Computing Camps for Girls – A First-Time Experience at the University of Limerick

Clare Mcinerney, Anna-Lena Lamprecht, Tiziana Margaria

Computing Camps for Girls – A First-Time Experience at the University of Limerick

Clare McInerney[1], Anna-Lena Lamprecht[2], Tiziana Margaria[1,3]

[1]Lero – The Irish Software Research Centre, University of Limerick, Ireland
[2]Department of Information and Computing Sciences, Utrecht University, The Netherlands
[3]Department of Computer Science and Information Systems, University of Limerick, Ireland
Clare.mcinerney@lero.ie, a.l.lamprecht@uu.nl, Tiziana.Margaria@ul.ie

Abstract. Increasing the number of females in ICT-related university courses has been a major concern for several years. In 2015, we offered a girls-only computing summer camp for the first time, as a new component in our education and outreach activities to foster students' interest in our discipline. In this paper, we describe the motivation for the camp and how we designed the program, and we report our experiences and survey findings from the first two editions of the camp. They can provide guidance for planning further events targeting females, and help to integrate awareness about underrepresentation of females in other activities.

Keywords. Computer science education, computational thinking, modelling, programming, women in STEM.

1 Introduction

According to the latest national enrolment statistics (for the academic year 2014-2015)[1], of all students enrolled in Information and Computer Technology (ICT) full time undergraduate courses in all Universities and Institutes of Technologies in Ireland, 85% were males and 15% females. In our university, the University of Limerick, females represented 16% full time undergraduate enrolments for ICT courses and males 84%. Increasing the number of females in these courses has been a major concern for several years, and has recently become even more important in the light of the Athena SWAN[2] accreditation processes at our university.

A recent Google report titled "Women Who Choose Computer Science - What Really Matters" [1], identifies the following top four influencing factors to whether or not a young woman decided to pursue a Computer Science Degree:

1. **Social encouragement** is having positive reinforcement of computer science from family and peers.

[1] http://www.hea.ie/node/1557

[2] http://www.ecu.ac.uk/equality-charters/athena-swan/

2. **Self-perception** is having an interest in puzzles and problem solving and a belief that these skills can be translated into a successful career.
3. **Academic exposure** is the availability of and opportunity to participate in computer science work.
4. **Career perception** is the familiarity with/perception of computer science as a career with diverse applications and a broad potential for positive societal impact.

In a similar Accenture report on "Powering economic growth; Attracting more young women into science and technology" [2], key barriers to women in the STEM field included that negative stereotypes persist, that STEM is perceived more suitable for boys, that parents, while being the main influencers, lack information on STEM career options, that information about STEM careers is fragmented, and that there is a disconnect between industry skills needs and subject choices in school. A recent literature review [3] on research about the impact of pre-college computing activities on choices of major furthermore emphasizes that females who participate in outreach activities are more likely to go for a computing degree [4-7].

As part of our education and outreach initiatives, we have been running summer computing camps for both post-primary boys and girls since 2010. These camps consist of three days each, with half-day sessions on different technologies. 20% females participated in the camps since 2012. While we were aware of the success of other institutions running summer camps for females and the challenges of underrepresentation of females in computer science [8-11], it was not something our institution had offered. In 2015 we received a Google RISE Award[3] to run summer camps specifically for girls. As the only recipient of this international award in our country, it helped us raise awareness about the underrepresentation of females in computing within our research centre and to highlight the need to increase female participation in our camps, and it enabled us to organise and run female-only camps free of charge. We devised new programme content for a girls-only camp, designed to address the influencing factors and barriers highlighted in the reports mentioned above. As well as incorporating a new set of tools that focus on logic and computational thinking [12] rather than on coding, so that no prior programming experience was required, we also invited (female) industry speakers and academics from the university to present to the students. Overall feedback from the camp suggests participants enjoyed the experience and also learned a lot about the field of computing. The insights gained from the surveys enable us to more easily plan further events and activities targeting females and integrate awareness about underrepresentation of females in other events and activities we run.

In this paper we describe the new programme and how we ran the camp (Section 2), and discuss the experiences of the 41 students that attended the camps and findings from the accompanying surveys (Section 3). Section 4 concludes the paper.

2 Overview of the Summer Camp

We ran two three-day camps for post-primary girls aged 14 and up during the summer of 2015 at the University of Limerick. We advertised the camps in May in local

[3] https://edu.google.com/resources/programs/google-rise-awards/

newspapers, online and social media and through our contacts in local schools. Table 1 outlines the schedule for the three days, with different colours marking the main components of the programme: The development of game strategies for the ChainReaction board game (blue), invited speakers (red), a robotics session (green) and presentations (yellow). The following describes these components in more detail.

Table 1: Camp Schedule

<table>
<tr><td></td><td>Day 1</td><td>Day 2</td><td>Day 3</td></tr>
<tr><td>10:00-10:30</td><td>Registration, pre-survey</td><td rowspan="2">Strategy Development/ Improvement</td><td rowspan="2">Preparation of Presentation Slides</td></tr>
<tr><td>10:30-11:15</td><td>Introduction to ChainReaction</td></tr>
<tr><td>11:15-11:30</td><td>Break</td><td>Break</td><td>Break</td></tr>
<tr><td>11:30-12:15</td><td rowspan="2">Exploring ChainReaction on paper</td><td rowspan="2">Strategy Development/ Improvement</td><td>Final tournament, discussion of results</td></tr>
<tr><td>12:15-12:45</td><td>Finalisation of presentation slides</td></tr>
<tr><td>12:45-13:30</td><td>Lunch</td><td>Lunch</td><td>Lunch</td></tr>
<tr><td>13:30-14:15</td><td>Invited Speaker</td><td>Invited Speaker</td><td>Invited Speaker</td></tr>
<tr><td>14:15-15:15</td><td rowspan="2">Introduction to jABC</td><td rowspan="2">Robotics session</td><td>Presentations</td></tr>
<tr><td>15:15-16:00</td><td>Post-survey, closing</td></tr>
</table>

2.1 Game Strategies for ChainReaction (blue)

The modelling of executable strategies for a board game, ChainReaction, was a major component of the programme (blue sections in the table). Games typically make attractive course topics for students of all ages [13, 14], and game development allows students to experience various aspects of software development, by systematically exploring the mechanics of a game.

ChainReaction[4] is a strategy game for two players, who play against each other on a special 6x5 board, both trying to initiate chain reactions of atoms to conquer the whole board and win the game (see e.g. the "Introduction to ChainReaction" page[5] for a detailed description of the rules). The development of the game strategies to be followed by a computer player takes place in a specially prepared version of the jABC modelling framework [15], which supports the intuitive, graphical development of flow-graph structures to define the behaviour of a system. Figure 2 gives an impression of how the modelling of ChainReaction strategies with the jABC works: The component library on the left contains the building blocks from which the strategies are assembled. The strategies focus on defining how the score for a cell on the board is to be computed. The framework then evaluates the strategies for all cells and places the next atom into the cell with the highest score (or, if there are multiple cells with the same highest score, randomly choosing one of them).

The framework, which is very similar to the successful jABC version for the modelling of game strategies for the more popular ConnectFour board game [16], combines an easily accessible application domain with a quick sense of achievement: The first game strategies are typically ready to run after a 30-minute introduction to

[4] http://chainreaction.freewarepoint.de

[5] https://hope.scce.info/chainreaction/

the modelling tool. Students can then work on incrementally improving this starting strategy. They also get immediate feedback about the quality of the results by playing against their own strategies or by letting the strategy play against other computer players. As such, it provides a very motivational framework and a fun and lightweight learning-by-doing way to acquire and practice computational thinking skills.

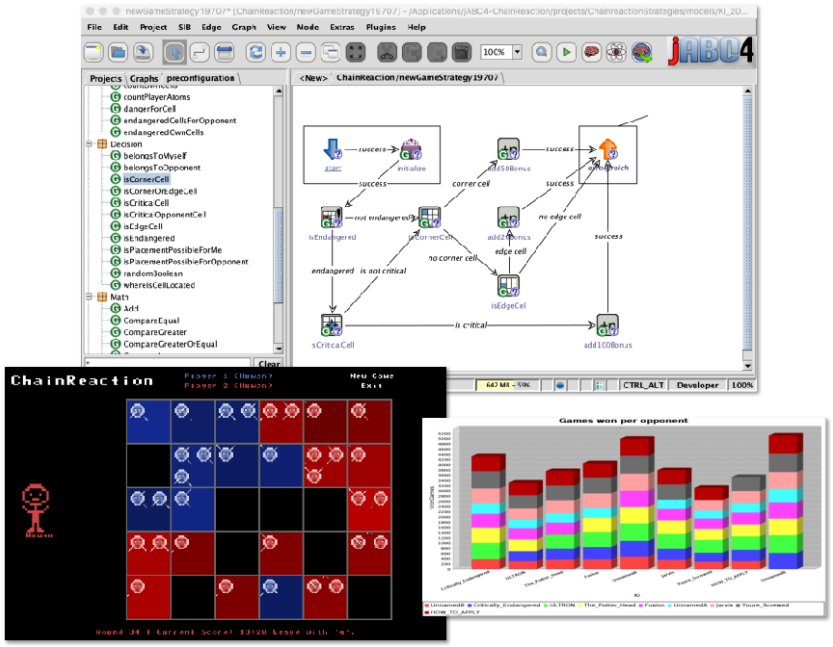

Figure 2: The ChainReaction game, modelling of ChainReaction strategies with jABC, and results of a tournament played between nine strategies.

In the first camp session, we introduced the participants only to the basic ChainReaction game and gave them some time to play and familiarize themselves with it. The girls paired up on one computer for this exercise, and we let them work together in these pairs for the rest of the camp.

The next session was designed to foster more strategic thinking about the game. The task for the girls was to write down – simply on paper – how they had actually played the game, that is, which strategy they had followed to decide where to place their atoms. We then let the groups exchange strategies on paper, and each group tried to play strictly according to what the other group had written down. In a very entertaining way, this demonstrated the importance of formulating precise and unambiguous instructions.

In the last session of the first day, we introduced the modelling tool and taught students how to model and execute their first simple ChainReaction strategy. The remainder of this session and the ChainReaction sessions on Day 2 were focused on the development and improvement of game strategies. At various intervals we

provided the girls with additional hints and suggestions to help them improve their strategies, which became quite sophisticated towards the end of the second day.

In the last ChainReaction session, on the third day, every group had to select and submit their final strategy, and we ran a final tournament with all strategies playing against each other to determine the best one. The bar chart in Figure 1 (lower right) shows the results of a tournament of nine strategies.

2.2 Invited Speakers (red)

The camps were held on campus at the University of Limerick so that the participants had the opportunity to experience the academic environment. Invited speakers from both academia and industry provided further insights into what it means to become and to be an IT professional. On the first day of the camp, the Head of the Computer Science Department talked to the girls. She described each of the available courses in detail, outlined the challenges that students face in their first year in college, but also the benefits of completing a computer science course. Regarding career progression, we invited industry speakers for Day 2 and Day 3 to give short presentations to the students based on their personal career experiences. Speakers included employees from Dell, Intel and Google. All invited speakers were women and, more importantly, did not correspond to common stereotypes about IT professionals. Recent research shows the importance of non-stereotypical role models when attempting to convey to girls or women that they can be successful in STEM fields [17].

2.3 Robotics Session (green)

The afternoon session of Day 2 introduced the students to robotics. While the effectiveness of using robots, over a year-long period, in encouraging students to select computer science as a field of study is negative [18, 19] we considered the use of robots in a short session as a fun and attractive example of an area of computing. The students explored robot programming using a NAO robot and a LEGO Mindstorms kit.

The NAO robot[6] is a 58-cm tall humanoid robot that can easily be programmed via the block-based Choreographe interface[7]. Students were broken up into groups of 6-8 and each group had access to a NAO robot for 45 minutes. They used Choreographe to program the robot, and made him, for example, speak, dance and do push-ups.

The LEGO Mindstorms[8] kits contain both hardware and software components with which small robots can be assembled and programmed. The students were given a basic demonstration of the use of different sensors (touch, light, and distance), and then had some time to experiment with them.

Equipped with smartphones and tablet computers, the girls also took a lot of pictures and video clips during this session, especially of the NAO robot in action. Thus, although this short session did not go into any detail of robotics and used mainly predefined functionality, it contributed a lot to a positive experience and good

[6] https://www.aldebaran.com/en/humanoid-robot/nao-robot

[7] http://doc.aldebaran.com/1-14/software/choregraphe/index.html

[8] http://www.lego.com/en-us/mindstorms/?domainredir=mindstorms.lego.com

memories of the camp, even for those who did not feel confident with the strategy development in the jABC tool.

2.4 Presentations (yellow)

The fourth component of the camp programme was presentations. The girls were asked to give presentations about the game strategies they had developed and about their experiences in the camp. In the morning of the last day, they had time to prepare PowerPoint slides. Notably, they were already familiar with the software, and creating colourful presentations with pictures and animations was easy and enjoyable for the group. The presentations were delivered in the last session of the camp, just before the closing and awards ceremony. In addition to practicing presentation skills, this part of the programme served the purpose of letting everybody see what the other groups had done, and what the perceived highlights of the camp were from the girls' perspective.

3 Survey Results

In order to assess the impact of the summer camp, we administered surveys at the beginning and at the end of the camp. We used the pre and post surveys developed by "Georgia Computes!" at Georgia Institute of Technology [20] with some modifications in order to address the top four influencing factors on whether or not a young woman decides to pursue a degree in Computer Science as described earlier. The surveys comprised three major parts: At the beginning of the camp we asked the girls about their prior computing experiences. These questions address social encouragement, and self-perception factors. Another set of questions, on different aspects of their attitude towards computing, was asked both before and after the camp, so that we could compare the answers pre-camp and post-camp. These questions address self-perception and career perception factors. The third set of questions was on the camp itself, and also asked at the end. These questions address academic exposure and career perception factors. We present and discuss selected results from the surveys in this section. They are based on the answers from 41 girls who participated in the 2015 summer camps.

3.1 Pre-Survey: Prior Computing Experiences (Social Encouragement/Self Perception)

Computing is offered optionally in schools in Ireland. If schools are offering "computers", what is taught in schools varies widely. 77% of our camp participants attend schools that offer computer classes. Content for these classes included HTML/Web Design, ECDL, browsing the web, typing, Scratch, GIMP and Microsoft Word and Excel. At the start of the camp, 26% of the participants stated that they had written a computer program before, while 51% stated they did not, and 23% did not know if they had (see Figure 3, left).

We can compare the data for the girls-only camps with data for the summer camps that we have been running for boys and girls since 2012 (see Figure 3, centre).

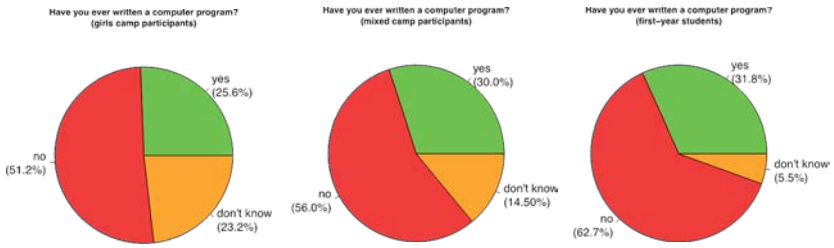

Figure 3: "Have you ever written a computer program?" (left: girls camp participants, centre: mixed camp participants, right: CS first-year students 2016/17)

Data gathered over the course of four years shows that 56% of camp participants had never written a computer program before, 14% did not know if they had, and 30% had written a computer program before. This indicates that prior computing experiences of students attending girls-only camps versus mixed camps do not vary widely in our institution. At the beginning of the last autumn semester, we also asked the computer science first-year students (110 students) to answer this question. As Figure 3 (right) shows, 63% stated that they had never written a computer program before, 32% said they had, and 5% did not know. This suggests that generally the computer science knowledge at the time of leaving school is not much different from early secondary school level. This is also reflected in the finding that only 11% of the first-year students reported that they had a computer science course at school.

In terms of social encouragement, 58% of the girls agreed and strongly agreed that they are encouraged by their families to use computers. 70% agreed and strongly agreed that their friends like using computers. While this means that the majority of the girls find themselves in an environment that is positive towards computing and using computers, there is also a considerable percentage that does not get this form of social encouragement.

3.2 Pre- and Post-Survey: Attitude towards Computing (Self-Perception/Career Perception)

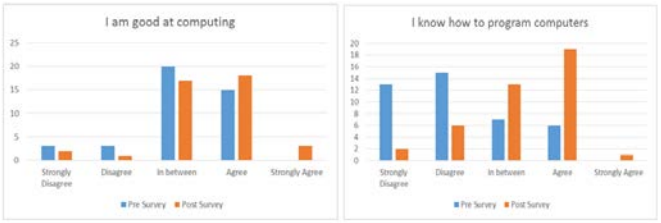

Figure 3: "I am good at computing." and "I know how to program computers." pre and post camp.

Regarding students' self-perception of computing, we can see an increase in students agreeing and strongly agreeing that they are good at computing by the end of the 3-day camp (see Figure 3, left). The number of students that are in between regarding

this statement has decreased between the pre and post surveys. The students' perceived ability to know how to program computers also increased between pre and post survey (see Figure 3, right).

In our post survey, 95% agreed and strongly agreed that they know more about computing as a job because of the camp. Also the students' interest in computing as a career increased during the camp (see Figure 4, left). In terms of whether students were considering doing a computer science related course at third level there was an increase in the participants strongly agreeing with this statement by the end of the camp (see Figure 4, right). Of course, most of the participants came to the camp already with or because of a positive disposition towards computing as a subject and/or job, so the high levels of agreement do not necessarily reflect the average attitude of girls in this age group. However, we know from the survey that some of the girls were also sent to the camp by their parents, presumably those that expressed disagreement to the statements related to interest, but the level of disagreement was lower after the camp.

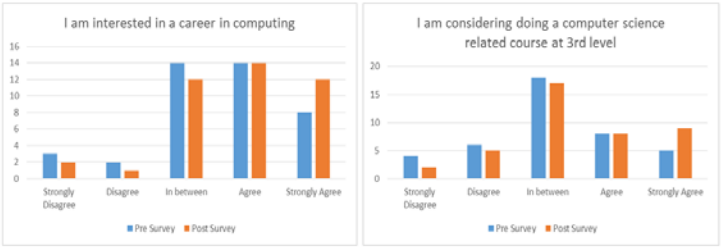

Figure 4: "I am interested in a career in computing." and "I am considering doing a computer science related course at 3rd level." pre and post camp.

As mentioned earlier, computing is not currently offered in a formal way at upper secondary school level in Ireland. One of the questions we asked the students after the camp was if a computing/computer science leaving certificate subject was available in their schools, would they choose it. 87% said yes. A recent government report, the Action Plan for Education 2017[9], outlines government plans to introduce Computer Science as a subject at senior cycle in 2018. This is an exciting development and we look forward to summer camp students having the opportunity to pursue their passion in school.

In terms of students' perceptions of ability of males and females to do computing we asked students if they agreed with the statement "Women can do computing". There was no significant change between pre and post survey. 93% strongly agreed with the statement pre and post. 7% agreed in the pre survey. 5% agreed and 2% were in between for the post survey. When we asked students if they agreed with the statement "Men can do computing", 90% strongly agreed and 7% agreed with this statement in pre and post survey. We asked the computer science first-year students (see above) similar attitude questions, and obtained very similar results. This indicates that secondary school students see males and females as equally capable of mastering

[9] http://www.education.ie/en/Publications/Corporate-Reports/Strategy-Statement/Action-Plan-for-Education-2017.pdf

computer science, and hence gender seems not to be perceived as the factor that prohibits learning the subject.

3.3. Post-Survey: Camp Experience (Academic Exposure/Career Perception)

After the camp, we asked the participants to rate their camp experience and to tell us what they liked best about it and why, what they liked least and why, and what changes they would make to make it better. The latter was asked in the form of open free-text questions, and indeed they showed a great variety of opinions and gave us good feedback about how the girls had experienced the camp.

Regarding what the participants liked best about the camp, the different components (ChainReaction workshop, invited talks, robotics session, and presentations) were mentioned almost equally often. Several answers also emphasized social aspects of the camp, like the good atmosphere, friendly people and new friends (two examples are: *"I liked the fact that I got to meet new friends and I also got to improve my computing skills"* and *"I liked the way the people working here are so friendly and so helpful")*. 78% of students agreed and strongly agreed with the statement "I made new friends at this camp". In fact, 15% of students mentioned "friends" or "friendly" in their responses to what they liked best about the camp. This compares with 3% citing "friends" or "friendly" from our mixed camps. One female participant in our mixed camps said: *"I love the experience and the people even though we were split up in to groups and I was the only girl in the group I still made friends."* Interestingly, when this student was asked about what she liked least about the mixed camps she said: *"I didn't dislike most things the only thing I would change is putting at least one other girl into the group that I was in."* This suggests that the young girls simply might feel uncomfortable being the only female in a group, and female-only or better balanced mixed-gender groups make them feel more comfortable.

The answers to the question what they liked least were a bit more diverse. From the four main components of the camp, only the invited talks were mentioned frequently, however predominantly by students who also stated that they had already attended similar presentations and that there was a lot of repetition for them. Many answers to this question pointed to organisational aspects, like the days being too short, too long or starting too early, and also the sandwiches that were provided for lunch were mentioned several times here. While we will certainly consider changing the latter for next editions of the camp, the former comments seem to be more a question of personal preferences and will be difficult to perfect for everybody.

Many answers to the question about changes to the camp were in fact "nothing", but there were also some concrete suggestions. For example, several participants said they would like a longer camp (like a week), and to include more "real coding" into the program. Other frequent wishes included more variety in the program (for instance by including more outdoor activities or exercises on fast typing), less talks, and something different for lunch. We are going to take these suggestions into account for the next camps.

4 Conclusion

Based on the participants' responses to the questionnaires we feel confident in saying that the girls-only camp was a very positive experience for them. Students' self-perception that they are good at computing and their perceived ability to know how to program increased by the end of the 3-day camp. In terms of the perception of computing as a career, participants knew more and were more positive about the field as a result of the camp. The answers to the survey questions also align well with our own impression that the students had an enjoyable time, while at the same time confirming that they learned a lot. The enthusiasm of the students can also be viewed in this video that was created from footage shot by the students on the last day of the camp.[10]

The Google RISE funding award for the girls-only camp has enabled us to raise awareness about underrepresentation of females in particular and we will continue to plan and run activities for females again in the future. We are going to use similar tools and technologies, but other aspects such as food choices, timing allocated to talks, and inclusion of outdoor activities may be tweaked based on survey feedback.

Specifically targeting females is however only one of many projects that our research centre is involved in to encourage an interest in computing from primary through secondary and into third level. Other initiatives include running (mixed-gender) events during TechWeek, EU Code Week, Hour of Code, Science Week, Smart Futures, the national Scratch competition and the Junior Cycle Short Course in Coding. Colleagues at another institution of our research centre registered interest in our summer camps in particular and they ran an Information Systems Innovation Workshop in 2016. During the camp, participants designed and built a prototype of a mobile application learning skills in innovation, design, problem solving, application development, business analysis, teamwork and collaboration. Feedback from this camp was similarly very positive.

Acknowledgments. This work was supported with the financial support of the Science Foundation Ireland grant 13/RC/2094 and co-funded under the European Regional Development Fund through the Southern & Eastern Regional Operational Programme to Lero - the Irish Software Research Centre (www.lero.ie). We would like to acknowledge the support of Google RISE funding.

References

1. Google. *Women Who Choose Computer Science - What Really Matters*. Google 2014 [21/08/2017]; Available from: https://docs.google.com/file/d/0B-E2rcvhnlQ_a1Q4VUxWQ2dtTHM/edit.
2. Accenture. *Powering economic growth; Attracting more young women into science and technology*. 2014 [21/08/2017]; Available from: https://www.accenture.com/ie-en/~/media/Accenture/Conversion-Assets/DotCom/Documents/Global/PDF/Industries_14/Accenture-STEM-Powering-Economic-Growth.pdf.

[10] https://www.youtube.com/watch?v=EzBXqouzd8k

3. McGill, M.M., A. Decker, and A. Settle, *Undergraduate Students' Perceptions of the Impact of Pre-College Computing Activities on Choices of Major.* Trans. Comput. Educ., 2016. **16**(4): p. 1-33.
4. Crutchfield, O.S.L., et al., *Berkeley Foundation for Opportunities in Information Technology: A Decade of Broadening Participation.* Trans. Comput. Educ., 2011. **11**(3): p. 1-24.
5. Doerschuk, P., J. Liu, and J. Mann. *INSPIRED Broadening Participation in Computing: Most successful strategies and lessons learned*. in *2010 IEEE Frontiers in Education Conference (FIE)*. 2010.
6. Dahlberg, T., et al., *The STARS Alliance: Viable Strategies for Broadening Participation in Computing.* Trans. Comput. Educ., 2011. **11**(3): p. 1-25.
7. Guzdial, M., et al., *A statewide survey on computing education pathways and influences: factors in broadening participation in computing*, in *Proceedings of the ninth annual international conference on International computing education research*. 2012, ACM: Auckland, New Zealand. p. 143-150.
8. Adams, J.C., *Alice, middle schoolers & the imaginary worlds camps.* SIGCSE Bull., 2007. **39**(1): p. 307-311.
9. Webb, H.C. and M.B. Rosson, *Exploring careers while learning Alice 3D: a summer camp for middle school girls*, in *Proceedings of the 42nd ACM technical symposium on Computer science education*. 2011, ACM: Dallas, TX, USA. p. 377-382.
10. Burge, J.E., et al., *Girls on the go: a CS summer camp to attract and inspire female high school students*, in *Proceeding of the 44th ACM technical symposium on Computer science education*. 2013, ACM: Denver, Colorado, USA. p. 615-620.
11. Margolis, J., *Unlocking the clubhouse: a decade later and now what?*, in *Proceeding of the 44th ACM technical symposium on Computer science education*. 2013, ACM: Denver, Colorado, USA. p. 9-10.
12. Wing, J.M., *Computational thinking.* Commun. ACM, 2006. **49**(3): p. 33-35.
13. Roscoe, J.F., et al., *Teaching Computational Thinking by Playing Games and Building Robots.* 2014 International Conference on Interactive Technologies and Games (Itag 2014), 2014: p. 9-12.
14. Mladenovic, S., D. Krpan, and M. Mladenovic, *Using Games to Help Novices Embrace Programming: From Elementary to Higher Education.* International Journal of Engineering Education, 2016. **32**(1): p. 521-531.
15. Steffen, B., et al., *Model-Driven Development with the jABC*, in *Hardware and Software, Verification and Testing: Second International Haifa Verification Conference, HVC 2006, Haifa, Israel, October 23-26, 2006. Revised Selected Papers*, E. Bin, A. Ziv, and S. Ur, Editors. 2007, Springer Berlin Heidelberg: Berlin, Heidelberg. p. 92-108.
16. Margaria, T., S. Jörges, and M. Bakera, *Test your Strategy: Graphical Construction of Strategies for Connect-Four.* IEEE International Conference on Engineering of Complex Computer Systems, 2009.
17. Cheryan, S., et al., *Do Female and Male Role Models Who Embody STEM Stereotypes Hinder Women's Anticipated Success in STEM?* Social Psychological and Personality Science, 2011. **2**(6): p. 656-664.
18. McNally, M., et al., *Do lego mindstorms robots have a future in CS education?* SIGCSE Bull., 2006. **38**(1): p. 61-62.
19. Fagin, B.S. and L. Merkle, *Quantitative analysis of the effects of robots on introductory Computer Science education.* J. Educ. Resour. Comput., 2002. **2**(4): p. 2.
20. Ericson, B. and T. McKlin, *Effective and sustainable computing summer camps*, in *Proceedings of the 43rd ACM technical symposium on Computer Science Education*. 2012, ACM: Raleigh, North Carolina, USA. p. 289-294.