Developing a Girls in Computer Science After-School Program Utilizing Social Robots

Emily Carroso
University of Illinois at Chicago
Computer Science
ecarro20@uic.edu

Sylvia Joseph
University of Illinois at Chicago
Computer Science
sjosep34@uic.edu

ABSTRACT

Various programs have been created to get more women interested in pursuing computer science careers but not enough have focused on the lack of belonging that often derail young girls' interests in computer science. We attempt to fill this gap by creating MyTurn, an out-of-school computing program that focuses not only on teaching girls computational thinking but also on creating a close community between the middle schoolers and their college-aged mentors to support a sense of belonging. This paper will outline the initial development of the MyTurn program and the activities that will be done, including how they will help develop the girls and their new community. We also discuss the future of MyTurn following the planning phase.

1. INTRODUCTION

The persistent lack of women in computer science (CS) inhibits the quality and growth of computer science as a field because it limits diverse points of view needed to solve complex problems more efficiently and effectively (Stoica et al., 2020). Despite many attempts in the past decade, there is still a stereotype that CS is a male-dominated field (Cheryan, et al., 2015). These stereotypes can be a barrier to women in CS, in part because they send a message that women do not belong in the field. Encouraging a sense of belonging, to combat these stereotypes, may encourage more women to engage in CS, but little work has been done to specifically target belongingness for women in CS (Master & Meltzoff, 2020).

To tackle this issue we are developing an out-of-school program, MyTurn, that focuses on creating a sense of belonging for middle school girls within computer science while teaching computing concepts through the use of social robots. The goal of this program is to help the girls build foundational knowledge and to create a sense of belongingness in computer science through targeted mentorship and tailoring the curriculum to align with their interests, ultimately encouraging them to pursue a career within the field.

In this paper, we lay out the groundwork behind the MyTurn program, describe the overarching goals and themes, summarize the design of the curriculum, and the development of a support tool that will be used throughout the program.

2. BACKGROUND

2.1 Belongingness

When someone feels that they are valued and respected based on their shared qualities, they feel a sense of belonging (Mahar et al., 2012). The sense of belonging can be seen in many different fields and can have different effects. Building a sense of belonging can come by forming connections and sharing information between members of a group. No matter the nature of the information, the social bonds between the members of the group are usually positively affected (Bergin, 2016).

Belongingness is key to building long-term interest in academic and non-academic subjects (Bergin, 2016). Curriculum can be designed to guide learners towards connecting previous interests with a current topic. When students connect with a topic due to related personal interest, their academic success and engagement with their fellow students increases (Pressick-Kilborn, 2015). Connectedness between students further triggers interest development as individual learners actively engage in conversations with their peers and learn from one another (Pressick-Kilborn, 2015). Connections can also be built through the use of the social-belonging intervention, where older peers share stories about their experience with belongingness to their younger peers (Walton & Brady, 2021). These stories can help others see that they are not alone and that others have had similar experiences (Lacrosse et al., 2020). All these connections can help facilitate social interactions between computer science students, which is also found to increase a sense of belonging (Mooney & Becker, 2020).

We believe computing with social robots is an applied area of computer science that will facilitate broad levels of student-tailored activities. Social robots allow the students to combine their interests with computer science as they will be in control of the social activities done throughout the program (e.g. dancing, art, athletics). It will also encourage students to work together if they need help with their robots. In this way, designing, programming, and testing social robot interactions that are important or meaningful to each student creates a space for them to see how computer science work relates to who they are and what they care about.

2.2 Computational Thinking

Part of building a sense of belonging can also be related to feeling that one has the capability of succeeding in an area of study. Modern conceptions of computer science education focus on building *computational thinking*, collection of problem-solving skills utilized in computer science, to prepare students for computing fields (Curzon et al., 2009). Typically, the framework of computational thinking skills is considered to consist of higher-level thinking in three stages: abstraction, automation, and analysis (Lee et al., 2011); sometimes described as *four pillars* of decomposition, pattern recognition, abstraction, and algorithm design (Tabesh, 2017). With technology being more embedded in our culture, it is important to begin teaching students computational thinking earlier on in school (Mohaghegh & McCauley, 2016). Not only will this become a helpful skill set the students can have, but it can also introduce them to computer science at an earlier age.

One way to teach students computational thinking is the use of robotics, or in our case social robotics. The act of programming the robot will allow students to work through the three stages of computational thinking. The students will first determine what they want the robot to perform (abstraction), program the robot (automation) and then run the program and determine if it ran the way they wanted it to (analysis; Lee et al., 2011). Robotics can also be used to teach the four pillars of computational thinking. The students will be encouraged to break their acts into smaller parts, (decomposition), determine patterns and how to best approach them by analyzing the data they will collect (pattern recognition and abstraction), and develop a program for the robot to perform the task (algorithmic design; Tabesh, 2017).

To support student development of computational thinking, scaffolding, or specific methods of allowing learners to complete and engage in tasks they would not be capable of without help (Puntambeker, 2009), can be utilized. The scaffolding used in the program consists of storyboarding, narrative writing, and pseudocode as this serves an early programming design process (Weintrop et al., 2019). Storyboarding consists of the student drawing out what they want a program to do. The storyboard can consist of different frames to represent the different key actions that will take place during the program. Narrative writing prepares students to write out their storyboard as pseudocode, where modern block code can be used as a form of pseudocode that scaffolds early programming (Weintrop et al., 2019). Specific scaffolding tools, particularly for designing and programming social robot interactions, can be crucial to allowing novice students to build computational thinking skills while engaging in self-designed social robotics development.

3. DESIGN

3.1 Intervention Design

The main goals of MyTurn are for the students to build a sense of belongingness within Computer Science communities and develop computational skills that they will need for their potential computer science careers.

To achieve the goal of belongingness, the program is designed for the students to work with a college-aged mentor on developing their own social robotic interactions. The mentor's main tasks are to create a welcoming environment, build connections, and be a support system for the students, including helping with coding concepts or providing emotional support. By having mentors share their personal experiences, the students can see themselves within their mentors and a place where they can belong within the program (Lacrosse et al., 2020). The mentor's training will provide them the tools to continue to bond with the students throughout the program. The ultimate goal is for the students to feel comfortable reaching out to not only their mentor but also their fellow students even after MyTurn's end.

The activities the mentors will lead rely heavily on group and partner work. This is designed so the students can make friends with similar peers to promote their interest in computer science as social influences have a direct effect on whether a student's interest is continued or not (Bergin, 2016).

For the goal of computational thinking, we utilized social robots to teach algorithms and pseudocode. The sequence of the activities was designed so the students would learn the steps of the design process. These steps include brainstorming an idea, storyboarding it, writing pseudocode, and finally programming their robot with block code.

Social Robot Platform

For MyTurn, the Cozmo robot by Anki will be used. Cozmo is a small educational toy with an API that allows it to act out different emotions, speak its own language, and move around and detect objects. Cozmo is also programmable using the Cozmo app. The program's final project consists of the students programming Cozmo to perform a social activity with them using the computational skills they have learned throughout the program.

3.2 MyTurn Program Task Sequence

The MyTurn program starts before the official first day when the students receive a welcome letter from their mentor. The welcome letter is meant to start the process of building a sense of belonging for the students. The mentor will introduce themselves in the letters and give the students some encouragement and advice about starting the program. The students will also receive the webcomic, *Social Robots - A Science Comic* (Korn & Grund, 2021), to read before the start of the program to learn a little bit about what a social robot is.

On the first day of the program, students will talk about what a social robot is and create their own definition with guidance from the mentors. They will also begin learning how to create a plan for what they want their robot to do. First, the students will learn how to brainstorm their ideas. They will then critically analyze different storyboards and learn what a good storyboard of a social robot looks like. Lastly, they will create their own storyboard.

As the program continues, the students will do more activities to build their computational thinking to help them in their final project. These activities aim to help the students understand how to develop pseudocode. First, the Social Storyboard Activity will help students develop a descriptive narrative of how a social activity should play out. This descriptive narrative will help them understand the importance of detail in their descriptions. The next activity, the Maze Game (Dejene et al., 2019), is also meant to help the students understand the importance of detail, but more systematically. With these acquired skills, the students will then work on developing their code for the social activity they will have their robot perform for their final project to present at the end of the program. Table 1 consists of the sequence of activities planned for the MyTurn Program at the time of this writing.

#	Name of Activity	Description	Goal
1	Welcome Letter	Students receive a letter from their mentor welcoming them to the program	To create a sense of belonging before the start of the program
2	Webcomic	Students read a webcomic about social robots before their first day	Help the students understand what a social robot is
3	Social Robot Definition	Students formulate a collective definition of what a social robot is	Help the students explain what a social robot is in their own words
4	Storyboard Brainstorm	Students come up with different social activities they can do with the robot	Help the students to begin to think about how they should act with the robot socially
5	Storyboard Example	Students compare and contrast a good storyboard and a bad storyboard	Help the students understand what a good storyboard looks like
6	Storyboard Activity	Students create their own storyboard	Help the students plan out what they want their program with the robot to look like
7	Social Storyboard Activity	Students create a storyboard of a social activity that they will perform with each other	Help the students to create a descriptive narrative of their work
8	Maze Game	Students work in groups of three to write, process, and execute a pseudocode algorithm for solving a maze	Teach the students the importance of specific and detailed algorithms to get the ideal results
9	Program Robot Final Project	Students develop and code a social activity for their robot from scratch throughout several sessions. They will use the digital tool and their storyboard to write narrative code and then rewrite it as block code.	Demonstrate the skills they acquired throughout the entire program

Table 1: MyTurn task sequence.

3.3 Tool Development

In addition to having a list of activities prepared for the students, a digital tool is being developed to provide scaffolding for the students to program their social robot interactions. The tool will help students observe the development process by watching each step of it unfold and closely tying the social interaction designs, from storyboards to the programming used to enact those interactions. It is also meant to act as a guide for students who may have little to no experience with code before the program. This is done by having the students first create a narrative from their storyboards, something they have experience with, and then using that to create their pseudocode, something they don't have experience with.

To make this connection, there are three main stages to using the scaffolding tool (See Figure 1). First, the students will upload a picture of their storyboard into the digital tool. They will then annotate the storyboard with narrative cards. Next, the tool will present each narrative card separately and the students will create pseudocode for each card. Finally, the tool will compile the separate pseudocode pieces to present a final pseudocode version of the program.

Two main design decisions took place when developing the scaffolding tool. The first decision was to allow the students to create their storyboard using paper and pencil instead of designing a way for the students to create their storyboard within the tool itself digitally. We felt it was important to not limit the students' creativity and having them create the storyboards digitally would do just that.

The second design decision was to present the students with a list of questions while they are in the pseudocode stage. These questions are meant to guide them to relevant block codes they can utilize from Cozmo's IDE for their program. The tool was designed to use the block code as a type of pseudocode to help guide the students (Weintrop et al., 2019).

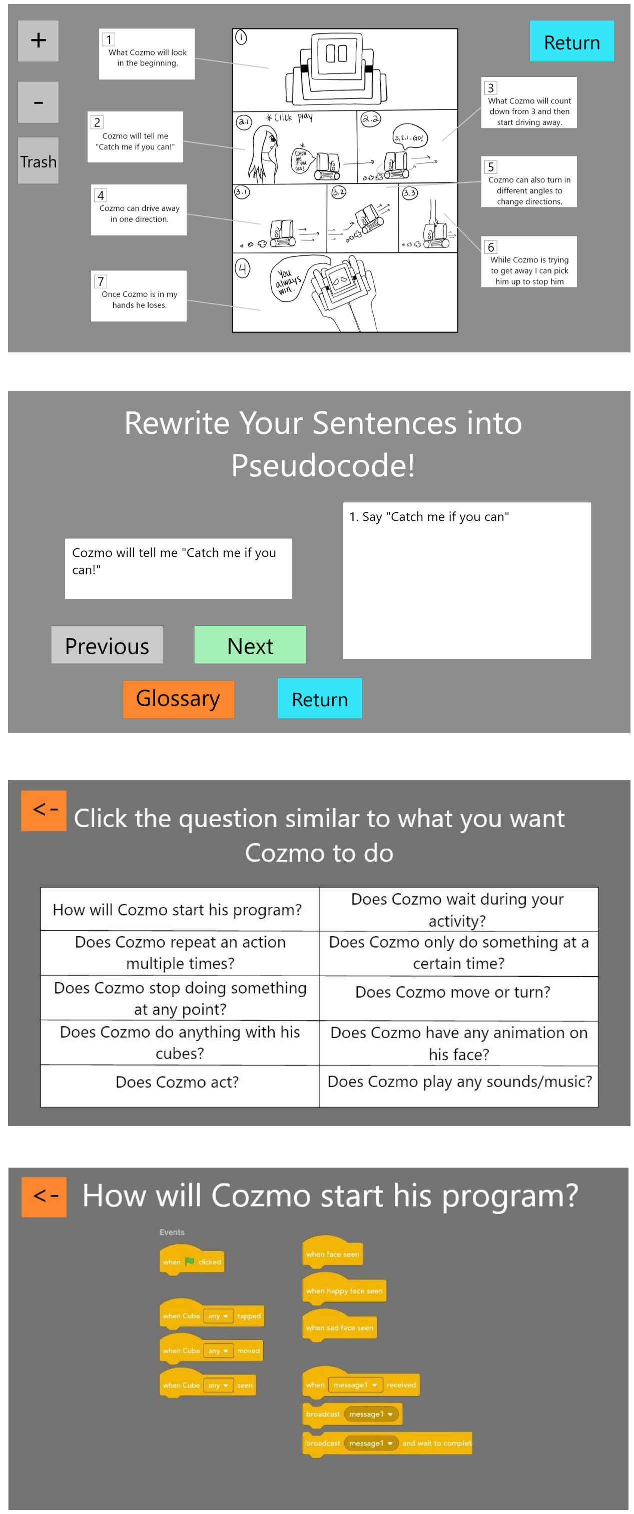

Figure 1: Key components of the digital tool

4. CONCLUSION

The MyTurn program aims to encourage middle-school girls to pursue computing-related fields through the use of social robots. The program will help lay the foundation of computing concepts that can be further developed through other programs or courses. The program also aims to help each student gain a sense of belonging within the program, which will then carry over even after it finishes. This is supposed to help the students not feel discouraged within the field and to encourage them to continue down their Computer Science path.

The MyTurn program is still being developed. The future steps include creating a pilot program to evaluate the current plan to see if it is effective. The pilot program consists of interviewing potential students from the Girl Scouts of Greater Chicago and Northwest Indiana and female undergraduate students from the University of Illinois at Chicago as mentors. After the interviews, the students and mentors will perform the curriculum. In addition to developing the pilot program, the digital tool will also be developed so it can be used during the pilot program. By analyzing the results from the pilot program and checking in with participants after they've graduated high school, we hope to determine if MyTurn is an effective program for eliminating the present stereotype surrounding computer science.

REFERENCES

Bergin, D. A. (2016). Social Influences on Interest. *Educational Psychologist*, *51*(1), 7-22.

Breazeal, C., Dautenhahn, K., & Kanda, T. (2016). Social Robotics. *Springer Handbook of Robotics*, 1935-1972.

Cheryan, S., Master, A., & Meltzoff, A. N. (2015). Cultural stereotypes as gatekeepers: Increasing girls' interest in computer science and engineering by diversifying stereotypes. *Frontiers in Psychology*, *6*.

Curzon, P., Black, J., Meagher, L. R., & McOwan, P. (2009). cs4fn.org: Enthusing Students about Computer Science.

Dejene, M. A., Figueroa, M. T., & Jariwala, N. M. (2019). *Using Arts and Crafts to teach Computer Science at the YMCA After-School Program*. https://digitalcommons.wpi.edu/iqp-all/5664

Korn, O., & Grund, J. (2021). *Social Robots - A Science Comic*. Affective & Cognitive Institute.

Lacrosse, J., Canning, E. A., Bowman, N. A., Murphy, M. C., & Logel, C. (2020). A social-belonging intervention improves STEM outcomes for students who speak English as a second language. *Science Advances*, *6*(40).

Lee, I., Martin, F., Denner, J., Coulter, B., Allan, W., Erickson, J., Malyn-Smith, J., & Werner, L. (2011). Computational Thinking for Youth in Practice. *ACM Inroads*, *2*(1), 32–37.

Mahar, A., Cobigo, V., & Stuart, H. (2012). Conceptualizing belonging. *Perspectives in Rehabilitation*, *35*(12), 1026-1032.

Master, A., & Meltzoff, A. N. (2020). Cultural Stereotypes and Sense of Belonging Contribute to Gender Gaps in STEM. *International Journal of Gender, Science, and Technology*, *12*(1).

Mohaghegh, M., & McCauley, M. (2016). Computational Thinking: The Skill Set of the 21st Century. *International Journal of Computer Science and Information Technologies*, *7*(3), 1524-1530.

Mooney, C., & Becker, B. A. (2020). *Sense of Belonging: The Intersectionality of Self-Identified Minority Status and*

Gender in Undergraduate Computer Science Students. Association for Computing Machinery.

Pressick-Kilborn, K. (2015). Canalization and Connectedness in the Development of Science Interest. *Interest in mathematics and science learning*.

Puntambekar, S. (2009). Scaffolding student learning. In *Psychology of Classroom Learning*. MacMillan.

Stoica, A.-A., Han, J. X., & Chaintreau, A. (2020). Seeding Network Influence in Biased Networks and the Benefits of Diversity. In *WWW '20: Proceedings of The Web Conference 2020* (pp. 2089–2098). Association for Computing Machinery, New York, NY, United States.

Tabesh, Y. (2017). Computational Thinking: A 21st Century Skill. *Olympiads in Informatics*, *11*(Special Issue), 65–70.

Walton, G. M., & Brady, S. T. (2021). The Social-Belonging Intervention. In *Handbook of Wise Interventions*. The Guilford Press.

Weintrop, D., Killen, H., Munzar, T., & Franke, B. (2019). Block-based Comprehension: Exploring and Explaining Student Outcomes from a Read-only Block-based Exam.