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ARTICLE

Drawing a computer scientist: stereotypical representations or lack of awareness?

Katarina Pantic[a], Jody Clarke-Midura[a], Frederick Poole[a], Jared Roller[a] and Vicki Allan[b]

[a]Instructional Technology and Learning Sciences, Utah State University, Logan, UT, USA; [b]Computer Science, Utah State University, Logan, UT, USA

ABSTRACT

Stereotypes people hold about computer scientists contribute to underrepresentation in computer science. Perceptions of computer scientists have historically been linked to males and a "nerd" culture, which can lead to lack of interest, particularly for girls. This article presents two studies conducted with two groups of middle schoolers: those who attended our programming camp (Study One) and those who did not (Study Two). After analyzing participants' drawings and two survey questions we found that perceptions youth holds about computer scientists may be improving. Additionally, we found that males (versus females) and those youth who did not attend our camp (versus those who did) tended to have more stereotypical perceptions of computer scientists. With this article, we contribute to the literature on CS stereotypes by examining both positive and negative representations youth had about computer scientists. We also cast light on the lack of awareness about this profession among the youth of this age.

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CS; drawing; computer scientists; middle school children; stereotypes

Introduction

One of the most widely accepted definitions of social stereotypes defines stereotypes as complex concepts that are more frequently erroneous and second hand than they are accurate and based on direct experience (Lippmann, 1922, as cited in Harding, 1968). As such, stereotypes describe a group of people (e.g. computer scientists) in a uniformed and oversimplified way, such as through a list of personality traits that reflect an underlying judgment held by another group of people (Perkins, 1979). Such judgements or perceptions can be positive, negative, or contain both positive and negative aspects. Ultimately, they can shape how one feels about, or how and if one interacts with a group of people.

It has been argued that the stereotypes people hold about computer scientists contribute to underrepresentation in computer science (CS) (e.g. Cheryan, Master, & Meltzoff, 2015). Such stereotypes may include images of

CONTACT Katarina Pantic katarina.pantic@aggiemail.usu.edu Utah State University, 2830 Old Main Hill, Logan, UT 84322-2830, USA

what a computer scientist looks like, in terms of their gender and/or physical appearance, their personality traits, and/or interests. Not surprisingly, it has been found that if the stereotypical beliefs that a person holds about computer scientists do not align with their own vision of self (Cheryan, Siy, Vichayapai, Drury, & Kim, 2011; Margolis & Fisher, 2003) or they do not align to their interests and value systems (Beyer, 2014), that person is unlikely to perceive CS as a potential career for themselves or choose a course inside this major (e.g. Eccles, Barber, & Jozefowicz, 1999).

The origin of CS stereotypes is multifaceted. Youth are routinely exposed to negative representations of computer scientists in the media, where computer scientists are most frequently portrayed as either White or Asian men (Google Gullup, 2015) who are socially awkward (Cheryan et al., 2015). Female scientists, on the other hand, are either underrepresented in the media or portrayed in a manner which downplays their expertise (Steinke, 2012). This is important because research suggests that representations in the media are what influences youths' perceptions of scientists (e.g. Steinke et al., 2007). In addition to the media, stereotypes are also embedded in academic culture (Margolis & Fisher, 2003). For example, a study by Cheryan and colleagues found that the design of computer classrooms often contain stereotypical features (Cheryan, Meltzoff, & Kim, 2011). They found that females were more likely to enroll in a computer science major when the classroom did not contain any objects stereotypically associated with computer science such as science fiction books, video games, and Star Wars items (Cheryan, Meltzoff et al., 2011).

So far, research has found a variety of stereotypes people hold about CS. Using interviews, surveys, and/or drawings, these studies found that college students linked the image of a typical computer scientist to geek mythology (Seik et al., 2006), or in other words, the image of a white male with various degrees of "geekiness", such as someone wearing glasses (e.g. Martin, 2004) or someone smart and isolated (e.g. Fisher, Margolis, & Miller, 1997). Additionally, students linked the image of computer scientists to the concept of masculinity, finding that if CS environments are designed in a way that fits the stereotypes, that is, they contain adornments traditionally liked by men (e.g. *Star Wars*-related artefacts), this could deter female students from wanting to be a part of such environments (Cheryan, Plaut, Davies, & Steele, 2009). Additionally, environments perceived as exclusively masculine may give an impression that only men succeed in them (Margolis & Fisher, 2003; Margolis, Fisher, & Miller, 2000).

This research shows that people often perceive those who succeed in CS majors as males who are socially awkward, isolated, unathletic, smart, geeky/nerdy, and obsessed with computing. Cheryan et al. (2013), for example, found that university students described computer scientists as "genius male computer hacker[s] who [spend] time alone on the computer, [have] inadequate social life, and [enjoy] hobbies involving science fiction" (p.61). Additional

stereotypical features such as glasses, pale complexion, or thin physique were also reported in this study.

The majority of studies on perceptions of CS that we have examined focused on college-level students. While some studies do investigate youth perceptions of scientists in general, very few focus specifically on computer scientists. In a study of elementary school children's drawings of scientists in general, Losh, Wilke, and Pop (2008) found that children depicted scientists as less attractive than teachers and/or veterinarians. Miller, Nolla, Eagly, and Uttal (2018) conducted a meta-analysis of Draw-A-Scientist studies in the US, and found that six-year-old girls drew an average of 30% male scientists, a tendency that switched at the age of 10 and grew to 75% of drawings of male scientists at the age of 16. For boys the percentage of male representations grew from 75% at the age of 6 to 98% at the age of 16. However, this meta-analysis focused on scientists and not computer scientists. One study that focused on middle school children's depictions of computer users found mixed results: there was a statistically significant difference between male and female participants depicting computer users, with females and 6th graders depicting a higher percentage of female computer users (Mercier, Barron, & O'Connor, 2006). The most commonly depicted stereotypical features in this study were males and glasses. Finally, male 6th graders depicted more stereotypical images than females of the same age. In a follow-up study, which was based on interviews and described in the same paper, youth described computer users as people who knew a lot about computers, spent a lot of time with computers, and loved working with computers. Some additional features appearing in their descriptions were abnormal body weight (e.g. overweight, thin), lab coats, and pocket protectors. Table 1 provides a summary of all the stereotypical representations found in existing literature in relation to computer scientists and the methods used in each study to identify them.

Although past studies show that youth hold stereotypical perceptions of computer scientists, lately there have been indications to suggest that the stereotypical male nerd may have been substituted by new and more complex representations. As an example, in their meta-analysis of five decades of papers on kids' drawings of scientists mentioned above, Miller et al. (2018) found that stereotypes linking science to men have actually weakened over the past five decades. Again, it is important to mention that their meta-analysis looked at depictions of scientists and not computer scientists.

In addition, a study at Carnegie Melon University, where women represented 53% of the sample, showed that CS students at this university perceived themselves as more well-rounded than average, usually social, demographically diverse, hardworking, and different from the stereotypes in terms of what they are like and what they like (Frieze, Quesenberry, Kemp & Velazquez, 2012). This is important because researchers at Carnegie Mellon have been working to change the CS department culture. From a set of

Table 1. Codes from literature on stereotypes about computer scientists.

Citation	Martin, 2004	Mercier et al., 2006	Margolis, Fisher, & Miller (2000)	Margolis & Fisher, 2003	Fisher et al., 1997	Cheryan, Plaut, Handron, & Hudson (2013)	Beyer (2014)
Method	Drawings + "What is computer science?" question	Study 1: survey, and drawings; Study 2: interviews	Longitudinal study, 4 years long; interviews	Longitudinal study, 4 years long; interviews	An ethnographic study with interviews	A questionnaire that asked them to "describe computer science majors" or "describe what computer science majors are like"	A survey
Codes							
Male	x	x		x		x	
Glasses	x	x				x	
Pocket protector	x	x					
Eyed glued to a computer monitor	x						
T-shirt with obscure computer code	x						
Abnormal body weight (e.g. overweight, skinny)	x	x		x		x	
Eating junk food	x						
Bleary eyed	x						
Drinking coffee	x						
Messy hair	x						
Acne	x						
Sloppy dress	x						
Facial hair	x						
Lab coat		x					

(*Continued*)

Table 1. (Continued).

Citation	Martin, 2004	Mercier et al., 2006	Margolis, Fisher, & Miller (2000)	Margolis & Fisher, 2003	Fisher et al., 1997	Cheryan, Plaut, Handron, & Hudson (2013)	Beyer (2014)
Pale		x				x	
Nerd		x		x			x
Negative personality (e.g. annoying, arrogant)		x				x	
Asocial/Antisocial/Isolated/ lonely		x		x	X	x	x
Knows a lot about computers		x					
Spends a lot of time using computers		x					
Loves/obsessed with computers/coding		x	x	x		x	
Smart			x	x	X		x
Unattractive						x	
Technology oriented						x	
Likes science fiction						x	
Enjoyed games like chess							x
Hard-working							x
Good at math and science							x

interviews with the same population, Larsen and Stubbs (2005) found that CS students distanced themselves from the geek stereotype, saying that "well-rounded" is a better description for them. These efforts by Carnegie Mellon, along with a recent push by Google to change perceptions of computer scientists (see Smith, Choueiti, Yao, Pieper, & Lee, 2017) call for a renewed investigation into youth perceptions of CS.

In the last few years, we have been teaching local youth how to program in summer App Camps. In these camps, we have noticed the complex and evolving nature of youth's perceptions of computer scientists, as well as a general lack of understanding of the CS field. Thus, we decided to build upon the Mercier et al. (2006) research mentioned above and investigate youth perceptions of computer scientists. Taking prior literature into consideration (see Table 1), we slightly modified the prompt to capture youth perception of computer scientists' (versus computer users') gender, physical appearance, personality attributes, and a description of what the profession actually entails (see *Data Collection* section for more detail). In addition, we were interested in exploring if stereotypes youth held served as barriers to participating in programming activities. Therefore, we compared perceptions of youth who attended our camps to their peers who did not attend our camp. In this study, we explore the following research questions:

RQ1: How do middle school youth perceive computer scientists?

RQ2: Do boys and girls perceive computer scientists differently?

RQ3: How do perceptions of those youth who pre-select for our programming camp differ from the perception of their peers who did not select to attend our camp?

Methods

This study is part of a larger research project which is investigating the impact of a summer App camp, led by near-peer mentors, on youth's interest in, beliefs about, and self-efficacy in programming. In earlier studies, we found that the camp was beneficial for mentors' self-efficacy beliefs (Clarke-Midura, Poole, Pantic, & Allan, 2017), and campers' interest and self-efficacy (Clarke-Midura et al., 2018).

Sample

Participants for the two studies presented in this article were drawn from several middle schools in the Intermountain West of the United States. Middle schools in

the United States are typically between two and three years in duration and can begin as early as fifth grade and end as late as ninth grade. Thus, middle school students can range in age from 10 to 14.

In Study One, our sample consisted of 91 youth (47 males, 44 females) aged nine to thirteen (M = 11.6). All participants in Study One attended our summer camp on mobile app development in the summer of 2016. In Study Two, which was conducted in the winter of 2017, the sample (479 students) was drawn from two middle schools located in the same geographic area that was used to recruit participants for Study One. We visited these same two schools when recruiting for our 2016 camps and we gave recruitment pitches in their career awareness classes. However, many of the youth we spoke to did not sign up for camps even though they were aware of them. Forty-six youth, who previously attended our camp, as well as those who were in the 9th grade (camps targeted 6th to 8th graders), were excluded from this study. The final sample in Study Two consisted of 433 middle schoolers (229 males, 204 females), aged 12 to 14 (M = 12.61).

Data collection

Study One. Prior to the start of the camp, youth were asked to complete an online pre-survey in which they provided background information and answered a variety of questions. In this study, we only include the data collected on youth's perceptions of computer scientists. More specifically, they were asked the following two questions: *How would you describe a computer scientist?* and *What does a computer scientist do in their job*? In addition to this data, we collected youth's drawings of computer scientists on paper. The instructions for the drawings were adapted from Mercier et al. (2006) and asked the participants to *close their eyes, imagine a computer scientist, and then draw and/or describe the person that they had envisioned*. As afore stated, we slight modified the overall prompt to capture youth perception of computer scientists' (versus computer users') gender, physical appearance, personality attributes, and a description of what the profession actually entails.

Study Two. During our visit to two middle schools, participants were asked to complete a brief survey. The survey contained both demographic and affective questions, two of which were included in this study. The two questions included are the same questions posed in Study One: *How would you describe a computer scientist?* and *What does a computer scientist do on their job*? As in Study One, we asked them to draw a computer scientist using the same instructions described above. However, in Study Two, the whole survey was administered via paper. While most participants chose to draw computer scientists (72 in Study 1 and 369 in Study 2), there were some participants who chose solely to write a description (19 in Study 1 and 64 in Study 2).

Data analysis

To answer our first research question, we combined deductive analysis with an open coding approach (Patton, 2002). In other words, by relying on existing literature (see Table 1), we started by creating a list of stereotypes (aka subcategories) of computer scientists already identified in literature. However, we remained open to all other perceptions youth had about computer scientists. In other words, we expanded on the subcategories identified in literature based on what emerged from the data (Saldaña, 2009). The purpose of this approach was to explore potential changes in middle-school aged youth's perceptions of computer scientists and their jobs. The names for subcategories, however, were aligned with literature wherever possible (see Table 3). Furthermore, subcategories were organized into four groups (aka categories).

The data in Study One was coded by two coders. After coding approximately 10% of the drawings, the coders discussed the coding process with a goal of reaching consistency in coding (e.g. if the drawing was ambiguous but a masculine pronoun appeared somewhere in the description, they agreed to code that submission as *male*). At this point, they created a codebook (see Table 3), where categories and subcategories were connected to corresponding definitions and examples. After they finished coding Study One, the coders discussed discrepancies in coding until they reached consensus on their coding decisions. At this point the codebook was also discussed and finalized. Identified subcategories were inspected, cleaned, and collapsed wherever overlap in meaning was identified. This resulted in a total of 27 subcategories. A final list of subcategories with corresponding definitions and examples is presented in Table 3. After finalizing the codebook, the whole study was looked at again by both coders, and recoded where necessary based on the discussion. The whole analysis procedure resulted in 570 codes (aka visually and/or verbally expressed CS features), which reflected the gender, physical attributes, personality traits of, and actions attributed to computer scientists. Inter-rater reliability scores for each category were calculated using Cohen's Kappa with all categories resulting in a κ greater than 0.78, indicating acceptable levels of agreement between the two coders (Landis & Koch, 1977). Please see Table 2 for the Cohen's Kappa for each subcategory in Study 1 and Study 2.

The data from Study Two was coded based on the codebook developed in Study One. However, we also looked for additional categories that emerged from the data. As a result, we identified one additional subcategory bringing the total to 28 subcategories. Upon identifying this category, we revisited the

Table 2. Intercoders' reliability per each subcate.

Subcategories	Study 1 Cohen's Kappa	Study 2 Cohen's Kappa
Who they are	0.88	0.93
Depictions	0.78	0.90
Attributes	0.93	0.73
What they do	0.89	0.73

Table 3. Codebook.

Categories	*Definitions & Examples*	*Literature*
Who computer scientists are		
Male	"*I think of a guy who is …*" or an image of a person with distinctive male features	Martin (2004); Mercier et al. (2006); Margolis and Fisher (2003); Cheryan, Plaut, Handron, & Hudson (2013)
Female	"*She has…*" or an image of a person with distinctive female features	Mercier et al. (2006);
Ambiguous	The gender of the person was not distinguishable, or they used pronoun "*somebody*"	Mercier et al. (2006);
Both	Drawing both male and female characters, or using a pronoun "*anyone*"	*Both* (Mercier)
Depictions		
Non-scientific clothes	Clothes items are either casual (e.g. jeans, T-shirts, cap) or professional (e.g. tie, shirt, suit)	*Sloppy dress* (Martin)
Scientific clothes	Clothes items reflect a scientist (e.g. boots, gloves, lab coats)	
Glasses	Self-explanatory	Martin (2004); Mercier et al. (2006); Cheryan, Plaut, Handron, & Hudson (2013)
(Abnormal) body type	Extreme body type mentioned (e.g. "*overweight*", "*thin*")	*Abnormal body weight* (Mercier et al., 2006); *Overweight* (Martin)
Messy hair	The drawing contains a person with messy hair style	*Messy hair* (Martin)
†Pocket protector	Self-explanatory	Mercier et al. (2006);
Attributes		
High levels of knowledge	This category combines attributes describing high levels of education (e.g. "*educated*", "*attended college for 4 years*"), high levels of effort (e.g. "*hard-working*", "*They keep trying even when they make a mistake*"), or high levels of knowledge about computers (e.g. "*good with computers*" "*nows [sic] the computer well*")	*Knows a lot about computers* (Mercier et al., 2006) *Hard-working* (Beyer, 2014)
A nerd	This category combines stereotypical attributes describing someone as nerdy (e.g. "*a nerdy-monkey man!*", "*a little nerdy*", "*geeky*") or asocial (e.g. "*awkward*", "*asocial*", "*shy*")	*Nerd* (Mercier et al., 2006; Beyer, 2014) *Geek* (Margolis & Fisher, 2003)
Problem solver	This category combines attributes describing someone curious (e.g. "*likes to mess around with technology*", "*curious*"), creative (e.g. "*imaginative*", "*can invent*", "*wants to invent cool things*") or into problem solving (e.g. "*problem solver*", "*good at solving problems*")	*Creative* (Beyer, 2014)
Smart/Intelligent	Someone "*smart*" "*intelligent*" "*talented*" "*fast thinker*" or with "*good grades*"	*Intelligent* (Margolis & Fisher, 2003; Fisher et al., 1997) *Intelligent/genius* (Cheryan et al) *Smart* (Margolis, Fisher & Fisher, 2003; Beyer, 2014)
Interested in/enjoys their work, likes technology	Someone who enjoys his/her work (e.g. "*interested in their work*", "*enjoys using computers*" "*really into it*" "*most likely happy*", "*content*", "*have a smile on*")	*In love with computers* (Margolis & Fisher, 2003) *Technology-oriented* (Cheryan et al)
Nice/cool	Someone pleasant (e.g. "*nice*", "*kind*"; "*awesome*" "*smart and funny*" "*really interesting*")	
Normal/regular person	An average Joe/Jane (e.g. "*A normal person*" "*an average person*" "*computer scientist actually looks like a regular guy*")	
Other	Attributes mentioned just once or twice, as well as "*I don't care*" or "*I don't know*"	

(*Continued*)

Table 3. (Continued).

Categories	*Definitions & Examples*	*Literature*
What they do		
Subject	Mentioning someone who is good at math or science (e.g. "*good at science*")	Beyer (2014)
Work at a computer	Anyone sitting/looking at/working with a computer/technology	
CS skills	Anyone having a specific CS skill (e.g. program ("writes codes"), test (programs), debug etc.)	*They dream in code* (Margolis, Fisher & Miller, 2000)
Cognitive effort	Actions related to cognitive effort (e.g. think, learn new things, experiment, explore, etc.)	
Design/Create	Actions related to making (e.g. create, invent, build, or "*designs technology*")	
General computer skills	Any computer-related actions that are not related to programming (e.g. "*types*", "*fixes things*", "*makes computers*")	
Career	Explanations referring to specific workplaces (e.g. "*works at [name of university]*" "*teaches CS*" "*works at NASA,*" "*works in a cool building*" "*earns a lot*" "*goes to work/works*" "*is a programmer*")	
Time at work	Anyone who works long hours, only works at night, works when convenient	*Spend a lot of time using computers* (Mercier)
No idea/Not sure	Any unspecified action (e.g. "*they do stuff*" or "*no idea*")	

data from Study One, but found no evidence of this code. Coding in Study Two resulted in an additional 2,499 codes (total number of codes = 3,069). Inter-rater reliability scores for each category were calculated using Cohen's Kappa with all categories resulting in a κ greater than 0.73, indicating acceptable levels of agreement between the two coders (Landis & Koch, 1977).

To answer our second research question, we used chi-squares to assess differences between males and females in each of the four categories. This was repeated for both Study One and Study Two. Finally, to answer our third research question, we used chi-squares to assess differences between Study One and Study Two participants in each of the four categories. In the next section, we present our findings by category (RQ1). For clarity, we present the findings from research questions two and three within each of the four main categories. However, in the discussion, we revisit each research question individually and we discuss how our findings compare to earlier literature.

Results

To answer the three research questions asked in this study, we thoroughly examined both the youth drawings and their answers to the survey questions. We organized our results into four overarching categories (see Table 3): Who computer scientists are (gender), Depictions (what they look like), Attributes (what attributes they possess), and What they do. The following sections provide a detailed explanation of those four categories and their subcategories. Some examples of participants' drawings can be found in Appendix A.

Who computer scientists are

This category represents both the gender of computer scientists that the participants specified as well as the absence of gender specificity. To code gender, we first looked at youths' drawings. If we were not able to specify gender (male, female, or both) from their drawing directly (e.g. it was a stick figure with no recognizable gender features), we looked for gender specific pronouns in the description of the drawing, or next, in their open-ended survey responses (e.g. if they described a computer scientist using the pronoun *he*, we coded that as "male" despite the ambiguous drawing). Drawings and descriptions for which we could not determine gender were coded as "ambiguous." Drawings that specified both male and female gender, or mentioned that "anyone can be a computer scientist" were coded as "both." As it can be seen from Table 4, 45% of the campers (Study 1) drew male computer scientists, 18.7% drew females, and about 11% of campers specifically noted that "both" males and females could be computer scientists. Male campers did not draw any female computer scientists. Only female campers drew female computer scientists. The difference between male and female participants in

Table 4. Percentage of computer scientists' gender depicted by campers or non-campers.

	Study 1 (n = 91)			Study 2 (n = 433)		
Who they are	Male (n = 47)	Female (n = 44)	*Total*	Male (n = 229)	Female (n = 204)	*Total*
Male	30 (63.8%)	11 (25%)	**41** *(45%)*	133 (58%)	72 (35.3%)	**205** *(47.3%)*
Female	0	17 (38.6%)	**17** *(18.7%)*	6 (2.6%)	44 (21.6%)	**50** *(11.5%)*
Ambiguous	14 (29.8%)	9 (20.5%)	**23** *(25.3%)*	77 (33.6%)	68 (33.3%)	**145** *(33.5%)*
Both	3 (6.4%)	7 (15.9%)	**10** *(11%)*	12 (5.2%)	21 (10.3%)	**33** *(7.6%)*

this study was statistically significant, χ^2 (3, N = 91) = 50, $p < 0.001$ (RQ2). This is not surprising given findings from past research that has provided additional explanations for gender differences in youth drawings. For example, Losh et al. (2008) suggest that male youth tend to be less aware of gender and other minority traits when drawing or describing occupations of scientists, teachers, and veterinarians.

In Study 2, almost half the participants drew male computer scientists (47.3%), while only 11.5% of them drew females. Some youth (7.6%) said "both" can be a computer scientist. Again, the majority of female computer scientists were drawn by females. Chi-square analysis indicated that there was a significant difference in who male and female middle schoolers depicted, χ^2 (3, N = 433) = 48.96, $p < 0.001$ (RQ2). Many figures in the drawings were too ambiguous for us to specify gender with certainty. These characters were coded as "ambiguous" (33.5%). Overall, there was no significant difference in the types of people drawn or described, that is, whether they were male, female, ambiguous, or both, between participants in Study 1 and Study 2, χ^2 (3, N = 524) = 5.7, $p > 0.05$ (RQ3).

Depictions

This category focuses on the physical appearance of the images drawn, such as accessories, clothes, and/or body features. As can be seen from Table 5, "glasses" (36.3%) and casual or professional attire, in other words, any non-scientific clothing (34.1%), were the most prominent subcategories in Study 1. Approximately 15% of campers drew computer scientists as someone who would wear scientific clothes, such as lab coats, boots, or goggles. About 12%

Table 5. Percentage of computer scientists' appearance features depicted by campers or non-campers.

	Study 1 (n = 91)			Study 2 (n = 433)		
Depictions	Male (n = 47)	Female (n = 44)	*Total*	Male (n = 229)	Female (n = 204)	*Total*
Pocket protector	0 (0%)	0 (0%)	**0** *(0%)*	**3** (1.3%)	**2** (1%)	*5 (1.15%)*
Body type	1 (2.1%)	1 (2.3%)	**2** *(2.2%)*	**4** (1.75%)	**5** (2.45%)	*9 (2.1%)*
Non-scientific clothes	11 (23.4%)	20 (45.45%)	**31** *(34.1%)*	**23** (10%)	**25** (12.25%)	*48 (11.1%)*
Scientific clothes	10 (21.3%)	4 (9.1%)	**14** *(15.4%)*	**24** (10.5%)	**26** (12.7%)	*50 (11.5%)*
Glasses	17 (36.2%)	16 (36.4%)	**33** *(36.3%)*	**74** (32.3%)	**47** (23%)	*121 (28%)*
Messy hair	8 (17%)	3 (6.8%)	**11** *(12.1%)*	**8** (3.5%)	**4** (2%)	*12 (2.8%)*

of campers also drew computer scientists as people with "messy" hair, a code taken Martin (2004). In this category, only non-scientific clothes had a significant gender difference in Study 1. Females drew more non-scientific clothes than males, $\chi^2(1, N = 91) = 3.99$, $p = 0.04$ (RQ2).

In Study 2, 28% of participants drew computer scientists with "glasses." Depictions of scientific and non-scientific clothes appeared in 11.5% and 11.1% of the drawings, respectively. In Study 2, only the depiction of computer scientists wearing glasses had a significant gender difference. Males were more likely to draw glasses on computer scientists than females, $\chi^2(1, N = 433) = 4.41$, $p = 0.03$ (RQ2). A pocket protector, which appeared five times (1.15%) in Study 2 was not something we noticed in Study 1. When comparing Study 1 and Study 2, we found that both non-scientific clothes and "messy" hair was significantly different. Participants in Study 1 were more likely to draw computer scientists as wearing casual, non-scientific clothes than those in Study 2, $\chi^2(1, N = 524) = 29.25$, $p < 0.001$ (RQ3), but they were also more likely to draw computer scientists with "messy" hair $\chi^2(1, N = 524) = 13.41$, $p < 0.001$ (RQ3). This suggests that there are some differences in how participants who opted to attend our camps perceived CS in comparison to youth who did not attend our camps. We elaborate on these findings in the discussion section.

Attributes

The third category identified in this analysis consists of all the adjectives and/or adjectival phrases used to describe characteristics participants attributed to computer scientists. As can be seen from Table 6, participants used a wide variety of attributes to describe the characteristics they believed computer scientists possess. Some of these characteristics were very stereotypical (e.g. "nerd" or "intelligent/smart"), while others were the opposite from the stereotypes identified in literature (e.g. "kind/cool" or "normal/regular (person)").

In both studies, the most frequent adjectives associated with working in CS were "smart/intelligent" (37.4% in Study 1 and 38.8% in Study 2). Campers

Table 6. Percentage of computer scientists' attributes depicted by campers or non-campers.

	Study 1 (n = 91)			Study 2 (n = 433)		
Attributes	Male (n = 47)	Female (n = 44)	*Total*	Male (n = 229)	Female (n = 204)	*Total*
Driven	5 *(10.6%)*	12 (27.3%)	**17** *(18.7%)*	46 (20.1%)	56 (27.4%)	**102** *(23.6%)*
Problem solver	0	1 *(2.3%)*	**1** *(1.1%)*	20 (8.7%)	19 (4.4%)	**39** *(9%)*
Nerd	3 *(6.4%)*	1 *(2.3%)*	**4** *(4.4%)*	23 (10%)	19 (9.3%)	**42** *(10.4%)*
Normal/Regular	3 (6.4%)	2 (4.5%)	**5** *(5.5%)*	12 (5.2%)	11 (5.4%)	**23** *(5.3%)*
Interested in/enjoys working with	0	7 (15.9%)	**7** *(7.7%)*	24 (5.5%)	26 (12.7%)	**50** *(11.5%)*
Nice/cool	5 (10.6%)	5 (11.4%)	**10** *(11%)*	22 (9.6%)	7 (3.4%)	**29** *(6.7%)*
Smart/intelligent	16 (34%)	18 (40.9%)	**34** *(37.4%)*	82 (35.8%)	86 (42.2%)	**168** *(38.8%)*
Other	7 (14.9%)	7 (15.9%)	**14** *(15.4%)*	27 (11.8%)	25 (10.8%)	**52** *(8.1%)*

(Study 1) also used "driven" (18.7%) and "nice/cool" (11%) to describe computer scientists, while other youth (Study 2) used "driven" (23.6%), "interested in/enjoys computer programming" (11.5%), and "nerd" (10.4%) as the most frequent attributes. No significant gender difference was identified in neither Study 1 nor Study 2. Additionally, no statistically significant difference was identified between these types of descriptions in the two studies.

What (computer scientists) do

The last category of codes incorporated all the activities or actions participants connected to the computer scientists' profession. The actions were grouped into related subcategories, such as CS Skills (e.g. programming), General Computer Skills (i.e. computer skills not related to programming), and so on (see Table 3 for more details). In Study 1, two thirds of campers described the job of computer scientists in a vague manner, such as, someone who "works at a computer" (see Table 7). The same number of youth (69.2%) described computer scientists as people who would perform CS-related actions, such as programming. A little less than half of the campers (49.45%) also used general computer skills, such as typing or fixing computers, in their descriptions. Other prominent subcategories included different types of cognitive effort (15.4%), specific careers (e.g. "works for NASA") (13.2%), or some type of design-related verb (design/create) (23.1%). In this category, we found no significant difference between male and female participants in Study 1 (RQ2).

In Study 2, "work at a computer" (48%), "CS skills" (44.8%), and "General computer skills" (28.6%) were some of the most prominent descriptions of what a computer scientist does. Additional subcategories that emerged were cognitive effort (28.4%) and design-related verbs (design/create) (33%). However, the terminology participants used was somewhat vague (e.g. experiment, explore, learn) and it did not reflect a deep understanding of what the profession actually entails. In Study 2, we found a gender difference in participants who described computer scientists as those who work at a computer.

Table 7. Percentage of computer scientists' activities depicted by campers or non-campers.

	Study 1 (n = 91)			Study 2 (n = 433)		
What they do	Male (n = 47)	Female (n = 44)	*Total*	Male (n = 229)	Female (n = 204)	*Total*
Subject (e.g. science)	2 (4.25%)	3 (6.8%)	**5** *(5.5%)*	17 (7.4%)	10 (4.9%)	**27** *(6.2%)*
No idea/not sure/does not know	1 (2.1%)	4 (9.1%)	**5** *(5.5%)*	15 (6.55%)	11 (5.4%)	**26** *(6%)*
Cognitive effort	7 (14.9%)	7 (15.9%)	**14** *(15.4%)*	60 (26.2%)	63 (14.5%)	**123** *(28.4%)*
Time at work	5 (10.6%)	3 (6.8%)	**8** *(8.8%)*	8 (3.5%)	15 (7.35%)	**23** *(5.3%)*
General computer skills	6 (12.8%)	11 (25%)	**45** *(49.4%)*	69 (30.1%)	55 (27%)	**124** *(28.6%)*
Career	5 (10.6%)	7 (15.9%)	**12** *(13.2%)*	6 (2.62%)	9 (4.4%)	**15** *(3.64%)*
CS skills	31 (66%)	29 (65.9%)	**60** *(65.9%)*	106 (46.3%)	88 (43.1%)	**194** *(44.8%)*
Create/design	10 (21.3%)	11 (25%)	**21** *(23.1%)*	66 (28.8%)	77 (37.7%)	**143** *(33%)*
Work at a computer	34 (72%)	29 (65.9%)	**63** *(69.2%)*	95 (41.5%)	113 (55.4%)	**208** *(48%)*

More females described computer scientists as someone who works at a computer than males, $\chi^2(1, N = 433) = 7.30$, $p > 0.01$ (RQ2). We also found that significantly more participants in Study 1 described computer scientists as someone who works at a computer than participants in Study 2, $\chi^2(1, N = 524) = 12.69$, $p < 0.001$ and that more participants in Study 1 described computer scientists as using CS skills than participants in Study 2, χ^2 $(1, N = 524) = 12.61$, $p < 0.001$ (RQ3). These findings will be expanded on in the following discussion section.

Discussion

Researchers have suggested that stereotypical portrayals of computer scientists may affect participation in CS when such portrayals do not align with how one envisions themselves (Cheryan et al., 2015, 2011; Margolis & Fisher, 2003). Past research indicates that the prevailing stereotype of who succeeds in CS has been that of a smart and isolated (Fisher et al., 1997) geeky white male (Martin, 2004) who wears glasses (Cheryan et al., 2013) among other things (see Table 1). In this article, we set out to explore how youth's perceptions of computer scientists and the CS field have changed. In particular, we were interested in whether boys and girls perceived computer scientists differently, and whether youth who attended our CS camp held different perceptions compared to those who did not.

Our first research question examined the perceptions youth had about computer scientists. We found that the most frequent depiction of a computer scientist was that of a smart male with glasses working on a computer. These stereotypical representations are similar to those found in past research (see Table 1). However, it is important to note that we did find differences from what previous literature reported (see Table 3). For example, we found that a subset of participants reported that "both" males and females can be computer scientists. Next, although stereotypical social attributes, such as "smart" or "nerd" were used by youth, positive attributes, such as "nice/cool," "normal/regular," or "driven" were more common attributes overall. Most of the research that we have found on perceptions of CS focused on stereotypes. Our study adds to the field by presenting both the stereotypical and the non-stereotypical attributes youth hold. Further, these findings illustrate a potential shift towards a more positive perception of the CS field.

Another finding was that youth in our study did not understand what the CS profession really entails. In addition to some participants who openly admitted not knowing what a computer scientist does (5.5% in Study 1 and 6% in Study 2), we found that computer scientists were often depicted in an inaccurate or vague manner. For example, some of the most frequent actions associated with them was "work with a computer," fixing computers (accompanied by a drawing of toolboxes and/or screwdrivers) or typing (accompanied

by a drawing of someone in formal office clothes) (see Appendix A). These drawings and descriptions suggest that the youth in our study described computer scientists as people who simply use or fix computers without a clear understanding of what the job of a computer scientist entails. Most of the research we investigated focused on perceptions of computer scientists' physical traits, rather than on perceptions of what a career in CS involves. Our findings are important because they suggest that current stereotypes held by youth may simply be a result of their lack of awareness about the field (Grover, 2014). In addition, these misconceptions may also be due to the absence of CS in K-12 education. In the US, only about 40% of K-12 schools offer CS programming courses (Gallup Research Group, 2016). This leads us to believe that most youth are not likely to have any programming experience prior to secondary schooling, which is problematic because research has found that the best way to support long-term persistence in STEM is to nurture kids' attitudes as early as middle school (Ing & Nylund, 2013).

Our second research question examined whether there was a gender difference in how youth perceived computer scientists. We found some differences between male and female perceptions of computer scientists in both our studies. In our overall sample (Study One and Study Two), there was a difference in how male and female participants drew the gender of computer scientists: male participants drew no (Study One) or few (Study Two) females, while females drew both. This finding suggests that male youth at this age are more inclined to draw representations of male computer scientists, which is what Mercier et al. (2006) found, as well. As a reminder, none of the boys in Study One drew female computer scientists and only 2.6% of them did so in Study Two in comparison to 38.6% of females doing so in Study One and 21.6% in Study Two. Furthermore, this finding suggests that future studies may need to examine youth's stereotypes in ways that target stereotypes more precisely than can be done with drawings. It could be that boys tend to draw males and non-gender images due to lack of awareness of gender rather than stereotypical perceptions (Losh et al., 2008), or it could be that boys tend to view CS-people more stereotypically (Beyer, 2014). In either case, these findings are important because males who hold stereotypes about how the field is supposed to be and who computer scientists are, may believe that women do not belong in the field.

In terms of physical depictions, we found two gender differences. In Study One, which consisted of youth who attended our camp, female participants were more likely to draw computer scientists in non-scientific (business or casual) clothes. This may suggest that the females in Study One had a more realistic view of what computer scientists wear to work, or it may mean that these females were more likely to draw details (Losh et al., 2008). In Study Two, however, more male participants drew glasses, a typical CS stereotype. This gender difference in the depiction of glasses was also found by Mercier et al.

(2006). Though we found no gender differences in the types of attributes used to describe computer scientists, we did find that female participants sampled from the general population (Study Two) more often described computer scientists as someone who works at or sits at a computer. This may suggest that females are less aware of this profession or that they perceive it as inactive and/or asocial.

For our third research question, we were interested in comparing perceptions of computer scientists by youth who attended our camps to those who did not. We found no difference in the type of gender or attributes youth in either of the studies used to depict computer scientists. In terms of the physical appearance, our results were mixed. For example, in Study One, participants drew more images with "messy hair," a stereotype found in Martin (2004), but they also drew more non-scientific clothes, which suggests a non-stereotypical view of computer scientists or potentially an understanding that computer scientists are different from the stereotypical view of scientists in a lab coat. In terms of describing the work of computer scientists, we found two differences. More participants in Study One described computer scientists as someone using CS skills (e.g. programming) and working at a computer. From our coding process, we know that these two actions were often used together to describe the work of a computer scientist. This suggests that participants in Study One were more aware of what the CS profession entails. It could be that the parents of participants in Study One signed them up for the camp which indicates they value CS at some level.

For example, research shows that parental values are likely to be shared and passed to their children (Eccles, 2015; Eccles & Jacobs, 1986; Eccles-Parsons, Adler, & Kaczala, 1982). However, more research is needed to confirm this hypothesis.

Overall, we found that a) perceptions of computer scientists may be improving, b) males tended to have more stereotypical perceptions of computer scientists than females, and c) those who attended our camp tended to depict a less stereotypical image of computer scientists than those who did not attend our camp. These findings, while important, are only one piece of the puzzle. Future research should explore factors that are related to the positive perceptions that we found in this study. In addition, future research should explore the effect of envisioning computer scientists as either "just a normal person" or as a "mad scientist" on youths' decision to pursue CS learning opportunities. Finally, more research is needed to determine how exposure to CS learning opportunities affects one's perception of computer scientists, and subsequently, one's decision to continue learning CS.

Conclusion

Stereotypes of CS as a male geek dominate the media (Smith et al., 2017). Understanding stereotypes youth hold about CS is important because it has

been argued that the stereotypes people hold about computer scientists contribute to underrepresentation in CS (e.g. Cheryan et al., 2015). In this study, we explored how youth perceive CS and computer scientists. We found youth have both positive and negative perceptions of computer scientists. Although we found some similar results to past studies, namely that the "smart male with glasses" stereotype still exists, we also found that youth are beginning to perceive computer scientists and, subsequently, CS in a more positive light. Participants who attended an app building camp and those who did not, reported computer scientists as being creative, driven, nice, and generally normal. Understanding the perceptions that youth hold of the CS field will continue to be important as the CS industry grows and, subsequently, the demand for more computer scientists increases. Future research should continue to examine the relationship between youth perceptions and motivations to enter the field. Furthermore, more longitudinal studies are needed to understand how perception changes between middle school, high school, and secondary education. Understanding these changes, and more specifically, what influences these changes will better inform the research communities interested in recruiting today's youth into the CS field.

Limitations

This study has several limitations that must be addressed. First, part of our data collected relies on interpreting student drawings. Losh et al. (2008) argue that drawings can be somewhat unreliable given that participants tend to draw characters that resemble themselves. In addition, they note that there are inherent differences in how young males and females add details to images. We attempted to address some of these issues by also allowing, and in some cases requesting, participants to write a description of their perceptions. Another limitation is the limited number of participants in our camps. It would have been better to have more campers to compare to our participants from the public schools. Finally, though we collected the same data (two open-ended survey questions and a drawing) in both studies, there is a slight difference in how we collected them, which might have potentially influenced the outcome of this study. In Study Two, the data was collected in written form on a single occasion, while in Study One the two research questions were collected online as part of a bigger survey.

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Notes on contributors

Katarina Pantic is a Graduate Research Assistant and a doctoral candidate in Instructional Technology and Learning Sciences at Utah State University. Her research interests focus on creating equal educational opportunities for girls and women in computer science (CS), as well as enhancing their interest in and capabilities to pursue CS programs and occupations.

Jody Clarke-Midura is an Assistant Professor in the Instructional Technology and Learning Sciences department at Utah State University. Jody's research focuses on digital media & games, assessment, and broadening participation in STEM+C, in particular, computer science education.

Frederick Poole is a Graduate Research Assistant in Instructional Technology and Learning Sciences at Utah State University. His research interests include digital game-based language learning, technology-based collaboration, and dual language immersion.

Jared Roller is a Graduate Research Assistant in Instructional Technology and Learning Sciences at Utah State University. His research interests include problem-based learning in online learning, role play, and game-based learning, especially tabletop games.

Vicki Allan is an Associate Professor in Computer Science at Utah State University. She is an active member of NCWIT, serving as affiliate chair for Aspirations in Computing for Northern Utah. She is a proponent of women in computing serving as advisor for ACMW and a former committee member for the Rocky Mountain Celebration of Women. Her research interests include advancing educational opportunities for women in computer science and multi-agent systems for ridesharing, image recognition, and stock trading.

ORCID

Katarina Pantic http://orcid.org/0000-0002-5462-1772
Jody Clarke-Midura http://orcid.org/0000-0001-5434-0324
Jared Roller http://orcid.org/0000-0001-5465-9423

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Appendix A: Examples of Youth Drawings

Figure 1. An example of a drawing where the participant specified "anyone" can be a computer scientist (Study 1).

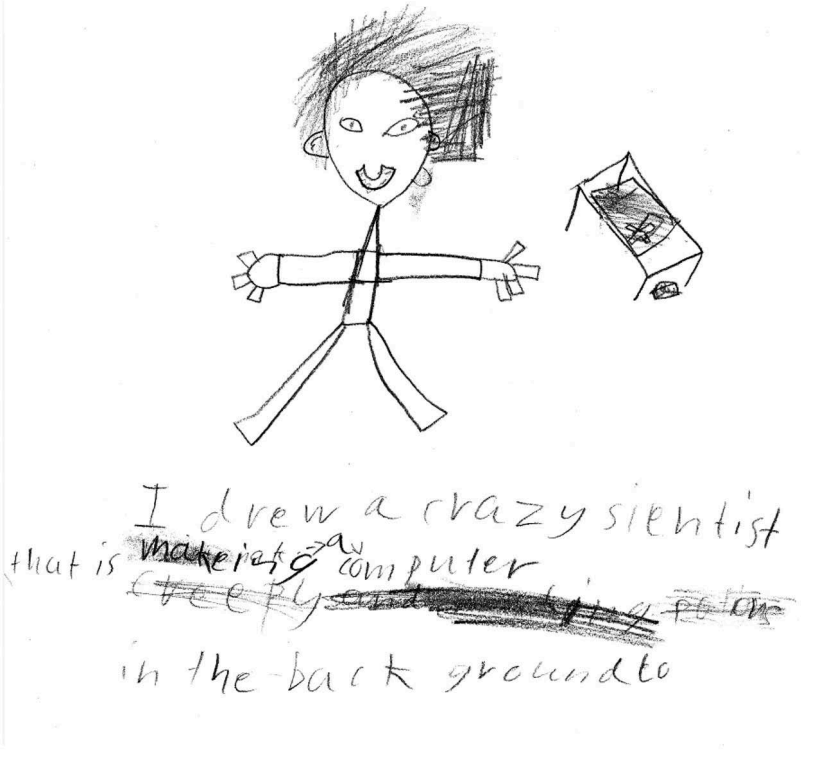

Figure 2. An example of a computer scientist being described as a "crazy scientist who makes computers" (Study 1).

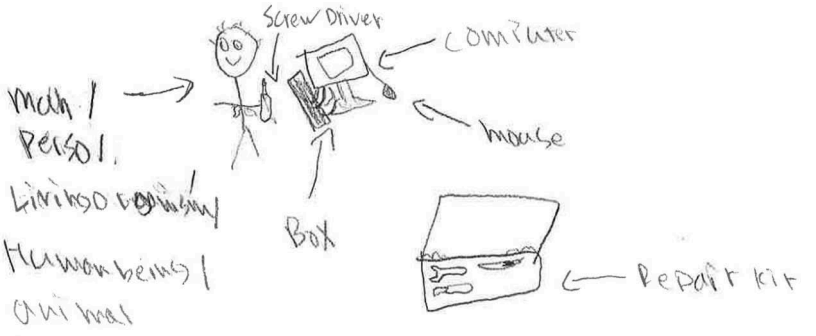

Figure 3. An example of a computer scientist holding a screwdriver and being described as someone who fixes computers (Study 2).

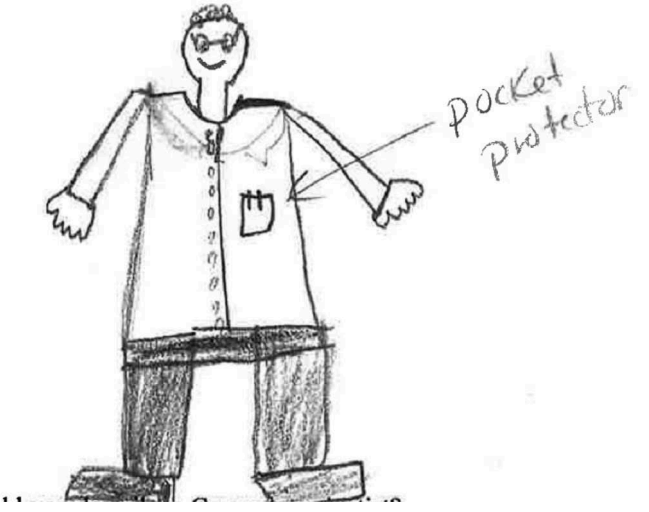

Figure 4. An example of a computer scientist drawn with glasses in a lab coat with a pocket protector (Study 2).