Introducing Computer Science to Brazilian Girls in Elementary School Through HCI Concepts

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Abstract. The participation of women in workgroups is essential to any kind of job. Nowadays Computer Science has little presence of women. Consequently, it is necessary to motivate girls to choose Computing as a career. This paper describes an experiment consisting of Human-Computer Interaction (HCI) activities that were used to demonstrate that Computing is more than only programming. The activities were based on the concepts and materials of the Computer Science Unplugged Project. Besides, this work presents the results with the HCI activities performed in the context two Brazilian projects. The results are qualitative in nature and provide insights about HCI activities to elementary school student girls. Fifty-two girls from two different cities and four different public schools participated. All students developed the five tasks designed by CSU materials and were able to articulate concepts of HCI.

Keywords: Women in computer science · Digital girls · Computer science unplugged · Human-Computer interaction

1 Introduction

The necessity of a larger representation of women in Information Technology (IT) is a worldwide issue. The participation of women, where computing is involved, both in academia and in the job market has been much discussed. The IEEE Women in Engineering (WIE) [11] is dedicated to promoting women scientists and engineers, facilitating the recruitment and retention of women in technical disciplines globally.

The Brazilian Computer Society (SBC) has held, in the last years, the WIT (Women in Information Technology) [12], a workshop to discuss subjects related to gender and IT and supports various project initiatives to attract women to Computing. The Project *Meninas Digitais* (Digital Girls) [7] was created from discussions in the WIT, which the main objective is to promote Computing and technology for girls from ten to sixteen at the end of elementary school or middle school, in order to generate interest in the area and motivate them to choose Computer Science (CS) as a career.

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Several activities are being carried out by various collaborators throughout Brazil such as lectures, technical visits and other initiatives.

In the end of 2013 the Brazilian Government through the National Council of Technological and Scientific Development (CNPq) launched the call for project proposals that would encourage the participation of girls in science, computing and engineering. Several projects were approved all over the country [2, 5]. Many of them have the objective to conducted activities to stimulate teenage girls to choose Computing as a career.

Emíli@s – Armação em Bits[1] is one of these projects approved. Differently of most of the projects to motivate girls to choose Computing as a career, *Emíli@*s also includes Database and Human-Computer Interaction (HCI) activities to demonstrate that Computing is more than only programming. The project has the involvement of Computer Science university teachers, a female Information System student, student girls and a female teacher from a public school in Curitiba in Paraná State (in the South of Brazil). The involvement with a public school is one of the requisites of the CNPq call.

This involvement is in line with one of the actions suggested by Medeiros (2005) [9] - one of the precursors of this discussion in Brazil - that may be considered to allow Brazilian women to become full citizens of the information society: to **provide the basis for adequate training of girls and teachers** - *One necessary direction requires rethinking the educational structure, and developing new kinds of content to be used in courses. These changes must start at an early stage*.

This paper presents the HCI activity performed in the context of *Emíli@s* and *Compute você mesm@*[2] project. The results of the activity performed in a small city of Paraná State were also presented. It is important to mention that the results are qualitative in nature and provide insights about HCI activities to elementary school student girls. Some similar initiatives are presented in the next section. The experiments' protocol is detailed explained in Sect. 3. In Sect. 4 the results of the experiments are shown. And finally, some considerations are made.

2 HCI Activities to Motivate Girls About Computing

In general girls perceive computing careers to be boring, solitary, and lacking real-world context as demonstrated by Yardi and Bruckman [13]. However, some researches have shown that HCI can positively impact interest in Computer Science courses. Yardi et al. [13, 14] gave a six-week HCI course to ten American students ages 11–13 and found that practicing HCI increased their interest in taking future computer related courses.

Margolis and Fisher [8] show that HCI has some promise in serving as a gateway to computing for females. Their work describes the Carnegie Mellon initiative that

[1] Emilia is one of Monteiro Lobato characters (author of Brazilian children's literature) the "Sítio do Picapau Amarelo" series. A talking doll, very creative, participating in various adventures.

[2] "Compute Você Mesm@" is an extension project aimed at the empowerment of minorities in computing, including women.

implemented curricular changes including an emphasis on HCI. The results demonstrate that the retention rates amongst women have increased.

Robinson and Pérez-Quiñones [10] conducted a weeklong HCI workshop with underrepresented middle school girls. The workshop was focused on an activity where girls created a paper prototype for a chat application. The results reveal that paper prototyping can be used as a motivator for a career path in computer science.

Maciel, Bim and Boscarioli [1, 6] also conducted an HCI activity with Brazilian girls following the Computer Science Unplugged (CSU) instructions to practice design concepts. The experience was a pilot experiment for the experiments presented in this paper. The results demonstrate the girls' high level involvement in the tasks proposed, showing that HCI is an attractive discipline.

As HCI is interdisciplinary in nature which gives the opportunity to explore the relationship between CS and other disciplines that may interest women. Besides this, HCI, as its name explicitly stated is concerned with human. It worries about the well-being of different users' profiles while interacting with diverse computational devices. Consequently, the stereotype of "nerd" disappears when practicing HCI.

Additionally, communication abilities are clearly needed to develop a computational application concerned with HCI approaches. Therefore, women could comprehend that Computer Science also involves the direct contact with people, which could attract them to the area.

3 The Experiments

All four experiments were carried out in three distinct public schools of Paraná state, in the South of Brazil. The participants were all girls ranging an equivalent age and socioeconomic status. The experiments took place at the girls' school as an extracurricular activity and lasted about three hours. In total the four experiments were conducted with the participation of 52 student girls as shown at Table 1.

The pairs and the groups were made by affinity. In the experiment Exp1 each pair was observed by a female student from a Computing course, who registered the interaction between the girls during the discussion about the solutions for the problems presented. In the experiment Exp2 the groups were observed by one of the researchers and also guided by a school teacher. In the experiments Exp3 e Exp4 the pairs were observed by three students from a Computing course and one of the researchers. The activities of the experiments are listed in Table 2 and explained in the following paragraphs.

The first activity was consisted in make the reception of the girls to explain the objectives of the experiments, and to organize groups to initiate activities. Secondly, a pre-survey was made with the application of a questionnaire with questions about the use (purpose and frequency) of computational devices, the girls' perception about Computer Science courses and their career intention. The results of this survey are presented in the Subsects. 4.1, 4.2 and 4.3.

The third activity consisted in five tasks, proposed by the Computer Science Unplugged Project [3] about HCI Design without Computer [4]. Each task (detailed explained in the following subsection) was presented separately to the student girls who had some minutes to develop their solutions.

Table 1. Experiments' date, city, quantity and arrangement of the participants

	Exp1	Exp2	Exp3	Exp4
Date	April 2013	May 2013	Aug 2014	Sept 2014
City	Curitiba	Guaiporã	Curitiba	Curitiba
Girls	6	10	8	28
Arrangement	pairs	groups	pairs	pairs

Table 2. Experiments' activities

	Exp1	Exp2	Exp3	Exp4
Introduction	x	x	x	x
Pre-survey	x	x	x	x
Computer Science Unplugged activities	x	x	x	x
Pos-survey			x	x

The third and fourth experiments had an extra activity, which consisted in a pos-survey. This questionnaire consisted of seven questions such as, "*What do you think of the activity? The activity met yours expectations? You ever imagine computing activities could be made without the PC?*". The goal of the post-survey was to assess the satisfaction of the students in participating in the proposed activity. The necessity of this fourth activity was identified after the first experiments.

3.1 Computer Science Unplugged Tasks

The Computer Science Unplugged Project [3] has as its main objective the promotion of Computer Science as an interesting, engaging and intellectually stimulating subject for young people. Therefore, its creators and collaborators have developed a series of activities addressing various topics in Computing including that of HCI – Human-computer interaction. "The Chocolate Factory activity" addresses human interface design [4]. It was translated into Brazilian Portuguese to be used by the girls in our experiment [6].

The setting is that of a chocolate factory and the users are the Oompa-Loompas[3] who have a number of characteristics that need to be considered: they cannot write, they cannot read and have very bad memories. Because of this, they have difficulty in remembering what to do in order to run the chocolate factory and things often go wrong. The goal of the activity, which consists of five tasks, briefly described hereafter, is to design a new factory that is supposed to be very easy for them to operate [4]:

1. Task1 - *Design new doors through which the Oompa-Loompas must pass carrying steaming buckets of liquid chocolate*: Oompa-Loompas cannot remember whether to push or pull the doors to open them, or slide them to one side. Consequently they

[3] The scenario is based on British book Charlie and the Chocolate Factory, by Roald Dahl, published in 1964, which inspired a movie of the same name, released in 2005.

end up banging into each other and spilling sticky chocolate all over the place. The girls should decide what kind of doors and handles to use in the factory. Targeted HCI concept: *Affordance*.

2. Task2 - *Design a stove with a better solution for the distribution of the buttons*: The stove is designed in a way that the Oompa-Loompas were always making mistakes, cooking the chocolate at the wrong temperature, and burning their sleeves when reaching across the burners to adjust the controls. The girls should come up with a better arrangement for the new factory. Targeted HCI concept: mapping.
3. Task3 - *Plan a visual warning system to control the conveyer belts*: The factory is full of conveyer belts carrying pots of half-made chocolate in various stages of completion. The people in the control room need to be able to tell the Oompa-Loompas to stop the conveyer belt, or slow it down, or start it up again. The groups should design a scheme that uses visual signals. It's important to consider the color pattern for the Oompa-Loompas: yellow means stop, red means go, and green means slow. Targeted HCI concept: transparency effect and user stereotype.
4. Task4 - *Create a solution for putting away utensils*: There is a cupboard with shelves for Oompa-Loompas to put articles on, but they always have trouble finding where things have been put away. Oompa-Loompas are very bad at remembering things and have trouble with rules like "always put the pots on the middle shelf". The groups should try to come up with a better solution. Targeted HCI concept: visible restrictions.
5. Task5 - *Create a control panel with buttons using individual icons for each operation*: In the main control room of the chocolate factory there are a lot of buttons and levers and switches that operate the individual machines. These need to be labeled, but because the Oompa-Loompas can't read the labels have to be pictorial – iconic – rather than linguistic. The girls have to design a control panel respecting the Oompa-Loompas limitations. Targeted HCI concept: designing.

4 Results

Participants' Profiles. The four experiments were conducted with teenage girls, from twelve to seventeen, from public schools. All of the girls have computers at home and use them daily. The activities performed using the computer mainly concern communication.

In Exp1, three of them mentioned using the computer to do their school homework. And only one mentioned playing games as one of the purpose to use the computer. The time spent on the Internet varies from two to fifteen hours a day (seven hours in average). Concerning the computational devices they used, only one does not use a smartphone. All of them but one use a personal computer. Three of them also use tablets and finally four of them have experiences with notebooks.

In Exp2, five participants referred to having a computer at home, and all use it at school. Reasons for use are social networking, gaming, school assignment research, and chatting with classmates.

The summary of the use of devices for each participant of four experiments is shown in Table 3.

Table 3. Devices X participants

Devices/Exp	Exp1	Exp2	Exp3	Exp4
PC	1	5	5	28
Smartphone	5	0	5	28
Tablet	3	0	3	9
Notebook	4	0	0	28

Concerning the use of technology and Internet access, both in Exp3 and Exp4, all mentioned using the computer to do their school homework and to have Internet access. Two in Exp3 and three in Exp4 quoted the use of computing devices for playing games.

In the Exp4, 13 students reported having family and/or friends working in the computing area and cited the reasons why they would take a workshop in the field: "a job demand, curriculum enrichment, and the lack of professionals in the area." In Exp3, all of them reported that they use the computer and Internet daily. The reasons for participating in a computer workshop are the same shown in Exp4.

Participants' Ideas About Computer Science Courses. The participants, in 4 experiments, were asked about their knowledge about Computer Science courses. In Exp1, one of them (the youngest one) mentioned *programming* (robot, websites and others) as the main activity in a Computer Science course. Three of them focused in *hardware* and two of them gave generic answers as "*They are interesting…*", "*They teach how to do virtual and graphical projects.*"

In Exp2, nine participants claimed to know nothing about courses in the field of computing and only one said, quite generically, that she knew "*almost nothing, and I never really looked more into it*".

Three students, in Exp3, considered that a computer science course has content about: computer assembly, creating websites and program installation. In addition, other four described the profile of a computer science student as "nerd-like" and "a very intelligent person, studious and good logical thinking." The rest of them did not know what to say. In Exp4, half of them indicated that CS involves activities such as website development and hardware. The other half could not explain.

Participants' Professional Career Intent. With the aim to comprehend the participants' expectation about the activity, they were asked about their professional career intent, in the four experiments. Journalist, photographer, doctor, History teacher, PhD in French Language, petrochemical engineer, lawyer, singer, dentist, politician, officer in charge, architect and P.E. teacher were mentioned. One girl, although not yet sure about her intentions, mentioned "*Program designer for the industry*". And finally, one answered, "*I would like to be a stylist or designer, because I like to draw and see it become true*."

It is interesting to see that most of them are not sure about their choices nor know them completely. For example, the girl who wants to be a PhD in French Language indicates this option because she considers French a beautiful language and because

she would like to live in France. Only one of them indicated that search for information to choose on future profession. The girl who wants to be a petrochemical engineer said she had researched the area in several websites because, in her own words, "*I always watch news which says this field will grow*." A participant said she wanted to be a P.E. teacher because she likes sports. Two of them revealed the intention of being the officer in charge at a police station due to influence by a successful TV soap opera, which shows the profession to be related to the fight against crime.

4.1 Task 1

The first pair (E1P1) didn't work as cooperatively as expected. One of the girls has a dominant attitude and the other one was more passive. In Task 1 they ignored the options offered in the activity and proposed the use of an automatic door (sliding to the right).

The second pair (E1P2) had quite a discussion to find the solutions for the tasks. For Task 1, after considering many possibilities they proposed a motion sensor door. However, they didn't explicit to which direction the door should open.

The third pair (E1P3) also had a deep discussion about each possibility before coming with the solution. For Task 1, they remembered the types of door in their daily lives and decided to propose a motion sensor door as the one used in malls.

In the second experiment (Exp2) all three groups worked collaboratively and decisions were made collectively. During the development of Task 1 a girl said that "*We should fashion a mat that slides the door open when stepped*", the first group (E2G1) checked the Sliding Door option and recommended, through a drawing, adding a surveillance camera that would cause it to open at the character's approach. In the second group (E2G2), a participant emphatically claimed, "*I'd remove the doors!*". However, her group checked the Common Door option, selecting the *Push to the right* and *Push to the left* options, and observed it would be somewhat a chase door, which, according to their explanation, would simplify their coming and going, for it would be made out of a light material. The third group (E2G3) checked the Sliding door option and added a commentary: *"A door that would open when somebody got close, started by a sensor"*. Another participant's remark is quite interesting: "*I'd rather have a door that opened at voice command*".

This task demonstrated just how creative participants were. We noticed that they were willing to suggest different doors from the models they were supposed to choose from the possibilities offered by the experiment material.

As in the second experiment, both in Exp3 as in Exp4 the students worked collaboratively on their pair. Sometimes they made general reflections to the class. This occurred especially in Task 1, in which several students began sharing their considerations aloud concerning the best options for doors.

The group of 8 students, in Exp3, collaboratively concluded that sliding doors "as we have in the malls" would be a great alternative. The fourth pair (E3P4) textually explained their intentions: "A motion sensor automatic double door that lets you know whether there is another person on the other side of the door, because it is transparent".

4.2 Task 2

The solution presented in Task 2 by (E1P1) was extremely simple: a cooker with four buttons in front of it, one for each burner. The solution brought E1P2 to the same task was a stove with five burners, representing the control knobs in perspective.

The most creative answer for Task 2 was presented by E1P3. They proposed an automatic stove with specific burners for each type of chocolate. The control knobs have colors to indicate whether the chocolate is the black or white one. Additionally, the knobs also indicate the appropriate temperature at which each type of chocolate needs to be cooked.

In Exp2 all three groups made drawings of conventional stoves, with the only variation being the number of burners, which were 4, 5 and 6. They reported that intensity would be controlled by turning the knobs. The only group which proposed something different was E2G1, by numbering both the knobs and the burners. When questioned by the E2G2 members on how the illiterate characters would handle that, they replied that being unable to read and write does not prevent them from matching corresponding digits. This fact points out to a visual identification of patterns. Interesting remarks were taken during the development of this task, such as "*Guys, they're so dumb – what a weak memory!*" and "*God, why do they have such weak memory?*", which is much of a concern to understand the final user's stereotypes.

It is worth mentioning that in Task 2 in Exp3, all pairs (E3P1, E3P2, E3P3, E3P4) placed the control knobs on the front of the stove to avoid the problem of burns. Two proposals (E3P1 and E3P3) use the position of knobs to show at which location the burner is. One group (E3P2) used, along with a visual indication of positioning, a color for each type of fire, with burners placed next to each other. The number of burners ranged from 3 to 6.

In Exp4, only E4P2 designed a stove with 6 burners. The other pairs used 4 burners. The pair E4P11 proposed a stove without circular burners. The proposed solution contained 4 rectangular areas, with their respective buttons (only on-off), bounded by lines. In addition the solution had a lateral area for temperature control.

4.3 Task 3

In Task 3 the pair E1P1 overlooked the Oompa-Loompas difficulty in memorizing things and proposed colored panels distributed along the factory to indicate: "slow", "stop" and "go". On the other hand the E1P2 proposed luminous signs respecting the Oompa-Loompas' color code but they didn't detail where the signs would be placed in the factory. E1P3 used the idea of a traffic light with the Oompa-Loompas' color code. They emphasize that the lights could be seen everywhere in the room.

In the second experiment E2G1 drew three doors placed alongside the conveyor belts. Such doors would change from green (meaning slow), yellow (meaning stop) and red (meaning begin), by means of a device that would cast the colored lights. The changing of colors would be run by the controller and the Oompa-Loompas would be guided by looking at them. Whereas one participant had thought to "*Give them all ear phones so they can only but hear voice commands"*, E2G2 presented a light panel

showing the colors, placed under the conveyor. Besides, they associated color intensity with action intensity, with commands such as "follow now" and "follow soon". E2G3 drew only a conveyor and wrote: "*Conveyor must change color so they know what the command is. Slow = green; Stop = yellow; Follow = red.*"

In both Exp3 and Exp4, girls proposed light signals according to the Oompa-Loompas' color code. All responses were based on traffic signs. One of the proposals (E4P5), considered the use of graphic signals using the drawing of hands to indicate the actions "stop" and "go". An open hand means "go" and a closed hand means "stop". As the pair did not find a symbol for "slowly", they returned to the traffic light scheme.

4.4 Task 4

The E1P1 suggested the use of images of each objects to indicate the place at the cupboard where they have to be kept.

Interestingly, the solution suggested by E1P2 used one element of Task 3. The girls proposed the use of belts to bring the objects to the cupboard. Besides, the cupboard would have pictures to indicate the correct place of each object.

Once again, the creativity showed up in the solution proposed by E1P3 for Task 4. The cupboard will have pictures of the objects (as suggested by the other pairs). However, as the Oompa-Loompas are troublesome when it comes to rules, they decided to put a sensor, as a kind of scanner, to identify the object that lies in the Oompa-Loompa's hands. Consequently, the cupboard only opens if the correct object is in front of the correct door.

In the second experiment E2G1 drew a cupboard with the knobs fashioned around the objects that ought to be put away. E2G2 created colorful cupboards and colorful objects, so as to guide Oompa-Loompas to place objects in their corresponding color cupboard. They mentioned that doors would be "almost transparent" so they could also make out what is inside. E2G3 designed cupboards that would remain open, with a picture next to each of them indicating the object to be put away inside.

Finally, the pairs of Exp3 and Exp4 used the concept of images to indicate the objects in the cupboard. There was no other solution.

4.5 Task 5

In the first experiment (Exp1) three groups of tags were distributed: Wrap it, Ingredients and Dimensions, as shown in Fig. 1:

The pair that drew the Wrap it tags made very detailed pictures. However, the two other pairs that had to "discovered" the meanings of the draws didn't completely get the right meaning. They gave different meanings for wrap with foil and stop conveyer belt (unwrap and put in the conveyer belt, respectively).

The pair that drew the Ingredients tags also made detailed pictures. But the other pairs gave different meanings for sugar and extra sugar: granulated (for sugar) and sugar and extra coconut (for extra sugar).

Wrap it	Ingredients	Dimensions:
- wrap with foil	Add:	- small bar
- wrap with paper	- cocoa	- medium bar
- put into bag	- milk	- large bar
- put into box	- sugar	- humungous bar
- stop conveyer belt	- extra sugar	- set bar size (in squares)
	- butter	- make chocolate chips

Fig. 1. Tags given to the three groups, respectively, during the Exp1

Wrap it	Ingredients	Try me!
- wrap in aluminum	Add:	- Try it
- wrap in paper	- cocoa	- Awesome – highest rating
- place in a bag	- milk	- Okay – medium rating
- place in a box	- sugar	- Eww – bake chocolate again
- send to shipping	- more sugar	- Eww, eww! – "throw away"
	- butter	

Fig. 2. Tags given to the three groups, respectively, during the Exp2

The E1P2 drew the Dimensions tags. The other pairs have difficulties only with the set bar size draw, one answered decreasing sizes and the other pair gave no answer.

In the second experiment (E2) Task 5 had to be explained twice. Concept understood, the girls started discussing the representation icons. Tags were provided for the groups (Fig. 2), where design solutions were to be drawn as icons.

E2G1 received the Wrap tag. The girls moved on to draw the corresponding wrapping material. They used dark grey to indicate aluminum, and shaped a heart to indicate paper, and so on. E2G2 was in charge of adding ingredients. Their concern was to draw cocoa on the tins, a cow to represent milk, sugar cane for sugar, and so on. E2G3 received the Try Me tag. They used the drawing of a tongue to illustrate "try me". They also used different facial expressions. For "Eww – bake chocolate again", they made a spoon inside a mixing bowl, and for "Eww, eww – throw away", they drew a trash can. Perhaps more time would have been necessary for this task, if better solutions were to be sought.

Each pair in Exp3 and Exp4 also got a set of tags. Thus they created individual icons to represent such buttons. Later there was the exchange of solutions, in pairs, to socialize the answers. The E3P2 created an icon that detail is the action "put into box" with a draw of a box ready to be filled. The label "Ingredients: Add milk" was well designed by E3P4 pair, who proposed the design of a milk box with the illustration of a cow.

In Exp4, in addition to tags already mentioned, the students used the "Making" tag with the following icons: star mixing, stop mixing, start heating, stop heating, pour into molds, stamp a pattern. The pair E4P5, developed an icon for "star mixing" and "stop mixing" representing the hand in both situations.

5 Considerations

Note that the use of HCI strategies with girls helps fighting the idea that computer is a hard science in essence. As it is seen nowadays, a sociotechnical approach to systems is on the rise, so that it is recommended to build diverse teams in terms of gender, for example. However, we still need actions as presented in this paper to demystify computing for girls. In the proposed tasks it was observed that the girls were able to meet the necessary requirements for the development of all tasks.

They also understood the importance of adopting different artifacts and managed to evaluate the concept of affordance when they analyzed the doors of Task 1, as it was reported in all the experiments; they understood the importance of knowing the users, understanding their expectations and needs in the course of all tasks, mainly in Task 2, as shown by the discussions in Exp2; in Task 3 they were able to work out concepts of "transfer effect" and "population stereotypes" to treat the signs and issues that required users' prior knowledge, according to the resolution by pair E4P5; Task 4 explored the concept of "visible constraints" for the design of the proposed cupboard; finally, Task 5 explored icons and the importance of representations and meanings; in all the experiments they were clearly understood.

As to *Programa Nacional Meninas Digitais* (Digital Girls National Programme), volunteers are working on a website that will concentrate information about various enterprises spread throughout Brazil, thus helping to disclose the issue and attract interest. The group communicates through an email list, which grows every year with the inclusion of the Forum participants and via Facebook social network[4].

As future works, we can mention the development of new activities, involving HCI and girls. Although the proposed CSU is relevant, we must develop new practices so that these girls are involved continuously other concepts of HCI are discussed.

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