Elementary Attitudes Toward Computer Science

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Abstract

This study explores the distinctions among elementary students in the greater Seattle area and their attitudes toward computer science. The objective of this study is to determine variations between how girls and boys feel about topics like their appreciation towards computer science (CS), their engagement in computer science (CS), and their future computer science (CS) work aspirations. Additionally, the study seeks to gather more information on their parental attitudes and values towards computer science. This survey was primarily distributed in person to kids at public parks across various cities near Seattle, with a few virtual samples coming from different references. The survey was completed by 106 kids total, 53 girls and boys, all falling within the age range of 6 - 11 years old. The findings reveal that, while boys and girls have parents with similar attitudes and values towards computer science, notable gender differences emerge in other areas. For example, boys had a higher appreciation, engagement, and future work aspirations in computer science than their female counterparts. These results imply that even in a tech hub like Seattle with families of relatively higher incomes, the gender disparity for computer science is still very prevalent. This disparity at such a young education age for elementary children raises concerns about its potential to affect children's future career decisions. In conclusion, this study highlights how important it is to address gender-related disparities in computer science attitudes and aspirations among elementary students, to create a more equitable environment and future for all students.

Keywords

Keywords: computer science, STEM, gender disparity, parental perceptions, attitudes, education, elementary students

Introduction

In recent years, the growth of the technology industry and the field of computer science has been booming. The projected employment growth rate for computer information technology occupations from 2021-2031 is estimated at 14.6%, which is a much higher rate compared to the average growth rate of all occupations at only 5.3%. This anticipated growth is expected to create over 680,000 new computer and information technology jobs (Krutsch, 2022). This rapid expansion of computer science and STEM jobs leads to the crucial question of who is going to fill all of these positions. The solution to this problem involves fostering an early interest in computer science through interventions integrated as a core component of elementary students' education. These young learners represent the future of the computer science industry (Miller, 2014).

The Seattle, Washington area is home to huge technology corporations such as Microsoft, Google, and Amazon, which employ more than 45,000 employees in various fields (Urwin, 2023). This technology-rich environment offers a helpful place when inspiring the next generation, with countless opportunities for kids as they progress from elementary to high school, with hundreds of computer science camps and programs available through companies like ID Tech, Kids Science Lab, and Coding with Kids.

Despite the numerous opportunities available to kids, the persistent stigma surrounding women working in computer science remains. This is evident when looking at women's participation in STEM, which has increased in all other fields except computer science since

1990 (DuBow & Wu, 2023). In 2021, a significant gender disparity was seen when 78.81% of computer scientists were men, while only 21.19% of computer scientists were women (Zippia, 2021). This gender gap is not only seen when inspecting post-college decisions, but also, in the decisions made in high school, the confidence students have in excelling in computer science, and their motivation to pursue a STEM field that results in only 18% of CS degrees being earned by women (Code.org, 2017). For instance, this issue is highlighted by the fact that only 29% of all AP computer science test-takers in the United States are female (DuBow & Wu, 2023). These statistics show the growing need for even more support and encouragement for girls towards a degree in computer science. Combating this issue by creating the most effective programs and resources requires understanding certain factors and beliefs that influence female students. This includes identifying barriers such as teachers, parents, and societal expectations that steer females away from the computer science field because of misconceptions that it is suited to be a male-dominated environment (Hill et al, 2010). Also, the systematic underrepresentation of female capabilities in computer science decreases their interest in pursuing computer science as well (Malik, Al-Emran, 2018).

Additionally, examining elementary attitudes towards computer science is vital because a negative attitude and lower confidence in the subject may be a pivotal factor in their future educational choices. This is reinforced by the fact that 74% of female computer scientists in 2020 were exposed to computer science in middle school (code.org, 2020). Emphasizing how crucial it is to consider that kids begin to form gender stereotypes and biases toward STEM rapidly between the ages of 6 and 10 (Law et al., 2021). This is why in this study there will be a focus on three questions relating to the attitudes of elementary school children. Through understanding and addressing these factors, an environment can be created that fosters gender equality and supports girls' participation in computer science.

What attitudes do elementary school students in the greater Seattle area have toward computer science activities? What factors shape these attitudes? Is there a difference according to gender?

Literature Review

The Effects of Parental Perceptions on Children

Differing Parental Perceptions Based on Gender

Children's initial exposure to computer science-related topics often comes through their interactions with parents and family members. However, the exposure tends to differ based on gender due to parental expectations. Although it is not common for parents in Western society to admit to stereotyping their children, parents naturally form expectations about their child's interests, skills, and behavior. These expectations then influence parental interactions and treatment of their children. For example, parents might buy babies and dolls for girls, while choosing trains and dinosaurs for boys (Mesman J & Groeneveld MG, 2018).

The Expectancy Value Theory (Eccles Parsons et al., 1982) holds significant relevance, explaining how a child's competence beliefs about themselves are formed from interactions with influential people like parents or teachers. Specifically, previous research has shown that parents' gender stereotypes contribute to strengthening these stereotypes within children.(Muntoni & Retelsdorf,2019). Considering the large amount of research that shows the general stereotype parents have that boys outperform girls in math (Gunderson et al., 2012), this belief affects children's self-concepts in math, which contributes to parental gender stereotypes affecting children's mathematical achievement (Jacobs, 1991).

Furthermore, research has also shown distinctions in how parents communicate with their children. Fathers tend to use more cognitively challenging words with boys, and parents tend to assume that science is easier for their sons than their daughters (Bhanot & Jovanovic, 2009). This is continued by parents tending to give their sons more technical toys, and earlier access to computers, driven by the assumption that their sons have greater computing interests than their daughters (Jane. & Fisher, 2002). While individually all of these differences may seem slight and unimpactful to the development of a child's aspirations, confidence, career choices, and interests, when they are all added up and continued for years they create astonishing changes.

Research reinforces the concept that early gender stereotyping within families creates a lasting impact in later stages of life, by demonstrating how children from families with traditional gender roles are more likely to have gender-stereotypical expectations of themselves (Child & Family Blog, 2018). This highlights the large influence parental perceptions, interactions, and stereotypes can have on a child's development.

Parental Perception Based on Career and Education Levels

Parents' career paths and educational backgrounds also have an immense effect on children's awareness and perception of computer science. Parents lacking programming and computer science education often experience anxiety, and lack of confidence, and perpetuate gender stereotypes about technology. Consequently, they might struggle to know how to best support their child's interests in computer science (Besnihan et al., 2021). Despite these challenges, evidence suggests that parents are interested in supporting and encouraging computer science. For example, a Gallup survey in 2015 revealed that 91% of US parents want their children to learn more CS, with two-thirds advocating that CS should be a mandatory subject in school (Gallup, 2015).

Culture also plays a significant role in the parent-child relationship towards STEM and computer science. Cultural expectations a parent holds for their child’s achievement in STEM-related areas greatly impact the child's self-efficacy and performance levels as they grow. Parents' own education experience, expectations, and aspirations not only affect the way they feel toward computer science but have also been highly associated with elementary achievement in science (Thomas & Strunk, 2017) and high school achievement in math (Yan & Lin, 2005). Adding on, parents' beliefs serve as predictors of elementary and middle school math achievements (Thomas et al., 2020). This expresses the importance of parents’ involvement and support in their child's academic and career aspirations while communicating the value of education with its correlation to future success. In conclusion, parents' career trajectories, educational backgrounds, and cultural values all influence a child's perception of computer science. Meaning that addressing challenges tied to parental anxiety and lack of knowledge of computer science, while maintaining their interest and support can lead to creating a more inclusive and diverse field within computer science.

Parental Perception Based on Social Socioeconomic Status

Research emphasizes another important factor to consider concerning the parent-child relationship towards computer science: the families’ social socioeconomic status (SES), which is significantly associated with children’s learning outcomes (Thomas et al., 2020). Even within the same cultural group, disparities still emerge. Parents with a higher SES provide more direct support for a longer period of time in comparison to parents with a lower SES.

The Program for International Student Assessment (PISA) shows the results of an international comparison done on the impacts of parental involvement. The global PISA assessment done in 2015 primarily evaluated students' proficiency in science. The survey done by the parents and students asked about parents' participation in science-related activities when their child was 10 years old. This included activities like reading books on scientific discoveries, watching science programs on TV, experimenting with a science kit, and many more. Although the survey indicated limited direct influence of parents' early support of science activities, the results did show a significant correlation between parents' early engagement in science activities and students' attitudes toward science, specifically their enjoyment and self-efficacy in science by age 15 (OECD, 2017).

Future Computer Science Work Aspirations

When contemplating future careers, young adults are often guided by their perception of personal success and envisionment of themselves doing tasks with a positive self-concept (Correll, 2001). So an essential influence for students preparing to enter either college pursuing a STEM career or a STEM field in the workforce is their academic attitudes and preparation towards math and science in school. Positive attitudes are found to have the most impactful influence on career aspirations and students' educational success in these subjects (Tran, 2018).

Knowing this, when considering why fewer women are interested in pursuing computer science, it is important to look at differing confidence and comfort levels reported by males and females in using computers (Temple & Lips, 1989). Even when computer experience is controlled, males still tend to exhibit more of a positive attitude towards computers (Kadijevich, 2001). In addition, research indicates that females are less attracted to a formal computer science education, and their priority with the major was to use it in other fields, while men wanted to major in computer science because of their interests in computer games (Du & Wimmer, 2019). These perceptions contribute to the growing gender rift in computer science participation. For instance, in a recent survey, 3 out of 4 U.S. students expressed no interest in pursuing a career in computer science. Adding on, there was a notable gender difference of three times as many male students (33 percent) compared to only 12 percent of female students who expressed interest in pursuing a computer science career in the future (Vegas et al., 2021).

There are a variety of theories of when kids begin to create their career aspirations and truly start narrowing down career choices. The most current theory by Gottfredson consists of four distinct development stages that a child goes through when determining a future career (Gottfredson, 1981). In the first stage (ages 3 - 5), children recognize that adults have occupational roles. Stage two (ages 6 - 8), involves orienting jobs to sex roles and eliminating careers that are not appropriate for their gender. By the third stage (ages 9 - 13), children start to become aware of social prestige and intelligence levels needed for certain jobs, and they thus start filtering out those that don't align with their perceptions. In the fourth and final stage (ages 14 and older), adolescents start considering their interests, values, desires, and skills when thinking about careers (Gottfredson, 1981). However, even during stage four, many careers have already been eliminated in previous stages, highlighting the significance of exposing elementary students to a variety of different careers with role models that push their stereotypes of what it looks like to do certain jobs.

Parental expectations play a pivotal role in children's college aspirations and career decisions. Families with members working in science careers are more likely to expect the same for their children, a trend even more prevalent among parents with university degrees. Also, after taking into account socio-cultural backgrounds children whose parents expected a career in science for them, were more likely to share this ideal and expect a career in science for themselves (OECD, 2017). Lastly, there are various factors guiding young adults' career choices, such as personal attitudes, parental expectations, societal perception, and exposure to diverse role models. Understanding these influences is crucial to creating a more diverse computer science industry.

Engagement in Computer Science and Science

As the demand for computer science professionals grows, early exposure to children in elementary school is becoming even more vital. Despite this need, Code.org shares that 93% of Washington parents want their child's school to teach computer science, while only 40% of Washington schools currently offer such programs (Hill, 2017). Recognizing its significance, computer science should be taught across all school levels. A compelling statistic from studies indicates that students who learn computer science in high school are six times more likely to major in computer science in college, and girls are ten times more likely to pursue this major (Living Computers, 2017).

Research has even shown that kids as young as five years old have demonstrated learning programming concepts through the use of developmentally appropriate resources like the TangibleK Robotics Project and the CHERP (Creative Hybrid Environment for Robotics Programming). These initiatives use software that allows children to create programs for robot control from tangible wooden blocks and/or graphical, or intuitive on-screen icons, creating comprehensible learning experiences (Bers, Flannery, Kazakoff, & Sullivan, 2014). As children progress, they can transition to other programs like "Hour of Code" (Code.org) with platforms such as Scratch that continue the visual block-based programming language. All of these early programming opportunities help avoid the early technical and syntax-related challenges of text-based programming languages, thus nurturing a passion for coding before a child may be developmentally ready for text-based coding (Bers. Flannery, Kazakoff, & Sullivan, 2014).

This early learning is so important in fostering positive attitudes towards computer science and STEM for elementary students. Studies reveal the majority of high school students interested in STEM careers as well as science-related graduates and workers attribute their interest to early experiences they had before middle school (Century et al., 2020). Computer science in the classroom has some unseen benefits too, a study done in 2020 demonstrated a positive relationship between additional hours of Code.org instruction and higher achievement on students' state ELA and mathematics testing. (Century et al., 2020).

However, a major challenge with incorporating more computer science into elementary schools is finding teachers who are equipped and prepared to teach the curriculum. Code.org's new K-12 computer science framework aims to address this issue by giving educators a setup to help prepare them to expand their computer science lessons and ensure accessibility for a diverse array of students, including minorities (Century et al., 2020).

Beyond formal education settings, various out-of-school computer science opportunities exist for elementary students including summer camps, after-school tutoring and classes, and many more types of clubs. Despite all of these opportunities, enrolling students, specifically girls to sign up and get exposure to computer science is very difficult due to stereotypes formed as early as age six, which label computer science and engineering as more suited for boys (Eckart, 2021). This stereotype alone can progress and affect girls' self-perceptions and their career choices in the future, contributing to the gender disparity in computer science. A 2019 study found males had significantly more exposure to computer science compared to females. And following the pre and post-test males were more likely to enroll in a programming class (Du & Wimmer, 2019). In conclusion, schools providing inclusive and accessible computer science education can be the key to nurturing positive attitudes, countering gender stereotypes, and ultimately addressing workforce demands in the growing STEM fields.

Appreciating Computer Science

Students' opinions about computer science are affected by many different factors like motivation, experience, and self-efficacy (Roberts et al., 2018). These perceptions, along with other preconceived ideas about computer science can impact future career choices. In the United States, there is a prevalent stereotype of computer scientists being men who are very technology-oriented with limited social skills. These stereotypes can be a major deterrent for women interested in computer science, as they struggle to envision themselves pursuing such a career (Cheryan et al, 2013).

This is further reinforced by a study done by Hansen et al. in 2017, who conducted a Draw-A-Computer-Scientist test (DACST) on 87 fourth graders. The results reveal several notable findings: 71% of students drew a male computer scientist, while only 27% drew a female computer scientist (3% of drawings did not include pronouns). Furthermore, 7% of the drawings included a bald scientist and 4% portrayed a computer scientist wearing glasses. In addition, 90% of the depictions placed the computer scientist in isolation, and 82% included a computer in the illustration. Following the post-test, which was done after students completed a 12-hour computer science curriculum, there was a notable shift: male computer scientists dropped to 51%, females rose to 31%, and 20% had no specific gender (Hansen et al., 2017). These findings demonstrate how greater exposure to what a computer scientist is can lead to a change in mindset for kids.

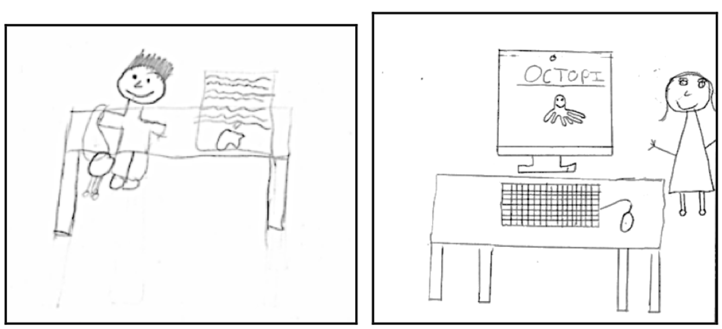


Figure 3. Pre- (left) and post-assessment (right) results for one student who changed the gender depicted.

(Hansen et al., 2017)

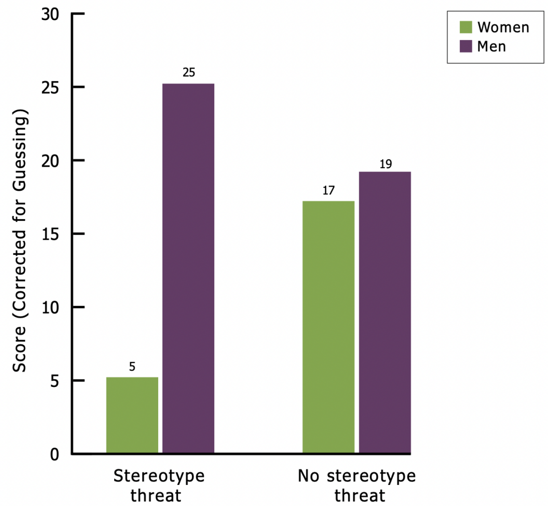
Exposure to computer science in a safe environment, where students can progressively build knowledge, is a crucial way for kids to foster positive self-efficacy beliefs toward computer science. For instance, when children learn in an environment that shares a positive attitude, like a classroom, they are more likely to embrace and adopt this mindset. Thus, in a classroom where STEM is consistently practiced kids can continue to improve their knowledge while interacting with their teachers and peers gaining confidence in themselves and their computer science abilities (Tran, 2018).

Stereotype Threat

Girls from a young age are exposed to many stereotypes that threaten to constrain their potential and shape their attitudes. Society often portrays boys and men as more capable, perpetuating two main stereotypes: first, that girls are not as good at math as boys, and second, scientific work is better suited for boys and men (Hill et al., 2010). These stereotypes extend to computer science where the prevailing attitude is that boys and men are better suited for this field. These stereotypes are important because they not only hinder girls' confidence in themselves but they have a direct effect on their performance on high-stakes tests like the SAT. Despite female students outperforming males in math and science coursework, they tend to underperform when it comes to big tests like the AP Calculus exam and the math portion of the SAT. Stereotype threat can be a prominent factor when determining these gender disparities. Girls may downplay their ambitions and interest in STEM fields to reduce the risk of being judged by negative stereotypes. In an attempt to avoid this issue, they might express disinterest in these fields altogether.

An important study that highlights the negative effects of stereotype threat is the Spencer et al. study conducted in 1999. This experiment involved 30 female and 24 male students from the University of Michigan, who all had strong backgrounds in math, getting similar test scores and grades. The students were divided into two groups where researchers administered math questions from the Graduate Record Exam. One group was told that men typically outperform women on the test (the threat condition), and the other group was told that there were no gender differences in test performance (the nonthreat condition). The results were stunning: women performed significantly worse than men in the threat condition and there was little gender difference in the non-threat condition. This study demonstrates the active role stereotypes can play on the outcomes of tests like the one given in the study, where even with similar prior knowledge between participants, stereotypes were able to infiltrate thought processes, hurting the scores of the females in the threat condition (Spencer et al, 1999). This is why addressing these stereotypes and fostering an environment that promotes confidence and self-belief among girls is critical to addressing the persisting gender disparities.

Performance on a Challenging Math Test, by Stereotype Threat Condition and Gender:



Source: Spencer et al., 1999, “Stereotype threat and women’s math performance,” Journal of Experimental Social Psychology, 35(1), p.13

Self-assessment and Confidence

How girls assess their skills in male-dominated STEM fields serves as a crucial indicator of why fewer girls are pursuing STEM careers like computer science. Shelly Correll, a sociologist at Stanford, sheds light on this issue by explaining how even when comparing women and men with equivalent past achievements in math, the girls assessed their mathematical abilities lower than the boys. This difference in confidence levels is critical, as it significantly influences the academic paths students choose. Correll’s research reveals that boys, due to their higher confidence in their math abilities, are 1.2 times more likely to enroll in advanced math classes like calculus compared to girls (Correll, 2001).

Enrollment in calculus has a big effect on whether an individual will take up a STEM or computer science major in the future. Correll found that women who take calculus in high school are three times more likely to select a quantitative major than those who do not. This highlights the importance of self-belief in career decisions. An individual must truly believe in their capacity to succeed and excel in their chosen career. If girls doubt they will be adequate computer scientists, they are more likely to choose an alternate career path. This is why Correll’s findings are so significant in emphasizing the importance of instilling in girls at a young age that they are equally capable in STEM as boys. This will help increase girls' self-assessment skills which will build confidence and encourage them to take more STEM and computer science-related classes (Hill et al., 2010).

Methodology

Survey Distribution

To investigate elementary students' attitudes toward computer science, a comprehensive survey was administered to 106 elementary participants in the greater Seattle area. This survey encompassed various factors such as future computer science work aspirations, appreciation of computer science, engagement in computer science, and parental attitudes and values. The survey data collection took place over six weeks from July 11th to August 22nd, 2023. The primary mode of distribution involved in-person interactions (85 participants) at public places, such as parks, within various neighboring cities in the Seattle area, to obtain the best representation of greater Seattle. Simultaneously the survey was also virtually distributed (21 participants) through the community from references, including teachers, and general kids camps. Before participating in the survey, clear guidelines were provided to the respondents outlining what was expected of them throughout the study. They were also informed about the study's commitment to the confidentiality of their responses. Participation in the study required parental consent, and the children themselves were required to provide assent. In addition, for the completion of the study participants could provide an email address to be entered in a free drawing with a chance to win a $50 Amazon gift card. Although this study does not collect any sensitive data an institutional review board (IRB) was still established to oversee and ensure that the research being conducted on human subjects adhered to ethical principles, prioritized safety, and maintained respect for all participants throughout the study.

The Study Instrument

This study drew on a pre-existing survey conducted by Tina Vrieler, Aletta Nylén, and Åsa Cajander on Swedish students aged 9 -16, in 2020 titled, *Computer Science Club for girls and boys – a survey study on gender differences*. Out of the numerous surveys that were evaluated from around the world on elementary students and their attitudes toward computer science, this was the one that matched this study's purpose and research objectives the best, and consent from the original author was given for the adaptation and use of this survey instrument.

However, modifications were necessary to ensure the survey questions resonated effectively with the elementary students in the greater Seattle area. One notable difference was the educational terminology used in the original survey, which was specific to Sweden's terminology. For instance, in Sweden, they have classes called "natural science" and "technology", whereas, in the United States, you would instead hear terms used like "computer science" and "coding" classes in reference to these school subjects. These terms were replaced to get the most accurate survey results for younger kids, who in Seattle are first exposed to coding through Scratch, and Hour of Code in 1st grade. To bridge any potential gaps of understanding, a brief description of coding was provided to participants before the study. It is worth noting the survey was designed for elementary students within the demographic ages of 1st grade to 5th grade, the proper demographic of elementary students, given their unique needs and experiences. Moreover, the survey was further modified by incorporating a parent/guardian answered section that addressed possible confounding variables like income, as well as the parental attitudes and values factor questions. This was done to ensure greater accuracy when dealing with a younger age group. The in-person distribution of the survey also made it necessary for certain questions to be changed to ensure clarity.

Data Analysis

The data collected through the single and multiple-answer questions was analyzed using descriptive statistics. For the questions that utilized Likert scales, including factors such as future CS work aspirations, appreciating CS, engagement in CS, and parental attitudes and values, a Factor Analysis (FA) was conducted which requires at least five cases for each item (Tabachnick & Fidell, 2013), which was met for this study. Because this study and survey are closely based off of the study Vrieler et al. (2020), which followed Kaiser's criterion for retaining the number of factors, this step was not repeated. However to ensure the reliability of the subscales Cronbach's alpha coefficients were calculated. The alpha coefficients for subscales in this study ranged from .644 - .813. An item is considered reliable with a Cronbach's alpha score greater than 0.6 (Raharjanti et al., 2022).

The alpha coefficients for this study are very similar to the alpha coefficients of Vrieler et al. (2020) which ranged from .601 - to .745. However, some adjustments were made to the scale to enhance the reliability, and additional questions were introduced to capture essential ideas. One potential explanation for the relatively lower alpha coefficient range could be the considerably young age range of the children participants, who fell within the age group of 6 - 11. This age range was deliberately chosen to get the best representation of what elementary students as a whole feel about computer science. Nevertheless, prior to the survey distribution, it was pre-tested on both male and female elementary students at the lower end of the age range. Their feedback regarding any questions causing confusion was invaluable in fine-tuning the survey to ensure clarity and comprehension among future participants.

The Mann-Whitney U test is used to determine differences between girls and boys on a variety of ordinal dependent variables. The analysis of the data was executed using SPSS version 28.

Survey Demographics

The survey collected responses from a total of 106 elementary participants and their legal guardians, consisting of 53 girls, and 53 boys, ages ranging from 6 - 11 in greater Seattle. Before the results of the survey can be analyzed it is important to look at certain confounding variables that could have affected the results.

First of all, an examination of the age distribution shows notable differences. The median age of boys to complete the survey was 9 years old, whereas the median age of girls to complete the survey was 8 years old. This suggests that the boys who took the survey may be slightly more cognitively developed than the girls because of their older ages. Also, when considering the grade level of the participants, boys had a median grade level of 3rd grade compared to girls who had a median grade level of 2nd grade. Another important demographic to consider when comparing the data from the survey is the social socioeconomic status of the participants' families. The parent guardian of the child was asked to indicate their total household income, with three income options: $0 - $94,999, $95,000 - $144,99, and $145,000 and above. The results for both gender groups, boys and girls, had a median income selected of the highest option of $145,000 and above. This means that when comparing the boys and girls surveyed it is suggested that these gender groups come from relatively similar social socioeconomic status families. However, it is important to recognize these findings may not align with broader socioeconomic trends. For example, when comparing this data with the median household income from the 2021 U.S. Census Bureau Current Population Survey data, the median household income for the entire United States was $70,784, and in Washington State, it was $82,400. Conversely, the median income of Seattle, Washington in 2021 was $105, 391. This shows how even though participants surveyed may have similar incomes, they may differ significantly from national and state averages, which could influence perceptions and attitudes.

Results

Significant differences in future CS work aspirations, appreciating CS, engagement in CS

The four factors in this study: future CS work aspirations, appreciating CS, engagement in CS, and parental attitudes and values were analyzed using the Mann-Whitney U test. After this, each factor is then compared between the two gender groups boy and girl through a Mann-Whitney U test. A Mann-Whitney U Test reveals statistically significant differences in the future CS work of males (n = 53) scoring higher than females (n = 53), U = 1061.5, z = -2.246, p = .025. A Mann-Whitney U Test reveals statistically significant differences in the appreciating CS of males (n = 53) scoring higher than females (n = 53), U = 920.5, z = -3.163, p = .002. A Mann-Whitney U Test reveals statistically significant differences in the engagement in CS of males (n = 53) scoring higher than females (n = 53), U = 923, z = -3.350, p = <.001. Engagement in CS also produces the largest effect size with a medium effect of r = .3254. A Mann-Whitney U Test reveals no significant difference in the parental attitudes and values of males (n = 53) and females (n = 53), U = 1264.5, z = -. 907, p = .364. The first factor 'future CS work' involves the attitudes these students have toward pursuing careers or engaging in computer science in the future. The next factor, 'appreciating CS,' pertains to a deep understanding and a strong valuation of computer science. 'Engagement in CS' describes the frequency with which elementary students actively participate in computer science-related activities. Lastly, 'parental attitudes and values' concerns how parents feel about computer science and its potential impact on their child's life.

Views of Coding

When looking at the series of yes or no questions administered at the beginning of the survey, it is important to look at the differences surrounding boys' and girls' responses. One question that led to interesting findings was when the participant was asked if coding was hard; 90.6% of female participants thought it was hard while only 79.2% of boys thought so. Interestingly, one question where both girls and boys showed remarkable alignment was with their responses on whether they thought coding could help you create new things. Of the participants, 51 boys (96.2% of the boys) and 50 girls (94.3% of the girls) responded yes to this question, emphasizing a shared belief of coding creative potential. Furthermore, the choice of terminology appears to influence young children's interest in computer science. For instance, when the participants were asked "Do you think you might want to learn about coding?" Of the boys, 79.2% said they wanted to learn about it and 67.9% of girls said they did. However, when the wording was shifted to refer to coding as "writing instructions for the computer" in the question, "Would you like writing instructions for the computer?" only 49.1% of both boys and girls selected "yes" in response to this revised question. Highlighting a possible relationship between gender and children's perception of coding, with emphasis on the impact of wording when introducing computer science topics.

Social Support

With interest in the level of support students feel to pursue their passions by talking and communicating with those around them, the study draws on this idea by asking the child participants whether they often chat or talk with others about coding. Participants who responded to the inquiry with either 'strongly agree,'' agree,' or 'neutral' were then directed to a new section that asked them who they primarily talked to about coding. The outcomes of this question show that a significant portion of the participants, precisely 74 of the participants (69.8% of the participants) "strongly disagreed" or "disagreed" about talking or chatting with anyone about coding frequently. Among the 17 boys (30.2% of the boys) who were either neutral or affirmative about talking to someone about coding often, 9 of them (17% of the boys) primarily talked to their friends about code, 7 boys (13.2% of the boys) talked to their parents, and 1 (1.9% of the boys) mainly talked to his teacher. The girls followed similarly in who they primarily talked to, with 14 girls (26.4% of the girls) expressing a neutral or affirmative view toward the question. Specifically, 7 girls (13.2% of the girls) talked with their friends, 4 girls (7.5% of the girls) talked with their parents, 2 girls (3.8% of the girls) talked with their siblings, and 1 girl (1.9% of girls) marked “other” and responded “Family, siblings, parents”. Yet the largest takeaway from this question is the limited extent of discussion that is done between both genders and an outside source about coding.

Coding Frequency

Understanding when and how frequently kids feel like they get to participate in coding is an important aspect of ascertaining why there is a possible gender difference in elementary attitudes toward computer science. The first question about this coding frequency asked the child participant whether they had learned coding in school. Among the respondents, 37 boys (69.8% of boys) and 34 girls (64.2% of girls) responded yes to learning about coding in school. The following question asked whether the child participant had learned coding outside of school. The responses revealed 24 boys (45.2% of boys), and 13 girls (24.5% of girls) responded yes to this, meaning they had engaged in coding outside their school curriculum. Notably, 84 participants (79.2% of participants) acknowledged coding exposure, either inside or outside of school. Conversely, 22 participants (20.8% of participants) reported never learning code in or outside of school. Among these 22 participants, 14 were girls (26.4% of the girls), and 8 were boys (15.1% of the boys). Next, the child contributors were asked to indicate their agreement with the statement “I get to learn coding often.” The results indicate that 41 boys (77.4% of the boys) responded with either neutral, disagree, or strongly disagree, while 45 girls (85% of the girls) exhibited similar responses. These findings collectively show the prevalent lack of regular coding exposure in young children's lives.

Computer Science Perception

The question “When you think of a computer scientist, who do you think of?” offered three response choices: boy, girl, or all genders, along with an “other” option. These responses offer insight into varying stereotypes that may be prevailing in the elementary age group regarding computer scientists. Among the participants, 73 (68.9% of all participants) envisioned computer scientists as all genders. This category comprised 32 boys (60.4% of the boys) and 41 girls (77.4% of the girls). In contrast, 31 participants (29.2% of participants) associated computer science primarily with boys. This includes 21 boys (39.6% of the boys) and 10 girls (18.9% of the girls) who thought this. Only 2 participants (1.9% of participants) visualized a girl when thinking of a computer scientist which included 0 boys and 2 girls (3.8% of the girls) who thought of a girl. Additionally, the free-response question, “When you think of ‘computer science’ what comes into your mind?” also led to new information on how computer science was perceived by elementary students. Participants were spontaneously encouraged to say the first word or idea that came to their minds. The top repetitions of responses for boys, in descending order, were “coding,” “video games,” and equal picks of “science/scientist” and “computers.” For girls, the most frequently reiterated responses in descending order were, “coding,” and “computers,” with equal responses of “science,” “video games,” and “robots,” and lastly “science on computers.”

These findings show many similarities in how girls and boys perceive computer science with boys having a bigger association of video games and girls emphasizing computers.

Future Work Aspiration Differences

To gain insights into the career paths that elementary students were contemplating for their future, participants were asked two questions: "What do you want to be when you grow up?" and a follow-up question, "What have you seen adults do as jobs that you might also want to do?" if they found it challenging to respond initially.

When boys were asked about their desired future professions, the majority expressed aspirations in the realm of sports. Specifically, 14 boys (26.4% of the boys) indicated a desire to pursue a career as a professional athlete. Additionally, 11 boys (20.7% of boys) responded with a career in engineering or technology. Finally, 5 boys (9.4% of the boys) mentioned a career in the arts, such as becoming a writer or illustrator. Conversely, girls provided different answers when asked the same question. A significant number of girls, 17 in total (32.1% of the girls) responded with a profession in the arts, including careers as artists, fashion designers, actors, etc. Also, 10 girls (18.9% of the girls) aspired to become an educator, while 8 girls (15.1% of the girls) said a profession related to animals. These occupation differences show a clear divide in how girls and boys perceive themselves and their career expectations at such a young age, even during elementary school years.

Discussion

The Difference in Future CS Work Aspirations

Statistically significant differences were found in the future computer science (CS) work aspirations of boys and girls. This suggests that in the future boys may be more inclined to pursue more CS-related classes or activities, aligning with their interest in CS work. This distinction is further proven when considering the response to the question, “Do you think coding is hard?” It was found that 48 girls (90.6% of the girls) felt coding was hard compared to 42 boys (79.2% of the boys) who shared this belief. These perceptions could influence their future involvement in computer science activities.

These findings relate to stages 2 and 3 of Gottfredson's career theory development (Gottfredson, 1981). Stage 3, which encompasses children aged 9 to 13, marks the awareness of social prestige and the intelligence levels required for specific jobs. If elementary school girls perceive coding as difficult, they might associate it with a higher intelligence threshold. In stage 2, which pertains to children aged 6 to 8, individuals begin associating jobs with gender roles and eliminate careers they deem inappropriate for their gender. This is evident in the survey question asking participants who they envisioned when thinking of a computer scientist: a boy, a girl, or all genders. Notably, 21 boys (39.6% of the boys) said they primarily envisioned a boy as a computer scientist, compared to only 2 girls (3.8% of the girls) who said they envisioned a girl. Conversely, 10 girls (18.9% of the girls) went as far as to say they primarily envisioned a boy as a computer scientist, and none of the boys mentioned a girl. While a significant percentage of girls (77.4%) envisioned a computer scientist as encompassing all genders, the disparity in the way boys answered underscores prevalent societal stereotypes. These stereotypes could cause young girls to eliminate certain careers that they perceive as gender-inappropriate.

Stereotypical gender roles in job aspirations also emerged when participants were asked about desired future professions. Boys frequently responded to this question with traditional stereotypically masculine jobs like professional athletes, and STEM jobs. Conversely, girls expressed more stereotypical feminine jobs like artists, educators, and animal relations. Showing even more prominently the relationship between perceived stereotypes of elementary students and their desired work aspirations.

Differences in Appreciating and Engagement in CS

Statistically significant differences are found in boys and girls in their appreciation of computer science ideals. These disparities indicate that boys tend to perceive a greater value in computer science and coding in their everyday lives, underscoring a gender-related gap in attitudes towards the subject. While both boys and girls had a median agreement (score of 4) when asked, “Knowing about computers can be helpful in my everyday life,” the real distinctions in girls’ and boys’ responses for this section emerged with the responses to the other statements in this section. These statements focused on how children view themselves and how others perceive their computer knowledge and interests. Boys had a higher median than girls in each of these Likert questions. This suggests that, from a young age, boys tend to possess higher confidence in their computer skills and self-perceptions related to technology. This phenomenon aligns with research indicating that, in fields like computer science, men often report greater comfort and confidence with technology compared to women (Temple & Lips, 1989).

This finding brings it back to the sociologist Shelly Correll’s work at Stanford, which highlights how women tend to compare themselves lower than men, specifically in STEM-related fields like math, even if they have equivalent past math achievements (Correll, 2001). Also interesting to point out that this was from 2001, and this problem still exists today. For instance, a 2019 study surveyed over 2,200 children and teenagers to understand their beliefs about computer science. The study found that 51% of the participants believed that boys were more interested in computer science than girls, while only 14% thought that girls were more interested than boys. This finding is significant because another study revealed that girls were considerably less interested in a computer science activity when they were informed that more boys were interested in it than girls (resulting in 35% of the girls choosing the activity). In contrast, when girls were told that both boys and girls had an equal interest in the activity, 65% of the girls chose to participate (Eckart, 2021). Once again, the data underscore the importance of boosting girls' confidence in computer science.

Even though the differences in engagement between boys and girls in computer science are statistically significant, meaning boys are exposed to and engage in more computer science than girls, this could be due to the higher appreciation that boys have towards computer science. Furthermore, this self-confidence plays a significant role in driving engagement. Research has shown that higher self-confidence motivates individuals to achieve more, leading to increased engagement (Druckman & Bjork, 1994). Building on Correll’s insights, higher confidence among boys in their computer science skills may prompt them to pursue more advanced computer science experience than their female counterparts. Correll’s work also indicates that higher confidence inspires students to take more challenging courses. As previously mentioned, she found that boys are 1.2 times more likely to enroll in calculus than girls simply because they believed they were good at math (Correll, 2001). Therefore, the gender difference in engagement with computer science can in part be attributed to the higher confidence levels exhibited by boys. These findings demonstrate how imperative it is to get girls' confidence in computer science up as early as possible. This will not only shift their attitudes in how they appreciate computer science but also boost their engagement levels in computer science as well.

No Perceived Parental Attitudes and Value differences

The analysis indicates there is no statistically significant difference found between the parents' attitudes and values towards computer science-related topics based on the gender of their child. This is further proven when looking at specific questions within this factor. For instance, one question asked, “I or another immediate family member in my child's life has explained to my child that coding and computer skills are useful for them in the future.” Both parents of girls and boys provided a median response of 4, indicating agreement. This consistent pattern was observed for all questions in this section, except for the final question, “I expect my child to go to college.” On this question, both parents of girls and boys recorded a median response of 5, indicating strong agreement. This outcome aligns with my expectations, considering the survey was distributed in the middle of the work week, typically in the middle of the day to parents and their children, which means that in most cases there was at least one stay-at-home parent present. This suggests that the other parent may have a higher level of education to be earning the high wage indicated by their income bracket in the demographic question. Lastly, as previously discussed, the higher education of a parent is positively correlated to their expectations of their child also getting a college education (OECD, 2017).

Conclusion

This study sheds light on the persistent and concerning gender gap in computer science attitudes that emerges at a very early age. It also emphasizes that this computer science gender gap is not solely due to outside demographic factors, such as varying socioeconomic statuses. Because this gender disparity remains prevalent even among children who come from high-income households, with the survey median income being more than $145,000. However, this observation raises concern over the fact that if the gender disparity is already prominent for higher-income families who have access to better resources for their children; then this gap could be amplified far worse for lower-income families. Moreover, this study also offers insights into how even though a city like Seattle may be a booming tech hub, gender stereotypes relating to STEM still heavily persist. These gendered stereotypes that society has created are still being passed down from generation to generation. Ultimately, even though parents' attitudes and values for their kids may be the same for each gender, children are still exposed to so many other factors that subtly continue to shape their attitudes, reinforcing societal gender norms.

This leads to the critical question of what is the best next step to continue to limit the gender attitudinal discrepancies between boys and girls concerning their computer science appreciation, engagement, and future work plans.

The first step to addressing this problem is by continual education of children from early elementary up to high school on what computer science entails and the limitless opportunities it offers. Continual exposure and engagement in computer science will help all children, specifically girls, begin to break down preconceived societal stereotypes about computer science. Great computer science engagement will help kids build confidence in their skills and self-efficacy toward computer science, which will motivate them to continue to follow their computer science interests with more STEM classes and activities. Another crucial aspect is the need for greater representation in computer science. It's essential for children to see a diverse array of role models who resemble them. These role models can help challenge stereotypes and inspire confidence, showing that anyone, regardless of gender, can thrive in computer science.

By taking these steps, society as a whole can work towards narrowing the gender gap in computer science attitudes, which will pave the way for more equitable opportunities that will help foster an environment that enables every child, no matter what gender, race, income, or any other factors, to pursue any passion that inspires them. This will create an inclusive world equipped with generations of kids who are ready to innovate the future with technology.

Limitations and Future Work

The limitation of this study was that there was no random sampling, instead to achieve the best representative of people, the survey was distributed to a variety of parks in various cities in the Seattle area. In addition, there was a lack of representation of lower income participants in the survey which if this is done again a better mix of family income levels would give a more accurate representation of the city as a whole. Every park where the survey was distributed could have been accessed through public bus transportation by all income-level families.

In the future, this study can be expanded on by including a larger number of kids to increase representation size, as well as by focusing on determining ways that would help boost elementary interest and engagement in computer science by making it more adaptable and easily implemented not just inside of the classroom, but at home too. It is also noteworthy, how the study indicates how interested and supportive parents are about their children learning computer science, yet engagement at home remains low. This means more at-home coding resources that are easy for parents to introduce to their child could be beneficial for increasing computer science engagement. Lastly, future plans for this study are, that it could be distributed across other cities in various states that are maybe not as big of tech hubs as Seattle, to determine if there are differing gender discrepancies between elementary students there.

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