Fostering High School Girls' Interest and Attainment in Computer Science

Mirela Gutica
British Columbia Institute of Technology
Burnaby, British Columbia, Canada
mirela_gutica@bcit.ca

ABSTRACT

Computing education and careers are male dominated. Identifying strategies to reduce this gender gap would create a more diverse and inclusive workforce, and would respond to the growing importance of computing and technology in our society. This paper presents an intervention designed and conducted in a post-secondary polytechnic institution aimed at inspiring and motivating computer science education among high school girls. Grounded in theory and related research, this intervention was designed to address aspects recognized as having relevance to girls. Using the expectancy-value theory of motivation developed by Eccles as a theoretical foundation, this study explores the intervention's impact on participants' interest and attainment in computer science. Twenty five students (nineteen girls) from local high schools participated in this pre-questionnaire, intervention, post-questionnaire quasi-experimental study. Participants were mentored by post-secondary students (at least one mentor for each pair of participants) through activities including writing an algorithm, coding, exploring an AR/VR technology and practicing programming skills with an educational game. Analysis of resulting data revealed that girls who participated in this study experienced a high level of enjoyment, increased interest, perceived positive learning gains, and were inspired by their post-secondary mentors. Post-questionnaire responses indicated that girls improved their ability beliefs and reduced their stereotypical views.

CCS CONCEPTS

• **Social and professional topics** → **CS1**; **K-12 education**.

KEYWORDS

women in computer science, expectancy-value theory of motivation, coding, stereotypes, ability beliefs, role models, spatial cognition

ACM Reference Format:
Mirela Gutica. 2021. Fostering High School Girls' Interest and Attainment in Computer Science. In *26th ACM Conference on Innovation and Technology in Computer Science Education V. 1 (ITiCSE 2021), June 26-July 1, 2021, Virtual Event, Germany*. ACM, New York, NY, USA, 7 pages. https://doi.org/10.1145/3430665.3456353

ITiCSE 2021, June 26-July 1, 2021, Virtual Event, Germany

ACM ISBN 978-1-4503-8214-4/21/06…$15.00
https://doi.org/10.1145/3430665.3456353

1 INTRODUCTION

Women are under-represented in computing education and jobs [1, 36]. Efforts are being made to increase young girls' and women's enrolment in STEM disciplines; however, even if women are in majority in medical and health sciences, only 19% of degrees in computer science (CS) and technology were awarded to women in US in 2016 - 2017 [1]. A study conducted by Statistics Canada in 2019 reported that women persist in their STEM field of study equally or even more than men; however the gender gap is caused by lower enrollment at the start of post-secondary education [36]. Consistent with this data, the September enrollment of female students at a computer science and technology undergraduate program in our post-secondary polytechnic institute between 2015 and 2020 was less than 17% which is even lower than the reported enrolment at a university from the same geographical area (23%).

Reducing the gender gap in STEM and especially in CS education and careers presents two distinct challenges: recruitment and retention [10]. This study is part of a larger research study conducted at our institution responding to these two challenges. This paper focuses on the first challenge and presents an intervention designed by the author of this study (who was also the principal investigator) aimed at sparking interest and curiosity, motivating and promoting CS education among high school girls through carefully designed extracurricular activities that took place in our post secondary polytechnic institution.

According to Eccles' expectancy-value theory of motivation [11, 41], expectations for success (domain-specific beliefs in mastering a task) and subjective task values influence a learner's achievement-related choices, engagement and persistence. There are four subjective task values that motivate a person to persist on a task: interest or intrinsic (inherent enjoyment when doing an activity), attainment (value or importance; consistency with self-image/identity), utility (short or long-term rewards) and cost (perceived cost e.g., monetary, effort, sacrifices, etc.).

Eccles' expectancy-value theory of motivation informed this study design and data analysis. All four subjective task values identified by Eccles [11] are important for achievement-related choices; however the focus of this paper is on only two: interest (intrinsic) and attainment. A comprehensive literature review was conducted to identify aspects influencing these values that contribute to the gender gap in CS.

The literature review revealed a large number of studies focused on gender differences in STEM/CS education and career choices [4, 14, 17, 18, 25, 37] and on deterrents responsible for discouraging girls to study CS, for example stereotypical perceptions of the field [5, 33], lack of role models [7, 10], and lack or limited exposure and training in skills that develop and improve spacial cognition

[35]. A solution to these problems is exposing high school girls to activities and a learning context that alleviate and possibly eliminate these deterrents. Intervening in high school can help girls shape their career choices. Strategies based on empirical evidence recommended for recruiting women in undergraduate computing majors are focused on outreach: reach prospective students, work with teachers and counselors and disseminate information in high schools and local communities [7].

The research question answered by this study is: How visual coding exercises, peer programming, an AR/VR learning environment and mentoring provided by post-secondary students impact high school girls' interest and attainment in CS?

2 LITERATURE REVIEW

Theories of Motivation. Expectations for success and task values are developed in childhood and adolescence and are influenced by several factors rooted in the cultural milieu (e.g., gender roles, cultural stereotypes and occupational characteristics), the socializers' (e.g., parents, peers, teachers) attitudes, beliefs and expectations, and ultimately the self-concept of one's abilities, and perceptions of task demands [11, 41]. Ability beliefs and subjective values are related empirically and are strong predictors of choice, persistence and performance [41]. Eccles' expectancy-value theory of motivation was used to explain differences between male and female students with respect to the choice to study mathematics, and later was extended to other domains, e.g., sports [40]. Eccles found that boys have more positive expectations for success in mathematics and sports, and girls in reading/English and music [11]. In a study of grade 7 - 11 Australian students, Watt found that boys rated themselves more highly on mathematics and girls more on English [38]. Eccles' expectancy-value theory of motivation was extensively used to evaluate motivational factors that influence girls' and women's school-related goals in different disciplines e.g., CS [9, 20] mathematics [24] and STEM [3, 23], and in career choices [12].

Deterrents to Women's Participation in Computing. The gender gap has deep roots in sociocultural factors like the societal beliefs of gendered differences in ability [11]. Based on a literature survey, Wang and Degol [37] reported that "women may be avoiding challenging careers in STEM not only because they erroneously believe that innate intelligence is needed for success in these fields but also because they erroneously believe that they belong to a group that is less likely to possess the qualities needed for success in these fields" [p.8]. Studies found that girls and women lack confidence in their computer skills [4, 18] and doubt themselves and their aptitudes to succeed in STEM fields [17].

Several studies revealed stereotypical images that negatively influence career choices in CS. Additionally, negative and hostile environments were reported in literature: e.g., cultural [27] and racial marginalization [32]. Stereotypical views of computer scientists include perceptions of technology-oriented persons with strong interests in programming and electronics, focused on computers, masculine, intelligent and lacking interpersonal skills [5, 6]. Physical features of computer specialists drawn by middle school students included glasses and abnormal body weigh [26]. The computer scientist image "pervasive in popular culture and in the minds of students as someone who is highly intelligent, singularly obsessed with computers, and socially unskilled" [p. 67] deters women's interest in the computing field; however, when presented with a fabricated newspaper article that stated that computer scientists no longer fit the stereotypes, women expressed more interest in CS [5]. It appears that the perception of stereotypes is rooted mainly outside the computing field. In a study conducted in an Australian University, Michell et al. [27] found that all student participants from non-CS disciplines described the field as a "male 'nerd/geek' zone, and in a way that suggests observations that 'nerd' and 'geek' culture is 'on trend' and increasingly valued" [p. 411]; however, students studying CS recognised and resisted this image.

Parents' and teachers' attitudes, beliefs and expectations can create gendered mind-sets in their children or students and influence their goals and self-concepts, and ultimately their expectations of success and achievement-related choices [41]. A study by Grunderson et al.[15] found that adults' own math anxieties, beliefs and behaviors result in girls having more "negative math attitudes, including gender stereotypes, anxieties, and self-concepts, than boys" [p.153]. By contrast, with parental and mentoring support women are sustained in male-dominated fields [14]. Female role models (e.g., faculty and upper-level students) are key to the retention of women in STEM and CS fields [7, 10]; however with respect to recruitment male and female role models could equally be effective [10].

Positive Influences: Spatial Cognitive Abilities. As reported in literature, spatial abilities present gender differences [35]. As spatial abilities are associated with success in STEM [8], playing computer games, an activity demonstrated to improve spatial skills, could reduce the gender gap [13, 25]. The literature review revealed that girls who grew up in an environment that enhanced their success in science and math with spatial skills training, were more likely to develop these skills as well as their confidence, and consider a future career in a STEM field [17]. Additionally, using spatial cognition when learning CS improved their learning experiences [17]. There are a variety of programming environments which teach children programming such as Alice, MicroWorlds LOGO and Scratch. Using visualization to promote learning and spatial cognition is a known teaching and learning method. AR/VR technologies started to be used for creating programming environments. For example, Radu and MacIntyre developed a 3D/AR version of Scratch for children between the ages of 9 and 11 [30]. Al-Tahat et al. demonstrated that including Alice 3D in an university first-year introductory CS Java language course improved female students' attitude and performance [2]. With the goal of increasing recruitment and retention in CS, Parmar et al. designed and empirically validated the Virtual Environment Interactions, a VR environment aimed to teach CS to middle school students through the process of choreographing movement for a virtual character [29]. With the same aim, Ortega et al. created a prototype of a 3D AR/VR Virtual Programming Language for undergraduate students [28].

Positive Influences: Collaboration. Kuhn and Villeval [22] found that collaborative work is preferred by women in the workforce as there is a "greater 'pure' preference for working in a team environment among women" [p, 1]. A study by Werner et al. [39] reports empirical evidence that pair-programming was effective to increase enrollment in introductory programming courses as "women view programming as a collaborative exercise" [p. 6].

3 METHODOLOGY

3.1 Study Design

This study took place at British Columbia Institute of Technology (BCIT), in the Computing Department and consisted of four half-day workshops. The study was quasi-experimental employing a pre-questionnaire / intervention / post-questionnaire design. The intervention was designed to address aspects recognized as having relevance to girls: coding activities intended to be attractive for girls involving spatial cognition, collaboration and pair programming, and mentors acting as role models. Through guidance and mentoring, this study design was intended to reduce stereotypical views and to increase confidence in individual abilities.

Participants. The participants in this study were 25 students (19 girls) grade 8 to 12, mean age 15.8 (15.7 for girls) recruited from local high schools by the Institute's High School Partnership Coordinator Office. The study was designed with both gender participation as the reality of the computing field (or any other STEM field) is that girls or women do not study or work in isolation. In addition, to increase the girls' comfort levels, the high school students were recruited with the condition that a majority of girls will participate in each workshop. Another condition was that each student should come with a friend such that each pair of students will know each other and feel comfortable to work together, as the literature review presents evidence of effectiveness of pair programming for women [39]. Ethical approval for this study was obtained from the Institutional Review Board.

Mentors. The study participants were mentored by five (two female and three male) sophomore post-secondary undergraduate students (a minimum of one mentor for two participants). Mentors had good programming skills and were passionate about coding. The post-secondary students were also representative of both genders as having only female role-models would present an inaccurate and artificial image of our institution. Additionally, as literature suggests, male and female role models are both effective in improving women's attitude towards CS [6]. The undergraduate mentors were trained with respect to the study design and completed a required online Course on Research Ethics. After each workshop, mentors wrote a report and had a group discussion with the principal investigator.

Workshop Description. The pre- and post-questionnaires were distributed and responded upon arrival and after the last activity, respectively. The half-day workshops, conducted by the principal investigator and mentors, consisted of three activities: (1) writing an algorithm, (2) implementing a Java-Script program with visual artifacts, and (3) exploring the HoloLens technology and playing the *CodeBlocks* game (described below). The workshop and coding activities were carefully designed and planned. As exposure to tasks that improve spatial cognition is important for girls' coding confidence [8, 25], the coding activities were designed around visual artifacts. As pair-programming and collaboration are relevant to girls [39], the high school students were grouped in pairs of two friends. Each pair was mentored by one or two post-secondary students for maximum collaboration and interaction. Lunch was served between the second and third activity. This was important as during lunch participants and mentors had informal conversations. After the high school students responded the pre-questionnaire, the principal investigator and the mentors presented a short introduction to programming defining code and programming languages.

(1) The first activity was writing an algorithm intended to instruct a robot to travel to a pet store, select a puppy that the participants would like most, purchase and bring the puppy home. Writing algorithms is very important for code comprehension as programmers need to design a model first [31]. Each pair of study participants wrote the algorithm, discussed it with their mentor(s) and presented the solution to the group. The activity concluded with the principal investigator and mentors presenting a solution to the problem and introducing the concepts of code repeatability and function/procedure.

(2) For the second activity, each pair of study participants was given a laptop and a JavaScript code skeleton with basic functionality (a fountain of bubbles in black and white). This coding activity was designed to foster program comprehension [19]. Guided by their mentors, participants identified the scope, completed code and reflected on the function of the code. Using their imagination, participants modified the code as they wished by adding color, images, movement, sound, etc. with help from their mentors. Again, they presented their solutions to the group.

(3) After lunch the third activity took place. Mentors explained the AR/VR technology and trained the participants to use HoloLens devices. Participants played the *CodeBlocks* game.

Game Design. The choice to implement an AR/VR HoloLens educational game, besides exposing the girls to a cutting-edge technology, was empirically validated in previous studies [28–30]. Additional pedagogical benefits are related to visualization and spatial skills as video games can be useful in equalizing these differences associated with gender [13, 34]. Problem solving and social play modes were included in the game design as these design characteristics are gender neutral [21]. The Hololens educational game *CodeBlocks* was designed by the principal investigator and developed by BCIT undergraduate students over several iterations as an intervention tool to complement this research study. The purpose of the game is to teach programming via block coding by increased 3D visualization in a novel medium. The game has a gender neutral character, Casey the bear. The learning objectives are introducing basic coding (sequential, decision and repetition) in a 3D environment. The game was implemented in Unity 2017.4.x. Figure 1 presents a game scene.

Questionnaires. The pre- and post-questionnaires were designed based on the theoretical framework and included Likert scale items and open-ended questions. Some questions were similar to allow comparison between responses given before and after intervention. Participants reported on aspects of interest (intrinsic) and attainment subjective values: enjoyment, self-image, ability believes, role models and stereotypes. Participants were also asked to describe and draw the image of a computer scientist.

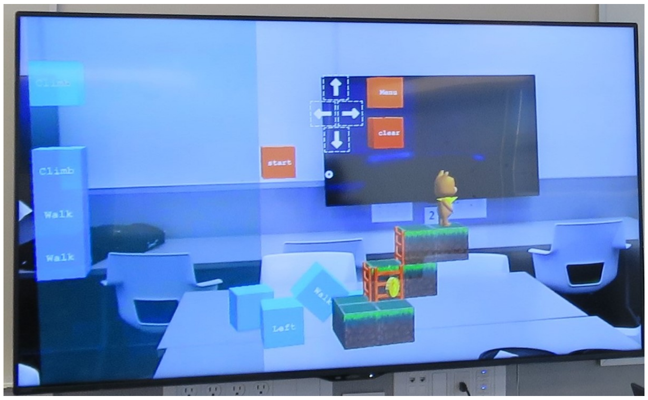

Figure 1: The CodeBlocks Game

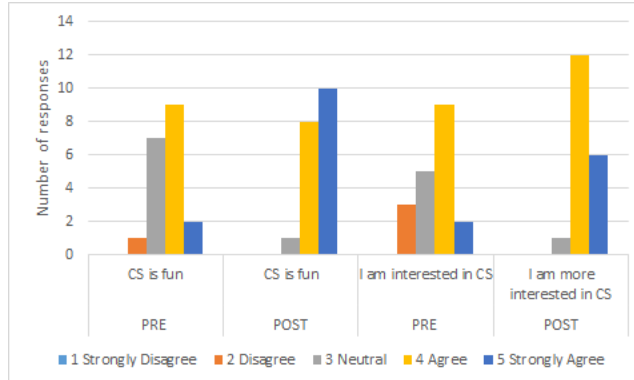

Figure 2: Interest in CS (Girls' Responses)

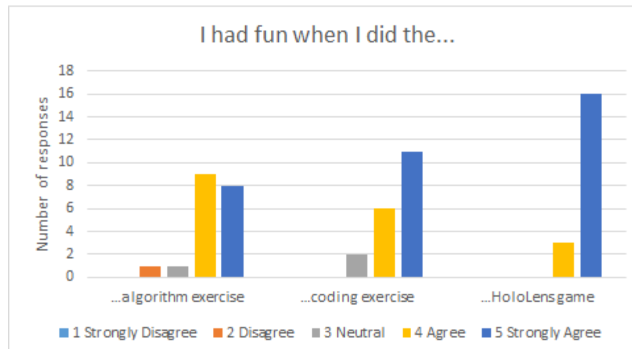

Figure 3: Enjoyment of Activities (Girls' Responses)

4 FINDINGS

The participants in this study were from middle and working class families characteristic to a large Canadian urban area (Metro Vancouver). The participants volunteered to participate in this study and were randomly selected; however, data analysis revealed that a majority of participants reported prior interest in CS (11 girls and four boys), five girls and two boys reported being neutral and three girls reported no interest. As coding is currently taught in schools in Canada, only one girl reported no exposure to CS; seven girls and two boys reported exposure, eight girls and one boy learned some coding, three girls and two boys were comfortable with CS concepts, and one boy reported extensive coding and being very comfortable with CS concepts.

Interest (Intrinsic) Value. The girls reported enjoyment of a variety of extra-curricular activities: drawing, music, movies, playing instruments, reading, writing, socializing with friends and sports. Three girls reported having fun programming, one doing mechanical maintenance on cars, and six playing video games. The boys reported outdoor activities (3) video games (5), and coding (3). Only two girls reported only non-STEM favorite subjects; all the rest enumerated several subjects including English, French, Spanish, law and at least one or more STEM disciplines. Six of them mentioned CS. All six boys reported STEM subjects (three reported CS), and two mentioned additional non-STEM subjects (history and music).

The comparison between responses to the statement "CS is fun" indicated an improvement in post-questionnaires as more girls strongly agreed to the the statement (ten compared to two), only one was neutral opposed to seven in pre-questionnaire, and nobody disagreed compared to one in pre-questionnaire (Figure 2). Similarly, a comparison of responses (post- to pre-questionnaires) related to interest in CS (Figure 2) indicated the same trend: more girls strongly agreed (six compared to two), agreed (12 compared to nine), only one response was neutral (compared to five), and nobody disagreed (compared to three). All girls reported having fun when playing the HoloLens game and a large majority when doing the algorithm and the coding activities (Figure 3). The open-ended questions revealed that all participants reported enjoyment. Nine girls mentioned all three activities and nine reported in particular the HoloLens game. Modifying the code, learning new technologies, hands-on activities, working with their mentors and pair programming were reported as fun activities that sparked interest during the workshop (Note: all names are pseudonyms):

> *"All three activities were fun, but HoloLens was the best. It was an experience I will never forget, thank you!... The first activity (algorithms exercise) made me want to build an actual robot with AI. Coding exercise made me want to create something similar to what we made together. HoloLens exercise entertained and surprised me with all the new technology I never knew existed....Thank you for having me and giving students like me a chance to learn something new in an unforgettable, amazing (magical) way." (Emma)*
>
> *"HoloLens! Writing algorithms + coding with partner was fun! (Chloe)"*

Lynn's interest was increased by pair programming:

> *"... could be creative, interactive, not frustrating." (Lynn)*

Tiffani reported having limited programming knowledge prior to the workshop. However she was able to write code:

> *"... when I was doing the coding exercise, I was able to actually type code myself, for example using the random number generator." (Tiffani)*

and extend her mathematics interest to CS:

> *"The activities increased my interest in CS/programming as it gave me an understanding on how coding works. In each activity, we were given a task/problem and had to figure out how to solve it. Considering I like math for this reason, I am now interested in CS as well" (Tiffani)*

The boys' responses were slightly different from the girls' responses; they also liked the coding and HoloLens activities; however none of them mentioned the algorithms activity. Marcus enjoyed the lunch time because:

> *"I had the most fun during lunch. We sat together and connected more." (Marcus)*

Attainment Value - Stereotypes. The attainment subjective task value is influenced by gender and occupational stereotypes [41]. The pre-questionnaire responses revealed the participants' prior biases. All participants strongly disagreed in pre-questionnaires that CS, mathematics and STEM are not for girls. When asked to describe how computer specialists contribute to the society, participants' responses acknowledged the ubiquity of computers and referred to advancing, creating and enhancing technology, and making peoples' lives easier; however only one boy referred to help ("help police solve crimes"), opposed to girls who in majority (10) referred to helping people and the society.

The participants were asked to describe a CS specialist. Responses included tasks (create animations, games, programs, software, etc.), skills (creative, organized, knowledgeable and problem solver) and abilities (intelligent, smart). Three girls explicitly included in description glasses. The participants were also asked to draw the image of a CS specialist. Seven girls drew female, six male and five unisex figures. One girl did not draw, but described the computer specialist being a man or a woman. Five drawings included glasses representing images of three boys and two girls. The boys described the computers specialists in a similar way. Three of them drew boys, one a stick man with male characteristics, one a boy and a girl, and one a girl. Three of the male participants' drawings included glasses representing images of two boys and one girl. All drawings presented isolated, singular figures.

In post-questionnaires, the participants were asked if the image of a computer scientist changed and how? Seven girls changed their perceptions, but none of the boys. From two of the re-drawn images, glasses were removed. Two of the post drawings included several people interacting, some wearing HoloLens devices. Post-questionnaire open-ended questions revealed reasons for change of perceptions:

> *"they do more than just sitting around coding, they also try whatever they code and also work algorithmic exercises to help peers understand more of what they need to do." (Carla)*

> *"I've just found a new respect for a computer programmer, because during the coding activity, my code did not work at first and so, you need a lot of patience to figure out what is wrong" (Donna)*

> *"They don't just make games they also use technology for a variety of things and it doesn't have to be on a computer" (Monica)*

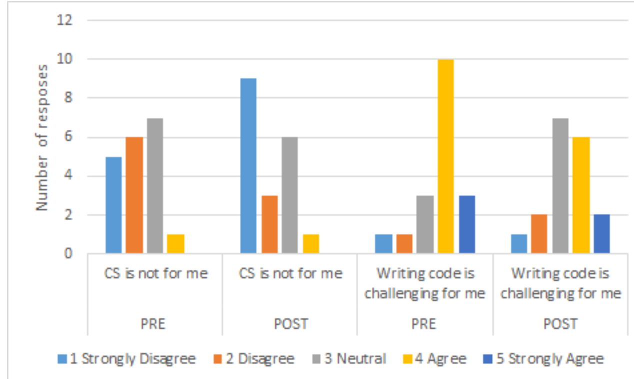

Figure 4: Ability Beliefs (Girls' Responses)

Attainment Value - Ability Beliefs. The attainment subjective task value is influenced by task-specific beliefs such as ability beliefs and the perceived difficulty of a task [41]. In pre-questionnaires all participants strongly disagreed with the statement "CS is not for girls". However, that was not the case for the statement "CS is not for me". Asked in pre-questionnaire to describe situations when they were discouraged to study CS, five girls responded "never", and the rest reported deterrents (code complexity, not knowing what to do, code not running and need to memorize), one girl felt intimidated by others being better, and one discouraged by friends. The boys' responses included being intimidated and code not running; in fact one boy revealed that he was discouraged by a relative.

There was an improvement from pre-to post questionnaires to the statements "CS is not for me" and "Writing code is challenging for me" (Figure 4). When asked in post-questionnaires if they would like to learn more programming, eight girls strongly agreed, eight agreed and three were neutral. A large majority agreed that they would like to learn with similar activities (Figure 5).

The open-ended post-questionnaire question "I learned programming when..." received a variety of responses from girls: customizing the code, doing step-by-step instructions, doing hands-on activities, learning programming language constructs, writing the algorithm, exploring the new technology, peer-programming and playing the HoloLens game. Boys responded in a similar way.

The spatial abilities needed for the coding activity and the HoloLens game did not present gender differences. Girls reported increased confidence as the activities facilitated code comprehension.

Betty felt more confident, Paula appreciated what she learned during the algorithm activity and Rose felt less intimidated:

> *"These activities make code seem simple and easy to understand. Maybe I can do this one day." (Betty)*

> *" We start the coding process and I did not know that [an] algorithm is a big help to understand it." (Paula)*

> *" Made Java[Script] language seem less scary and ok to learn. I had never use it before and was nervous to try but now I feel more confident and it will probably be the same for other coding language." (Rose)*

Attainment Value - Role Models. Role models (socializers' attitudes and beliefs) are important in the formation of the attainment

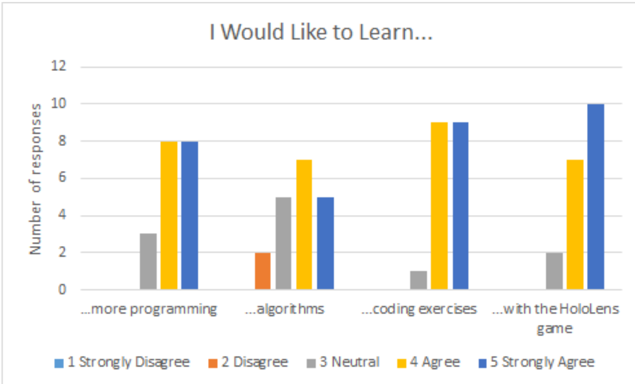

Figure 5: Learning (Girls' Responses)

subjective task value [41]. The participants in this study described their mentors as "fun", "engaged", "helpful", "kind", "knowledgeable" and "passionate". Participants reported being inspired by their mentors. Engaged in informal conversations during lunch, mentors shared stories about their own career choices, and personal and school projects. Chloe learned about mentors' educational paths and Emma credited her increased interest to her mentors:

> *"The BCIT students did not start in computer science straight out of high school, so it makes me think I have potential to develop skills and interests after high school." (Chloe)*

> *"The BCIT students were nice and explained well. I am interested, more than before, in CS/programming. (Emma)"*

Mentors observed a high level of engagement in all three activities. They reported that participants were impressed that the *CodeBlocks* HoloLens game was coded by BCIT students. One of the mentors described how girls improved their confidence during the coding activity:

> *"[girls] got more confidence when the coding activity got to the section where they could play with colour, velocity, etc. Having visible changes was really helpful to see the change. The beginning of the coding activity was less immediately rewarding, because individual lines of code don't create visible changes. They seemed to gain confidence in writing as we went on nonetheless, but were more enthusiastic at the end." (Mentor)*

5 DISCUSSION AND CONCLUSIONS

This study addressed deterrents responsible for discouraging girls from studying CS: stereotypical views and perceptions of the field [5, 33], lack or limited exposure and training in skills that develop and improve spacial cognition [35], and lack of role models [7, 10]. The strategies employed in this study can be successfully reproduced and implemented by other post-secondary institutions.

Results suggest that extra-curricular activities such as writing algorithms and coding visual artifacts, exposure to new technologies, and playing a game in an AR/VR learning environment impacted girls' perceptions and influenced their interest and attainment in CS. Findings revealed an increase in girls' interest and attainment subjective values based on reported enjoyment, desire to learn more, improved ability beliefs and the perception of self-confidence. In addition, girls reported a widening of their perceptions of the field and reduction of their stereotypical views. An important aspect of these activities were that they were mentored by post-secondary students in a peer-programming collaborative setting, and organized in a post-secondary institution. All participants regardless of gender appeared to enjoy the activities, and participants and mentors engaged in lively even passionate conversations. Results indicate a high level of engagement, increased enjoyment and interest, and perceived learning gains reported by all participants, and observed by mentors. Data analysis revealed no gender differences with respect to enjoyment and interest of coding activity and HoloLens game; however, more interest was expressed by girls for the algorithm activity. The visual coding activities offered opportunities for girls to improve their spatial cognitive abilities. The learning activities rich in visual artifacts were designed to appeal to girls; they appealed to boys, too.

Implicit biases still existed for some participants. All participants strongly disagreed that CS is not for girls; however, it was interesting to see that the stereotypical image (technology-oriented, computer-focused male, intelligent, wearing glasses person) reported in previous studies [5, 26] was still present in drawings, even though more has been done recently to promote CS to girls. Moreover, glasses (a physical feature associated with the image of a computer scientist [26]) were added to female figures in drawings. Girls reported that computer scientists are helping the society and are making peoples' lives easier; this is an important finding and represents a departure from the "singularly focused on computers" stereotype [5]. It is notable to observe that seven girls improved their perceptions of computer scientists after the workshop, but none of the boys. However, the computer scientist's image of a lonely obsessed with computers and socially unskilled person [5] was not reflected on our participants' perceptions of their mentors as they were described as fun, engaged, helpful, kind, knowledgeable and passionate. As stereotyped images are rooted mainly outside the computing field [27], conducting the study in a Computing Department had additional benefits for the study participants.

This study has limitations. One of the limitations of this study was the number of participants (25). We intended to organize more workshops in our institute; however, COVID-related restrictions prevented us from conducting similar workshops. Another limitation was the constitution of the sample as the study attracted more participants with reported prior interest in CS. The sample was homogeneous with mostly middle/working class students who live in a large urban area. Therefore, the results might not generalize to other student populations.

A future goal is to advance this work designed to facilitate girls' achievement related choices towards building well-developed individual interest in CS [16] with a wider involvement in high schools and community. This workshop was a good example of computing activities that spark interest. When possible, this study will be continued with more participants and with a long-term intervention where high school girls can practice and improve their skills in a particular area of CS. Future scholarship should continue to design strategies to inspire girls to study CS.

REFERENCES

[1] [n. d.]. Digest of Education Statistics, 2018. https://nces.ed.gov/programs/digest/d18/tables/dt18_322.10.asp

[2] Khalid Al-Tahat, Nashrawan Taha, Basela Hasan, and Bayan Abu Shawar. 2016. The impact of a 3D visual tool on female students attitude and performance in computer programming. In *2016 SAI Computing Conference (SAI)*. 864–867. https://doi.org/10.1109/SAI.2016.7556080 ISSN: null.

[3] Christopher Ball, Kuo-Ting Huang, R. V. Rikard, and Shelia R. Cotten. 2019. The emotional costs of computers: an expectancy-value theory analysis of predominantly low-socioeconomic status minority students' STEM attitudes. *Information, Communication & Society* 22, 1 (Jan. 2019), 105–128. https://doi.org/10.1080/1369118X.2017.1355403 Publisher: Routledge _eprint: https://doi.org/10.1080/1369118X.2017.1355403.

[4] Sylvia Beyer, Kristina Rynes, Julie Perrault, Kelly Hay, and Susan Haller. 2003. Gender Differences in Computer Science Students. In *Proceedings of the 34th SIGCSE Technical Symposium on Computer Science Education (SIGCSE '03)*. ACM, New York, NY, USA, 49–53. https://doi.org/10.1145/611892.611930

[5] Sapna Cheryan, Victoria C. Plaut, Caitlin Handron, and Lauren Hudson. 2013. The stereotypical computer scientist: Gendered media representations as a barrier to inclusion for women. *Sex Roles* 69, 1-2 (2013), 58–71. https://doi.org/10.1007/s11199-013-0296-x

[6] Sapna Cheryan, John Oliver Siy, Marissa Vichayapai, Benjamin J. Drury, and Saenam Kim. 2011. Do Female and Male Role Models Who Embody STEM Stereotypes Hinder Women's Anticipated Success in STEM? *Social Psychological and Personality Science* 2, 6 (Nov. 2011), 656–664. https://doi.org/10.1177/1948550611405218

[7] J. McGrath Cohoon. 2002. Recruiting and retaining women in undergraduate computing majors. *SIGCSE Bull.* 34, 2 (June 2002), 48. https://doi.org/10.1145/543812.543829

[8] Ana R. Delgado and Gerardo Prieto. 2004. Cognitive mediators and sex-related differences in mathematics. *Intelligence* 32, 1 (Jan. 2004), 25–32. https://doi.org/10.1016/S0160-2896(03)00061-8

[9] Oliver Dickhäuser and Joachim Stiensmeier-Pelster. 2003. Gender Differences in the Choice of Computer Courses: Applying an Expectancy-Value Model. *Social Psychology of Education* 6, 3 (Sept. 2003), 173–189. https://doi.org/10.1023/A:1024735227657

[10] Benjamin J. Drury, John Oliver Siy, and Sapna Cheryan. 2011. When Do Female Role Models Benefit Women? The Importance of Differentiating Recruitment From Retention in STEM. *Psychological Inquiry* 22, 4 (Oct. 2011), 265–269. https://doi.org/10.1080/1047840X.2011.620935

[11] Jacquelynne Eccles. 1984. Sex differences in achievement patterns. *Nebraska Symposium on Motivation* 32 (1984), 97–132.

[12] Jacquelynne S. Eccles. 1994. Understanding Women's Educational And Occupational Choices: Applying the Eccles et al. Model of Achievement-Related Choices. *Psychology of Women Quarterly* 18, 4 (Dec. 1994), 585–609. https://doi.org/10.1111/j.1471-6402.1994.tb01049.x Publisher: SAGE Publications Inc.

[13] Jing Feng, Ian Spence, and Jay Pratt. 2007. Playing an Action Video Game Reduces Gender Differences in Spatial Cognition. *Psychol Sci* 18, 10 (Oct. 2007), 850–855. https://doi.org/10.1111/j.1467-9280.2007.01990.x

[14] Janelle Gaines. 2017. Women in Male-Dominated Careers — Cornell HR Review. http://www.cornellhrreview.org/women-in-male-dominated-careers/

[15] Elizabeth A. Gunderson, Gerardo Ramirez, Susan C. Levine, and Sian L. Beilock. 2012. The Role of Parents and Teachers in the Development of Gender-Related Math Attitudes. *Sex Roles* 66, 3-4 (Feb. 2012), 153–166. https://doi.org/10.1007/s11199-011-9996-2

[16] Suzanne Hidi and K. Ann Renninger. 2006. The Four-Phase Model of Interest Development. *Educational Psychologist* 41, 2 (June 2006), 111–127. https://doi.org/10.1207/s15326985ep4102_4

[17] Catherine Hill, Christianne Corbett, and Andresse St. Rose. 2010. *Why So Few? Women in Science, Technology, Engineering, and Mathematics.* American Association of University Women. https://eric.ed.gov/?id=ED509653

[18] Alison Hunter and Raewyn Boersen. 2016. Attracting Girls to a Career in Programming: A New Zealand Investigation. *International Journal of Gender, Science and Technology* 8, 3 (Dec. 2016), 338–359. http://genderandset.open.ac.uk/index.php/genderandset/article/view/424

[19] Cruz Izu, Carsten Schulte, Ashish Aggarwal, Quintin Cutts, Rodrigo Duran, Mirela Gutica, Birte Heinemann, Eileen Kraemer, Violetta Lonati, Claudio Mirolo, and Renske Weeda. 2019. Fostering Program Comprehension in Novice Programmers - Learning Activities and Learning Trajectories. In *Proceedings of the Working Group Reports on Innovation and Technology in Computer Science Education (ITiCSE-WGR '19)*. Association for Computing Machinery, New York, NY, USA, 27–52. https://doi.org/10.1145/3344429.3372501

[20] Lee Kenneth Jones and Rebecca L. Hite. 2020. Expectancy Value Theory as an Interpretive Lens to Describe Factors That Influence Computer Science Enrollments and Careers for Korean High School Students. *Electronic Journal for Research in Science & Mathematics Education* 24, 2 (2020), 86–118. https://eric.ed.gov/?id=EJ1261786 Publisher: Southwestern University and Texas Christian University.

[21] Mable B. Kinzie and Dolly R. D. Joseph. 2008. Gender differences in game activity preferences of middle school children: Implications for educational game design. *Educational Technology Research and Development* 56, 5-6 (2008), 643–663. https://doi.org/10.1007/s11423-007-9076-z

[22] Peter J. Kuhn and Marie-Claire Villeval. 2011. Do Women Prefer a Co-Operative Work Environment? *SSRN Journal* (2011). https://doi.org/10.2139/ssrn.1946160

[23] Rebecca Lazarides and Angela Ittel. 2015. Gendered Motivation and Choice in STEM-Individual and Contextual Factors. *International Journal of Gender, Science and Technology* 7, 2 (2015), 107–111.

[24] Rebecca Lazarides, Charlott Rubach, and Angela Ittel. 2016. Motivational profiles in mathematics: What role do gender, age and parents' valuing of mathematics play? *International Journal of Gender, Science and Technology* 8, 1 (Feb. 2016), 124–143. http://genderandset.open.ac.uk/index.php/genderandset/article/view/406

[25] Lynn S. Liben. 2015. The STEM Gender Gap: The Case for Spatial Interventions. *International Journal of Gender, Science and Technology* 7, 2 (June 2015), 133–150. http://genderandset.open.ac.uk/index.php/genderandset/article/view/418

[26] E. M. Mercier, B. Barron, and K. M. O'Connor. 2006. Images of self and others as computer users: the role of gender and experience. *Journal of Computer Assisted Learning* 22, 5 (2006), 335–348. https://doi.org/10.1111/j.1365-2729.2006.00182.x

[27] Dee Michell, Anna Szorenyi, Katrina Falkner, and Claudia Szabo. 2017. Broadening Participation Not Border Protection: How Universities Can Support Women in Computer Science. *Journal of Higher Education Policy and Management* 39, 4 (2017), 406–422. https://doi.org/10.1080/1360080X.2017.1330821

[28] Francisco R. Ortega, Santiago Bolivar, Jonathan Bernal, Alain Galvan, Katherine Tarre, Naphtali Rishe, and Armando Barreto. 2017. Towards a 3D Virtual Programming Language to increase the number of women in computer science education. In *2017 IEEE Virtual Reality Workshop on K-12 Embodied Learning through Virtual Augmented Reality (KELVAR)*. 1–6. https://doi.org/10.1109/KELVAR.2017.7961558 ISSN: null.

[29] Dhaval Parmar, Joseph Isaac, Sabarish V. Babu, Nikeetha D'Souza, Alison E. Leonard, Sophie Jörg, Kara Gundersen, and Shaundra B. Daily. 2016. Programming moves: Design and evaluation of applying embodied interaction in virtual environments to enhance computational thinking in middle school students. In *2016 IEEE Virtual Reality (VR)*. 131–140. https://doi.org/10.1109/VR.2016.7504696 ISSN: 2375-5334.

[30] Iulian Radu and Blair MacIntyre. 2009. Augmented-reality scratch: a children's authoring environment for augmented-reality experiences. In *Proceedings of the 8th International Conference on Interaction Design and Children (IDC '09)*. Association for Computing Machinery, Como, Italy, 210–213. https://doi.org/10.1145/1551788.1551831

[31] Anthony Robins, Janet Rountree, and Nathan Rountree. 2003. Learning and Teaching Programming: A Review and Discussion. *Computer Science Education* 13, 2 (June 2003), 137–172. https://doi.org/10.1076/csed.13.2.137.14200 Publisher: Routledge _eprint: https://doi.org/10.1076/csed.13.2.137.14200.

[32] Allison Scott, Alexis Martin, Frieda McAlear, and Sonia Koshy. 2017. Broadening participation in computing: examining experiences of girls of color. *ACM Inroads* 8, 4 (Oct. 2017), 48–52. https://doi.org/10.1145/3149921

[33] Jenessa R. Shapiro and Amy M. Williams. 2012. The Role of Stereotype Threats in Undermining Girls' and Women's Performance and Interest in STEM Fields. *Sex Roles* 66, 3-4 (Feb. 2012), 175–183. https://doi.org/10.1007/s11199-011-0051-0

[34] Kaveri Subrahmanyam and Patricia M. Greenfield. 1994. Effect of video game practice on spatial skills in girls and boys. *Journal of Applied Developmental Psychology* 15, 1 (Jan. 1994), 13–32. https://doi.org/10.1016/0193-3973(94)90004-3

[35] Melissa S. Terlecki and Nora S. Newcombe. 2005. How Important Is the Digital Divide? The Relation of Computer and Videogame Usage to Gender Differences in Mental Rotation Ability. *Sex Roles* 53, 5 (Sept. 2005), 433–441. https://doi.org/10.1007/s11199-005-6765-0

[36] Katherine Wall. 2019. Persistence and representation of women in STEM programs. (2019), 18.

[37] Ming-Te Wang and Jessica L. Degol. 2017. Gender Gap in Science, Technology, Engineering, and Mathematics (STEM): Current Knowledge, Implications for Practice, Policy, and Future Directions. *Educ Psychol Rev* 29, 1 (March 2017), 119–140. https://doi.org/10.1007/s10648-015-9355-x

[38] Helen M. G. Watt. 2004. Development of adolescents' self-perceptions, values, and task perceptions according to gender and domain in 7th- through 11th-grade Australian students. *Child Dev* 75, 5 (Oct. 2004), 1556–1574. https://doi.org/10.1111/j.1467-8624.2004.00757.x

[39] Linda L. Werner, Brian Hanks, and Charlie McDowell. 2004. Pair-programming helps female computer science students. *J. Educ. Resour. Comput.* 4, 1 (March 2004), 4–es. https://doi.org/10.1145/1060071.1060075

[40] Allan Wigfield and Jenna Cambria. 2010. Expectancy-value theory: retrospective and prospective. In *Advances in Motivation and Achievement*, Timothy C. Urdan and Stuart A. Karabenick (Eds.). Vol. 16. Emerald Group Publishing Limited, 35–70. https://doi.org/10.1108/S0749-7423(2010)000016A005

[41] Allan Wigfield and Jacquelynne S. Eccles. 2000. Expectancy–Value Theory of Achievement Motivation. *Contemporary Educational Psychology* 25, 1 (Jan. 2000), 68–81. https://doi.org/10.1006/ceps.1999.1015