

interesting

math

programming

nerd

technical

challenging

future

internet

fun

geek

smart

complicated

nerdy

science

money

nerds

programs

software

confusing

dull

google

none

tedious

useful

applications

coding

computer

hardware

jobs

techy

uninteresting

apple

changing

cool

data

facebook

games

income

innovative

intelligent

it

job

knowledge

research

ugh

uninterested

advanced

career

code

computing

demand

electronics

employment

engineer

engineering

essential

exciting

exploring

geeks

geeky

graphics

growing

help

high-tech

important

involved

laptop

microsoft

needed

network

no

numbers

program

programming

sitting

4. Uncontrollable & Non-Influential Factors

The most heartening outcome of the study is the limited role that uncontrollable factors play in influencing the pursuit of a Computer Science degree. For example, in the high school model, uncontrollable factors like household income and ethnicity contribute only 4.9% to the explainable factors—statistically insignificant when compared to factors that can be controlled. The remaining **uncontrollable** factors:

- having a family member in a Computer Science related field,
- having a family member with a Computer Science degree, and
- geography

were even less statistically significant—to the point of being non-influential—compared to income or ethnicity. Other controllable, but **non-influential** factors include:

- early exposure to technology,
- age of first computer exposure,
- access to mobile devices,
- natural aptitude, and
- topical depth/breadth of existing pre-college Computer Science curriculum.

This means that while factors like natural aptitude and the breadth of academic exposure may influence success in the field, it is controllable factors like encouragement and topical exposure that influence and generate interest in the field and a desire to pursue educational opportunities.

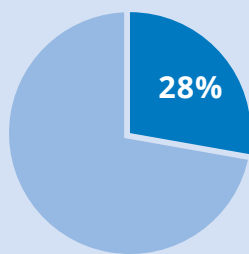
5. Conclusions

While there are still many open questions related to degree follow-through and career longevity, the results of this study are very encouraging in terms of actionability. Not only do uncontrollable factors play a limited role in explaining a young woman's decision to pursue a Computer Science degree, the controllable factors of encouragement and exposure are the largest influencers.

The bottom line is that the factors most related to female participation in Computer Science are actionable. That's not to say this is a problem that can be solved easily, but it is a problem that can be tackled with deliberate and directed action focused on encouragement and exposure:

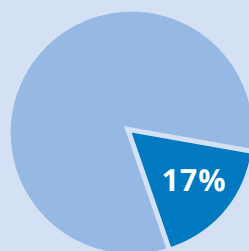
- 1 **Social Encouragement:** encouragement from family, friends and educators, regardless of their technical expertise, reinforces existing interest and can foster interest where none exists. Outreach programs should include a parent education component, so that parents learn how to actively encourage their daughters.
- 2 **Self Perception:** interest in puzzles, problem solving and tinkering can lead to a passion for, and personal confidence in, Computer Science abilities. Providing young women with the opportunity to practice these skills in a supportive environment in activities related to their passions can help build confidence and interest.
- 3 **Academic Exposure:** experience with Computer Science in middle and high schools can motivate young women to pursue computing. Support for organizations working to expand these opportunities to more schools can increase academic and informal access, provide a greater understanding of Computer Science, and help young women make informed decisions about degree and career options.
- 4 **Career Perception:** visibility of female role models in Computer Science and telling stories about the positive social impact careers in computing can have, can enable young women to visualize themselves in the field.

1. SOCIAL ENCOURAGEMENT



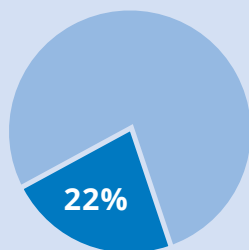
For young women in high school, it comprises 28.1% (total) of the explainable factors influencing the decision to pursue CS. Peer encouragement (11%) is almost as important as familial support (17%).

2. SELF PERCEPTION



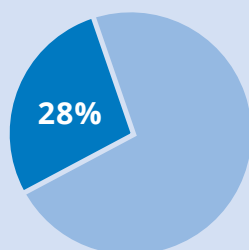
For young women in high school, self perception comprises 17.1% of the explainable factors influencing the decision to pursue a Computer Science degree.

3. ACADEMIC EXPOSURE



The ability to participate in Computer Science courses and activities accounts for 22.4% of the explainable factors influencing the decision to pursue a Computer Science degree.

4. CAREER PERCEPTION



For young women in high school, career perception accounts for 27.5% of the explainable factors influencing the decision to pursue a Computer Science degree.

Individually, these factors strongly influence whether or not a young woman pursues a Computer Science degree, but their interrelated nature—exposure provides encouragement and encouragement fosters interest, which cultivates exposure—means that their combined influence is multiplicative. There is enormous potential for positive change.

Above all, the most illuminating and encouraging result of this study is that the top factors influencing the participation of young women in Computer Science all have practical solutions, approachable by anyone, requiring little more than time and interest.

This study was an important step in an ongoing journey to address this important and increasingly relevant problem. We'd love to hear your feedback and hope to share more information with you as Google, and other groups, continue to work toward long-term solutions to achieving higher female participation in the field of Computer Science. For more information on Google's efforts in education, visit us at www.google.com/edu.

Endnotes

¹ National Science Foundation, "Science and Engineering Indicators 2012," <http://www.nsf.gov/statistics/seind12/c0/c0i.htm>, (January 2012).

² National Center for Education Statistics, "Degrees conferred by degree-granting institutions," http://nces.ed.gov/programs/digest/d12/tables/dt12_318.asp, (May 2012).

³ National Science Foundation, "Science and Engineering Indicators 2012," <http://www.nsf.gov/statistics/seind12/c2/c2s2.htm#special1>, (January 2012).