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# Children's Interest in a CS Career: Exploring Age, Gender, Computer Interests, Programming Experience and Stereotypes

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## ABSTRACT

**Background and Context.** Increasing gender diversity in the field of Computer Science (CS) benefits the economy as well as gender equality. However, several obstacles - including underdeveloped CS interests, lack of programming experience, and a misfit with the stereotypes of computer scientists - prevent women from entering the field. Although these barriers develop from an early age, research focused on children is limited. Furthermore, limited work is done within European countries.

**Objectives.** In this study, we research the interest children aged 7 to 14 have in a CS career. Additionally, we look into whether children with different characteristics have a different interest in CS. As such our research question: *How does children's interest in a CS career differ based on their a) age, b) gender, c) computer interests, d) programming experience, and e) stereotypical beliefs?.*

**Method.** We collected data from 200 children in a science museum located in the Netherlands. We gathered data on their gender, age, computer interests, programming experience, stereotypical beliefs and interest in becoming a programmer - as representative of a CS career. We used self-reported closed questions and reduced-length Child Implicit Association Tests.

**Findings.** In general, the participating children are not interested in a CS career. We did find several characteristics related to a higher interest in a CS career: being a boy, having an interest in computers or video gaming, gaining programming experience at home or at an out-of-school activity, and the belief that programmers are social.

**Implications.** To increase the participation of women in CS, we suggest motivating girls more to engage in computer and programming activities - especially out-of-school activities - while ensuring that these activities are gender inclusive.

## CCS CONCEPTS

• **Social and professional topics → User characteristics**; **Computing occupations**.



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## KEYWORDS

age, gender, computer interests, programming experience, stereotype, career orientation, computing

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## 1 INTRODUCTION

Increasing gender diversity in the field of Computer Science (CS) is beneficial for the economy as well as for gender equality. The high amount of unfilled IT vacancies in Europe, combined with the digitization of society, is a serious threat to the development of the EU economy [19]. Women not pursuing a career in CS is not only a missed opportunity to fill these vacancies, but it also disproportionately excludes them from a sector with in-demand and high-paying careers [21]. The lack of gender diversity in CS also results in biased products and services [19, 52], disadvantaging female users of technology that plays an important role in everyday life [37, 52].

Previous research shows that female students being less interested in a CS career is influenced by, among others, computer interests, programming experience and stereotypes [1, 8, 26, 28, 46, 50]. Girls are less stimulated by their environment to develop their interests in computers and to gain experiences in CS [37, 46]. Moreover, they might not see themselves working in CS if they do not fit the stereotypical image of a computer scientist [7, 20, 26]: being male, asocial and technologically oriented [7, 8, 20].

The obstacles faced in pursuing CS are well studied among secondary school and post-secondary school students [36] but less among younger students. Furthermore, we see that a majority of the work is conducted within the United States. This is supported by van der Meulen et al. [47] who found that 71% of the CS education studies published at three main conferences are conducted in the United States and only 13% within Europe. Therefore, we focus on children aged 7 to 14 in the Netherlands aiming to answer the following research question:

**RQ.** *How does children's interest in a CS career differ based on their a) age, b) gender, c) computer interests, d) programming experience, and e) stereotypical beliefs?*

To answer our research question, we collected data from 200 children in a science museum. The quantitative study gathered data on age, gender, computer interests, programming experience and stereotypes which we measured with both self-reported closed questions and reduced-length Child Implicit Association Tests.

# 2 BACKGROUND

## 2.1 Career interests

Childhood (till the age of 14 [49]) is an important life stage to explore different careers [29, 48]. Children are exposed to and learn about various careers through textbooks, adults they know, and multimedia sources [38]. Children tend to be attracted to sensational and glamorous jobs and jobs occupied by people of their gender and social class [38].

OECD [25] collected data on career aspirations from 15-year-olds in 41 countries. The top 5 occupations among girls were doctors, teachers, business managers, lawyers, and nursing and midwives, while the top 5 among boys consisted of engineers, business managers, doctors, ICT professionals and sportspeople. Within the United Kingdom, 13,070 primary school children aged 7 to 11 drew a picture of what they wanted to do when they were older [6]. For girls, 57 professions were identified and ranked with the top 5 being teacher, vet, sportspeople, doctor and artist. Two computer-related professions were found at number 15 (social media and gaming) and number 57 (IT consultant). For boys, 65 professions were identified and ranked with the top 5 being sportspeople, social media and gaming, police, army/navy/airforce/firefighter, and scientist. The IT consultant was ranked number 49 for boys. The study revealed gendered patterns in STEM-related professions: over four times the number of boys wanted to become engineers (civil, mechanical, electrical) compared to girls.

Research on STEM career orientation - which includes but is not exclusive to CS careers - found that children up to about age 10 are interested in science and technology but children at a later age indicate that a STEM profession 'is not for me' [48]. According to van Tuijl and van der Molen [48], too many children prematurely exclude STEM-related study and work options based on negative or vague images of the field or negative ability beliefs. Furthermore, dissatisfaction with the school (science) curriculum contributes to the lack of choice for STEM subjects and studies [48].

Research on CS career orientation identifies several factors influencing whether someone pursues a CS career including personal interest or intrinsic motivation [1, 24, 37], personal abilities [24], career perspectives [37, 46] and fitting in [7, 8, 20, 26, 36]. Girls being less interested in a CS career is influenced by, among others, computer interests, programming experience and stereotypes [1, 8, 26, 28, 46, 50].

## 2.2 Computer interests

Having experience with computers has a positive impact on students' interest in CS [37, 46]. Findings from a survey on 25,101 children aged 9-16 from 19 European countries indicate that, taking the average of the countries, 43% uses a computer daily [45]. The most frequent device to go online is, however, the phone. The average time spent online every day varies little between boys and girls, but in countries where the difference is more than 10 minutes, boys spend a little longer on the internet than girls. Findings also include that 15 to 16-year-olds spend almost twice as much time online than 9 to 11-year-olds. Among secondary school students, significantly more boys than girls use a computer in the home [37] and do so more frequently. This is in line with the findings of Tsagala and Kordaki [46], where female Computer Science and Engineering (CSE) students more often report having no previous computer experience than male CSE students.

Computer gameplay and social media are the two most common forms of entertainment in the digital age [43]. Frequent computer gameplay is found to be strongly associated with CS career interest for both male and female college students [43]. Especially those who play a large variety of game genres have higher levels of interest in CS [42]. A study conducted in 19 European countries found that, in the majority of these countries, playing online games is strongly structured by gender with more boys playing daily [45]. This is in line with the results of a more recent monitor on media usage in the Netherlands [30] in which parents of 7 to 12-year-old children indicated that 21% of the boys and 8% of the girls play games. These gender differences can be explained by the gaming industry being male-oriented and not having made active efforts to incorporate the interests of girls [43, 46]. However, several studies use game playing or designing as a mechanism to increase girls' interest in a CS career [5, 44].

## 2.3 Programming experience

Previous programming experience is significantly correlated with the CS career orientation of primary school students [1]. Moreover, gaining programming experience in secondary school is the best predictor of persistence in female CS college students [50]. However, boys are more involved in CS courses at secondary school than girls [26, 37]. At code clubs (where the majority of participants are 9 to 16-year-olds) girls are underrepresented and code club teachers report that boys are more familiar with and have more prior knowledge compared to girls [2]. This is supported by the findings of Papastergiou [37], where more boys in secondary school state knowing a programming language than girls. In the Netherlands, programming or CS education is not mandatory within both primary and secondary schools. Only about half of the secondary schools offer CS courses [32].

## 2.4 Stereotypes

The stereotypical image of a computer scientist includes being male, asocial and technologically oriented [7, 8, 20]. Stereotypical beliefs can occur at an early age; 6-year-old children think that boys are better than girls at robotics and programming [27] and endorse stereotypes that girls are less interested than boys in computer science and engineering [28]. However, another study employing self-reported closed questions found that students (aged 8-12) are not inclined towards any particular belief of a computer scientist being male, asocial, singular-focused or competitive [1].

Having stereotypes about CS can impact students' interest in a CS career [7, 26]. CS appeals most to those who feel that they fit the stereotypes, and, thus, girls (who are less likely to feel that they fit the stereotypes) report less belonging and interest in enrolling in CS compared with boys [26]. This is supported by Master et al. [28], where young girls who endorse gender-interest stereotypes have lower interest and sense of belonging in CS. However, some students are able to reject stereotypes about what is required to be a computer scientist [20, 36]. Among these non-stereotype adopters, girls can even have a similar sense of belonging as boys [36].

A stereotype can be held unconsciously or implicitly and consciously or explicitly. An implicit stereotype is relatively inaccessible through conscious awareness and thus can not be measured by directly asking participants about it. However, implicit stereotypes can be measured via automatic responses, for instance, response time in categorization tasks [39]. An explicit stereotype, on the other hand, is one we can deliberately think and report about and thus can be measured by asking participants about it [10], for instance via self-reports [39].

# 3 METHODS

## 3.1 Participants

We recruited participants at NEMO Science Museum in Amsterdam for 14 days in a row during the summer of 2020. Visitors were recruited via screens at the entrance of the museum as well as by the research team actively asking visitors who walked by the research space to participate. The research team at the museum consisted of eight women. The team was a mix of researchers, student assistants and employees from the non-profit organisation VHTO. Before participating, a guardian signed an informed consent form. The design of the study is approved by the ethics committee of Leiden University.

The 200 participants in the presented study are between the age of 7 and 14 (mean = 9.94, median = 10). The age distribution is shown in Figure 1.

Of the participants, 85 (or 43%) identify as a boy, 97 (or 49%) as a girl, 4 (or 2%) as neither a girl nor a boy and 14 (or 7%) prefer to not disclose their gender. The majority of the children (154 or 77%) have both parents born in the Netherlands, and 21 (or 11%) have one parent born in the Netherlands. More than half of the participants (114 or 57%) have experience with programming. Of these participants, 79 (or 69% of the experienced children) gained this experience at school, 35 children (or 31% of the experienced children) at home and 21 (or 18% of the experienced children) at out-of-school activities. More boys (58 or 68% of the boys) than girls (49 or 51% of the girls) indicated to have programming experience. Figure 2 shows the programming experience of boys and girls in percentages.

## 3.2 Measures and materials

Data were collected digitally on laptops with the use of open-source software[1] we developed for this study. The software was developed with a focus on usability, data security, and creating a neutral environment without distractions. The interface of the software is kept simple: only research-related components were visible and we primarily use black-and-white elements. For the images included

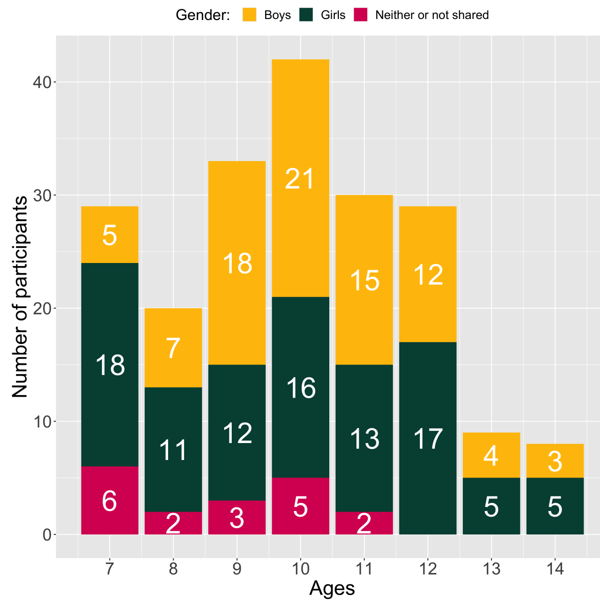



**Figure 1: Age distribution of participants (n = 200) and their gender**

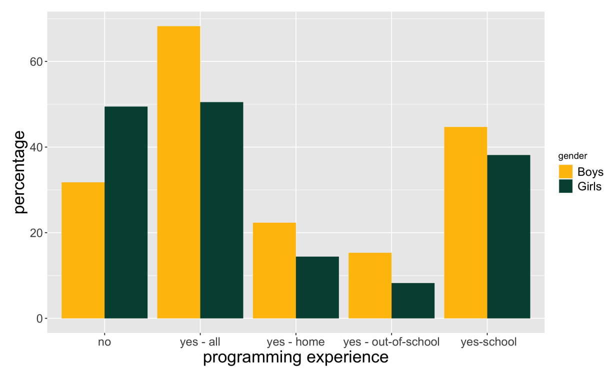



**Figure 2: Programming experience of boys (n = 85) and girls (n = 97) in percentages**

in the application, used to measure stereotypes as described in Section 3.2.6, we used artist-drawn black-and-white images designed for this study.

*3.2.1 CS career orientation.* We measured the interest in a CS career similar to [1, 12] by asking children to what extent they agree or disagree with the 5-point Likert-type item *'I want to become a programmer'* (translated from Dutch). Although the field of CS includes a variety of professions such as software engineers and computer scientists, most of these professions don't have a fitting translation in Dutch. Therefore, we used the commonly known term 'programmer' to represent a CS career.

[1]Materials including the questions, software, scripts and anonymized dataset can be found at https://shirleydewit.com/icer2023

*3.2.2 Age.* Children indicated their age by answering the multiple choice question *'How old are you?'* (translated from Dutch).

*3.2.3 Gender.* We asked children about their gender with the multiple choice question *'I feel like a ...'* (translated from Dutch). They could respond with 'boy', 'girl', 'neither' or 'prefer not to disclose'.

*3.2.4 Computer interests.* We asked participants about their interest in computers with the use of a 5-point Likert-type item ranging from agree to disagree. We also asked the participants if they prefer video gaming or playing tennis with a 5-point Likert-type item. Asking about the stereotypical video gaming and non-stereotypical playing tennis is in line with the categories used to measure implicit stereotypes and is explained in Section 3.2.6.

*3.2.5 Programming experience.* We asked participants via a multi-select multiple choice question whether they have previous programming experiences and, if so, whether they obtained these experiences at school, at out-of-school activities such as a code club, at home with family or friends, or a combination of the above. The children with no experience include the children who indicated that they did not know what programming is.

*3.2.6 Stereotypes.* We measured both the unconscious or implicit stereotypes and the conscious or explicit stereotypes participants hold on the 1) gender, 2) social skills and 3) interests of a programmer. As explained in Section 3.2.1, we used the term 'programmer' to represent a CS career.

**Implicit stereotype.** The implicit stereotypes were measured with the reduced-length Child-Implicit Association Test [41, 51] which is based on the widely used Implicit Association Test (IAT) [15]. Table 1 shows the 5 blocks of the Child-Implicit Association Test, with the gender-profession IAT as an example. As described by [12], in each block participants need to categorize images to the left or right on a computer with the use of the keyboard. The number of images per block is indicated by the number of trials in Table 1. The order of these images is random, however, each image appears an equal amount of times. A participant can familiarize themselves with the images and to which category they belong in the mandatory practice blocks (blocks 1, 2 and 4 in Table 1). Within the successive test blocks (block 3 and 5 in Table 1), participants need to sort two categories to the left and two categories to the right, for example, boys and programmers to the left and girls and writers to the right. Within these blocks, reaction time is measured. The quicker the response, the stronger the implicit association between the categories on the same side. For example, when a participant is faster in categorizing boys and programmer images to the left than girls and programmer images, the implicit association between boys and programmers is stronger than that of girls and programmers. The order of block 3 (stereotype consistent block) and block 5 (stereotype inconsistent block) are counterbalanced, as suggested by [41, 51].

All concepts, categories and images used within the IATs are described in Table 2. For the profession concept, we decided on a writer opposite to a programmer in line with other IAT studies [11, 34, 54], where science and mathematics are contrasted with language. We also considered a programmer to be the creator of software whereas a writer is the creator of new texts. Since both professions can use similar tools such as computers, we decided to use images of products a programmer or a writer creates. For the interests concept, we use the categories video gaming and tennis. Video gaming is considered to be one of the stereotypical hobbies of a computer scientist [9, 26] and is consistent with having a singular focus on computers. One of the non-stereotypical hobbies is playing sports [9]. A sport that is evenly popular in the Netherlands among boys and girls, as well as among major and minority groups, is tennis [13] and therefore chosen as the second category in the interests concept.

**Explicit stereotype.** We asked participants about their explicit stereotypes regarding programmers' gender, social skills and interests with two types of questions. Children indicated whether a statement applies to programmers or writers, with the categories being in line with the IATs as described in Section 3.2.6, for example *'Which profession do you think is for girls?'* (translated from Dutch). We also asked children to indicate whether a statement applies to programmers, for example *'Being a programmer, that is a profession for...'* (translated from Dutch). All questions on explicit stereotypes are 5-point Likert-type items.

*3.2.7 Pilot.* Before conducting the study, the software and images created for this study [1] were tested on stability and usability in a two-day pilot. Within this pilot, located at the same science museum where the experiment was conducted, 17 children participated.

During the pilot, some children had difficulties navigating through the software. We adjusted the layout to include larger buttons and prevented the need for scrolling. Furthermore, we removed an open question because it took children a lot of time and effort to enter their answer. We also added a read-aloud functionality since some children asked the researcher to read aloud the texts. To help children control the IATs, we added yellow stickers on the keys they needed to use. Additionally, we created a fruit-vegetable categorization task which we encouraged children to do before entering the research space. During the experiment, we observed that the changes we made solved the usability issues identified in the pilot.

We also tested whether the images for the IAT were clear and logical for the children. Initially, the gender images were not. For almost all children, long hair equals a girl and short equals a boy. Therefore we changed the images such that all girls have long hair and all boys have short hair in the study. For the interests concept, children did not recognize one of the video gaming consoles so we updated this illustration as well.

## 3.3 Procedure

We collected data from children aged 7 to 14 who were visiting a science museum in the Netherlands. We did not recruit children under the age of 7, since self-report is difficult for younger children [49]. We excluded all participants over 14 since we focus on childhood of which the upper age limit is agreed to be 14 years [49].

Participants were informed that the research was about professions, without disclosing what we measured for which professions. Afterwards, participants had the opportunity to ask more questions. The data was collected digitally on laptops in a dedicated research space in the museum. The space was not decorated and only contained materials for the study such as desks with laptops. During the 14 days of data collection, we ensured that at least one of the authors was present (except for one day due to health problems)

**Table 1: The structure of the reduced-length Child-IAT with the gender-profession IAT as example**

| Block | Trials | Function | Left response | Right response |
|---|---|---|---|---|
| 1 | 16 | Practice | Programmer | Writer |
| 2 | 16 | Practice | Boy | Girl |
| 3 | 32 | Test | Programmer + boy | Writer + girl |
| 4 | 16 | Practice | Girl | Boy |
| 5 | 32 | Test | Programmer + girl | Writer + boy |

**Table 2: Concepts, categories and images used in the gender-profession, social-profession and interests-profession IAT**

| Concept | Category | Images |
|---|---|---|
| Profession | Programmer | Website, video streaming, video calling, social media |
| | Writer | Magazine, book, newspaper, papers |
| Gender | Boy | Four different boys |
| | Girl | Four different girls |
| Social skills | Alone | Four persons standing alone |
| | Together | Four groups of two persons standing |
| Interests | Video gaming | Four different video game controllers |
| | Tennis | Tennis racket, ball, shoe, net |

and that, after the first day, at least one of the three people present conducted the study on a previous day.

The quantitative study conducted in the Dutch language included a video in which a programmer explains what a programmer does. Participants included in this study saw this video after completing all questions and tasks. Implicit gender stereotypes were measured for all participants with the gender-profession IAT followed by either the social-profession IAT or interests-profession IAT. By only having two instead of three IATs per participant, the length of the study was limited to retain the focus of participants. Whether participants started or ended with the video as well as the appointment of the IAT was done randomly. The data on children who started with the video as well as a more detailed analysis of implicit and explicit stereotypes is reported on [12].

## 3.4 Data analysis

We included data from participants who completed the entire study - indicated by whether participants filled in their age and gender (which were the last questions) as well as additional notes made by the researchers during data collection. When collecting data, the study was open for participants till the age of 18. Excluding all participants over 14 - since we focus on childhood [49] - resulted in excluding 8 participants. All data analyses are done with R [1].

*3.4.1 CS career orientation, computer interests, explicit stereotypes.* We measured CS career orientation, computer interests and explicit stereotypes with 5-point Likert-type items. There is controversy on whether data from these items should be analysed as ordinal or continuous data [18]. According to Boone and Boone [4], a Likert-type item is a single question while a Likert scale contains at least four Likert-type items. They state that data from single Likert-type items should be considered ordinal. Moreover, Wu and Leung [53] suggest that 11 scale points are needed to consider the data continuous. Thus, we analysed the Likert-type items as ordinal data and thereby we report on mode, median and frequency distribution.

To determine correlations, we used the non-parametric Spearman Rank Correlation. A correlation with a correlation coefficient below 0.19 is considered very weak, between 0.20 and 0.39 weak, between 0.40 and 0.59 moderate, between 0.60 and 0.79 strong and above 0.80 very strong [35]. We compared correlations by using Fisher's z-transformation [14, 31].

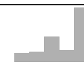
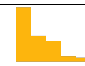
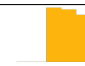
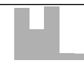
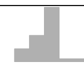
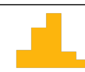
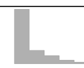
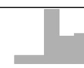
*3.4.2 Age.* We analysed the age of participants in groups: 7-8-year-olds, 9-10-year-olds, 11-12-year-olds and 13-14-year-olds. For differences between the age groups, we used and report on the non-parametric Wilcoxon-Mann-Whitney test following [14]. Next to analysing solely on age, we incorporated age groups within the gender, computer interests, programming experience and stereotypes analyses.

*3.4.3 Gender.* When analysing gender, we only considered boys and girls since the other two categories have insufficient data points. To determine differences between boys and girls, we used and report on the non-parametric Wilcoxon-Mann-Whitney test following [14]. Next to analysing solely on gender, we incorporated gender within the age, computer interests, programming experience and stereotypes analyses.

*3.4.4 Programming experience.* Participants indicated their programming experience with the use of pre-defined categories, as described in Section 3.2.5. These categories are used within our analysis. For differences between groups, we used and report on the non-parametric Wilcoxon-Mann-Whitney test following [14].

*3.4.5 Implicit stereotypes.* For the implicit stereotype, we re-used the D measure of [12] which is calculated with the improved scoring algorithm [17]. For IATs in which more than 10% of the trials have very low latency (below 300 ms) no D measure is calculated. This results in the exclusion of 2 social-profession IATs and 1 interests-profession IAT. The D measure is usually between -2 and 2 and

**Table 3: Likert-type items on CS career interest, computer interests and explicit stereotypes and their mode, median and frequency distribution as well as the frequency distribution for boys (n = 85) and girls (n = 97)**

| Measure | Description | Mode | Median | Distribution - all | Distribution - boys | Distribution - girls |
|---|---|---|---|---|---|---|
| CS career interest | I want to become a programmer<br>1 = agree, 5 = disagree | Disagree | Slightly disagree |  |  |  |
| Computer interests | I am interested in computers<br>1 = agree, 5 = disagree | Agree | Slightly agree |  |  |  |
| | I am more interested in playing<br>1 = video gaming, 5 = tennis | Video gaming | Bit more video gaming |  |  |  |
| Explicit stereotype - gender | Profession suitable for girls<br>1 = programmer, 5 = writer | Both | Bit more writer |  |  |  |
| | Profession suitable for boys<br>1 = programmer, 5 = writer | Both | Bit more programmer |  |  |  |
| | Programming is a profession for<br>1 = boys, 5 = girls | Both | Both |  |  |  |
| Explicit stereotype - social skills | Makes friends easier and prefers to work together<br>1 = programmer, 5 = writer | Both | Both |  |  |  |
| | Programmers make friends easily and prefer to work together<br>1 = agree, 5 = disagree | Neutral | Neutral |  |  |  |
| Explicit stereotype - interests | Likes to play video games<br>1 = programmer, 5 = writer | Programmer | Programmer |  |  |  |
| | Likes to play tennis<br>1 = programmer, 5 = writer | Both | Both |  |  |  |
| | Programmers like computers and have little other interests<br>1 = agree, 5 = disagree | Slightly agree | Neutral |  |  |  |

its absolute value indicates the strength of the implicit association: above 0.15 indicates a weak implicit association, above 0.35 indicates a moderate implicit association and above 0.65 indicates a strong implicit association [3]. We report on the median, mean, standard deviation and distribution for the D measure. We looked into correlations between the D measure and CS career orientation by using the non-parametric Spearman Rank Correlation.

# 4 RESULTS

Overall, the children that participated in this study do not want to become a programmer (mode = disagree, median = slightly disagree). The responses on CS career interests, computer interests and explicit stereotypes, which are measured by the Likert-type items, are included in Table 3. For the D measures of implicit stereotypes, the mean, median, standard deviation and distribution are shown in Table 4.

## 4.1 Age

The interest in a CS career does not significantly differ between the 7-8-year-olds (n = 49, mode = disagree, median = slightly disagree), 9-10-year-olds (n = 75, mode = disagree, median = slightly disagree), 11-12-year-olds (n = 59, mode = disagree, median = disagree ) and 13-14-year-olds (n = 17, mode = disagree, median = slightly disagree). When comparing girls and boys within the four age groups, no different CS career interests are found.

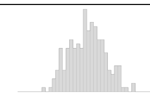
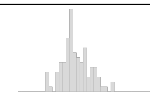
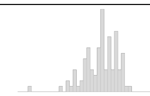
Thus, no different interest in a CS career is found based on the participants' age.

## 4.2 Gender

The interest in a CS career between boys and girls differs significantly with W = 5181, p = .00129, r = -.239. Boys' interest in becoming a programmer has the mode disagree but the median is neutral. Girls' interest in CS has the mode disagree and median disagree. The distributions of interest in a CS career for boys and girls are shown in Table 3. The difference between girls and boys holds for the 9-10-year-olds (W = 692.5, p = .0457, r = -.244), where boys (n = 39) have a mode of disagree and median of neutral and girls (n = 28) have a mode of disagree and median of disagree, and for the 13-14-year-olds (W = 61, p = .00874, r = -.636), where boys (n = 7) have a mode of neutral and median of neutral and girls (n = 10) have a mode of disagree and median of disagree.

Thus, even though both boys and girls are not interested in a CS career, girls are even less interested in a CS career than boys.

**Table 4: Implicit gender, social skills and interests stereotypes represented by the mean, median, standard deviation and distribution of the D measures**

| IAT | Measured association | n | Mean | Median | Standard deviation | Distribution with x from -2 to 2 |
|---|---|---|---|---|---|---|
| Gender-profession | programmer/writer and boy/girl | 200 | 0.0670 | 0.0821 | 0.513 |  |
| Social-profession | programmer/writer and alone/together | 99 | -0.264 | -0.342 | 0.402 |  |
| Interests-profession | programmer/writer and video gaming/tennis | 98 | 0.459 | 0.527 | 0.481 |  |

## 4.3 Computer interests

Interest in computers is weakly correlated with interest in a CS career, with $\rho$ = .325 and p = 2.68e$^{-06}$. The weak correlation also exists for girls ($\rho$ = .273 and p = .00691) and for boys ($\rho$ = .347 and p = .00115). These correlations are not significantly different.

A moderate correlation holds for 9-10-year-old children ($\rho$ = .446 and p = 6.19e$^{-05}$) and a weak correlation for 11-12-year-old children ($\rho$ = .375 and p = .00343). The correlations are not significantly different.

Interest in video gaming is very weakly correlated with interest in a CS career with $\rho$ = .166 and p = .0188. When only considering boys or girls, no correlation between interest in video gaming and a CS career is found. For the age groups, only the 9-10-year-olds have a weak correlation between interest in a CS career and interest in video gaming with $\rho$ = .264 and p = .0222.

Thus, children with an interest in computers as well as those with an interest in video gaming have more interest in a CS career.

## 4.4 Programming experience

The CS career interest based on programming experience is shown in Table 5.

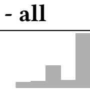
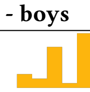
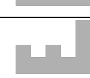
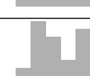
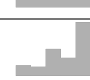
We found that children with no experience have a lower interest in a CS career than children who gained experience at home (W = 1898, p = .0218, r = -.208) and than children who gained experience out-of-school (W = 1219.5, p = .0102, r = -.247).

CS interest of boys who gained experience at home (mode = agree, median = neutral) is higher than that of boys without programming experience (mode = disagree, median = neutral, W = 346, p = .0386, r = -.305) and than boys who gained experience at school (mode = disagree, median = slightly disagree, W = 239, p = .0333, r = -.282). We found that girls with out-of-school experience (mode = disagree, median = neutral) have a higher interest in CS than girls with no experience (mode = disagree, median = disagree) with W = 281.5, p = .0174, r = -.318.

When comparing boys and girls with similar programming experience, we found significantly higher interest for boys than for girls with programming experience (W = 1086.5, p = .0276, r = -0.213) and without programming experience (W = 484, p = .0415, r = -.235). When experience is gained at home, boys have a higher interest in a CS career than girls (W = 60.5, p = .00657, r = -.473).

The interest of children aged 11 and 12 without experience (n = 21, mode = disagree, median = disagree) and experience gained

**Table 5: Mode, median and frequency distributions (including frequency gender distribution) on CS career interest based on programming experience**

| Programming experience | N | Mode | Median | Distribution - all | Distribution - boys | Distribution - girls |
|---|---|---|---|---|---|---|
| No | 87 | Disagree | Disagree |  |  |  |
| Yes - all | 114 | Disagree | Slightly disagree |  |  |  |
| Yes - home | 35 | Disagree | Neutral |  |  |  |
| Yes - out-of-school | 21 | Slightly agree | Neutral |  |  |  |
| Yes - school | 79 | Disagree | Slightly disagree |  |  |  |

at home (n = 8, mode = neutral, median = neutral) differ with W = 123, p = .0348, r = -0.392).

Thus, higher interest in a CS career is found in children who gained programming experience at home or at an out-of-school activity than in children without experience. Boys who gained experience at home also had a higher interest in a CS career than boys who gained experience at school.

## 4.5 Stereotypes

*4.5.1 Implicit stereotypes.* No significant correlations are found between implicit stereotypes on gender, social skills or interests of a programmer and CS career interest for all children. However, 7-8-year-olds do have a moderate correlation with $\rho$ = .433 and p = .0344 between social skills and CS career interest which is an indication that the more social 7-8-year-olds think a programmer is, the more they are interested in a CS career.

Thus, in general, there are no correlations between implicit stereotypes and CS career orientation except for the 7 and 8-year-old children's belief that programmers are social.

*4.5.2 Explicit stereotypes.* No correlations were found between the explicit gender stereotypes and CS career interest for all children. For girls, we did find that the more girls state that being a programmer is something for girls the more they are interested in becoming a programmer, indicated by a weak correlation ($\rho$ = .264, p = .00903).

The more children think programmers are social, the more interested they are in becoming a programmer. This is indicated by a weak correlation ($\rho$ = .194, p = .00592) between thinking that programmers can make friends easily and prefer to work together and an interest in becoming a programmer. This correlation is also found for girls ($\rho$ = .253, p = .0123), and 9-10-year-olds ($\rho$ = .229, p = .0477) and as a moderate correlation for 13-14-year-olds ($\rho$ = .589, p = .0129). For the 11-12-year-olds, we found a weak correlation between thinking programmers make friends easier than writers and interest in CS Career with $\rho$ = .279 and p = .0324.

No correlations were found for the explicit stereotypes related to interests.

Thus, we found a higher interest in a CS career in children who think programmers are social. The more girls believe that being a programmer is something for girls the more they are interested in becoming a programmer.

# 5 DISCUSSION

We researched whether children's age, gender, computer interests, programming experience and stereotypical beliefs result in different interests in a CS career. Quantitative research on interest in a CS career among children is limited, especially in Europe. With this paper, we contribute to the understanding of which children are (not) interested in CS. In line with previous research, we found a higher interest in a CS career in children who identify as a boy and have an interest in computers. New insights include finding a higher interest in a CS career in children who believe that programmers are social. Furthermore, our results show that children with programming experience have a higher interest in CS. Additionally, our findings indicate that where this experience is gained can play a significant role.

## 5.1 Reflection on the results

*5.1.1 Age.* We did not find a different interest in a CS career based on age. This contradicts other work where children up to the age of 10 have an interest in science and technology and from the age of 11 they indicate a lesser fit with these fields [48]. We did find correlations between CS career orientation and children's characteristics that only hold at specific ages - such as for the interest in video gaming for 9-and-10-year-olds. Notable is that for the group of 7 and 8-year-olds this was only the case for the implicit social skills stereotype and not for any of the self-reported characteristics. This might be due to 7 and 8-year-olds not fully understanding what the questions entail. Interest in computers is found to relate with CS career interest in the 9-and-10-year-olds and the 11-and-12-year-olds, but not in the 13-and-14-year-olds. This might relate to them being in secondary school instead of primary school, but also to the fact that older children use computers and their phones more often [45]. With the use of computers being the standard, they might look differently at what it means to be interested in computers.

*5.1.2 Gender.* We found that girls are less interested in a CS career than boys. This contradicts the work of Aivaloglou and Hermans [1] but is in line with Papastergiou [37]. Notable is that no gender differences were found in CS career interest for the children who gained programming experience at school or at out-of-school activities. Maybe children are equally encouraged in these settings, while this might differ at homes where children will be motivated by parents instead of teachers. For children without experience, their interest might be based on (gendered) assumptions and not on actual experiences. However, overall both boys and girls lean towards a disinterest in a CS career. This might be because of an actual disinterest in a CS career. However, it could also be because children have a limited view of CS [37], or due to children having little to no interest in careers in general [33].

*5.1.3 Computer interests.* Interest in both computers and video gaming correlates with interest in becoming a programmer. Similar results are found by [37, 43, 46]. Although previous work indicates that computers and video games are used differently among boys and girls, we did not find differences in their CS career interests related to computer interests. It might be that boys act on these computer interests more than girls do, for instance, because they are stimulated by their environment, or that there is a bias in our sample of children since we did tell children in our recruitment that the research was conducted on laptops with a 'gamelike' task. For the interest in computers, we did not ask whether children see devices as tablets and phones as computers. However, a media monitor [30] shows that 71% of the Dutch children between 7 and 12 use a laptop or notebook.

*5.1.4 Programming experience.* Children that gain experience at home and at out-of-school activities are more interested in becoming a programmer than children that have no experience. Boys had more interest in becoming a programmer when programming experience was obtained at home over at school. We should note that combining age and programming experience did result in small samples for some categories. So not finding differences for most age groups may say more about the sample size than about the absence of differences. Children learning to program through informal experiences being more interested in a CS career could be due to these children being motivated by their parents and/or having intrinsic motivation for these activities [1]. When considering the four phases of interest development [40] - which states that interest is not binary but develops through different phases - it could be that children with informal experiences have more or varied experience with programming, which leads to them being at a more advanced phase of interest. Other factors that might be at play are the lesson materials and the teachers. In coding clubs, half of the teachers have a CS-related background but only 18% of them have a background in education [2]. In contrast, school teachers primarily have a degree in education and do not always have knowledge of CS. This might result in different teaching practices and contexts in which CS is taught.

*5.1.5 Stereotypes.* Children who think programmers are social are more interested in becoming programmers. For girls, we found that the more girls state that being a programmer is something for girls the more they are interested in becoming a programmer. This is in line with Master et al. [26], since a better fit with the stereotypes results in more interest in CS. These findings stress the importance of showing children that CS involves working together and is for all genders. Not finding correlations for all stereotypes could be because of the rejection of stereotypes [20, 36] or the absence of some stereotypes, such as the implicit gender stereotype. Not finding implicit gender stereotypes might be influenced by all team members present in the museum being women.

Based on our findings, to increase the participation of women in CS, we suggest motivating girls more to engage in computer and programming-related activities - such as out-of-school activities - while ensuring that these activities are gender inclusive. The results also emphasize the importance of girls knowing that the programming profession is for girls and is a profession in which you can work together. Examples of how to achieve this include organising a guest lecture by a counter-stereotypical role models [16], having CS classrooms without stereotypical decorations [26], and including cooperative instructional approaches (such as pair programming and working on projects together) within programming activities.

## 5.2 Limitations

The sample consists of science museum visitors which might result in a biased dataset since these visitors, or their families, might already have some motivation to learn about science. We had no control over the demographics of the participants, resulting in fewer 13-and-14-year-olds. We only asked participants about their age but did not include a question about their school level and class, limiting the interpretation of the results. Another limitation is the choice of and the limited variety of professions. Despite the work of a programmer being in the field of CS and having some overlap with a computer scientist, CS is not only programming. We also didn't include a question to collect children's perceptions of the programming profession. Furthermore, the included writer profession may come with its own biases and stereotypes. Including multiple professions within and outside the CS field might result in different insights. In a way, the same holds for interests: we only ask about computers, video gaming and tennis. Moreover, self-reported interest in computers and video gaming does not define the type and duration of use. However, we needed to restrict the variety and depth of the questions because of the length of the study. We aimed at exploring different characteristics instead of focusing on a smaller set of characteristics more in-depth. Furthermore, developing a verified instrument was not within the scope of this research. We should note that due to the nature of the data and statics used, R calculated estimates of the p-value in some cases. The results might also change based on the nation or culture where the study is conducted, which makes it harder to generalise the results, although it also strengthens the contribution of this research because of the limited work on our topic in Europe and specifically in the Netherlands.

# 6 CONCLUSION AND FUTURE WORK

Increasing gender diversity in CS is beneficial for the economy as well as gender equality. From an early age, girls are less stimulated to develop CS interests, to gain programming experience and they might not fit the stereotypes. In our study, we explored children's interest in a CS career based on their age, gender, computer interests, programming experience, and stereotypical beliefs.

By analysing data from 200 children between the ages of 7 and 14, we found differences in CS career interest (specifically in becoming a programmer) based on gender, interest in computers and video gaming, programming experience and stereotypes. Higher interest in a CS career is found in boys, children that have an interest in computers or video gaming, children who gained programming experience at home or at an out-of-school activity and children that believe that programmers are social. For girls, we also found a higher CS career interest when they believe that a CS career is for girls.

For future work, we suggest including self-efficacy measurements since previous research found it being related to STEM career orientation for girls [1, 22, 48]. Extended future work could be connected to computing identity, which is found to be a predictor of students' CS career choice [23]. We also suggest adding questions on different CS careers and connecting them to relatable applications - for instance measuring interest in working on a social media platform. Finally, we stress the importance of future work in the school context. Gaining programming experience in school did not make a difference in CS career interests, while informal education did. More work is needed to understand this better and see how we can help schools in motivating a diverse group of students in a CS career. Our study, as well as suggested future work, contributes to understanding why children are (not) interested in a CS career and how to increase gender diversity in CS.

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