# TEACHING PROGRAMMING SKILLS TO GIRLS

Nataša Hoić-Božić, Martina Holenko Dlab, Ivona Franković, Marina Ivašić-Kos
*University of Rijeka, Department of Informatics, Rijeka, Croatia*

**ABSTRACT**

Educational digital games have the potential to motivate students and make complex and abstract topics like programming more appealing. This paper presents an innovative game based learning (GBL) approach, developed within the project Coding4Girls, that aims to prepare and motivate girls for building programming skills. It is based on playing games related to programming concepts, as well as on providing the students with skills and knowledge to design and develop their own games in Snap! visual programming interface.

**KEYWORDS**

GBL, Coding4Girls Project, Digital Games Project, Visual Programming, Snap!

## 1. INTRODUCTION

Women represent only the 17% of ICT specialists and the 34% of STEM graduates while UNESCO affirms that less than 30% of researchers worldwide are women (European Commission, 2019). According to the National Center for Education Statistics in the US (Cunningham, Hoyer, & Sparks, 2015), women make up only 18% of university graduates in computer science so it is necessary to try to make computer science and related fields attractive to girls from early age using appropriate approaches such as GBL.

According to (Carmichael, 2008), learning computer science concepts combined with video games is useful, specifically for younger female target group. A conceptual model for gender-based engagement in educational games has been developed (Alserri, Zin, & Wook, 2018), consisting of five elements:

- Learning elements that distinguish entertainment games from educational games;
- Female preferences for digital games that consist of exploration, character customization, storyline, social interaction, collaboration, challenges, fun, control and feedback;
- Flow state theory elements: challenges, fun, control, feedback, concentration, clear goals, skill and immersion;
- Female game types and genres: fantasy and role-playing games;
- Social gender factors: parental, peers and teacher influence.

Computer games can be used to teach coding not only by allowing the students to play serious games that include learning outcomes related to programming, but also by teaching students to develop and create their own basic games through visual programming languages or block-based environments for teaching programming (Kazimoglu et al., 2012). Examples of some popular visual programming languages are: Scratch ("Scratch," 2020), Snap! ("Snap!," 2020), and Alice ("Alice," 2020).

This paper presents an innovative approach for building programming skills, developed within the project Coding4Girls, that aims to prepare and motivate girls and boys to enter computer science careers by pointing out the possible application of programming knowledge in solving real-life problems.

## 2. CODING4GIRLS PROJECT

The Coding4Girls (C4G) project (www.coding4girls.eu) is an ongoing project funded by the Erasmus+ Programme that aims to address the gap between male and female participation in computer science education and careers by introducing early methodological learning interventions that make computer science

attractive to all, girls and boys. The main goal is to attract girls by raising their awareness on the wide array of possibilities for professional and personal growth that computer science offers. The project started in September 2018 and lasts until August 2020. The project coordinator is the University of Ljubljana (Slovenia) and partners are universities and institutions from Portugal, Greece, Bulgaria, Italy, Turkey, and Croatia ("Coding4Girls web site", 2018).

Coding4Girls aims to develop innovative methodological learning framework for building programming skills and introduces innovation in several different aspects: into a pedagogical approach, into the field of technology use, and at the level of learning interventions. In terms of pedagogical approach, the project will introduce design thinking that encourages students to think entrepreneurially about how computer science and ICT can solve real-world problems (Wrigley & Straker, 2017). At the technology-based learning level, Coding4Girls will validate the proposed design thinking pedagogical approach through the development and implementation of didactic games (Backlund & Hendrix, 2013). At the learning intervention level, Coding4Girls will promote active learning through game-based learning (GBL) and link specific learning objectives to scenarios that promote critical thinking as an integral part of programming.

# 3. APPROACH TO TEACHING PROGRAMMING TO GIRLS USING GBL

The C4G approach to teaching programming is based on the GBL. It is not just about playing games related to programming concepts, but also providing the girls with skills and knowledge to design and develop their own games taking a constructive approach to learning.

In the context of C4G project, playing video games is combined with games development in order to develop a GBL methodological framework for building programming skills among young people in primary and secondary education. The methodology encourages participation in programming activities through a "low entry high ceiling approach" that has low knowledge requirements in the beginning while not limiting problem-solving challenges for more advanced students. Students are provided with "half baked" scenarios of simple games in block-based visual programming environment Snap! and encouraged to finish partially completed solutions by building blocks of code. Snap! scenarios are included in the Coding4Girls adventure game for learning basic programming concepts. This game is a part of C4G software designed for the learners. The second part of the software is the teacher's platform.

## 3.1. Coding4Girls Software

C4G software for the learning environment consists of two interconnected parts or platforms, one for teachers and one for students.

The platform for students includes a 3D single player first person adventure game. The game is developed in Unity and includes various logical games or mini-games such as puzzles, mazes and other problem-solving mini-games that are chosen to be attractive to girls.

Teachers are using web-based platform for creating the courses implemented into the C4G game. Those courses are functioning as a grouping space for connected activities called "challenges" or chapters of the game which are related to programming concepts such as variables, loops, conditionals, etc. At the beginning of each "challenge", a task related to a concept is displayed to students. Students play different types of mini-games to reach the final challenge where they need to solve the Snap! assignment. The goal of mini-games is to entertain and motivate the players, but also to introduce new programming concepts more easily. It is expected that Snap! coding environment will help students to use and apply these concepts (Franković, Hoić-Božić, Holenko Dlab, & Ivašić-Kos, 2019).

## 3.2. Design of Coding4Girls GBL scenarios for teachers

In order to help teachers integrating the C4G approach into the courses for the game as well as to include Snap! activities in their teaching practices, learning scenarios have been prepared and adapted to the design thinking approach and the structure of the C4G software. The focus is on the identified characteristics of games preferred by girls but also on the activities related to the real-world problems. In that way the games are suitable for building programming skills for both girls and boys.

The prepared learning scenarios present in concise manner the following information:

- Learning scenario title
- Required programming experience
- Expected learning outcomes
- Aim, tasks and short description of activities
- Duration of activities
- Learning and teaching strategies and methods
- Teaching forms
- Step-by-step description of all Coding4Girls game design based learning activities
- Questions for initiating discussion among learners in the context of class collaboration
- Assessment methods for evaluating the knowledge and skills
- Tools and resources for the teacher and students.

A total of 21 learning scenarios have been prepared and divided into two groups: the first group is related to the “basic learning scenarios” (with some simple programming concepts) while the second one is referred to the "advanced ones" (with multiple programming concepts). All learning scenarios contain activities for developing games in Snap! that include real-life problems. For example, in the basic learning scenario “Picking up trash and cleaning the park” students learn how to use variables and how to duplicate a block of code or a whole Sprite (Figure 1). In an advanced scenario “Buying food for a picnic” students learn how to work with variables: setting different starting values, using conditionals to compare variables’ value, changing variables’ value, using variables for counting (un)healthy food (Figure 2). Teachers can use the scenarios in the proposed sequence or can select them freely according to their preferences and needs.

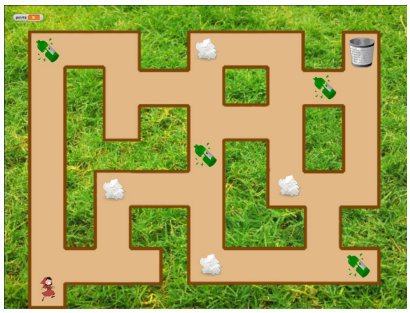

Figure 1 – Game “Picking up trash and cleaning the park”


Figure 2 – Game “Buying food for a picnic”

The learning scenarios are available in English as well as the national languages of project partners – Bulgarian, Croatian, Greek, Italian, Portuguese, Slovenian and Turkish (Coding4Girls project documentation and results, 2020).

## 4. CONCLUSIONS AND FUTURE WORK

Currently, the project team is engaged in testing the C4G methodology for building programming skills in the project partner countries. Teachers from primary and secondary schools were selected to apply developed learning scenarios for teaching programming using GBL with their students. This represents the first iteration of the Design Based Research (DBR) approach (Wang & Hannafin, 2005) that was chosen to evaluate the proposed framework.

Teachers were advised to choose a subset of the prepared learning scenarios according to their needs, and to try to achieve learning objectives related to programming concepts presented in the chosen scenarios. Just before the start of the implementation, schools were closed due to COVID-19 pandemic so activities were adjusted for online teaching in virtual learning environments like Microsoft Teams, Edmodo and similar. Additional instructions for teachers and students were prepared in written and video form, to enhance teaching and learning in virtual classrooms.

Upon completion of implementation, students and teachers were asked to fill questionnaires and give their feedback about the C4G methodology and the implementation that will be used to make improvements in the

following DBR iterations. Preliminary results show that both teachers and students accepted the C4G approach for building programming skills. Students like to learn programing by creating games, especially those related to real-life problems, and teachers find the approach effective for achieving learning objectives.

Research will be continued within the project Digital Games. In the next DBR cycle, teaching programming in Snap! will be combined with the use of the C4G game. To familiarize students with the environment of the 3D adventure, the game will be at first used to explain just one programming concept. Subsequently, the game will be improved based on the obtained results and feedback and more concepts will be added. In the last DBR iteration, the entire framework will be tested. During the Digital Games project, additional learning scenarios for the use of the abovementioned game will be developed.

## ACKNOWLEDGEMENT

The research has been co-funded by the Erasmus+ Programme of the European Union under the project „Coding4Girls“ (2018-1-SI01-KA201-047013) and by University of Rijeka under the project “Digital games in the context of learning, teaching, and promoting inclusive education” (uniri-drustv-18-130).

## REFERENCES

Alice, 2020. Retrieved May 25, 2020, from http://www.alice.org/

Alserri, S. A., Zin, N. A. M., & Wook, T. S. M. T., 2018. *Gender-based Engagement Model for Serious Games*. International Journal on Advanced Science, Engineering and Information Technology, 8(4), 1350–1357.

Backlund, P., & Hendrix, M., 2013. *Educational games - Are they worth the effort? A literature survey of the effectiveness of serious games.* 5th International Conference on Games and Virtual Worlds for Serious Applications (VS-GAMES), 1–8. https://doi.org/10.1109/VS-GAMES.2013.6624226

Carmichael, G., 2008. *Girls, computer science, and games*. ACM SIGCSE Bulletin, 40(4), 107–110. https://doi.org/10.1145/1473195.1473233

Coding4Girls web site, 2018. Retrieved May 26, 2020, from https://www.coding4girls.eu/

Coding4Girls project documentation and results, 2020.

Cunningham, B. C., Hoyer, K. M., & Sparks, D., 2015. *Gender Differences in Science, Technology, Engineering, and Mathematics (STEM) Interest, Credits Earned, and NAEP Performance in the 12th Grade*. In Stats in Brief. Retrieved from https://eric.ed.gov/?id=ED554303

European Commission, 2019. *Shaping Europe’s digital future - Women in Digital*. Retrieved May 25, 2020, from https://ec.europa.eu/digital-single-market/en/women-ict

Franković, I., Hoić-Božić, N., & Holenko Dlab, Martina Ivašić-Kos, M., 2019. *Supporting Learning Programming Using Educational Digital Games*. Proceedings of the 13th European Conference on Game Based Learning, 999–1003. Denmark.

Kazimoglu, C., Kiernan, M., Bacon, L., & Mackinnon, L., 2012. A *Serious Game for Developing Computational Thinking and Learning Introductory Computer Programming*. Procedia - Social and Behavioral Sciences, 47, 1991–1999. https://doi.org/10.1016/j.sbspro.2012.06.938

Scratch, 2020. Retrieved May 25, 2020, from https://scratch.mit.edu

Snap!, 2020. Retrieved May 25, 2020, from https://snap.berkeley.edu

Wang, F., & Hannafin, M. J., 2005. *Design-based research and technology-enhanced learning environments*. Educational Technology Research and Development, 53(4), 5–23. https://doi.org/10.1007/BF02504682

Wrigley, C., & Straker, K., 2017. *Design Thinking pedagogy: the Educational Design Ladder*. Innovations in Education and Teaching International, 54(4), 374–385. https://doi.org/10.1080/14703297.2015.1108214