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How to Encourage girls to code Through Embroidery Patterns?

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Abstract: At the age of 13, many young women lose interest in programming. To sustain the interest of young women in programming, the Graz University of Technology has initiated several coding activities over the last years especially for girls. One of these activities is the Girls Coding Week (GCW) which also took place this year in August 2020. Many approaches to learning programming use game design and teach kids to build playable artifacts. Gender differences in gaming behavior and preferences raise concerns about possible gender inequalities when games are used as a motivation to learn to program. The question that occurs is whether there are other playful and interesting approaches that encourage girls to program? During the GCW we provide two main activities: game design and embroidery coding. To demonstrate the basic steps of programming as well as to create games and embroidery designs, the coding app Pocket Code has been used. Pocket Code uses Catrobat's mobile visual programming framework for smartphones. It allows users to develop games and animations directly on their device, by simply sticking bricks together. The possibility of embroidery coding with a mobile phone should give young females new access in today's technical World. We use tutorials and instructions that were created in advance by students and co-workers of the Graz University of Technology. In this paper, we show that embroidery coding gives an alternative opportunity for young women to be creative and to learn to program. During the GCW qualitative and quantitative data were collected through interviews, created games and embroidery designs and surveys, which refer to motivational aspects. First results show that this playful, easy and effective way of learning to program while creating an embroidery design reinforces young women for coding and gives them especially a new perspective for future careers. The findings show that girls were very passionate about designing their own pattern and stitch it on fabric instead of game coding. The authors argue that the programming of embroidery designs can be intended to prevent the falling interest of girls for coding.

Keywords: Gender, Learning environments, embroidery coding, game design, encouraging computer science, coding week

1. Introduction

The proportion of women with university degrees is rising but is still low in STEM (Science, Technology, Engineering and Mathematics) fields. Statistics like the U.S. BUREAUF LABOR STATISTICS (*BLS*, 2021) say that most job growth from now until 2030 will be in tech, however very few women will be qualified for them. In order to counteract this and to give women the opportunity to shape our future as well it is necessary to strengthen and support the entering of women in STEM studies (Mcnally, 2020). So far, there are a lot of projects such as Ada Developers Academy, Women Who Code, Girl in Tech, to name just a few, to promote a higher proportion of women in technology (*26 Organizations Teaching Women Coders & Girls Around The Globe*, 2020). One of these initiatives is the Girls Coding Week at Graz University of Technology, which has already been held several times. The GCW was held last year in August 2020 in Graz, Austria. The purpose of the one-week course was to motivate and encourage young girls for coding. The course should motivate young women for coding and furthermore take the fear and prejudices about programming.

The 14 girls were between 12 and 15 years old, the average age was 13,57 years. The goal was to motivate the participants in a playful way to program, teach them some basic knowledge and give them their first experiences in computer science. As a main tool the girls used the Pocket Code app. The object based programming languages Catrobat, a block-based language, makes it easy to program and learn computational thinking. This visual programming language has been initiated by Prof. Wolfgang Slany at the institute of Software Technology and is available worldwide in more than 53 languages and is still further developed. The availability in different languages makes it easy for the youngsters to learn programming in their native language.

Catrobat's building blocks simply fit together like Lego bricks, allowing users to create their own custom-programmed games, animations or interactive music videos without any previous knowledge. Another interesting feature is the control of hardware such as drones, lego nxt, arduino, or embroidery machines.

Due to the current covid situation, specifically ensuring hygiene compliance, the girls used their own smartphones to program with Pocket Code. As known from other projects, the "bring your own device" initiative can also lead to young people programming beyond the time they spend in the course. In this way, we hope that the girls will continue programming in their leisure time.

2. Related work

Women are still under-represented in ICT- related fields (Choney, 2018). In Europe only 17% of the specialists are female, this work area is male dominated. The number of ICT professionals is increasing rapidly and shows a further increase in the course of digitalization (Eige, 2018). Even though women in ICT fields receive fair payment, compared to non ICT fields, nevertheless, few women choose this career path (Lamborelle and Fernandez, 2016). Digital competencies and ICT are taught in european schools, but not enough. Many new technologies and increasing digitalization require much more than just teaching how to use these technologies. Students should gain the ability not only to understand these technologies, but also to be able to develop them further (Council, 2017). Further on the number of female publications has increased, from 1955 with 12% to 2005 with 35%, but there are big differences in various fields. In Mathematics, Physics and Computer Science only 15% are female publications. In addition, differences are also apparent with regard to different regions (Huang *et al.*, 2020). Proper use of today's technology is an important skill, but to be able to shape and develop the technology is a privilege limited to a few.

Due to the current situation with COVID-19 everyone needs modern invention to keep up with the work situation. Different fields were affected differently by the pandemic.

Especially female scientists with kids are affected in their field of research. Scientists in physical labs had a very sharp decline, compared to areas that are not device-bound. The smallest decrease in research time was found in the fields of mathematics and computer science. In contrast to the rising working hours, the research time has dropped by 24% (Myers *et al.*, 2020). Many initiatives as well as projects try to inspire young women to pursue a career in computer science. These are for example Webgrrls, Women Who Code, PyLadies, Black Girls Code and Girls Who Code (Vuyst, 2020). Due to the decreasing interest of girls in participating in computing, different approaches are used to try to prevent this. One approach is for example a code club for girls (Zagami *et al.*, 2015). TU Graz also has several initiatives to encourage young women to enter the field of technology, one of them is the annual Girls Coding Week (Spieler, Krnjic and Slany, 2019). In this one week course the tool Pocket Code was used. It is a visual programming language based on a block structure similar to scratch (Slany, 2014). The visual programming language makes it easy to teach simple programming concepts based on algorithms or logic. There is no need to pay attention to syntax errors (Fraillon *et al.*, 2019). A great peculiarity of Pocket Code is that its use on a mobile phone makes it easy and simple in usage for the student (Luhana *et al.*, 2018). The great benefit is that students are already familiar with the device. Additionally, regarding the COVID-19 situation we had not to handle disinfecting the devices, because each participant used her own smartphone.

Nowadays there are already some stitching and coding initiatives. One of them is using turtlestitch, a web-based platform to generate patterns for an embroidery machine (Wolz, Auschauer and Mayr-Stalder, 2019). Furtheron there were successful lessons held with the usage of turtlestitch to demonstrate that ‘women’s work’ is based on computer science (Wolz *et al.*, 2018).

The previous approach of the GCW was teaching programming skills primarily through game design. In this work we want to compare the new approach of embroidery coding versus game design with the Pocket Code app.

3. Methodology

The Girls Coding Week (GCW) 2020 was supervised exclusively by female trainers, to be able to act as a role model as well, they helped the participants and taught them coding skills. Each of them has a broad and fundamental knowledge in computer science. The time for this week was limited, to sum it up: we had about 6 hours per day to encourage, teach and help the young girls.

In advance there were tutorials prepared, devices and robots organised. Due to the covid situation, we had to change the framework and let the girls bring their own devices (a mobile phone) for the coding experience. The prepared material focused on game design, embroidery coding and robotics (truetrue robots, Bigtrack and phiro

robots). The girl's passion in this course was found in game design and embroidery coding. For game development, the participants needed their smartphone with the coding environment Pocket Code. Prepared tutorials were available to all participants for support and inspiration. In addition to the tutorials, the trainers offered help at any time. The girls needed also their mobile phone to program the embroidery patterns. First of all, they drew a design on a piece of paper, afterwards they started to implement this in the Pocket Code app. To realize their projects we prepared three embroidery machines, a big collection of different colours of embroidery threads, fabrics, scissors, needles, and everything else which could be needed. After the girls finished their self-programmed pattern, it could be stitched on a t-shirt, bag or anything else they wanted it to be stitched on.

For the development of games and the patterns, the Pocket Code app was used. With this easy and playful approach, we made it possible for our young students to realize their games and patterns. Due to the covid situation, it was a great benefit to use the app, because the only hardware the girls needed was their smartphone. Most of the participants had their smartphone. Few girls who own an Apple device had to borrow an Android smartphone from us and thus there had been less disinfection to handle.

The course was held according to the open learning concept (Reigeluth, 1999). There was no strict time frame for the lessons. The participants were free to choose their starting topic. Some of them started with game design and some began with embroidery coding. For both they used the same software, the Pocket Code app.

To be able to evaluate the course both objectively and subjectively, at the beginning of the course and at the end of the course each girl answered a questionnaire about her interests towards programming. Furthermore we observed the girls throughout the week and interviewed them about their expectations at the end of the week. We also appreciated suggestions from the participants.

In contrast to the previous GCW the GCW 2020 was designed to be more free and open and there was no strict time frame. The focus lies on learning or improving already existing coding skills. In addition, there should be a loss of fear regarding programming or coding, but not only that to encourage girls for coding. The importance to intervene at young girls to establish a basic foundation for STEM (Master and Meltzoff, 2016) is given.

First of all, the course started with getting to know each other. They introduced themselves to each other. Afterwards the topics for the course were presented, so they could choose with which topic they would like to start. After lunch the girls had time to play a game in the group. The game Werewolves was the most popular among all the girls. In the afternoon they were already into programming in two separate groups.

On one day the group showed interest in some background and theoretical knowledge for coding. The main topic coding was deepen into questions and answers:

- What is a computer?
- What does a person do in a technical field?
- What is algorithm?
- What is a software?
- What is a motherboard?

There had been room for terms like pseudocode, programming languages, artificial intelligence, games, ….

Figure 1: impressions of the first coding experiences

After satisfying this big interest for theoretical knowledge we continued to gather more programming experiences.

The main goal for our educators had been to help, guide and encourage the young girls for their own projects. Whether embroidery coding or game design or rarely chosen robots programming. The content of this course

had its frame, but the girls could choose in which topic they can deepen their knowledge. Therefore the tutorials should give inspiration for their projects.

4. Results and Observations

The results and observations of the course are particularly interesting. Even though the sample was very small to show significant results, insightful findings were evaluated. Three out of the fourteen girls mainly participated in embroidery coding. There had been one participant that exclusively was into embroidery coding. Nine out of fourteen prefered programming an embroidery pattern instead of game design. In contrast there were only three girls who preferred game design.

We can definitely say that embroidery coding is interesting and is getting attention from young girls. To design, code and stitch on their own clothes or further on their self made cherry stone pillow was a great feature for the participants.

This course was very intensive and has produced many impressive results from the participants. There is a rating about the depth and the degree of advancement in game design and in embroidery coded designs:

- simple,
- medium,
- advanced.

Simple for embroidery coded designs means that there have been easily programmable movements. The rating medium is for designs with some movements that are not easily programmed. This could be for instance a heart. Therefore you need some mathematical and logical thinking and furthermore, this knowledge needs to be implemented. Advanced designs are more specific and need a lot of experience in embroidery coding. At this level, the participant can create creative designs consisting of curves and different patterns.

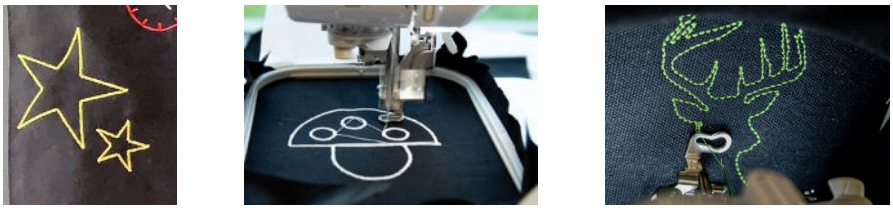

Figure 2: from left to right: simple, medium and advanced

A simple game is based on a provided tutorial. In this category there might be realized own ideas, but the overall game is still too close to the existing tutorial. A medium game has more specific levels, movements, or other detail, which is not shown in any tutorial. A realized game of the participants gets the rating advanced, if it deepend the coding experience and has knowledge and basic understanding as a prerequisite.

In

Table **1** there is one row for each participant and its finished projects during the Girls Coding Week. There is the number of finished embroidery designs with the highest degree of advancement and the number of finished games with its highest degree of advancement. In the last column are listed other projects, which has been realized in addition to their games or embroidery designs.

The majority of the time the girls spent with embroidery coding. There had been just one, who could not be motivated to participate in this topic. The 13 others had impressive designs and all, except one reached the advanced level. In contrast to the game design, there had been three girls, which couldn't be motivated to participate in game design. There had been 4 medium level games and the rest of them reached advanced.

Four out of fourteen tried robotics. There was a girl who even realized a project in embroidery coding with a conductive thread and LEDs, see Figure 3.

Table 1: overview of the finished projects of each participant

Number of Embroidery	Depth in embroidery	Number of Games	Depth in games	Others
1	medium	2	advanced	
2	advanced	1	advanced	
3	advanced	2	medium	1 LED Embroidery
4	advanced	-	-	-
4	advanced	2	medium	
3	advanced	-	-	robots
3	advanced	1	medium	
3	advanced	1	advanced	
2	advanced	1	advanced	
4	advanced	1	medium	
2	advanced	-	-	
3	advanced	1	advanced	
2	advanced	2	advanced	
-	-	1	advanced	

Figure 3: impressions of the results of the embroidery coding

In order to get an overview of the participants' existing skills and current circumstances, they completed a questionnaire before and after the course.

Each participant has access to a computer, even more particularly, most even have their own. All but three are allowed to use a computer daily, or whenever they need one.

The evaluated self-assessment of programming shows that the participants got more confident with programming as such. It can be seen that they got more interested in learning programming, its importance, confidence and even the fun factor. The questions are:

- Question 5: Learning programming interests me.
- Question 6: It is important to be able to program.
- Question 7: I am sure I can learn how to program.
- Question 12: Programming is fun for me.

The answers for questions 5, 6, 7 and 12 are shown in Figure 4.

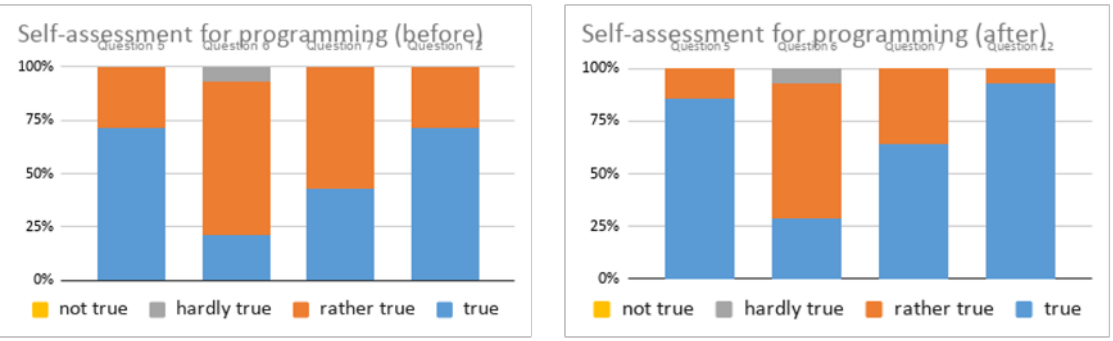

Figure 4: answers to questions 5,6,7 and 12, before and after the course

Both before and after the courses, 50% say they like STEM subjects. Before the course, eleven participants say 'rather true' while three say 'true' that they are well versed in smartphones and computers; after the course, this assessment rose to five 'true' and nine 'rather true' answers. The participants' confidence in using technology has improved.

Only four participants are inexperienced in programming, while the others have already gained some impressions at school or home. The questionnaire shows that the girls already had first experiences in the technical field. The same results were obtained from the observations and interviews.

There are 85,8%, who can imagine what people in technical professions do. Furtheron 78,6% sees themselves in a technical field and 85,7% believe that programming is important for their future profession.

To gather an impression about the interests and background we can show an overview of the rating for different types like programming games, apps, websites, machines and so on.

The greatest interest of the participants is in both game programming and app programming. Closely followed by the interest to edit images. There is less interest in website design, programming machines (robots, embroidery machines,..) and at least to design blogs. After the course, the biggest interest was in programming apps, closely followed by edit images. The interest in programming games decreased, but the interesit for machine programming increased. The experiences with the embroidery machine and programming has definitely influenced the interest of the participants. The time for this course had been too short, most of the participants, in total 92,9%, would have liked to spend more time with programming. To go into some detail: 35,1% of the participants answered with 'true' and 57,1% with 'rather true', that they would have liked to spend more time with embroidery programming. A full 92,5% are proud of their design.

In game design, 23,1% answered 'true' and 46,2% 'rather true' to spend more time and 92,8% are proud of their games. The participants were fully caught up in the enthusiasm, especially in embroidery coding.

The questionnaire shows that everyone felt comfortable and taken seriously. The expectations of the participants have been fulfilled. There were no more open questions. The course was diversified, which had a good impression on the girls. The breaks with the werewolf game were also a great benefit for the participants. Most of them were fancy about handicraft (making their cherry stone pillow). Trying out many different things has left a good impression on the participants.

At the end of the course, the participants had presented their works to the other group members. In the presentation, we made the observation, that they inspired each other. In Figure 5 are some posters of the final presentations. In this last presentation, it also became apparent once again how proud they were of their programmed projects. The resulting games and embroidery designs are impressive. Figure 6 shows a collected work of embroidered and self-programmed designs of the participants.

Figure 5: final presentations of the Girls Coding Week

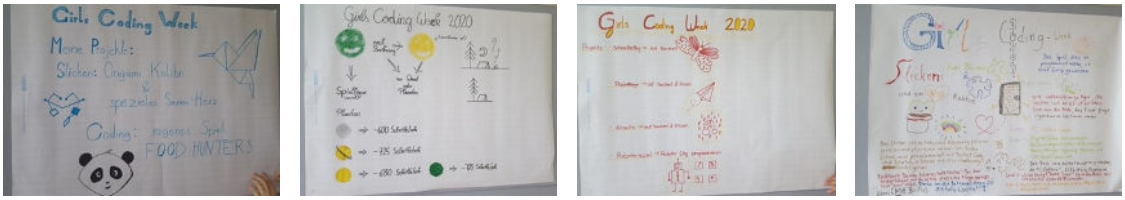

Figure 6: collection of stitched design of the participants

5. Conclusion

The GCW was held at Graz University of Technology and has tested the new access embroidery coding with the Pocket Code app. The participants showed a great interest in embroidery pattern programming. Some were gripped by enthusiasm that they almost couldn't stop improving or expanding their designs. They didn't even realize how much they had actually programmed. Embroidery coding can provide a new entry point for young women into technology. This approach found particular appeal, and therefore it would only make sense to pursue it further. Drawing, programming, and stitching the design with an embroidery machine onto clothes or bags put the focus on the work, not the programming. Creating, designing and realizing a design aroused the enthusiasm of the girls.

To integrate the embroidery coding with existing initiatives to promote women in technical fields, therefore an embroidery machine would be useful. In Austria, every now and then there is a school that is willing to purchase an embroidery machine for this purpose itself. Here the costs are about 600 euros (Stickmaschine Test 2021, 2020). In some cities, there are also shops where you can have a work embroidered on a piece of clothing. However, this is not always so easy and also associated with costs.

To sum it up, we can say that it is definitely a good and meaningful approach for young women and can definitely be pursued further.

6. Outlook

In the meantime, Embroidery Designer app, a new version of Pocket Code that focuses on programming embroidery designs, has been developed and is available for free in Google Play Store. In future coding workshops this new app Embroidery Designer should be used. With the app it is planned to make the programming of embroidery patterns even more convenient, such as the filling of areas and surfaces, which until now could only be realized with complex programming.

The field of smart textiles represents a new trend in software development with great potential. In the future, we will focus our research on creating access to smart textiles for the next generation. The Embroidery Designer app will be used for this purpose. This access should represent a significant step in the production of smart textiles: to programm the textiles by oneself, easily, everywhere, at any time and on site with the own mobile device. Figure 7 shows the first results that could already be implemented during the GCW.

Figure 7: first steps toward smart textiles

On the whole, this approach can be further developed in a wide variety of directions to offer an even broader range of applications for programming initiatives. However, the already existing tool is ready for use and already represents a marvelous approach for the encouragement of young people into technology. In particular, embroidery coding intends to inspire girls who lose interest in technology in their teens and to continue to raise their interest in technology.

References

26 Organizations Teaching Women Coders & Girls Around The Globe (2020). Available at: https://learntocodewith.me/posts/13-places-women-learn-code/ (Accessed: 14 January 2021).

BLS (2021).

Choney, S. (2018) *Why do girls lose interest in STEM? New research has some answers — and what we can do about it*. Available at: https://news.microsoft.com/features/why-do-girls-lose-interest-in-stem-new-research-has-some-answers-and-what-we-can-do-about-it/ (Accessed: 14 January 2021).

Council, E. (2017) *Are We All In The Same Boat? Association for Computing Machinery*. Available at: http://10.0.4.121/3106077.

Eige (2018) *Women and men in ICT: a chance for better work-life balance - Research note*. doi: 10.2839/441540.

Fraillon, J. *et al.* (2019) *IEA International Computer and Information Literacy Study 2018 Assessment Framework*. Cham: Springer International Publishing. doi: 10.1007/978-3-030-19389-8.

Huang, J. *et al.* (2020) 'Historical comparison of gender inequality in scientific careers across countries and disciplines', *Proceedings of the National Academy of Sciences of the United States of America*, 117(9), pp. 4609–4616. doi: 10.1073/pnas.1914221117.

Lamborelle, A. and Fernandez, L. (2016) *Women in ICT – How do EU member states measure up?*

Luhana, K. K. *et al.* (2018) 'Rock bottom, the world, the sky: Catrobat, an extremely large-scale and long-term visual coding project relying purely on smartphones', *arXiv*.

Master, A. and Meltzoff, A. N. (2016) 'Building bridges between psychological science and education: Cultural stereotypes, STEM, and equity', *PROSPECTS*, 46(2), pp. 215–234. doi: 10.1007/s11125-017-9391-z.

Mcnally, S. (2020) *Gender Differences in Tertiary Education: What Explains STEM Participation? | IZA - Institute of Labor Economics*. Available at: https://www.iza.org/de/publications/pp/165/gender-differences-in-tertiary-education-what-explains-stem-participation.

Myers, K. R. *et al.* (2020) 'Unequal effects of the COVID-19 pandemic on scientists', *Nature Human Behaviour*, 4(9), pp. 880–883. doi: 10.1038/s41562-020-0921-y.

Reigeluth, C. (1999) *Instructional-design theories and models, Vol. II: A new paradigm of instructional theory (92)*.

Slany, W. (2014) 'Pocket code', in *Proceedings of the companion publication of the 2014 ACM SIGPLAN conference on Systems, Programming, and Applications: Software for Humanity - SPLASH '14*. New York, New York, USA: ACM Press, pp. 35–36. doi: 10.1145/2660252.2664662.

Spieler, B., Krnjic, V. and Slany, W. (2019) 'Girls create games: Lessons learned', *arXiv*, (July).

Stickmaschine Test 2021 (2020). Available at: https://www.rtl.de/vergleiche/haushalt/stickmaschine-test/ (Accessed: 15 January 2021).

Vuyst, S. De (2020) *Hacking Gender and Technology in Journalism*. Taylor and Francis.

Wolz, U. *et al.* (2018) 'Code Crafters Curriculum', in *Proceedings of the 49th ACM Technical Symposium on Computer Science Education*. New York, NY, USA: ACM, pp. 1055–1055. doi: 10.1145/3159450.3162360.

Wolz, U., Auschauer, M. and Mayr-Stalder, A. (2019) 'Code crafting with turtlestitch', in *ACM SIGGRAPH 2019 Studio*. New York, NY, USA: ACM, pp. 1–2. doi: 10.1145/3306306.3328009.

Zagami, J. *et al.* (2015) 'Girls and computing: Female participation in computing in schools', *Australian Educational Computing*, 30(2).