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Coding Initiative Provides Different Approaches to Inspire Girls for Programming

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Abstract: Attracting more women into science, technology, engineering, and mathematics continues to be a significant concern in the scientific research community. Especially the demand for specialists in computer science is increasing. However, interest drops significantly among teenage girls. Many coding initiatives aim to increase motivation and enthusiasm and provide young women with a bright future in science, technology, engineering, and mathematics. This paper demonstrates a one-week coding initiative with different approaches to encourage 21 teenage girls to program. The different approaches, game design, embroidery programming, and robotics provide a suitable setting to answer the research questions: 1) Are the girls inspired to program through the coding initiative? 2) Has the girl's self-perception of programming skills improved? 3) Do these approaches arouse the girl's interest? The results show that the girls' enthusiasm and interest are successfully raised. We proved that the girls obtained a fundamental understanding of programming skills and computational thinking. Their understanding of loops, variables, data, if-else statements, objects, and local and global constructs confirms the results. The most interesting approaches are embroidery programming closely followed by game design. These validated and purposeful approaches teach (girls) programming and basic computational thinking skills. Researchers and practitioners will benefit from these findings. The results will advance the field of computing education.

Keywords: girls, programming, coding initiative, STEM, gender

1. Introduction

A gender gap exists in science, technology, engineering, and mathematics (STEM) fields, with fewer women than men studying and working in these areas. Worldwide less than 30% of researchers are female. Only 30% of female students choose STEM studies (UN, 2021). At the same time, these disciplines include a broad spectrum of potential applications in a professional field. In Addition, qualification in science, technology, engineering, and mathematics offer graduates a wide range of careers, which can be an asset both professionally and personally (Gough, 2015). Furthermore, the demand for occupations with skills in the technical field is increasing. The European Union intends to increase the participation of women in all areas of STEM education and its employment market (Garcia-Holgado et al., 2020). The field of computing education is well suited for this purpose. Therefore skills in science, technology, engineering, and mathematics are essential, and women and girls should get the chance to shape their own future in the field of technology. Inspiring young girls to enter these fields remains an essential topic in the scientific community. One way of reducing this gap is by encouraging and supporting women in STEM (Beede et al., 2011). Many initiatives and projects try to encourage young women to pursue a career in science, technology, engineering, and mathematics.

The research paper aims to identify appropriate approaches to encourage (novice) girls to program. To compare these different approaches, the same device (smartphone) and the same programming environment (Pocket Code App) were selected for all three approaches in the framework of the one-week coding initiative.

1) Are the girls inspired to program through the coding initiative?
2) Has the girl's self-perception of programming skills improved?
3) Do these approaches arouse the girl's interest?

2. Related Work

Closing the gender gap is a social and global challenge in computing education. In the case of girls, interest drops when they reach their teens (Stein, 2019), and this does not happen in the case of boys. However, coding initiatives inspire young women to pursue a career in computer science and STEM-related fields. These would be, among others, for example, Webgrrls, Women Who Code, PyLadies, Black Girls Code, Girls Who Code, czechitas, and CODING4GIRLS (De Vuyst, 2020), (czechitas, 2021), (Hoic-Bozic et al.,), (Gursch et al., 2020), (Spieler et al., 2019). A particularly successful approach among these is that of the code clubs for girls only (Zagami et al., 2015). Based on these successful and validated coding initiatives for girls, a coding initiative for girls is best suited to test different approaches to give girls first programming experiences. The teaching approaches vary from Makerspaces (Makerspaces, 2022), robots (Sapounidis and Alimisis, 2020), wearables (Merkouris and Chorianopoulos, 2015), embroidery machines (Wolz et al., 2019), game design (Rugelj and Lapina, 2019), to storytelling (Vinayakumar et al., 2018). Compared to the previous work, this research focuses on different approaches that can be used with one device and the same programming language. Furthermore, it should be a device that the participants are familiar with to reduce possible entry barriers. Therefore, a smartphone is the tool of choice. In addition, most participants already have their own smartphones (smartphoneTeens, 2022), which can be used for the course. The coding initiative uses the Pocket Code app to teach programming. In particular, the programming environment of the Pocket Code app is based on a block structure similar to Scratch (Slany, 2014). Block-based programming languages provide a simple method for acquiring first programming skills at a young age. This reinforces concepts such as loops, if-else statements, data, and others (Armoni et al., 2015). Learning programming fosters computational thinking skills (Plaza et al., 2019). This could yield a career in computer science or STEM-related fields.

3. Methodology

The coding week was from July 12 – 16, 2021, at Graz University of Technology. The five days were held all day, with the adequate course time amounting to three hours in the morning and three hours in the afternoon. The coding initiative was aimed at female teenagers who want to learn to program. However, the course was not limited to beginners. This course was promoted on summer course platforms and flyers. Therefore different approaches (for novices) were prepared that provide the first basics for learning programming in an easy, understandable, and fun way.

The Pocket Code app supports many different approaches. It is possible to create a program, like a game, an embroidery pattern, a control for drones, a control for Lego NXT robots, or more. The Pocket Code app was deliberately selected as the tool for this course. The visual block-based programming environment is a successful way to teach programming to novices (Price and Barnes, 2015). Furthermore, additional hardware such as Lego NXT or embroidery machines were used depending on the approach. The different approaches were assigned to individual stations. The station on game design offers the opportunity to program their own games. The approach embroidery programming deals with the area of producing embroidery patterns. The participants could design patterns and program a file for an embroidery machine. These self-designed and programmed patterns are stitched on a bag or t-shirt with the help of an embroidery machine. In the robotics station, Lego NXT robots were programmed and controlled. Thus, the selected different approaches shape three stations in the coding initiative: game design, embroidery programming, and Lego NXT (robotics), Figure 1.

Figure 1. Game design, embroidery programming, and Lego NXT (robotics).

Each station had an introductory example to give the participants a basic understanding. After completing the first basics, there is enough time to program their games, embroidery patterns, or robots. The stations were under the supervision of trainers. Each trainer created the material for their station based on predefined approaches and previous work. The previous work builds on gender-sensitive materials and research experiences. The focus here is to guide the girls in the course through a gender-sensitive approach and with exclusively female trainers (Guenaga et al., 2022). They act as role models and intermediaries, conveying their passion for technology to the girls. The trainers are students in a STEM-related field at the university and have already achieved excellent programming skills.

3.1 Participants

Some girls signed up for the coding initiative, some through legal representatives. Both the girls themselves and their legal guardians gave their consent for the study. A total of 21 girls participated in the course. The participants ranged from 12 to 18 years, eleven girls were 13 years old. The extent of prior programming knowledge was varied; 25% had never programmed before the course, 50% had learned to program in school, and the remaining 25% had already programmed at home or with friends.

3.2 Evaluation Method

At the beginning and end of the coding initiative, a questionnaire was distributed and filled out by the participants. Comparing the questionnaire data before and after the course, conclusions about the method were drawn. The questionnaire asked, among other things, whether the girls had already programmed. Furthermore, they were asked to rate their interest, the importance of learning programming, or how familiar they are with concepts (loops,...) with a 4-level scale (true, rather true, hardly true, and not true). This information was compared with the results of the quiz. Each participant completed a quiz after finishing each station, once for each different approach. The results served as a control for the participants' self-assessment of the questionnaire's answers. In Addition, individual interviews with the girls and their observations helped verify the questionnaire.

4. Results

The evaluation of the questionnaires, quizzes, and observations address the three research questions:

1) Are the girls inspired to program through the coding initiative?
The evaluations show that the interest in learning programming has increased from 36.8% to 68.4%. Surprisingly, the importance of learning to program decreases, and the initial confidence of the participants to be able to program decreases very slightly. However, a significant increase from 36.8% to 63.2% in programming is fun for the participants. Figure 2 shows more details of the results after the coding initiative.

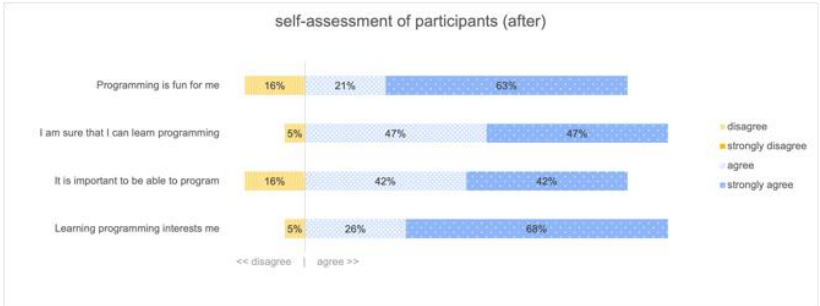

Figure 2. Answers were given in the questionnaire about programming after the coding initiative.

2) Has the girl's self-perception of programming skills improved?

The evaluation of the questionnaires shows that some of the girls had already gained their first experience in programming and computational thinking before the coding initiative. 15.8% of the participants are unfamiliar with loops, whereas 26.3% know what a loop is and can use it in programming. The use of variables or data is unknown for 26.3% of the participants, but an equal number of participants know and use this term. The gap is even more significant for if-else statements. While 36.8% state that they are well aware of this construct and can use if-else statements professionally in programming, 31.6% are not familiar with this term. The area of global and local constructs gets the weakest self-assessment by the participants. Only 5.3% say that they understand these, while a total of 31.6% are not familiar with them. When dealing with objects, quite 42.1% state being able to use them, and only 10.5% do not understand what a construct it is, Figure 3.

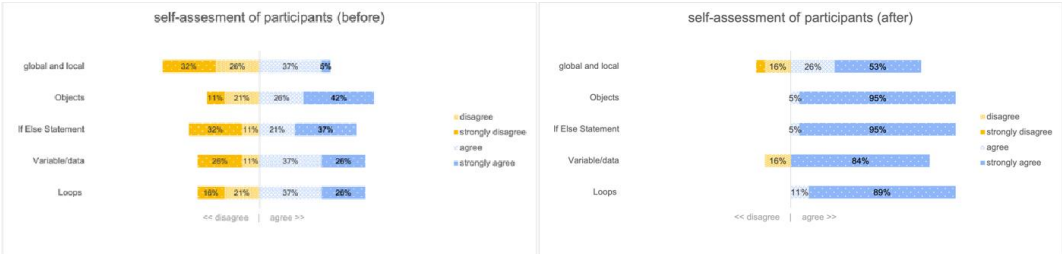

Figure 3. Programming skills before (left) and after (right) the coding initiative.

After the coding initiative, the evaluation of the questionnaire about the skills for loops, variables, if-else statements, objects, and local/global constructs is significantly higher. The lowest percentage in programming skills achieves the participant's understanding of local and global constructs with 52.6%. The programming skills for loops, variables, if-else statements, and objects are generally better assessed, with all participants rating around the 90% mark (see Figure 3). The results show that the participant's self-assessment of their programming and computational thinking skills has risen.

The results of the quizzes are consistent with the participant's self-assessment in the questionnaire about their programming skills. The quizzes reflect a test in which questions are judged based on answers. The questions dealt with programming in the Pocket Code app and comprehension questions about the different concepts in programming. Furthermore, there was a big focus on loops, objects, or how to implement specific shapes in the code. Overall the quiz results confirm that the participants learned to program, and in addition, they also acquired computational thinking skills.

3) Do these approaches arouse the girl's interest?

Before and after the coding initiative, the participants were asked in the questionnaire about their interest in the presented approaches. The interest in programming games decreased slightly. While one station in the coding initiative dealt with robotics (Lego NXT), interest in programming robots fell from 63.2% to 57.9%. A substantial increase can be seen in the programming of embroidery machines. At the end of the course, 68.4% of the girls stated they were interested in embroidery programming, whereas, before the course, the proportion was 31.6%. In addition, the interviews held with the participants after and between the courses confirm that they were very enthusiastic about embroidery programming. The girls created complex programs to embroider elaborate designs on their t-shirts and bags. The questionnaire evaluation matches the observations on whether the participants would have liked to have spent more time in the individual stations.

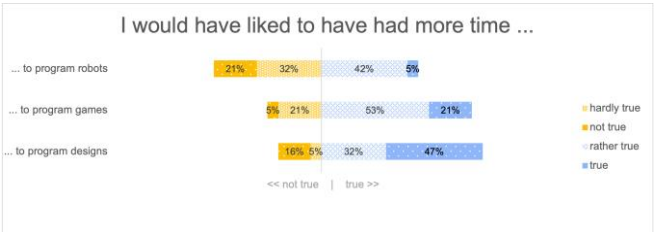

Figure 4: More time for different approaches

The results show that interest was the highest in spending more time on embroidery programming, followed by game design, the station with the least appeal was programming robots, Figure 4. In addition, participants stated that they were proud of their games and the embroidery work they had created during the course. Overall, we found that embroidery programming is a very appealing approach, closely followed by game design.

5. Conclusion

The one-week-long coding initiative was successful in terms of both the results achieved and the efficiency of the applied methodology. The results show that the different approaches, ranging from game design to embroidery programming to robotics (Lego NXT), have aroused the girls' engagement in programming. A total of 21 (primarily novices) girls participated in the coding initiative. Although the sample size is too small to make a significant statement, it became clear that game design and embroidery programming fascinate girls. The approach embroidery programming was top-rated. On the one hand, actual tasks, topics, and problems increase motivation and enthusiasm (Topalli and Cagiltay, 2018). On the other hand, taking home self-created work can arouse excitement because creative projects arouse girls' interest in computer science (Sax et al., 2017). We speculate that embroidery programming might be a particularly high-yield approach to awaken girls' interest in programming. Future studies may repeat this process for a larger sample to broaden our findings. The following steps are enlargement and enrichment. Another dimension by highlighting the role of the different approaches could be performed by enlarging the content by using other different approaches. Future research will enrich this study by deepening the skills in programming. Therefore, teaching even in-depth programming knowledge in an inspiring and fun way.

These findings advance the field of computing education. Educators, practitioners, and researchers will benefit from these results. The different approaches can help to design curriculums or development professional programs. New programmable materials, interactive activities, and traditional and cultural communities of girls significantly motivate them to participate in computing education (Kafai and Burke, 2014). Game design, embroidery programming, and robotics offer excellent opportunities for girls to get (first) experiences with programming. Depending on the availability of hardware like Lego NXT robots or an embroidery machine, a researcher or educator could also choose just one of these approaches. The use of the (own) smartphone offers a particularly outstanding advantage. Mostly the participants use their smartphones, which reduces entry barriers. In addition, this could lead to more opportunities in computing education, where access to a computer or tablet is limited. Although the coding initiative was held exclusively for girls, this does not limit these approaches to heterogeneous groups.

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