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Draw a Software Engineer Test - An Investigation into Children's Perceptions of Software Engineering Profession

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***Abstract*—Context: The gender gap is particularly affecting the software engineering community, as both academia and industry are dominated by men. Literature reports how the lack of women is a consequence of gender stereotypes around certain figures that begin in the early stages of education, affecting children's perceptions of the role they can play across scientific fields.**

Objective: In this study, we asked children to draw a software engineer in order to collect their perceptions and let us check whether gender stereotypes still persist.

Methods: We asked a total of 371 children to draw a person who works in the software engineering field. We analyzed the drawings based on a set of parameters extracted from literature and inspected the results through a cross-sectional study.

Results: Children agreed on their representations of a software engineer: 51% drew a man and 44% drew a woman, while 5% a non-recognizable figure. The main differences emerged when the data were grouped by age and gender: only 23% of eleven-year-old girls drew a woman software engineer, while 54% drew a man, and in 23% gender was non-recognizable.

Conclusion: The findings revealed a favorable gender balance in children's perceptions of software engineering. They seem more willing to recognize diversity, an improvement compared with what was reported in previous studies. Children's perceptions of technology may have become more accessible as a result of the COVID-19 situation. These findings may draw positive comparisons with the current gender gap in software engineering, encouraging future developments.

***Index Terms*—gender stereotypes, children's drawings, software engineering, draw-a-computer-scientist test, primary school students, drawing, coding**

I. General Abstract

The gender gap is hard to close because of gender stereotypes that begin in the classroom and continue in the workplace, where the software engineering field is still male-dominated. Stereotypes heavily impact occupations and behaviors that are regarded as suitable for boys or girls, which have an influence on personal job decisions as well as how people perceive and comprehend the world. Over the years, researchers have focused on children's perceptions of professions in STEM fields (Science, Technology, Engineering and Math), and many have detected the presence of stereotypes associated with the figure of the scientist. The purpose of this study is to explore children's perceptions of software engineers based on their knowledge and beliefs, and to determine whether or not gender stereotypes influence their mental models of this field. We collected samples from 371 children in 10 different schools in Milan, Italy, using a drawing-based tool. Boys, girls, and children who identified as other overall agreed on their representations, and produced a balanced proportion of male and female depictions of software engineers. Older children depicted more stereotyping elements than their younger peers, particularly girls. The findings painted an overall positive picture of children's perspectives of the software engineering field, showing a gender balance that contrasts with the current gender imbalance of the workplace. The COVID-19 pandemic may have impacted how certain jobs are perceived, and we are left to wonder whether these changes are a permanent shift in society or a temporary response to the pandemic.

II. Introduction

Women make up less than 10% of the software engineering workforce [22], [71]. The gender gap is hard to close because of gender stereotypes that begin in the classroom, where girls are discouraged from studying computer science [80], and continue in the workplace, where job advertisements favor men [35] and the work environment can be hostile [28], [44], [60], [76], [77].

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Starting from the youngest [6], the presence of professions and attitudes deemed appropriate for boys or girls fuels and is fuelled by stereotypes [51], influencing the individual's career choice [32], [52], [65] as well as their perception and understanding of the world. Over the years, several researchers focused on children's perceptions of professions in the STEM fields, and many assessed the presence of stereotypes associated with the figure of the scientist: a man in a white coat with eyeglasses and an unusual haircut [10], [50], [68], [72]. Similarly to the research carried out on the scientist, several contributions shed light on children's perceptions of a computer scientist, who is typically described as an unattractive white male with acne and eyeglasses. [29], [45], [48], [57]. This stereotypical perception appears between 6 and 8 years of age, and it is reinforced as children grow up [15], [58], [63], [75].

Recent changes in technology use as a result of the 2019 pandemic [19], as well as the increased consumption of videogame content by children, such as game tutorials and or watching other people play [54], make us wonder if the perception of computer scientists, particularly software engineers, has changed and is not more heavily portraying stereotyping elements.

The purpose of the study is to explore children's perceptions of software engineers based on their knowledge and beliefs, and to determine whether or not gender stereotypes influence their mental models of this field. In order to do so, we conducted a study with 371 children from 6 to 11 years old, coming from ten different schools in Milan, Italy. By following protocols and procedures of studies done with children to collect their perceptions [10], [11], [15], [29], [36], [45], [57], we asked a young audience to draw a *"person who works in the software engineering field"* and we recorded their think-aloud process.

Unlike previous findings, the collected drawings lacked traditional stereotyping elements. Boys, girls, and children who identified as other overall agreed on non-stereotypical representations, with a balanced proportion of men and women software engineers. The figures depicted were not unattractive; they did not usually wear glasses or have a beard, and they wore usual clothes. Some differences were observed across age groups, with older children depicting more stereotypical elements than their younger peers, particularly girls. We also gathered evidence of how the perception of technology has changed in terms of being mobile and ubiquitous. Children drew software engineers working in the open air or at home, sometimes standing with a smartphone in their hand instead of sitting at a desk.

With this study, we aim to contribute to the gender balance debate in software engineering. Because gender stereotypes influence students' career choices, it is critical to understand the perceptions of younger students in order to identify when these stereotypes appear. While the results are positive as they differ from the traditional representation of computer scientists as isolated, unattractive men, older girls still depicted more men than women, emphasizing the need for intervention in the social representation of software engineers, and computer scientists in general.

III. Background and Related Works

A. Stereotypes and gender gap in STEM

A stereotype is *a standardized mental picture that is held in common by members of a group and that represents an oversimplified opinion, prejudiced attitude, or uncritical judgment* [83]. Stereotypes aid us in deciphering the world around us, but they can also lead to biased behaviors that affect all aspects of our society, including the perception of gender roles [4], [6]. Their influence is evident in STEM fields, particularly in STEM workplaces, where gender biases influence hiring decisions, resulting in a work environment that does not support diversity and inclusion and instead drives people out of the field [2]. As a consequence, today's STEM communities are still male-dominated despite the benefits they offer [70].

The attractiveness of STEM fields is frequently related to the advantages of their job positions [27], [73]. As a result, they appear more appealing in countries with lower average incomes, where they can improve people's quality of life, rather than in richer countries, including those known for their gender policies [12], [74]. However, the gender gap in STEM exists in both cases, resulting in the gender equality paradox [12], [74]. Although we are working on solutions to major problems related to discrimination and violence against women [53], we still have some progress to make in addressing the gender imbalance in industry and academia [82]. To address these challenges, it is necessary to concentrate on tools, methods, and awareness that can lead to a more inclusive society [66].

B. Gender (non)diversity in software engineering

In software development, gender imbalance is one of the most significant challenges to achieving diversity [66]. According to a global software developer survey conducted in 2022, men make up the vast majority of developers, accounting for 91.88% of all participants [71]. The reason behind this imbalance can be traced to the presence of stereotypes [12], [31], [47], [68]. Stereotypes and their influence on parental or teacher support limit women's opportunities in academia and industry to pursue a career in software engineering [31]. Poor support can lead to low confidence and to the imposter syndrome, which discourages women who are afraid to try and fail [31]. Most women do not want to reinforce existing stereotypes, so quitting before even trying is a defense mechanism to avoid being associated with negative beliefs [32]. Moreover, women have to constantly prove their technical skills [44], as technical leadership is implicitly male-typed [20], [81].

Due to the scarcity of common goals and values with coworkers, a lack of diversity in software engineering can reduce women's sense of belonging [24], [27]. On the one hand, interdisciplinary learning approaches from the beginning of education could promote combinations of different fields and enrich diversity and innovation in research while also bringing girls closer to the world of technology [31], [49]. On the other hand, to counter lack of belonging, there's a need for a diverse, inclusive workforce [2]. A gender-diverse work environment would benefit everyone, not just women: gender-diverse teams foster a friendlier environment [9], are less likely to be affected by poor organization and communication [14], and are more productive [78] and innovative [55].

C. Children's gender schemata and their influence on career choice

Children begin forming the concept of gender early on [21]. From the start, they are surrounded by distinctively gender-typed objects, like feminine or masculine clothing, toys, games, stories, books, and advertising [37]. Through gender-typed objects and attributes, children train their gender-schematic processing, thus shaping their gender schemata [6]. According to gender-schema theory, a gender schema functions as an anticipatory structure that helps sort information into masculine and feminine categories [6]. As as they grow and participate in our society, children learn what items and attributes are traditionally gender-appropriate [6], [56]. Consequently, their self-concept becomes gender-typed as well [6].

Occupational interest and competence, among the attributes that children can identify with themselves, can be a barrier to entry into STEM fields [7], [16], [18], [39], [64]. Because people-oriented occupations are associated with feminine relational attributes, women are less likely to identify with things-oriented occupations that rely on agentic attributes [20], [43], such as science and technology, which are typically masculine-typed [33], [34], [59]. As a result, young children see men as more successful in those fields than women [42]. This type of gender association limits both boys and girls by making them believe they are not qualified for jobs traditionally associated with the opposite gender, thereby influencing their choices [7], [16], [18], [39], [64].

D. Draw-A-Scientist: looking at STEM through children's eyes

Because of the influence on career choice of gender-typed professions, it is critical to investigate children's perceptions and their evolution. Several studies used the Draw-A-Scientist Test (DAST), an arts-based tool, to collect the imagery of people working in STEM fields. Since its first use in the 60s [15], the DAST has been frequently employed in the last sixty years [51]. In the DAST, participants are asked to draw a picture of a scientist. Later, drawings are analyzed by assessing the presence of stereotypical elements according to its checklist, the DAST-C [25]. Because the task is the same, it is possible to trace possible evolutions in children's perceptions as our society changes. In particular, the perception of scientists has become more and more gender-diverse with time [51]. Furthermore, the DAST task's ease of translation facilitates cross-national research. As a result, it is feasible to compare drawings from various countries and investigate contrasts and similarities that may be influenced by cultural differences [23], [46].

TABLE I
PREVIOUS REPRESENTATIONS OF PEOPLE WORKING IN INFORMATICS

Paper	Year	Children's age	Depicted gender
[3]	1994	5-11	M 0.43 F 0.56 Both N/A
[3]	1994	12-18	M 0.51 F 0.48 Both N/A
[13]	1999	5-11	M 0.61 F 0.39 Both N/A
[48]	2006	10-14	M 0.51 F 0.13 Both N/A
[30]	2016	8-11	M 0.64 F 0.30 Both N/A
[29]	2017	8-9	M 0.71 F 0.27 Both N/A
[57]	2018	12-14	M 0.47 F 0.11 Both N/A
[11]	2018	10-13	M 0.66 F 0.34 Both N/A
[38]	2020	12-14	M 0.37 F 0.11 Both 0.51

The success of the DAST was followed by the creation of similar tools to investigate other professions, like the Draw-An-Engineer Test (DAET) [36], or the Draw-An-Engineering-Teacher Test (DAETT) [79]. Among these adaptations, researchers have investigated the perception of the computer scientist (DACST), the programmer (DAPT), and the computer user (DACUT) as well. According to these studies, the computer scientist ([11], [29], [30], [38], [57]) and the computer user ([3], [13], [48]) are usually depicted as men [Table I]. Children described them as nerd or geek [3], [11], [45] and unattractive [11], [45]. Computer scientists are usually isolated [11], [29] and in a bad mood [3], [11], [13]. They occasionally wear glasses [11], [45], [48], [57], and they have messy hair and acne [45]. Sometimes, they are drawn overweight [45], [48], eating junk food and drinking coffee [38], [45].

IV. STUDY DESIGN

A. Aim of the study

In this paper, we want to explore the perception of software engineers based on children's beliefs and, if it is possible, try to detect which are the major elements that influence and carry out these ideas. More specifically, we are designing a study to help answer *how children perceive a software engineer and what are the stereotyping elements present in their representations.*

In order to answer this research question, we designed the study based on different specific points: What is children's perception of software engineers? Do children's representations of software engineers change based on their gender and age?

By understanding children's gender schemata about computer science and technology, we envision the possibility of designing an intervention that helps increase awareness of gender stereotypes in informatics, starting with a younger audience. Additionally, raising awareness among teachers can lead to more balanced interpersonal interactions, addressing not only technology but the whole education system. Lastly, fewer gender stereotypes can result in a new image for software engineering, creating an inclusive informatics environment.

B. Selection and participation of children

The following study was conducted during summer camps in Milan, Italy. We managed to visit ten schools in seven different boroughs, and this helped us collect a sample of children with diverse socioeconomic and cultural backgrounds [67]. We were able to enroll 371 primary school students (M = 8.4 years, SD = 1.3). We included 13 children who identified as *other* (M = 8 years, SD = 1), 192 girls (M = 8.2 years, SD = 1.3), and 166 boys (M = 8.5 years, SD = 1.4). Due to the fact that the study involved a young audience, the schools notified parents about the activity to get their consent to participate. Moreover, the participation was voluntary, so children could drop out at any moment of the activity. With the exception of the children's gender identification (*girl, boy, other*) and grade level, which were only accessible by the researchers for this study, all information gathered during the study was completely anonymous.

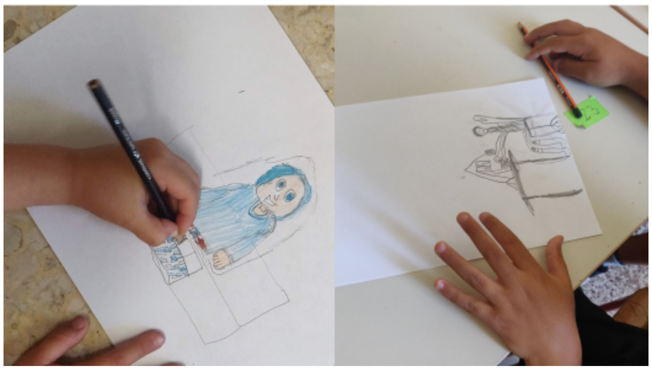

Fig. 1. Children's drawings of software engineers during the activity.

C. Instruments and procedure

The activity was based on the children's knowledge of the general concept of informatics. We asked each of them to *"draw a person who works in the software engineering field."* We were careful with the terminology used to avoid influencing them. For this reason, we opted for *person* as a gender-less word. Due to the young age of participants, before beginning the drawing activity, we asked them what they associated with software engineering. Some of the keywords that emerged were related not only to software engineering but also to informatics and computer science in general, such as computers, hackers, videogames, robots, microchips. This enabled us to confirm their understanding of the task required for this specific activity.

As summer schools carried out fun activities, we had to keep children engaged and motivated during the sessions. We decided to present activities and goals with storytelling. As some studies show [1], it could be challenging to keep focus and interest from such a young audience, especially if they are required to do simple tasks, and storytelling acts as an educational method for developing creativity and critical thinking. We realized a human-controlled robot that simulated emotions as a response to children's drawings. The artifact, called CYB, was presented as a new-born robot who still had to learn all about software and informatics topics and could only understand drawings. Children could interact with CYB at the end of the task by placing their drawings on top of it and hugging it, making it vibrate and display a happy smile. To ensure that children understood the assignment, the robot showed a happy face only if the drawings were on topic; otherwise, no emotion was displayed. This small interaction rewarded children, keeping them engaged the whole session. At the same time, CYB helped us explain the rationale behind the task in an easy way.

Each session was conducted with a group of 15-20 children at a time. We gave them 30 minutes to complete the activity after repeating the instructions. We placed signs on the floor and/or on the desks to keep distance between them and therefore avoid any influence of peers on the results. Children could use pencils and markers to complete the drawings, and were instructed to write their gender and grade level on the back of the sheet [Figure 1].

Fig. 2. Drawing of a man software engineer with stereotypical parameters such as lab coat, glasses and various tech equipment.

D. Coding scheme

A coding scheme was developed in order to identify all the items and features presented in children's drawings. The parameters were identified based on the existing literature [8], [10], [29], [57] and classified as the following:

- **Validity:** these parameters determines whether the drawing contains a person and is on topic, or if the main subject is represented either as a stickman or has too few details to be considered for the analysis. When a drawing falls into the second value, it is considered null and therefore not part of the data.
- **Generalities:** these parameters refer to personal details of the main subject of the drawing to capture both its gender (man; woman; not identifiable;) and its skin color (pink, brown, unshaded).
- **Appearance:** these parameters refer to stereotypical characteristics children use to enrich their drawings, such as

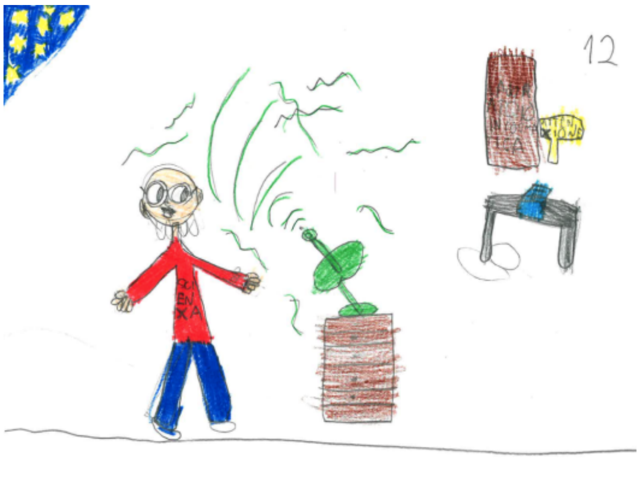

Fig. 3. Drawing of a software engineer with non-recognizable gender. The software engineer has stereotypical elements such as glasses, warning signals, a shirt with elements related to informatics on it, a computer, and science lab tools.

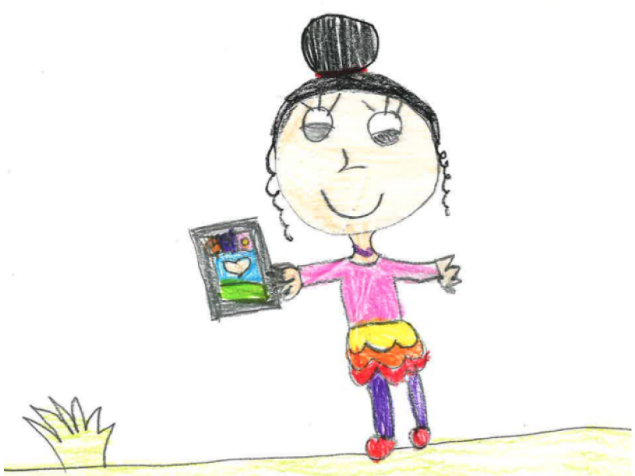

Fig. 4. Drawing of a woman software engineer. The drawing presents stereotypical feminine characteristics.

white lab coat [Figure 2], tie or an elegant shirt, shirt with elements related to informatics on it, glasses, beard, acne, crazy hair.

- **Environment:** these parameters refer to the objects that enrich the imaginary environment in which children picture a software engineer, such as chairs and desks but also some specific ones like signs or warnings of "private" or "keep out" [Figure 3], as well as toys or statuettes.
- **Tech equipment:** these parameters refer to all the technical equipment used by the depicted software engineers during work-related tasks, such as computer, robot [Figure 2], headphones, keyboard, mouse, phone, tablet, console, controller, TV.
- **Other equipment:** these two additional parameters indicate whether the software engineer in the drawing is represented with some additional features related either to science lab tools [Figure 3] and equipment or mechanical ones.

We did not consider drawings that were out of topic, that did not depict a person, or that presented too few details, like in the case of stick figures.

To help with the correct coding and to limit the freedom of interpretation, parameters were precisely described. In particular, binary gender was identified by looking at common stereotypical representations of men and women. To be marked as women the drawing had to show feminine clothes, bows, long hair, long eyelashes, or makeup [Figure 4], whereas men had to present short hair, beard, mustache [Figure 2].

Three of the authors individually evaluated each drawing by marking the presence or absence of every element. To understand if the description of parameters was effective, we calculated Fleiss' kappa, which revealed a high inter-rater reliability value (k = 0.82). Before analyzing the data, we merged the three datasets. The resulting values are the average values of the three raters' evaluations.

V. Results

Nonvalid drawings were not taken into account in the main analysis. As shown in Table III, boys created the majority of nonvalid illustrations (P = 0.79), drawing slightly more stick figures (P = 0.41) than off-topic representations (P = 0.37). Girls produced less nonvalid work (P = 0.18) than boys, and the proportion of off-topic and stick figure drawings is comparable, with slightly more off-topic representations (P = 0.10) than stick figures (P = 0.8).

Balanced proportions between children who identified as other, girls and boys were found throughout all the parameters. As shown in Table II, half of the participants drew a man software engineer (P = 0.51). Similarly, women software engineers were depicted in 44% of the cases, while the gender was not stereotypically identifiable in 5% of the cases. In gender comparisons, boys drew a man software engineer more frequently (P = 0.56) than a woman software engineer (P = 0.39), with no significant differences among the five age groups [Table IV], both in the case of men software engineers (SD = 0.06) and women software engineers (SD = 0.07). Similarly, girls drew women software engineers more frequently (P = 0.48) than men software engineers (P = 0.46). However, when compared to boys, they differed more depending on their age. Older girls depicted more men software engineers (P = 0.55, 0.54) than women software engineers (P = 0.42, 0.23) compared to younger ones [Table IV]. All participants who identified as other portrayed software engineers as men or women, and there were no drawings with unidentifiable gender.

In terms of race, children colored their software engineers' skin in pink shades (P = 0.63), with no children using darker colors [Table II]. The remaining participants chose not to

TABLE II
PARAMETERS PERCENTAGES

Parameter	Other (NB) (n = 13)	Girls (n = 192)	Boys (n = 166)	Total (n = 371)
Man Software Engineer	P = 0.54	P = 0.46	P = 0.56	P = 0.51
Woman Software Engineer	P = 0.46	P = 0.48	P = 0.39	P = 0.44
No gender Software Engineer	P = 0.00	P = 0.06	P = 0.05	P = 0.05
Pink skin	P = 0.54	P = 0.66	P = 0.60	P = 0.63
Brown skin	P = 0.00	P = 0.00	P = 0.00	P = 0.00
Unshaded skin	P = 0.46	P = 0.34	P = 0.40	P = 0.37
White lab coat	P = 0.00	P = 0.04	P = 0.05	P = 0.04
Elegant clothes	P = 0.00	P = 0.02	P = 0.04	P = 0.03
Geek shirt	P = 0.00	P = 0.04	P = 0.02	P = 0.03
Glasses	P = 0.15	P = 0.15	P = 0.19	P = 0.17
Beard	P = 0.08	P = 0.05	P = 0.08	P = 0.06
Acne	P = 0.00	P = 0.00	P = 0.01	P = 0.01
Crazy hair	P = 0.08	P = 0.03	P = 0.03	P = 0.03
Desk	P = 0.69	P = 0.58	P = 0.57	P = 0.58
Chair	P = 0.23	P = 0.29	P = 0.27	P = 0.27
Office chair	P = 0.00	P = 0.04	P = 0.11	P = 0.07
Bookshelf	P = 0.15	P = 0.02	P = 0.02	P = 0.02
Production machine	P = 0.00	P = 0.04	P = 0.06	P = 0.02
Secrecy symbols	P = 0.00	P = 0.03	P = 0.01	P = 0.01
Toys	P = 0.00	P = 0.01	P = 0.02	P = 0.01
Videogames	P = 0.08	P = 0.02	P = 0.06	P = 0.04
Food	P = 0.00	P = 0.01	P = 0.01	P = 0.01
Drinks	P = 0.08	P = 0.03	P = 0.03	P = 0.03
Computer	P = 0.62	P = 0.54	P = 0.52	P = 0.54
Robot	P = 0.31	P = 0.45	P = 0.37	P = 0.41
Earphones	P = 0.08	P = 0.01	P = 0.06	P = 0.03
Keyboard	P = 0.08	P = 0.16	P = 0.16	P = 0.16
Mouse	P = 0.00	P = 0.07	P = 0.07	P = 0.07
Smartphone	P = 0.00	P = 0.07	P = 0.11	P = 0.08
Tablet	P = 0.00	P = 0.02	P = 0.02	P = 0.02
Console	P = 0.00	P = 0.01	P = 0.04	P = 0.02
Controller	P = 0.00	P = 0.05	P = 0.04	P = 0.04
TV	P = 0.08	P = 0.03	P = 0.01	P = 0.02
Laboratory tools	P = 0.00	P = 0.02	P = 0.01	P = 0.01
Mechanic tools	P = 0.08	P = 0.05	P = 0.02	P = 0.04

TABLE III
NONVALIDITY OF DRAWINGS

Parameter	Other	Girls	Boys
Off-topic	P = 0.02	P = 0.10	P = 0.37
Stick figure	P = 0.02	P = 0.08	P = 0.41
Total	P = 0.04	P = 0.18	P = 0.79

shade their figures' skin (P = 0.37). In gender comparisons, children's drawings showed no significant differences, whereas in age comparisons, girls' drawings showed more differences. These differences, however, can be found when comparing pink shades (SD = 0.14) and unshaded drawings (SD = 0.12), as darker shades were consistent (SD = 0.02).

There was no statistically significant presence of stereotypical elements in the other appearance parameters of the software engineer [Table II]. Drawn software engineers did not wear white laboratory coats (P = 0.04), formal clothing (P = 0.03), or t-shirts with geek and nerd culture graphics (P = 0.03). Glasses were the most common element (P = 0.17), while beards (P = 0.06), acne (P = 0.01), and mad-scientist hair (P = 0.03) were unusual. Boys' drawings presented slightly more stereotypical elements than girls'. Considering the age groups, girls (Mean SD = 0.05) disagreed slightly more than boys' (Mean SD = 0.04). Regarding glasses, the most common

TABLE IV
AGE DIFFERENCES IN GENDER REPRESENTATION

Participant	N	Man	Woman	NoGend
Girl 7 y.o.	71	P = 0.44	P = 0.47	P = 0.09
Girl 8 y.o.	61	P = 0.45	P = 0.50	P = 0.05
Girl 9 y.o.	21	P = 0.37	P = 0.62	P = 0.02
Girl 10 y.o.	26	P = 0.55	P = 0.42	P = 0.03
Girl 11 y.o.	13	P = 0.54	P = 0.23	P = 0.23
Boy 7 y.o.	57	P = 0.49	P = 0.46	P = 0.06
Boy 8 y.o.	29	P = 0.55	P = 0.40	P = 0.05
Boy 9 y.o.	36	P = 0.61	P = 0.33	P = 0.06
Boy 10 y.o.	26	P = 0.65	P = 0.28	P = 0.08
Boy 11 y.o.	18	P = 0.54	P = 0.41	P = 0.06
NB 7 y.o.	5	P = 0.40	P = 0.60	P = 0.00
NB 8 y.o.	4	P = 0.50	P = 0.50	P = 0.00
NB 9 y.o.	3	P = 1.0	P = 0.00	P = 0.00
NB 10 y.o.	1	P = 0.00	P = 1.00	P = 0.00

element, the standard deviation of girls' choices is higher (SD = 0.15) than boys (SD = 0.04). As for software engineers' gender, also in this case older girls presented more frequently glasses (P = 0.46, 0.23).

The majority of depicted software engineers were in a home office setting (P = 0.60), while a few were in a natural environment (P = 0.04). The remaining drawings were not set in a specific context (P = 0.36) [Table V]. In the environment, children placed desks (P = 0.58) and chairs (P = 0.28) [Table II]. Few children opted for office chairs (P = 0.07). The use of stereotypical elements such as secrecy symbols (P = 0.01), toys (P = 0.01), and videogames (P = 0.04) was uncommon. Few children placed bookshelves and books (P = 0.02), and industrial machinery (P = 0.02). Similarly, children did not associate junk food (P = 0.01), soft drinks and hot beverages (P = 0.03) with software engineers. In both gender and age comparisons, there were no statistically significant differences.

TABLE V
ENVIRONMENT IN DRAWINGS

Parameter	Other	Female	Male	Total
Office	P = 0.60	P = 0.55	P = 0.65	P = 0.60
Nature	P = 0.00	P = 0.07	P = 0.02	P = 0.04
No context	P = 0.40	P = 0.37	P = 0.33	P = 0.36

Computers were the most common technology element that appeared in the drawings (P = 0.54), followed by robots (P = 0.41) [Table II]. Children drew distinct keyboards alongside computers in one-sixth of the drawings (P = 0.16), but the mouse was less common (P = 0.07). Earphones and headphones appeared on occasion (P = 0.03). Smartphones (P = 0.08), joysticks and controllers (P = 0.04), consoles (P = 0.02), tablets (P = 0.02), and TVs (P = 0.02) were also present. Few children added laboratory tools (P = 0.01), and mechanics tools (P = 0.04). Girls drew computers (P = 0.54) and robots (P = 0.45) more frequently than boys (P = 0.52, 0.37). Students identified as other showed a stronger preference for computers over robots (P = 0.62) compared to girls and boys. The difference in frequency between computers and robots grew with age [Table VI]. In girls' drawings, computers were always more common, but in younger children the difference is small (P = 0.53 computers, P = 0.51 robots), while older children' representations exhibited significantly fewer robots (P = 0.38). Unlike girls, younger boys preferred robots (P = 0.51) to computers (P = 0.46), but older boys drew fewer and fewer robots (P = 0.22). Boys' drawings displayed no technology more frequently (P = 0.17) than girls' ones (P = 0.08), who also exhibited slightly more often several devices per drawing (P = 0.39) than boys (P = 0.35).

TABLE VI
AGE DIFFERENCES IN DRAWN DEVICES

Participant	N	Computer	Robot	Other
Girl 7 y.o.	71	P = 0.53	P = 0.51	P = 0.26
Girl 8 y.o.	61	P = 0.55	P = 0.39	P = 0.23
Girl 9 y.o.	21	P = 0.60	P = 0.57	P = 0.10
Girl 10 y.o.	26	P = 0.49	P = 0.40	P = 0.22
Girl 11 y.o.	13	P = 0.62	P = 0.38	P = 0.13
Boy 7 y.o.	57	P = 0.46	P = 0.51	P = 0.25
Boy 8 y.o.	29	P = 0.44	P = 0.28	P = 0.34
Boy 9 y.o.	36	P = 0.53	P = 0.42	P = 0.17
Boy 10 y.o.	26	P = 0.60	P = 0.22	P = 0.22
Boy 11 y.o.	18	P = 0.59	P = 0.22	P = 0.24
NB 7 y.o.	5	P = 0.60	P = 0.40	P = 0.00
NB 8 y.o.	4	P = 0.25	P = 0.25	P = 0.00
NB 9 y.o.	3	P = 1.00	P = 0.22	P = 0.44
NB 10 y.o.	1	P = 1.00	P = 0.00	P = 0.00

Values indicate the presence of at least one item.

VI. DISCUSSION

A. Children's perceptions of software engineer

We could determine that all children, whether they were boys, girls or represented themselves as other, define the software engineer as either a man or woman with pink skin, mostly surrounded by tech equipment such as computers and robots [Table II]. The results of the present study reveal a balanced ensemble regarding the children's perceptions of a software engineer. In fact, confronting the present results with previous studies [Table I], we can infer that given children's general description, there are no significant distinctions between perceptions of men and women software engineers, opposed to the current gender gap problem in the field in Central Europe countries [69]. If we take into consideration the appearance parameters, we can observe how in the present study there is a substantial lack of stereotypes for what concerns the typical representation depicted in DACST and DAST literature [Table I], leading to the consideration that children are less influenced by certain stereotypes in scientific fields. This could be traced to the evolution of children's ideas of technology in a more accessible and mobile way, which therefore associates the role of a software engineer with more common tasks. In children's drawings technology is portable and laboratories are substituted by natural environment and offices often in normal home settings; it is more common to individuate a person next to technical equipment such as computers, robots, and phones, often with a desk but without a chair. This is probably the result of the impact technology has in everyday life, where children are more used to engage with tech devices through social media and videogames. Reference role models may also be part of the world close to them *("I drew my dad at the PC!" 8 y.o. girl)*.

The evolution in the perception of software engineers does not only affect technology and equipment, but their emotional representation well. Software engineers often have a friendly and cheerful relationship with hardware and software, determining that children have an overall positive perception of technology as a companion to support them. However, children's imaginations with respect to specifically technical figures could be limited when they have no reference point *("I don't know any software engineer, can I invent one?" 9 y.o. boy)*, and therefore they use equipment and appearance features to enrich their representations. We can also highlight that software engineers and computer scientists tests reveal fewer stereotyped images compared to scientists' representations [10], probably due to the fact that images of informatics are less common in media.

B. Representations based on participants' gender

If we look particularly at the gender representation collected during the analysis of the results of this study, we detect a balance between women and men associated with software engineering. We can observe that boys, girls, and students who identified as other depicted almost an equal number of men and women software engineers [Table II]. This finding is surprising and deviates from the results of the aforementioned studies, where most of the drawings made for the representation of scientists or computer scientists identified a considerably higher percentage of common stereotypical elements. This result therefore leads us to two considerations. Firstly, the younger generation seems to be less susceptible to the influence of stereotypical roles in the work environment. Nonetheless, we can still detect the presence of gender stereotypes as reported by children in their spontaneous think-aloud, which gives us a deeper insight of their mental models. For example, one girl commented: *"I was wondering if I could draw a girl with a computer or if it had to be a boy"*, and a boy also affirmed: *"I'll draw a girl, I bet everyone is going to do a boy"*. These comments suggest that children still feel the pressure to associate men with software engineers, although they both decided to represent this professional figure as a woman.

The second consideration is about the impact of the COVID-19 pandemic during the school period [19], which was observed in children's perceptions of scientists as well [40], [61]. Children who participated in the study, who were starting or continuing their studies in primary school, perceived a greater proximity to technology, having frequently observed both parents and teachers, who in Italian primary schools are mostly women [26], working alongside computers and different digital and technological equipment. This experience created a much more familiar and normalized association with technology, which may have contributed to change the representations. Although COVID-19 may have had a significant impact on children's perceptions of technology and gender, we do not know how long these effects will last. It will be interesting to examine future data with similar samples to see if these results indicate a future exponential growth or simply a short-term increase.

C. Representations based on participants' age

A higher percentage of stereotypes increases proportionally with grade level and thus with children's age. While gender stereotypes begin early on, children's limited familiarity with computer science and software engineering could impact their perceptions, as it happens with science in general [41], making them less stereotypical. Similarly, older children's exposure to media representation of computer users and computer scientists [17], [62] may develop stereotypical mental models. As shown in Table VI, as the age of girls rises, the proportion of women software engineers decreases. This is supported by previous research that showed indicators of increasing stereotypes on scientific figures as children grew older [48], [51], mostly around age 6-8 [58]. The effect of stereotypes could have positive or negative consequences that could impact children's decisions and beliefs. What is surprising is that this effect seems to influence girls more than boys, who produced slightly better balanced representations over time [Table VI]. This could be caused by the effects of social rules enforced on boys and girls. For example, at school a lack of encouragement and role models for girls could generate a feeling of inadequacy towards their technical skills [32], but boys could be led to think that they have a natural instinct for science, math, and other technical tasks [5].

VII. Limitations and Future Work

The present study offers a large sample of participants and represents the first contribution to children's perceptions of software engineering figures with a draw-based tool. Regarding the general representation, it should be noted that since we referred to the professional field of informatics when explaining the activity and we used a gender-less robot for narrating it, children could have been influenced to associate any gender to software engineers and to draw computers and robots as the most common equipment. Moreover, children could be influenced by the researchers who conduct the study, both of them who identify as women and presented themselves as working in the computer science field. We should emphasize that, while the results about gender balance perceptions were interesting, the drawings did not represent a complete tool for gathering information about children's perspectives. It would be interesting to design a study in the future that uses a diverse set of tools, for instance some that would combine drawings and interviews, or text production and maybe a check list, to collect both quantitative and qualitative data. Furthermore, the study reveals interesting data about other aspects of diversity in the software engineering field, taking into account the broad gender spectrum. The coding of gender was based on stereotyped binary characteristics of the depicted figures, such as long or short hair, pants or skirts, as necessary to identify the gender representation. When these elements were not specified, we marked the results as NoGender, which does not necessarily refer to non-binary or other identifications who do not fall into the binary representation.

The adopted prompt attempted to use straightforward language so that children could understand what a software engineer is and does. In order to clarify that, we shared with participants what kind of activities, performance and outcomes are expected from a software engineer, with extreme care paid to avoid using gendered terms that are highly present in Italian. Both *"ingegnere del software"* and *"ingegnere informatico"* were considered as accurate translations of the term "software engineer".

The design of future studies could be built upon these results, keeping in mind the possibility to incorporate not only new considerations about the data collected, but a broader variety of tools and methods for understating the presence of different stereotypes as well. It would also be possible to investigate what children expect from technology through the same coding scheme and include a comparison and contrast with similar studies across all over the world.

VIII. Conclusion

We have made it clear that gender balance remains a challenge, particularly in the software engineering field, which is predominantly male-dominated. The reasons for this reality have deep roots and may be influenced by stereotypes that are traceable from a young age. Indeed, the related works we discussed have shown how the presence of stereotypes affects children's perceptions of scientific figures over time. This study sought to better capture how children perceive software engineers, employing a draw-based test as a data collection tool that proved effective in gathering stereotypical images. The findings painted a positive picture of gender balance in the software engineering field, with the participating children identifying the software engineer as either man or woman. Although the tool used alone may not provide an accurate picture of the participants' true perceptions, the encouraging data shows that the younger generation is more willing to recognize diversity, compared to the past studies we reported. Furthermore, in this case, the representation of scientific figures is not related to stereotypical elements such as crazy hair, warning signs, or acne, but rather focuses on a simple representation of the figures that are part of a more accurate picture of reality. It is interesting to highlight how the COVID-19 pandemic situation may have influenced the normalization of certain job roles and how the software engineering field appears to be more accessible to a wider population in general. Overall, this was another first step towards getting a better understanding of how to foster diversity with the goal of achieving gender balance in the software engineering community and beyond.

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