Computational Thinking for Youth and Adults Education: Towards a Socially Aware Model

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Abstract. *Research on teaching Computational Thinking has been growing over the last years, mainly focusing on Elementary and High School students. However, challenging audiences, such as Youth and Adults Education (YAE), are rarely addressed. This Master's research investigates Computational Thinking as a way to promote digital literacy and proposes a model to plan and conduct initiatives for YAE, respecting the characteristics and particularities of this public. The proposed model was applied and analyzed in a case study inside a public school. Results show the model as promising to design practices to develop Computational Thinking for inclusion, aware of the audience's context. As additional contributions, the activities applied and lessons learned from their application are presented to inform and support further initiatives.*

1. Introduction

Computational Thinking (CT) has received growing attention in academic literature. Studies have reported initiatives to develop CT skills and concepts to different audiences as researchers around the world defend their benefits not only for computer scientists but for everyone [Wing 2006, Nardelli 2019, Tissenbaum et al. 2019]. However, in a systematic mapping review, we identified the vast majority of studies has focused on children and teenagers, and few studies have addressed adult students, especially those in digital and social vulnerability [Ortiz and Pereira 2019b], such as students of Youth and Adults Education[1] (YAE).

In Brazil, 11,3 million citizens cannot read or write [IBGE 2018], reinforcing a condition of digital and social exclusion. YAE is a modality for people who have not completed elementary and high school at the expected age. Among several reasons why students leave school, the main one is the need to start working to help their families [Neri 2009]. YAE students have unique characteristics, social and cultural contexts, vulnerabilities, barriers, necessities, and expectations, all deepened due to lack of study. For these students, before the issue of using technology, there are socio-cultural-economic challenges that prevent them from being in contact with technology. These barriers are so strong that United Nations' Sustainable Development Goal #4[2] is dedicated to gather forces to ensure inclusive and equitable quality education, promoting lifelong learning opportunities for all, particularly for marginalized and vulnerable people.

If for children and teenagers CT represents important abilities to live in a digital age, for people in situations of social and digital exclusion, developing these skills is

[1]Translated from the Portuguese: *Educação de Jovens e Adultos*.
[2]Available at https://sustainabledevelopment.un.org/sdg4 last access on 30 June 2020.

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a matter of inclusion, identity and existence for the exercise of citizenship. However, our systematic literature mapping found no material to support the design, planning, and conduction of initiatives to develop CT for YAE students [Ortiz and Pereira 2019b].

Giving the gap in the literature, this research addressed the problem of lack of knowledge to support the design, planning, and conduction of initiatives to develop CT with YAE students. Contributing to advance the knowledge body, this Master's research proposed a Socially Aware Model for practicing CT, designed to support the understanding and conduction of initiatives sensible to YAE students' socio-cultural context and particularities, understanding CT abilities as promising to promote digital inclusion and, therefore, actually useful for everyone.

The goals of this research were: to propose a model for supporting CT initiatives with YAE students; to conduct studies in real settings to investigate the model effectiveness (if it meets the objectives for which it was proposed); to document the model, the activities developed for its application and their observed outcomes; to analyze and document lessons learned; and to share the results obtained throughout this research to support further initiatives for YAE audience.

From a conceptual perspective, the main original aspect of this research is to approach CT as a way to foster digital inclusion. Concepts such as abstraction, algorithms, problem decomposition and pattern recognition have the potential to enhance students' comprehension, use, and appropriation of technology. This understanding, aligned with the practice of CT abilities, has the potential to set forth an autonomous and positive experience for using technology. The more people practice, the more they understand and more autonomous and confident they get, in a cycle of continuous reinforcement.

The Socially Aware Model was created adopting a constructive and applied research, and was inspired by literature on education and computing. Different principles informed the model and different practices support its application. The model was constructively applied during 8 workshops in a case study situated in a public school. Evaluation methods used were voting and feedback from students, structured observation from researchers, and unstructured interviews with YAE teachers. Results show the model as promising to support CT practices with YAE students as it helped us to understand our audience and to propose and conduct activities that kept them engaged and interested, moving from students' feelings of fear and inadequacy to an increasing sense of self-confidence and interest to learn more about technology.

The case study led to a set of 9 principles to guide initiatives, produced 12 different activities, and resulted in 17 lessons learned, having the potential to inspire and support other initiatives designed for YAE students. These contributions are available for the public and have been published or are under review in different papers.

2. Methodology and Theoretical Grounds

The methodology conducted for this Master's research covered conceptual and applied investigations through i) Pilot study, ii) Literature Review, and iii) Case Study. For the i) Pilot Study, a service Project named "Programming my Context" was carried out with students between 12 and 29 years old (age range partially eligible for YAE) to teach CT skills for the development of games [Schultz et al. 2018]. The project served as an exploratory case study for conceiving the model and for the authors' experience in planning and conducting contextualized activities.

For the ii) Literature Review, a systematic mapping covering initiatives to develop CT was conducted to identify works published in Brazilian and international digital databases between 2007-2017, since Wing's seminal paper on "Computational Thinking" [Ortiz and Pereira 2019b]. From this systematic mapping, only 1 from 46 initiatives addressed adult students in situations of social, economic, and digital vulnerability. The only one, conducted by Ortiz and Raabe (2016), reveals challenges for working with this public, especially regarding students' engagement. Results from the systematic mapping also revealed that only 5 of the 46 initiatives mentioned addressing social and cultural aspects of students' context [Ortiz et al. 2019b]. As we could identify, the lack of connection to the real world negatively affected students' motivation and their perception of how thinking computationally could be useful for their lives.

For the iii) Case Study, we conducted practical activities inside a public school where CT was approached as a way to foster digital inclusion. Instead of focusing on teaching CT abilities, we embedded them into meaningful activities to promote the contact with technologies. This Case Study is presented in Section 3.

2.1. Towards a Socially-Aware model

Several initiatives have failed to connect to specific personal interests and lives of learners, and this scenario makes them feel CT is not relevant for them to learn, says Tissenbaum et al. (2019). Claiming for the need to move from computational thinking to action, the authors argue that while learning about computing, people must be engaged in experiences that have a direct impact on their lives and their communities. To this end, we must situate activities in real-world contexts that *matter* to students.

Contributing to advance the movement towards computational action, this Master's research draws on authors from different fields. The understanding of what is a socially aware initiative comes from Baranauskas (2014). The works from Freire (1997) and Vieira Pinto (2013) provide a greater understanding of teaching adults, especially those in vulnerable settings. Finally, CT's technical aspects are provided by Tissenbaum et al. (2019), Nardelli (2019), and Raabe et al. (2018). Built on this background, the Socially Aware Model was proposed with 3 steps, as Figure 1 shows.

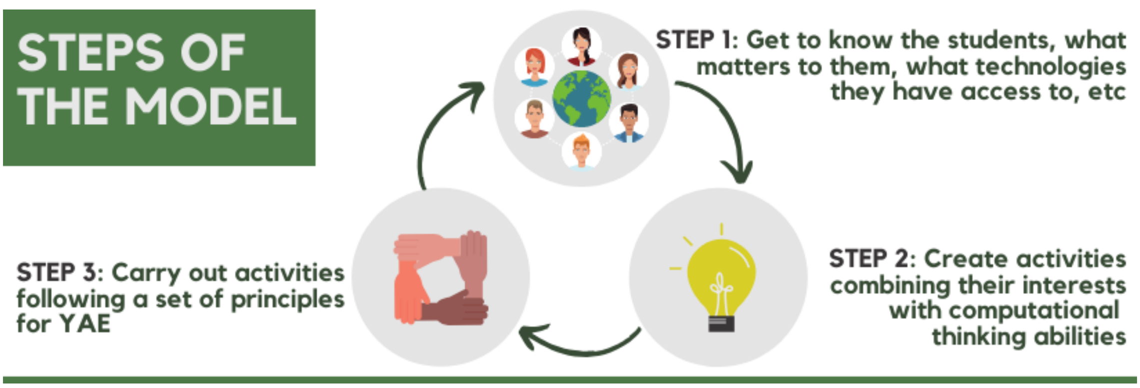

Figure 1. Steps of the Socially Aware Model

Step 1 - get to know the students: enter into students' worlds, understand what is relevant and useful to them, to further determine what technologies to use and what contents and activities to explore involving CT abilities. This step must start an open and trustful working environment for all the participants. Important issues to identify are students' expectations, needs, knowledge, contents they are studying in the regular class, technologies they know or have access to, the ones they would like to learn about, etc. Different techniques or strategies can be put into practice here to raise this information in a positive, volunteer, and funny way (e.g., games and storytelling). The starting point is to engage people in meaningful and positive experiences with technology usage, promoting well-being and a feeling that we are all learning together.

Step 2 - create activities: combine all the information previously raised to determine the contents and technologies to be addressed, and CT skills to be practiced in activities to engage students. Each activity must address relevant and useful things students want to learn more about and must explore possibilities via devices they may have access to, naturally exploring CT concepts and skills in them. New activities can be elaborated and existing ones can be adapted, as long as they incorporate relevant aspects of students' context. Activities must be as universal as possible to attend the diversity of students. Defining activities to be conducted, outcomes to be evaluated, and elaborating the necessary materials to its conduction are also part of this step.

Step 3 - carry out activities: when putting activities into practice one must be aware of YAE particularities and characteristics. This step also encompasses socialization and evaluation, which may occur according to the main goal of each initiative (*e.g.*, the students' progress, what they have learned with the activity, their perception of technological devices usage, etc). Every activity must be elaborated in this movement from Step 1 through Step 2, and Step 3. During the practice of activities in Step 3, new interests, doubts, and needs may arise and serve as input for a new cycle, creating an iterative and constructive movement.

Our case study in a YAE school refined the Socially Aware Model. This case study was carried out as a collaborative project involving YAE teachers and other HCI and Informatics in Education researchers.

3. Case Study

The Case Study was conducted at the public School Rachel Mader Gonçalves, in a low-income neighborhood in Curitiba/Brazil. The Socially Aware Model was applied to support context understanding, and activities planning and conduction. This initiative was part of a service project No. 20184842 approved by both the University and the School. The informed consent form was obtained orally as students were in literacy process.

For using the model, the goal was to investigate its applicability and capability of reaching students' context and to get ideas and recommendations for its improvement. As a first result and positive evidence, the model helped us to define our main goal: to promote students' familiarity with contemporary technology. This goal was an adequate one, as we validated with YAE teachers that the students have strong barriers for the contact with technology, especially the internal ones, involving their feelings and personal perception of capability and autonomy.

Because the initiative's main goal involved students' perceptions about themselves (their capacity and self-esteem), their opinion about their own progress and their interest in the activities would give us the most trustworthy evidence. More important than reaching a specific performance or grade is whether students have felt they were learning and wanted to keep learning. Observations from teachers and researchers could contribute as additional evidence about whether we were succeeding to reach students' context and being part of it. Therefore, feedback from students, interview with teachers, and observation by researchers were adopted as evaluation methods.

For this Case Study, 8 workshops (2 hours each) were conducted, for which 12 activities were elaborated and performed. A group of 17 students with ages from 16 to 70 and 2 YAE teachers took part in this initiative. At least 3 researchers were present during the workshops: the first author who acted as the main facilitator, a colleague who acted as an observer, and the advisor (second author) who acted as both observer and participant with students and YAE teachers.

When we agreed on the initiative with the teachers, we presented it as a season of 4 episodes (workshops). If students and teachers (our audience) wanted more, we would extend the season adding more episodes. As other positive evidence, episodes were extended from 4 to 8, reaching the end of the term. Table 1 present an overview of the 8 workshops[3], with their title, goals, CT abilities involved, and a brief of the outputs.

At the end of each workshop, students were asked to answer 2 questions by using colored cards, cards with *emojis*, and a ballot box. For identifying students' engagement, the first question was: "*Do I want to keep learning about technology?*", and for identifying their learning self-perception, the second question was: "*How much do I think I have learned from this workshop?*". Details about the possible answers for these questions are presented in Figure 2. Voting was optional and anonymous as the ballot box was placed outside the classroom. Explicit feedback from the participants was also registered by teachers and researchers.

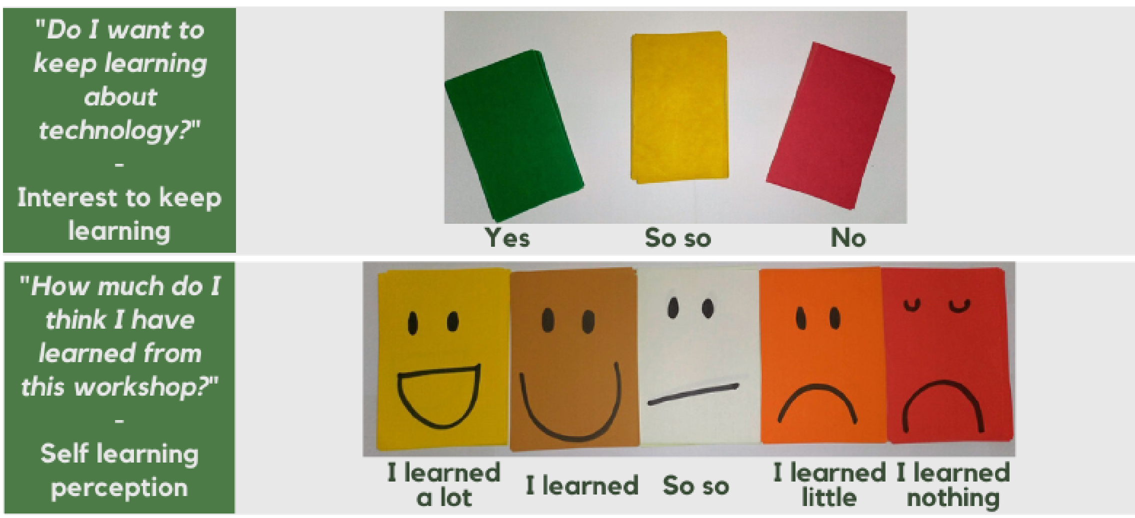

Figure 2. Questions asked to students, and its possible answers

[3]Indeed, after this first season we have already conducted another entire season with 8 new episodes and we are planning a special (remote) season to start after August 2020.

Title and Goal	CT abilities	Outcomes
1: The icebreaker. Introduce the initiative, get to know the students, understand their context and discuss about technologies in a StoryTelling style.	—-	Informed the following workshops and promoted the feeling of belonging to a group that everyone had possibilities and limitations, and what to learn and teach. Students' interest about technology were: smartphones, music, making calls, taking pictures and ATMs.
2: Training family photographers. Discuss about photos, describe and perform a sequence of steps to take photos in different devices.	Algorithms, pattern recognition and automation.	Explored the connection between home, personal life and school, creating opportunities for them to show and practice at home what they were exploring in the classroom.
3: Let's talk about voting. Discuss about the voting terminal, describe and execute a sequence of steps to vote.	Algorithms, decomposition, automation, simulation and pattern recognition.	Aligned with the 2018 election scenario, the exercise of citizenship was discussed by involving the voting terminal, an important device that still caused anxiety and was challenging for them.
4: Searching on YouTube. Introduce YouTube and the voice-based search. Perform a sequence of steps to search.	Algorithms, automation, pattern recognition and simulation.	Involved them in using voice-based commands, exploring the use of new forms of interaction and new applications through positive and useful experiences for their lives, researching recipes and songs they liked.
5: Game night! Play a game and remember what have been seen regarding technology so far.	Algorithms, problem decomposition, data analysis and pattern recognition.	Fully integration with the literacy content that teachers worked with them, in which they could see even more clearly their progress while enjoying a Youtube soundtrack they had created in the previous workshop.
6: Lady Miroca: movie and popcorn. Watch a movie that presents the execution of an algorithm by someone with similar characteristics to the students, and discuss it.	Algorithms, simulation, data analysis and pattern recognition.	Film session, part of school's official program, indicating workshops were connected with other events in school life. Also showed a connection with what they had been learning and producing in the previous workshops.
7: Hello? Who is this? Introduce WhatsApp audio and video calls. Debug and perform a sequence of steps to make a call.	Algorithms, pattern recognition, data analysis, automation and simulation.	They have put all their skills into practice, both in terms of contact with technology and in terms of didactic content worked, showing confidence and familiarity with the activities.
8: The Grand Finale. Remember all workshops, talk about the initiative and get feedback from students about the classes for a further season with more workshops.	—-	The socialization and the remembrance of all the way through the season brought the feedback on what was worked and what could be even better, resulting in the renewal of the partnership for a new season.

Table 1. Overview of 8 the workshops

4. Results & Discussion

After 8 workshops involving many activities and technologies (see Figure 3), teachers' and researchers' observation indicates a reduction in students' resistance to contact with technological devices, as well as an increase in the interest to learn more about technology. In the early workshops, only talking about technology seemed to make them feel uncomfortable. Sentences we have heard were: "*I will not be able to learn about it*", and "*my grandchild knows how to do all this, he is the one who should be here*", suggesting a feeling of incapability. As the workshops were taking place, this kind of comment disappeared and, instead, students were getting engaged in the activities and having fun, elaborating and testing their solutions.

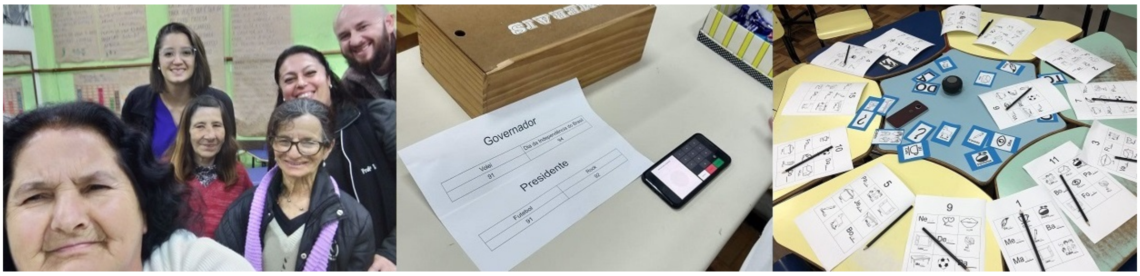

Figure 3. Photos of classes and activities during the initiative

The workshops took place once a week and the participation was voluntary. However, not only all the present students decided to participate but they were always excited for the next one. We consider that students' engagement in activities is strong evidence of the reduction of internal barriers for their contact and use of technology, as well as of our success to make activities relevant for their life context.

The answers to the questions we have asked corroborate our perception of students' engagement and positive learning perception (using the cards presented in Figure 2). Out of 68 cumulative votes received during the whole season, 68 were "*Yes*" for their interest to learn more about technology. Regarding their learning self-perception, asked in classes that involved practical activities and content (from 2nd to 7th), from 64 cumulative votes, 57 were "*I learned a lot*", 6 were "*I learned*", 1 was "*So so*", and none was "*I learned a little*" or "*I learned nothing*". Based on these results, we confirmed students were motivated and had an excellent perception of their learning progress.

During the workshops, students always had many experiences and personal stories to share about the addressed topics, indicating the initiative was able to involve contexts that were related to their lives. Additionally, teachers reported students had used at home the knowledge they have created during the activities, and they have shared these experiences with their colleagues. Taking pictures of their family's Sunday lunch or calling grandsons on WhatsApp are a few examples of knowledge they have practiced outside the school. These statements indicate the workshops were able to involve contents from students' contexts and to contribute to them.

Regarding CT and digital inclusion, the more they could complete the activities with technological devices, the more they seemed to feel part of a group. In the Workshop 3, with a voting terminal prototype, we identified students around their sixties who had never voted with this equipment before because they could not have help while operating it. Many of them even described the act of voting as something bad or painful, based on their previous experiences with this technology. Together, we created an algorithm for the whole voting process, and as the discussion was going on, students realized they only did not know a few steps of the process and how to perform them on the voting terminal.

Practicing CT abilities, like problem decomposition, simulation, and algorithm, helped students to perform a complete algorithm to vote in the voting terminal prototype. After this workshop, in October 2018, one student reported having voted for the very first time. This observation, together with the results they have achieved throughout the initiative (making calls, searching for videos on YouTube, taking pictures, etc.) corroborates that the practice of CT abilities supported them to use technological devices.

Hence, we understand that practicing CT as a natural part of positive experiences and activities helps to understand how the technology works, what are the possibilities and restrictions on its use, and how it should be used. The more one comprehends these aspects, the more favored the interaction with technological devices tends to be. Thus, for people who have no technology as part of their daily lives, practicing CT abilities can provide fundamental structures to experience digital environments.

Based on the results discussed above, we consider that the Socially Aware Model for YAE students was helpful to plan and conduct workshops that achieved students' socio-cultural contexts, needs, and expectations, contributing to students' motivation to learn and use technology.

From this Master's research, we were able to identify and produce additional relevant contributions[4] to support further initiatives with YAE students. Figure 4 shows a summary of the principles, activities, and lessons learned. Contributions were published in different papers listed below.

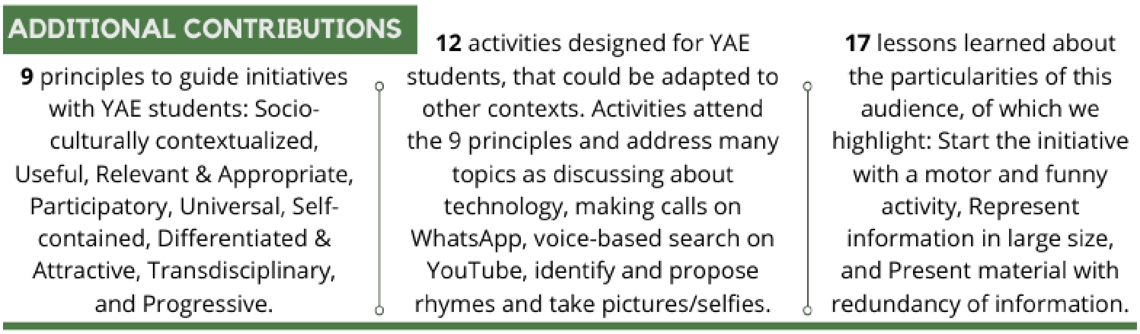

Figure 4. Additional contributions achieved through the Master's research

- [Ortiz and Pereira 2018]: Presents general discussions about the literature panorama of ten years of CT initiatives since 2007.
- [Ortiz et al. 2018]: This paper presents a discussion about socio-cultural issues within the CT initiatives from the literature panorama.
- [Ortiz and Pereira 2019b, Ortiz et al. 2019b]: These are extended versions of the papers above, respectively. Both were invited by the Journal on Computational Thinking.
- [Ortiz and Pereira 2019a]: This paper discusses the 9 principles outlined to guide the practice, that came from the theoretical grounds, the pilot study and the experience with the case study.
- [Ortiz et al. 2019a]: This paper discusses a relation between CT and Digital Literacy, presenting details about activities and results from Workshop 7.

[4] All contribution products are available at https://bit.ly/contribuicoesortiz last access on 30 June 2020.

- [Ortiz 2019]: Presents details about each lesson learned. In situations involving such a specific public this kind of knowledge is desirable to inspire other initiatives and to prevent someone from starting from scratch, as the authors of the very first initiative with CT and YAE described.
- Book Chapter: This chapter was written with two YAE teachers and is under publishing process with the title "*Computational Thinking in Youth and Adult Education: principles and challenges for a socially-aware practice*".
- Journal: As studies with YAE are rare even in the international scenario, a journal paper presenting the model and the workshops' results is prepared for an international journal.

5. Conclusion

This research approached CT as a way to foster digital inclusion, where the practice with CT abilities has the potential of favoring comprehension and autonomy in the usage of technological devices. This approach, however, cannot be detached from students' socio-cultural context, from the relevant aspects of their lives.

A Socially Aware Model was proposed to help planning and conducting initiatives with YAE students, context-sensitive to students' particularities. This model was applied and analyzed during 8 workshops with YAE students in a public school, which resulted in a set of 12 activities that can be reused, 17 lessons learned discussed with researchers and teachers, and 9 principles to guide research and practice in YAE contexts. The model, activities, principles and lessons learned have been published in academic forums and are freely available for download.

Results from the 8 workshops suggest the model was helpful to plan and conduct activities that involve contents that matter to students, that are useful for their daily lives at home, contributing to students' motivation to learn more about technology. During the case study and the practice with CT abilities and skills, we observed a reduction in students' resistance to contact with technological devices, an increase in their interest to learn more about technology and an excellent self-perception of learning. Progress was observed and felt by everyone, everyday: from the very first class when they were not comfortable in holding a smartphone, until the last class, in which they were calling each other on smart phones by themselves and taking pictures of their houses to share with other students.

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