Programming teaching tools and the gender gap in the Information Technology field

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Abstract. *The lack of participation of women in Information Technology is a worrying fact since diversity in any environment is vital for its evolution, especially in a field in which the role of users is changing and they have passed from consumers to producers. This study aims to analyze the reaction of boys and girls to an educational tool for teaching the basics of computer programming and computational thinking.*

1. Introduction

Technology plays an increasingly fundamental role in the digital society we are currently living on. Although the number of professionals required on this field is increasing every day, the ratio of women is getting lower.

According to the NCWIT (National Center for Women and Information Technology), in 2016, only 26% of technology workers were women and less than 10% were African-American women. These numbers are not increasing, since, in 2015, only 18% of the graduate students in Computer Science were women. One of the main reasons girls do not choose careers like Computer Science is the lack of knowledge about topics related to the field and career opportunities [Moreira et al. 2014].

The difficulty of including women in male-dominated environments is not a current problem, and raises important issues such as the role of women in society, whose rules are imposed and created by men [de Beauvoir 1949]. The social motivation, as saw in advertising and marketing, reflects on a greater interest of boys in the use of computers and later in undergraduate courses related to Information Technology.

The difference in early use and familiarity with computers by girls and boys have direct response on the access and promotion of men and women in the academic and corporate environments [Tavares and Sosa 2017]. As a result, women have little representation and voice in the area, as can be seen in Figure 1, which reflects the number of users per gender of Stack Overflow, one of the most famous sites on Information Technology[1].

Nowadays, several projects aim to teach basic programming for young girls, always with the main goal of empowering them to become innovators and leaders in Computer Science and Technology.

Girls Who Code [Saujani 2017][2] is a nonprofit organization created in 2012 which aims to support and increase the number of women in computer science. It has several courses for girls, such as a 7-week summer immersion program and a 2-week specialized

[1]https://insights.stackoverflow.com/survey/2017 Retrieved March 12, 2018
[2]https://girlswhocode.com/ Retrieved March 12, 2018

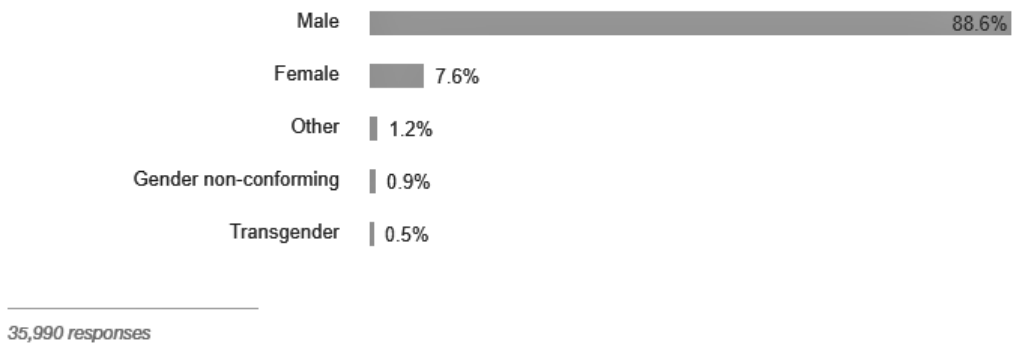

Figure 1. Stack Overflow's users by gender.

campus program in several cities in the USA. In 2 years, more than 3,000 students had completed a Girls Who Code program, and 95% of them went on to major in Computer Science at university [Dockterman 2014].

The Black Girls Code Project [Phanor-Faury 2014][3] is a nonprofit organization created on 2011 that tries to rectify the under-representation of African-American women in the digital space. It offers local courses in computer programming, robotics, and mobile application to girls of color ages 7 to 17. In less than two years, it affected 2,000 students within The USA and South Africa.

Among the Brazilian projects, we can highlight The Digital Girls Program, an initiative of the Brazilian Computer Society (SBC) that carries out forums, lectures and workshops to high school and elementary school female students teaching several areas of Computing and Information Technologies, in order to motivate them to pursue a career in these areas [Maciel and Bim 2016][4].

This program has partner projects in several Brazilian cities, such as #include <meninas.uff> Project[5] located in Niterói, Rio de Janeiro, at the Institute of Computing at Fluminense Federal University. This work is part of this project that in addition to work with young girls from elementary and high school, also aims to work with undergraduate students already enrolled in an IT course, supporting and empowering them, guaranteeing their well-being and free expression as a gender minority [Mochetti et al. 2016, Mochetti et al. 2017].

In this paper, we analyze the effect of current tools for teaching the basics of computer programming and computational thinking on boys and girls. Our focus is to identify how these tools can deal with the gender gap and how they can influence both positively and negatively on this issue [Mochetti and Braga 2018].

2. Literature Review

The Computer Science Programs for undergraduate students can train professionals to development technologies in several fields, including basic education and the teaching of

[3] `https://www.blackgirlscode.com/` Retrieved March 12, 2018
[4] `http://meninas.sbc.org.br/` Retrieved March 12, 2018
[5] `http://www.facebook.com/include.meninas.uff.` Retrieved March 12, 2018

programming skills. However, when analyzing the gender of the students, we have that the number of women is expressly lower than the number of men, which can have a direct influence on the education and enrollment of girls in IT [dos Santos 2017].

Focusing in this issue, it is possible to find several attempts to make the technological space more democratic and egalitarian. As an example we have a course held in São Paulo by female undergraduate students with the goal of teaching the Python language [Dantas et al. 2017]. The students were divided into two age groups, of 30-60 years old and of 19-25 years old. Despite the evasion during the classes, the students showed greater commitment and expressed the desire to use the knowledge learned to optimize their functions. It also brought trust to both sides, teachers and students, and promoted the culture of teaching and continuous learning among the participants.

The growing development and importance of computing to society and the popularization of Gamification and Games-Based Learning [Ariffin et al. 2014] have led to the creation of a large number of projects to teach computational thinking and programming to children and young people [Lemos and de Freitas 2017].

Several examples can be found of projects to teach logic and computational thinking for teenagers. A Brazilian project [da Silva Marinho et al. 2017] aimed on students aged 15 to 20 years old, separated the activity in two stages, first focusing on teach basics of programming in a playful way using the Hour of Code Project [Wilson 2015] and second deepening the subject using the Scratch tool [Monroy-Hernández and Resnick 2008].

Also using Scratch and the Hour of Code Projects, another project introduced concepts of computational thinking relating them to basic discipline such as mathematics, physics and chemistry [Gomes et al. 2014]. The group age was 15-16 years old girls that had not previous knowledge of computer programming. First, motivational videos were used to introduce the Computer Science field, then games from the Hour of Code Project were used to teach the main structures of a programming language. Finally, each student was responsible for a basic discipline and would have to play a game using the Scratch tool.

Also using the Hour of Code Project [Wilson 2015], but replacing Scratch with App Inventor[6], a project [dos Santos Silva et al. 2017] aimed at ages 14 to 15 years old and promoted a debate on the female presence in the technological area. Using a qualitative methodology to analyze the answers, their result shows that activities done in the Hour of Code Project environment aroused the interest of the students, but activities with App Inventor were more enjoyable since they were able to create an application. Therefore, joining both tools showed that the insertion of technologies into the school environment can also stimulate the development of not only computational thinking, but also logical reasoning, creativity and abstraction.

It is importance to notice the number of projects being created and executed using the same tools to teach computational thinking and programming to children and young people. But unfortunately, most aim at the age group of young people and some focus only on young girls. Our contribution is to focus on a younger age group, with less concrete knowledge of the world and more open-minded, and to evaluate their response to new concepts taught according to their genre.

[6]`http://appinventor.mit.edu/explore/front.html` Retrieved March 12, 2018

3. Methodology

Active learning methodology is a process in which the student is the principal agent responsible for their own learning. The process of educating is no longer based on the mere transmission of knowledge and students must commit themselves to their learning.

In this context, active methodologies arise as a proposal to focus the process of teaching and learning in the search for active participation of all those involved, focusing on the reality in which they are inserted [Oliveira and Pontes 2011, Borges 2014].

For this work, we search for tools that use active teaching-learning methodologies to introduce programming and computational thinking to young girls and boys. Our goal is to analyze the stimulus of such tools in students of both genders.

Among the tools studied, we first highlight the Code.org Project[7] that features Disney-themed games and incentive videos specifically for girls. One of the main features of the platform is the 'Hour of Code' activity organized by Microsoft and designed to teach computational thinking and basic programming skills for all ages in over 45 languages. The portal focus not only on gender and socioeconomic diversity, but also on increasing participation among underrepresented minorities. They have affected 11 million of girls, which represent 45% of their students.

Another popular project, CS Unplugged has a collection of free activities that teaches several topics of Computer Science, such as binary arithmetic, sorting algorithms, and error correction through games and puzzles that use cards, string and crayons, but without the use of a computer [Nishida et al. 2009]. It was created by Tim Bell and it is actively promoted by Google since 2007.

CodeCombat[8] is an open-source project that features an RPG-style game with stages divided by computer areas. It has a teacher's area with the detailed progress of each student, allowing a close follow up in the difficulties of each one. It also has the possibility of creating a special level for each class.

The Made With Code[9] is a project from Google only for girls using fashion as the main theme. Their site is all in pink and violet, usually colors associated with girls, and it uses female characters such as Wonder Woman to encourage girls into learning computer logic and programming.

A gender-neutral project, with a diverse range of characters and games, the Tynker Project[10] includes teachers and parents in its methodology and teaches not only computational thinking, but also some programming languages such as Python and Java Script.

Other important educational programming tools for children include MIT's project Scratch [Monroy-Hernández and Resnick 2008], in which the student is free to create and share their own story, learning programming using command blocks and the Code Avengers[11], a payed platform from New Zealand with mini-courses on several computing

[7] `https://code.org/` Retrieved March 12, 2018

[8] `http://.codecombat.com` Retrieved March 12, 2018

[9] `https://www.madewithcode.com/` Retrieved March 12, 2018

[10] `https://play.google.com/store/apps/details?id=com.tynker.Tynker&hl=pt_PT` Retrieved March 12, 2018

[11] `https://www.codeavengers.com/` Retrieved March 12, 2018

areas for all ages, including college students.

For our activity we chose the 7 through 10 age group without any previous knowledge of computer programming. We also chose the games from Project Code.org with the themes Frozen, Minecraft and Angry Birds.

According to Piaget's theory of cognitive development [Piaget 1977], children in this age group are at the concrete operational stage in which they become more aware of external events, and less egocentric. Also during this stage, a child's thought processes become more mature and they start solving problems in a more logical fashion.

The Code.org Project was chosen due to its diversity in game themes, which allows for a better analysis of the children behavior. Although the 'Code Time' activity does not have a gender separation, it is possible to identify games designed to encourage girls in the IT field and neutral gender games. These diversity of goals in similar games was crucial to aid analyze the reaction of boys and girls to each king of game. Also, the Code.org Project has affected more than 500 millions of users, among 10 million girls and has the support of several companies such as Google, Apple and Amazon, showing its importance and success [Code.org 2017]. Based on the theme we identified three games: the Frozen themed that we assumed it was more appealing to girls, the Minecraft themed that we assumed it was more appealing to boys and the Angry Birds themed, that we assumed it was gender neutral.

At first glance, the Frozen themed game appears to be a great opportunity to attract girls, but a closer analysis reveals that the game has a much higher level of complexity, comparing to other games for the same age group and it also has fewer levels and character options. We also noted that this game requires concepts of angles, lines and geometry, making not only harder for the children, but also less appealing since math is not a popular subject among young students. By comparing the first phases of the three games chosen, we saw that, although they all have the same goal, the language used in the Frozen themed game was much more mathematical, making it more difficult and less attractive.

Throughout the classes we will try to answer the following questions:

1. Did students like the activity?
2. Has any student given up and if so, why?
3. Would they like to learn more?
4. Does the theme have any different response in girls and boys?
5. Did girls react differently than boys?

In order to analyze the results we chose a qualitative method, in which the focus is to investigate the response of children towards games. The collected data was obtained through questions to the students and through their examination during each class. These observations and notes are the raw materials used for the qualitative analysis, carried out to construct answers to the research questions.

In addition to the qualitative method, we will use Vygotsky's theory of human cultural and bio-social development [Vygotsky 1978]. According to this theory, man and woman develop through interpersonal connections and actions with the social environment. Therefore, the group of teachers plays an important role in the gender analysis, so four undergraduate students – two girls and two boys – were chosen to teach the class, with the professor only observing and taking notes.

We have two different groups, on the first we will use the Frozen and Minecraft games, letting each child choose between them while on the second we will use the Angry Birds game. Our goal in the first group is to identify motivation of choice, through individual and social behaviors answering Question 4. For the second group, our goal is to answer Question 5, analyzing the behavior of girls and boys in the face of a common logic problem. Questions 1 through 3 can be answered by both groups.

4. Results

Our activity consisted of teaching computational thinking for three different classes. In the first two, we used the Frozen and Minecraft themed games, leaving upon the children to choose between the games. For the last class, we used only the Angry Birds themed game. The classes were mixed-gender, having nearly equal representation of girls and boys, as an average elementary school class, and it were taught by four undergraduate students of a Computer Science course, two boys and two girls. They were supervised by a professor and the main goal was to observe the choices, difficulties and interests of each student for the chosen game, analyzing their reaction and achievements for each gender. The number of students and classes were determined by the school where the activity took place, limited either by the number of students in the appropriated age range and also by the capacity of the computer laboratory available.

For the first two classes we prepared the room, interspersing the games of Frozen and Minecraft in each computer, but letting each student change the theme whenever they liked. Students were free to leave the class at any time, and they were asked if they prefer to play in groups or individually.

For the first class we had 13 (thirteen) students, in which 9 (nine) were boys and 4 (four) were girls. Even though some computers were logged on the Frozen themed games, all students asked to play the Minecraft. The main reason given by them was the mathematical need for the Frozen themed game and that they did not like math. When changed to Minecraft all students were engaged on the game and played through the whole hour without stopping. Some students started the game in couples, but since both wanted to play at the same time, they ended up being separated.

Throughout the activity we noticed that the main difficulty for the students was to understand the use of repetition commands. Some made the repetitions by themselves, copying the code a fixed number of times. Others understood only the command, but not how to used it, putting the code after the repetition command, not inside it. But all students understood the need of a repetition in the logic.

While playing the game, students were asked if they were liking the game and if they thought it was hard. All students liked the game and wanted to learn more, some asking the project name so they could keep playing at home. There was no dropout by any student, girls and boys. Some changed the game from Frozen to Minecraft, but no one asked to leave the class.

Due to a mistake at the school administration, students of the second class were younger and still learning to read, so they presented difficulties in understanding the texts and commands to play the game. They demanded more from the teachers that had to help them reading some instructions. After the first contact with the game, they could keep up

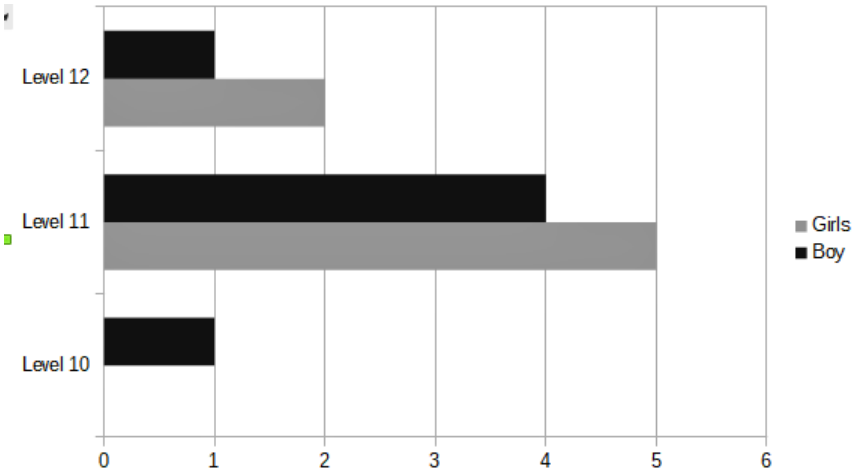

Figure 2. Level achieved by each gender on the Angry Birds Game.

by themselves. Even though they had difficulties in the beginning, they all liked the game and there were no dropouts. It is important to notice that for this class a few girls stayed on the Frozen themed game, although finding it difficult. This indicates that for a younger group of age, game with "girly" themes can be more appealing.

For the last class we used only the Angry Birds game since it is gender neutral. Since all students started with the same game, it was possible to compare the progress of each student based on the level achieved by them. Although the students could not choose the theme, they were still free to leave at any time. The goal was to observe the response of girls and boys to the same game, comparing their achievements and effort. For this class we also had 13 (thirteen) students, with 7 (seven) girls and 6 (six) boys.

Throughout the class we could noticed once again that the main difficulty was not with the logic, but with the spatial awareness, and the ability to distinguish left from right in a space. The class engaged on the game and even found a glitch on level 9 given an alternative solution for that stage. Girls and boys started to compete among themselves and each level completed by a student was widely celebrated. At the end, girls achieved higher levels than boys, showing that women are as capable as men regarding logic and computational thinking.

Of the 13 students, there were 5 girls at level 11 and 2 at level 12. All of the girls passed level 10. Of the 6 boys, 1 ended in level 10, another in level 12, and the 4 remaining ended at level 11. Figure 2 shows the level achieved by each gender on the Angry Birds Game.

After talking to each class teacher we could notice that most students, from both genders, do not have problems with math, but most of them do not like the subject. The main difficulty among the students were on reading and understanding the goals of each level, but not on logic or computational thinking. Still, we could note that students on the Frozen themed game did not advance as much as students on the other two games.

5. Research Questions

After analyzing each student reaction to the activity we can conclude that for Research Question 1, all responses were positive, with the students really engaged during the activ-

ity and even complaining when it ended. One of the students was really amazed when he first learned the repetition command, expressing happiness and satisfaction saying *"Wow, he is moving by himself!"*. Following the results for this question, we can say that no student has given up, answering Research Question 2. Some students gave up on the Frozen themed game, but as soon as they changed to the Minecraft, they were engaged on the activity.

Since some students complained when the class ended and asked for the website address so they could continue at home, we can say that for Research Question 3, both girls and boys would continue to learn computational thinking and possibly will like to learn programming languages if motivated to do so.

While comparing the response of girls and boys, we could noticed that the Frozen themed game did not have a positive reaction on girls within the right age group, that either gave up, changing the theme to Minecraft, or stated that the game was too difficult. For the gender-neutral Angry Birds theme, all girls and boys reacted the same, engaging fully in the game and even competing for each level. It is important to notice that, even though the girls changed to Minecraft without hesitation, some boys questioned the teachers if girls were also allowed to like Minecraft. This shows that for some children the gender stereotype is already being established.

For the final Research Question we can say that by our analysis, girls and boys reacted the same throughout all the activity. They were all equally motivated, engaged and capable, despite the theme chosen. We can conclude that for our students, girls did not need specially themed games to be interested and enjoyed the game as much as boys.

6. Conclusion

It was clear the interest and engagement of all the students during the classes, despite their gender. We could notice that previous knowledge in math was not required for the most popular games, since math is a subject that dispels students. It is important to note that other subjects were more essential to understand the games than math, such as reading and spatial awareness. After arousing the curiosity on computational thinking, we can remove the fear of math that it is an usual reason for girls to not choose technological fields.

This initial activity also show how girls and boys are equally interested and capable, and that "girly" themed games were not an important factor. Girls can be as motivated as boys to learn knew subjects, even on the STEM field. Therefore, when tested in the same environment and under the same conditions, the results are apparently equivalent for girls and boys.

As future work we intend to extend the analysis to other games and projects, and to test on larger groups, gradually increasing the sample space of our research. We also intend to rise the age range, analyzing adolescents and other cognition stages.

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