Literature Study

CSE 2000 - Software Project
Delft University of Technology

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Abstract

Gender inequality remains to this day a global issue, with harsh consequences in areas such as personal development, job opportunities, wages, social and behavioural equity, and even health. While the aforementioned situations seem to positively change in numerous fields due to the effort of various non-profit organisations, this change is unnoticeable in computer science. While many factors contribute to this gender gap, this study will focus on the stereotypes revolving around computer scientists. Studies have shown that girls who hold strong stereotypes about programming have lower interest and self-efficacy in programming which in turn leads to them choosing a different career orientation. Stereotypes begin at an early age and it's therefore imperative that enough attention is devoted to finding out if children hold this kind of stereotypes. However, so far studies have been inconclusive. In our project, we aim to fill this gap by researching if children hold stereotypes about programmers and whether they can be influenced by a virtual intervention with role models.

Introduction

Gender inequality (referred also as gender bias, gender inequity or gender gap) is the effect on individuals caused by the natural (biological) differences between men and women, but accentuated by cultural influence [1].

Computer Science, despite being one of the largest and continuously growing fields, currently faces a major gender gap. Although concrete numbers for the world-wide situation are difficult to estimate, the situation can easily be summarized by recent surveys within the European Union (Figure 1).

Camp et al.[3] offers a more in-depth overview of the situation of the world-wide gender gap, signaling the reverse trend that started as early as the 1980s (see Appendix for Figure 2).

This article aims to review the causes of gender gaps in the context of computer science. We will especially focus on the preconceived opinion that individuals of age 6-18 have, as well as elucidate the socio-economic factors caused by such gender discrimination. The main methods of the paper include gathering and analyzing scientific papers that already

A summary of the sources found per group member can be found at the end of the document.

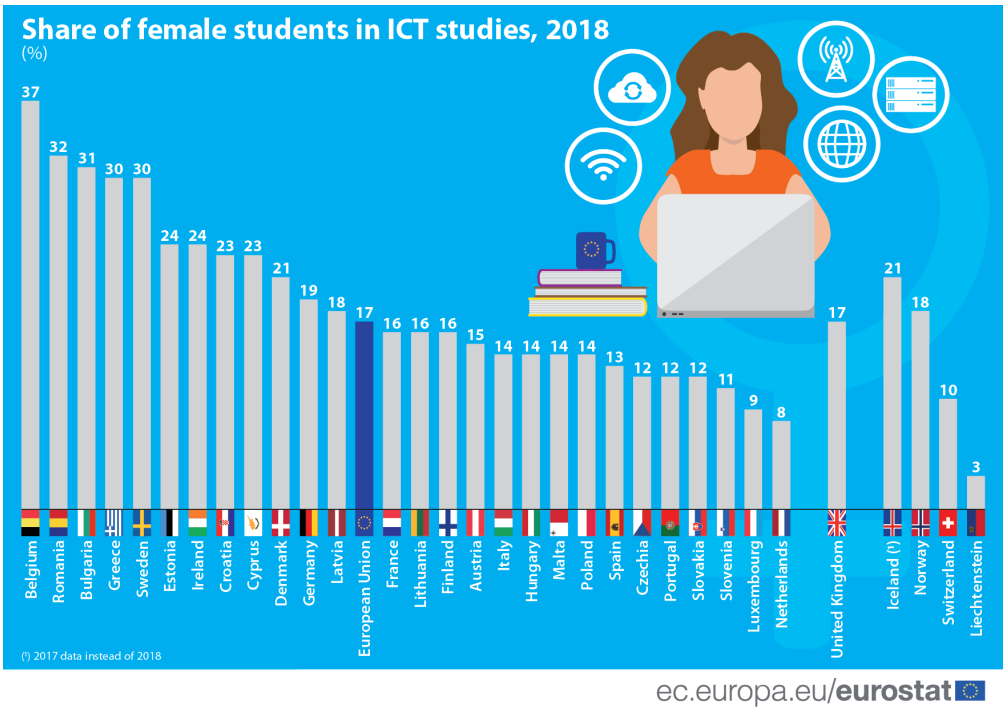

Figure 1: Share of female students in ICT studies 2018, from [2]

conclude various reasons on the topic [4] with the purpose of establishing and categorizing these prejudices.

In this article, we will first review the causes of the low gender diversity in computer science and reflect on the effects that oppressed individuals face, as well as to elucidate the socio-economic factors caused by such gender inequality. We will then elaborate on stereotyping as a primary cause while highlighting results from different studies. Lastly, we will elaborate on the unconfirmed nature of research on stereotypes among children and introduce the methodology used in our project.

Stereotypes in Computer Science

Kendall's 2011 paper [5] correctly identifies the computer scientist's 'nerd identity' to be a key factor for lack of interest of certain groups (the paper is not limited to girls, but also other minorities).

The author states that the associations between 'computers' and nerds have a much deeper aspect, with major influences in music, cinematography, mass-media, gender and race. To quote the article, the following five points summarize the nerd identity, which teenage girls often find repulsing:

1. Computers are an important but problematic type of technology.
2. Nerds understand and enjoy computers.
3. Those who understand and enjoy computers are nerds.

4. Nerds are socially inept and undesirable.

5. Nerds are white.

Women in Computer Science

Understanding the factors that prevent girls from enrolling in introductory computer science courses requires a deep understanding of how stereotypes affect girls, even from early ages. Recent studies emphasised the importance of the sense of belonging in female's interest in computer science [6]. Since interest is a critically important motivational variable that can affect subsequent learning performance [7], it is crucial to understand the way stereotypes shape it, in order to narrow the gender gap in the field of computer science.

Various experiments have shown that ambient factors have a statistically relevant impact on girls' choice to enrol in STEM courses. In an experiment carried by Master et al [6], high-school students were shown photographs of two different classrooms, one stereotypical and one non-stereotypical, in which the same computer science oriented course would have been carried. While girls were more likely to choose the non-stereotypical classroom, there was no preference in boys' choices. At the same time, girls were less concerned of negative stereotypes (e.g. boys perform better in STEM courses) when showed the non-stereotypical environment.

This experiment, among others, paints the same consistent picture about the role of stereotypes in the girls' decreasing interest in computer science. Although there exist other variables involved in the enrollment choice, such as students' expectations for success and subjective task value [8], evidence that class environments could be a way of engaging female gender students in computer science related courses should be a point of further discussion for change in educational institutions.

Stereotypes in children

Stereotypes held by children greatly influence their career development process. During different stages of children development, changes might occur in the way they describe occupations. In a study by Borgen and Young [9], when describing occupations, elementary school children were more likely to consider activities and behaviours while older children focused more on interests, aptitudes and abilities. Studies, in fields like mathematics, have shown that math-gender stereotypes are acquired as early as elementary school and they "differentially influence boys' versus girls' self-identification with math prior to ages at which differences in math achievement emerge" [10].

It seems that the gender might also have an influence on the type of occupation aspired by the children. It has been found that boys tend to aspire to more physically active, concrete and practical occupations, while girls have a preference towards more people-related, artistic and data-based occupations [11]. Research by Bandura et al [12] has also determined that boys show greater confidence in aspiring to scientific and technological occupations, while girls are more confident when it comes to occupations in education, health and the social services [11].

From the ideas and studies that we have considered until this point, there seems to be a general assumption that children, regardless of age, have some kind of occupational gender stereotypes. However, for computer science related fields, current studies have been inconclusive. In one recent study by Aivaloglou and Hermans [13], during an eight-week Scratch programming course, children in elementary schools were asked to complete a questionnaire in order to measure their belief on four stereotypical traits of computer scientists: singularly focused, asocial, competitive and male. The results of the study showed that the children did not hold any particular stereotypes and were therefore not influenced by them.

At the same time, a study by Hansen et al [14], where children were asked to draw a computer scientist produced different results. In the study, children were asked to draw a computer scientist before and after being exposed to a computer science curriculum. The results showed that before seeing the curriculum, students viewed computer scientists as scientists who use computers, who are predominantly male and who perform their tasks alone. After the students have finished their programming course, they drew a computer scientist for a second time. Perhaps one of the most notable changes is that after the curriculum, the number of drawings of female computer scientists increased, which could be a result of the fact that the course was taught by a female teacher who could act as a role-model. This result could help us address the low gender-diversity in computer science since it shows that one of its main factors, stereotyping, can be influenced by positive experiences in the field to the extent that girls can better self-identify as computer scientists.

Identifying stereotypes in children

Implicit association tests (IATs) represent a way to measure implicit correlation and biases of a target group of people towards a certain aspect. Compared to a self-reporting study, where subjects fill out a form to answer explicit questions about a topic, in an IAT the subjects take part in a more complicated test process meant to observe their automatic associations by measuring reaction times with regard to a certain subject. [15]

Harvard University provides an online platform called 'Project Implicit', where anyone can take implicit association tests. For us, it provides good examples which can be used to create our own IATs.

In one study [16], three implicit association tests were conducted on female college students to examine "implicit gender-math stereotyping (greater male-math than female-math association), implicit gender identification (greater self-female than self-male association), and implicit math identification (greater self-math than other-math association)". The tests were given on a computer where the screen was split vertically into three parts. A word would appear in each part, and the participant had to assign the middle one to either one of the left or right category. By pressing the '5' key, the participant assigned the middle word to the category shown on the right. By pressing the 'a' key, the participant assigned the middle word to the category shown on the left. Each IAT consisted of 5 stages. The first two stages introduced two pairs of words to be shown in the left and right sides of the screen (e.g, 'them' and 'self', 'male' and 'female'). In the next stage, the two categories were superimposed, such that middle word had to be assigned to be 'them or male' or 'self or female'. Stage 4 and 5 consisted of switching the 'a' and '5' keys either for the entire

test or for random parts of it. The purpose of superimposing is to record response times for the various 'combined' terms. These response times, together with the responses of the questions, can be used to draw conclusions regarding the topic of the test.

Therefore, IATs can also be designed as a way to document this type of stereotypes for children. They could be modeled as an interesting and fun activity that would make them want to take such test with ease.

Conclusion. How to solve the stereotype problem?

Current research shows stereotypes influence one's choice for a career. An undergraduate student of female gender is less prone to consider Computer Science as a viable career path because of the ideas held about this field [17]. Therefore, we should increase research regarding Computer Science stereotypes of young students, to identify and correct the stereotypes from an early age.

In our approach, we will be studying the stereotypes of children aged between 6 to 18 years old, by building a secure, reliable, and progressive web-application where they can test their beliefs about computer scientists. More technical details will be discussed in the Project Plan document.

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Appendix

Figure 2

Academic Year	CS
1980-81	32.5
1981-82	34.8
1982-83	36.3
1983-84	37.1
1984-85	36.8
1985-86	35.7
1986-87	34.6
1987-88	32.4
1988-89	30.8
1989-90	29.9
1990-91	29.3
1991-92	28.7
1992-93	28.1
1993-94	28.4
1994-95	28.1
1995-96	27.5
1996-97	27.2
1997-98	26.7

Figure 2: Percentage of degrees awarded to women in CS, from [3]

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