CODING FOR GIRLS: DISMISSING THE BOYS CLUB MYTH

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Abstract

This paper describes a study that was conducted over a two-year period. The aim of the study was to introduce girls to programming through the use of innovative tools. These tools, namely Mindstorms Robotics and Scratch were carefully chosen for their unique characteristics. The objective of the study was to provide girls with an opportunity to view programming in a positive manner. A quantitative analysis was performed, and the results indicate that the majority of the girls were motivated to learn programming skills. This paper not only provides insight into the minds of girls learning programming, but can also serve as motivation for educators teaching girls programming skills.

Introduction

Research indicates that the growth of computing careers is set to continue rising until 2020 (Watson & Li, 2014). However, the dropout rate of students enrolled for Computer Science 1 (CS1) is high (Bennedsen & Caspersen, 2007), and female student enrolment is on the decline (Kelleher, Pausch, & Kiesler, 2007). This may be due to a number of factors. For example, female students tend to be less confident about CS1, and they underestimate their ability (Carter & Jenkins, 1999; Funke, Berges, Muhling, & Hubwieser, 2015). This may be due to the stereotype of the male scientist that still persists today. It is well known that students who are introduced to computer programming at a young age, may well become the computer science university graduates of tomorrow. Therefore, it is important to equip young minds at an early age. This may be particularly relevant given the stereotype that girls seem to think exists.

To address the issue of skilled programmers, some governments, such as the UK and Finland, have introduced programming within the classroom from primary school level (Department for Education, 2013). However, due to the cognitive difficulties associated with programming it may be beneficial to teach students the art of algorithmic problem solving as well as programming in a fun and motivating manner (Badger, 2009). Games and interactive graphical user interfaces (GUI's) are approaches that have been seen to be successful.

Extant literature indicates that such approaches (tools) provide necessary elements for learning. Elements such as understanding and motivation can strongly contribute to easier learning of how to code (Piteira, 2011). These tools provide a platform for students to build, reinforce and practice fundamental computer programming concepts, while adding an element of fun. Such tools often scaffold students as they make use of action instead of

explanation; accommodating a variety of learning styles and skills; reinforcing mastery skills; providing an opportunity to practice; and affording an interactive, decision-making context.

This research aims to investigate whether such tools appeal to girls, as in almost all western countries, women are severely underrepresented in the discipline of computer science. Only 20% of an intake within any given department are female (Funke et al., 2015).

Literature Review

Women are significantly under represented within the field of computer science, with gender differences significantly noticeable already at school level (Funke et al., 2015). For example, female students often have weaker marks, only doing what is required of them, and they are less fascinated, adopting a pragmatic approach to programming. However, they are also more enthusiastic to seek assistance and readily attend extra tutorials, preferring smaller groups over larger ones. Interestingly, female students are more consistent and, when confronted with a problem, admit that there is a problem before the problem becomes a larger one. Another aspect that affects the learning process for girls is emotions (Chetty & van der Westhuizen, 2013). Research indicates that happiness has a positive and anxiety a negative influence on the learning process and the motivation of female students (Funke et al., 2015). Communication is very important to female students. Denner et al. show that girls benefit from collaboration where they work together as a pair, one being the driver and the other the navigator.

On the contrary, male students are more confident as they depict the typical role model of the male computer scientist. They seem to have more hands-on experience, try and test things out (scientific curiosity), and have more interest probably due to the gaming industry. The result is that male students often produce better marks. However, male students are often less structured and often do not admit when there is a problem until the problem at hand is almost insurmountable (Carter & Jenkins, 1999). Additionally, they do not readily attend extra tutorials.

Funke, et al surveyed computer science teachers with the notion of observing the gender differences (Funke et al., 2015). The main findings of this qualitative study resulted in 14 categories (coded) that teachers perceived to be true about programming and gender, namely:

- Structuredness;
- Self-confidence;
- Scientific curiosity;
- No differences;
- Results;
- Interests;
- Learning receptivity;
- Accuracy;
- Previous knowledge;

- Perseverance;
- Creativity;
- Frustration;
- Teamwork and
- Evolution (Funke et al., 2015).

It is interesting to note that a high number of participants (teachers) did not perceive any differences between genders.

Although genders differ in terms of programming, the idea of using games to teach fundamental computer programming concepts could be a generic approach that is not influenced by gender (Lawhead, 2002). Using games as well as interactive GUI's as a learning tool is advocated, as games have the potential to positively contribute to successful learning (Piteira, 2011). For example, the use of Lego Mindstorms robots is one such game that can provide an innovative teaching tool for building students computer programming skills. Scratch is another useful tool that can be used to promote the notion of programming.

There is still a need to further examine and analyse quantitative evidence on the topic of gender as enrolment figures drop, especially amongst females. This can only benefit the research community so that educators can get an understanding of how to attract female scientists into the field of computer programming.

Research Design

Previous research indicates that female computer programming students are on the decline and gender inequality within the workplace is prevalent. The motivation for this study arose to transform the notion of girls' perceptions of programming so that they are able to make more informed decisions in the future related to their careers.

While Funke, et al. based their work on surveying computer science teachers' responses to gender differences, this study is based on analysing the responses of the girls themselves.

Research Questions

To expand on other researchers' work, the research questions posed for this study were as follows:

1. Did gender differences influence learning programming skills? Which gender differences influenced learning?
2. Did the use of tools used to learn programming skills influence gender?

Participants

In 2015, 36 Grade 4 girls participated in learning fundamental computer programming skills ranging from variables, step-by-step instructions, decision making, loops and modular programming using Lego Mindstorms Robotics. In 2016, 32 Grade 5 girls learnt similar skills using Scratch

Additionally, three computer programming holiday clubs were conducted, two for Lego Mindstorms Robotics and one for Scratch. These holiday clubs were also conducted with girls ranging from ages 9 to 13 and one of the holiday clubs included boys. The first Lego Mindstorms Robotics holiday club consisted of 25 girls, and the second holiday club for Lego consisted of 6 boys and 8 girls. The Scratch holiday club consisted of 14 girls and 9 boys.

Materials

The coding course in 2015 (Lego Mindstorms Robotics) was conducted over a period of three months, each class being held weekly for one hour. The class was structured according to aims and objectives with tasks that the girls needed to complete. For the Lego Mindstorms Robotics course the girls worked in groups of two or three.

The coding course in 2016 (Scratch) was also conducted over a period of three months, again for one hour a week. These were the same girls who had completed the Lego Mindstorms Robotics course the previous year so they had prior knowledge of programming skills. For this course, the girls worked independently. The holiday courses for both the Lego Mindstorms Robotics and the Scratch course followed a similar pattern in terms of structure and content. These holiday courses took place in 2016.

For all of the courses each lesson comprised of learning a fundamental programming skill. A discussion as well as demonstrations were presented. The girls were then asked to complete a basic task around the skill, and then they were given a problem to solve that included the programming task. For example, one task may have been to program the robot to stop at a red traffic light. Another task may have been to develop a game using Scratch where the sharks eat the fish.

Instrument

A questionnaire was distributed to the girls at the end of each course. There were a variety of questions, and they were identical for both courses except for the tool name change. Girls were asked questions, such as “What did you enjoy most about programming?” And “Did you find programming easy?”. The questionnaires for the holiday courses were the same as the questionnaires used for the school coding courses. Students were asked to stipulate gender.

Data Analysis

The questionnaire consisted of ten questions with one of the questions having sub-questions related to a topic. The data was analysed quantitatively using SPSS.

Results

The results are discussed according to the questionnaire with a focus on answering the research questions.

Lego Mindstorms Robotics

Enjoyment of the course. Ninety-six of the participants agreed that they enjoyed the Lego Mindstorms Robotics course. Interestingly, all the boys enjoyed the course, and there were a few girls that did not enjoy it.

Skills enjoyed expanded. This question was a follow up question from the previous question where students were asked what they enjoyed. Some of the written answers were:

- We learnt new things I didn't know;
- Bot fighting;
- Mazes;
- I enjoyed learning about the switch and sensors;
- I enjoyed that at the age of 10 you can do amazing things;
- I enjoyed experimenting with the programming and working with the partners; and
- I enjoyed how the robots were real and we programmed real robots.

Ease of building the robot. Fifty-one girls found it easy to build the robot and 13 girls found it to be difficult. Three of the 5 boys found it easy to build the robot.

Programming skills. Eighty-three percent of the boys found programming easy compared with 63% of the girls. This is particularly interesting as it corresponds with previous research where boys do better than girls. This question is aligned with skills enjoyment and is discussed in detail below.

Keeping up with peers. Again, this question may highlight some gender differences as 100% of the boys felt that they could learn programming at the same pace as their peers. However, only 74% of the girls felt that they were academically aligned with their peers. This response reflects previous research that stipulates that girls are less confident and afraid to experiment.

Collaboration within the group. Both boys and girls felt that collaboration within the group took place and that their peers would assist them if need be, with 75% boys and 73% girls indicating positive collaboration. However, when asked to expand on their answers, girls' group dynamics were complex. Some girls indicated that their peers were controlling and that there was much unnecessary arguing.

Skills enjoyment. This question was divided into sub-questions pertaining to a skill learnt. The students were asked to rate the level of enjoyment from 1 (most enjoyed) to 6 (least enjoyed). Each sub-question is now discussed.

Building the robot. All of the boys indicated that this task was most enjoyable (level 1) whilst only 36% of the girls indicated building to be most enjoyable. Ten percent of the girls found this to be the least enjoyable activity while the rest of the girls' indicated across the range (level 2 to level 5).

Basic movement. Interestingly, both genders found the basic fundamental skills of learning to program using step-by-step instructions least enjoyable. One hundred percent of the boys and 39% of the girls reflected this.

Looping. Again, most girls and boys disliked learning how to program using a loop where 100% boys and 33% girls found this task tedious.

Decision-making: colour sensor. A third of the girls (33%) indicated that learning to program using the colour sensor was very enjoyable. The colour sensor allows educators to develop interesting tasks, such as "when the robot gets to the colour green it must sing a song and turn around." Interestingly, all the boys only found this task to be moderately fascinating.

Decision-making: touch sensor. All of the boys found the touch sensor enjoyable. This may be attributed to the fact that the boys enjoyed the "bot fighting," where the robots had to touch each other and score points, as well as bump into each other and push the robot off the mat. Thirty-nine percent of the girls found this skill to be moderately enjoyable.

Development of the final project. Only 50% of the boys enjoyed developing the final project, which included all the programming skills learnt. Almost 80% of the girls felt that this task was enjoyable.

Dislike of the course. The students were asked whether there was anything that they disliked about the course, and none of the boys indicated that they disliked anything. However, 29% of the girls disliked aspects, such as building the robot and negative group dynamics.

Scratch

Enjoyment of the course. All the boys enjoyed the Scratch programming course, and 81% of the girls enjoyed it.

Skills enjoyed expanded. This question was a follow up question from the previous question where students were asked what they enjoyed. Some of the written answers were:

- Learning all the coding like variables and broadcasts;
- Writing a program;
- Creating and playing games which adds a bit of fun to the lesson;
- I enjoyed making the ball game;
- I enjoyed how we got to program it ourselves;
- I enjoyed the maze and how we worked independently; and
- I enjoyed programming different programs and making the ball game with the counter and high-score.

Table 1

Gender Influencing Programming Skills

Gender Difference	Highlighted
Girls	
Have weaker marks, only doing what is required of them	
Less fascinated, adopting a pragmatic approach to programming	√
More enthusiastic to seek assistance	√
Prefer smaller groups over larger ones	√
More consistent and when confronted with a problem, admit that there is a problem before the problem becomes a larger one.	
Happiness has a positive and anxiety a negative influence on the learning process and the motivation	√
Communication is very important	√
Girls benefit from collaboration	√
Boys	
More confident	√
They seem to have more hands-on experience, try and test things out (scientific curiosity)	√
Produce better marks	
Often less structured and often do not admit when there is a problem until the problem at hand is almost insurmountable	
They do not readily attend extra tutorials	

Programming skills. Interestingly, only 67% of the boys found it easy to write a program using Scratch as opposed to 73% of the girls. This differs from the results found when the students were learning to program using Lego Mindstorms Robotics. However, more than 80% of the girls tested had already completed the Lego Mindstorms Robotics course. This may have influenced the result, as previous research shows that prior programming experience is an advantage to learning a new programming language (Bergin & Reilly, 2005).
Keeping up with peers. Although the boys found the programming more challenging than the girls, more of the boys (88%) felt that they were able to keep up with their peers. This may be due to the notion that boys often feel more confident as computer scientists. Fewer girls, 73%, felt that they were able to keep up with their peers.

Collaboration within the group. The Scratch course was structured in such a way that students worked independently of each other. However, students worked along-side each other where they could assist each other. All the boys as well as 78% of the girls felt that their peers would readily assist them if they required help. As their facilitator, I observed that students were keen to assist each other. It seemed to provide them with an opportunity to solve problems and learn from other' code.

Skills enjoyment. This question was divided into sub-questions pertaining to a skill learnt. The students were asked to rate the level of enjoyment from 1 (most enjoyed) to 6 (least enjoyed). Each sub-question is now discussed.

Building a Sprite. All the boys rated this aspect of Scratch as level 4 – not really enjoyable. Thirty-two percent of the girls also did not really enjoy this while 39% of the girls did enjoy developing a Sprite.

Creating a background. The majority of both the girls and the boys did not find this aspect very enjoyable with more than 60% of both genders indicating it at level 4 – 6.

Movement and the Sprite. All of the boys found this aspect reasonably enjoyable while 50% of the girls enjoyed coding the Sprite (s) to move. Fifty percent of them did not find it enjoyable.

Controlling the movement of the Sprites. All of the boys as well as 70% of the girls enjoyed developing the code to enable the Sprites to move in a controlled manner. For example, they learnt programming instructions that allowed a user to press the up, down, left and right arrows so that the Sprite would move around. This often took place as part of a game that was developed, such as a Sprite moving through a Maze.

Creating a game. All of the boys and 85% of the girls found it enjoyable to develop the code for a game. As facilitators, we observed that there was much excitement around the coding with students using their imaginations and extending or adding elements to the games that were developed. They enjoyed playing each other's games and learning from each other.

Creating an interactive storybook. Both the boys and girls did not enjoy creating an interactive storybook. This aspect of Scratch makes use of repetitive instructions. Students may have found this monotonous.

Discussion

The findings of this study confirm the results from previous research conducted by Funke et al. As shown in Table 1 this study found comparable results based on gender.

Did gender differences influence learning programming skills? Which gender differences influenced learning?

When considering whether gender differences influenced learning a programming skill, this study shows that gender can influence learning. Some of the gender differences that may have influenced learning refer to:

- Boys found it easier to learning programming concepts as opposed to girls;
- Boys felt more confident in the role of learning programming skills;

- Both genders benefit from collaborative learning, however group dynamics within girl groups can be challenging; and
- Gaming is a beneficial tool for both genders to make use of for learning programming skills.

Table 2 tabulates Funke et al.'s categories to show whether any of these gender differences are highlighted for this study.

Table 2

Funke et al. Categories Linked

Category	Gender
Structuredness	Girls
Self confidence	Boys
Scientific curiosity	Boys
No differences	
Results	
Interests	Boys
Learning receptivity	Boys
Accuracy	Girls
Previous knowledge	Girls
Perseverance	Boys
Creativity	Boys, girls
Frustration	Girls
Teamwork	Boys
Evolution	Boys, girls

Did the use of tools influence gender?

Bruckman, Jenson and De Bonte (2002) found that gender did not influence learning and performance for programming. However, they did find that motivation and interest were factors that influenced both genders learning programming. Boys tend to spend more time playing computer games and more time programming. Therefore, one key element to encourage girls to learn programming skills may be the tool used to teach girls.

Table 3

Tool Characteristics and Gender Appeal

Tool Characteristic	Gender	
	Boys	Girls
Lego Robotics Mindstorms:		
Enjoys learning programming skills	√	√
Building the robot	√	

Tool Characteristic	Gender	
	Boys	Girls
Ability to learn programming skills	√	
Confident in learning programming skills	√	
Collaboration	√	
Basic programming skills		
Complex programming skills	√	√
Development of a project for demonstration		√
Scratch:		
Enjoys learning programming skills	√	√
Ability to learn programming skills		√
Confident in learning programming skills	√	
Independent learning of programming skills		√
Learning programming skills through gaming	√	√

Table 3 tabulates a list of characteristics found from this study that attract girls as well as boys to the tools used in this study. Boys found that it was easier to learn programming skills when Lego Mindstorms Robotics was the tool as opposed to Scratch. The girls felt that Scratch was a good tool to make use of to learn programming. However, both boys and girls enjoyed learning programming skills using both tools. Therefore, these tools can be seen to motivate both genders to learn programming skills. In both cases girls were less confident learning programming so ensuring that the tool is fun motivates girls. This may lead to an increase in confidence among the girls. Interestingly, girls' confidence in their ability seemed to rise when they had prior knowledge of programming skills. This needs to be investigated further and can be a key element in female student enrolment

Limitations

The samples used as part of this study are small and are not representable of a significant portion of a population. The socioeconomic representation is small as the school is a private school with pupils' representative of affluent families within a community.

Conclusion

Over the last 30 years much research has been focused on the development of programming skills. From low pass rates, to the difficulty that surrounds the learning and teaching of computer programming, as well as the group of people that engage in the activities around learning programming. It has also been validated that male students are motivated and confident to take CS1 while female students remain reluctant. Therefore, more research should focus on changing these statistics given that computer programming skills are still on the rise. Attracting young girls at an early age may be key to changing perceptions. In this study, we address the concept of gender within a programming context to determine whether gender does influence the learning

of programming skills at a young age. We also observed a variety of learning characteristics that may attract girls to learning programming skills. The research was motivated to provide a learning environment for girls where the mechanics of learning a programming language is not the only system in place to learn programming. Creating environments that address sociological factors, such as fun, motivation and collaboration may provide learning for a more diverse group of people (Kelleher & Pausch, 2003).

Future Work

Future work will focus on finding techniques that assist girls in engaging with programming as well as researching tools to assist girls with programming. Evaluating the impact of such methods is imperative to furthering research in this area.

References

Badger, M. (2009). *Scratch 1.4 Learn to program while creating interactive stories, games, and multimedia projects using Scratch Beginner's Guide*. Birmingham, UK, Mumbai, India: PACKT.

Bennedsen, J., & Caspersen, M. E. (2007). Failure rates in introductory programming. *SIGCSE Bulletin, 39*(2), 32-36.

Bergin, S., & Reilly, R. (2005). *Programming: Factors that influence success.* Paper presented at the *IGCSE'05*, St. Louis, Missouri, USA.

Bruckman, A., Jenson, C., & De Bonte, A. (2002). Gender and programming achievement in a CSCL environment. *Proceedings. CSCL 2002* (pp.119 - 227), Colorado, USA.

Carter, J., & Jenkins, T. (1999 June). *Gender and programming: What's going on?* Paper presented at the *ITiCSE'99*, Cracow, Poland.

Chetty, J., & van der Westhuizen, D. (2013 July). "I hate programming" and other oscilating emotions experienced by novice students learning computer programming. Paper presented at the *EdMedia '13*, Victoria, Canada.

Denner et al. (2012). Computer games created by middle school girls: Can they be used to measure understanding of computer science concepts? Computers & Education 58 (2012) 240–249

Department for Education. (2013). *Computing programmes of study: Stages 1 and 2*. Department of Education, United Kingdom Government, United Kingdom.

Funke, A., Berges, M., Muhling, A., & Hubwieser, P. (2015 November). *Gender differences in programming: Research results and teachers' perception.* Paper presented at the *Koli Calling '15*, Koli, Finland.

Kelleher, Pausch, & Kiesler, S. (2007 April). Storytelling Alice motivates middle school girls to learn computer programming. Paper presented at the *CHI 2007*, San Jose, California.

Kelleher, C., & Pausch, R. (2003). Lowering the barriers to programming: A survey of programming environments and languages for novice programmers. ACM 1073-0516/01/0300-0034

Lawhead, P. B., Bland, C. G., Barnes, D. J., Duncan, M. E., Goldweber, M., Hollingsworth, R. G., & Schep, M. (2002 June). *A road map for teaching introductory programming using Lego Mindstorms robots.* Paper presented at the *ITiCSE*-WSR. Copenhagen, Denmark.

Piteira, M., Haddad, S.R. (2011 July). Innovate in your program computer class: An approach based on a serious game. Paper presented at the *OSDOC'11*, Lisbon, Portugal.

Watson, C., & Li, F. W. B. (2014 June). Failure rates in introductory programming revisited. Paper presented at the *ITiCSE '14. New York, USA*.

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