Increasing high school girls' exposure to computing activities with e-textiles: challenges and lessons learned

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ABSTRACT
The number of female students in computer science degrees has been rapidly declining in Denmark in the past 40 years, as in many other European and North-American countries. The main reasons behind this phenomenon are widespread gender stereotypes about who is best suited to pursue a career in CS; stereotypes about computing as a 'male' domain; widespread lack of pre-college CS education and perceptions of computing as not socially relevant. STEAM activities have often been used to bridge the gender gap and to broaden the appeal of computing among children and youth. This contribution examines a STEAM pilot workshop organized by the IT University of Copenhagen which targeted high school girls. The workshop aimed to introduce the girls to coding and computing through hands-on e-textiles activities realized with the Protosnap Lilypad Development board. This contribution discusses the advantages and challenges of using e-textiles activities as introduction to coding and computing.

Author Keywords
Gender gap in CS; wearables; e-textiles; STEAM; computing education; gender stereotypes; Denmark.

ACM Classification Keywords
K.3.2. Computer science education.

INTRODUCTION
Computer science degrees have become less and less popular for women in Denmark. In 2015, women made up just 9,3 % of the total student population in software development degrees - whereas in the 1970s they were approximately 25% [1]. National statistics from 2016 show that the Danish university with the highest percentage of female students admitted in computer science education was DTU with 12%, while Aalborg university lagged behind with just 2% [2]. According to international research literature in the field of gender and computing education, these are the main barriers preventing women from entering CS education:

1. **Gender stereotypes and gender bias** about who is best suited to pursue computing prevent girls from identifying with the field. [3, 4, 5, 8]. Gender bias and stereotyping can also lower the girls' self-confidence, and might prevent parents and teachers from encouraging them to experiment with technology and computing.
2. **Stereotypes about the CS domain** and the prevalence of the **'male nerd'** archetype [3, 6, 7].
3. **Lack of CS education in high school** [4].
4. **Perceptions of computing** as not socially relevant and too narrowly focused on technology [9].

In recent years, several hands-on educational computing activities have been specifically designed and employed to broaden the appeal of computing education across genders, in an attempt to break stereotypes and make clearer connections to real life applications of computer science. STEAM activities have been successfully used to expose children and youth to computing activities combining coding, crafts and design. Researchers have experimented with teaching coding through **electronic textiles** as a successful way to specifically engage more girls and women in CS education [10, 11].

E-textiles activities effectively combine two domains that have developed strong gender connotations. They bring together sewing and textiles - usually associated with femininity - with computer programming, commonly associated with the male domain.

CONTEXT
ITU has varying percentages of female students enrolled in its bachelor courses: as of October 2016 the bachelor with the highest proportion of females was the BS in Digital Media and Design (41,5%), while the one with the lowest proportion was the BS in Software Development (11%). In order to actively experiment with new ways to engage more female high-school students in computer science activities and careers, the IT University of Copenhagen (ITU) has launched a one-day pilot course in e-textiles adopting Lilypad Arduino kits (Protosnap Lilypad Development Board) and recycled t-shirts. The target group for the workshop, which took place at ITU in the spring 2017, were 22 girls aged 16 to 18 from a local *gymnasium* (high school). All participants had previous sewing experience, but most of them did not have any coding experience. Roughly half of the girls were enrolled in their school's specialized study program in Math, and half in the social sciences program. The workshop has been taught by three ITU students from the Digital Media and Design program supervised by me.

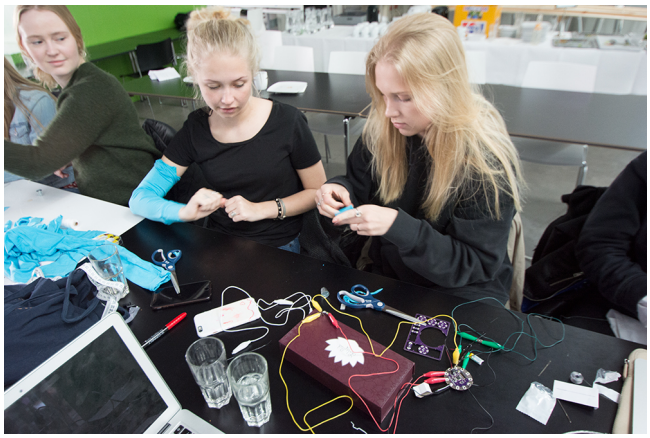

Figure 1. Two participants of the workshop working on their design

CONTRIBUTION

Through the unification of coding and craft, the goal of the workshop was to show that programming is approachable and applicable in a wide variety of contexts. The workshop also aimed to create a comfortable, counter-stereotypical exposure to programming and computing through tinkering and live coding. This contribution discusses whether and how hands-on e-textiles activities can reach these goals.

I also analyzed some of the challenges posed by this approach by asking the following question:

- How can educators avoid to reinforce gender stereotypes while connecting coding with a domain that traditionally has strong 'feminine' connotations?

LESSONS LEARNED

During the workshop, students learned the basic of coding and designed their own interactive wearables through embedding microcontrollers, switches and LEDs onto the t-shirts. After an introduction showing the many different applications of computing to the physical world – not least in art and design - the students familiarized themselves with the role of input and output devices, as well as algorithms. They learned to code using the Arduino software, and during the last two hours they brainstormed and crafted wearables such as a stretchy hat for joggers with light sensors and LEDs programmed to turn on in low light; a party t-shirt with a switch to select one's status to potential partners (single/taken), and various garments with decorative blinking lights embedded in pre-existing patterns.

This is what I have learned from the experience:

- Using a variety of **scaffolding techniques** is crucial for increasing students' self-confidence within a subject they have no familiarity with, such as computing and e-textiles, and to create a comfortable learning environment. As scaffolding, the instructors have successfully used questions (i.e. 'what is a computer?'; 'what forms can a computer have'?), what-if questions, prompts and visual scaffolding - such as showing a picture of ingredients such as flour, eggs, yeast to represent the *input (sensors)*, a photo of the Disney's cookbook to stand for *algorithms*, and a picture of a loaf of bread to illustrate the *output* (*actuators)*.
- **Well planned group work** is necessary to maximize resources, reduce costs and **ensure equal participation**. Dividing the class in groups of 4 reduced the costs for micro-controllers and other materials, but required strategic planning in the live coding portion of the class. Working with only one computer every 4 people and requiring each student do *at least* one coding exercise ensured that everybody gained hands-on experience with the Arduino software.
- Combining theoretical aspects of the basics of computer science, electronics, design thinking and tinkering proved successful in presenting a **holistic approach to computing**, encompassing more than just coding. It also made it easier for the participants to making explicit connections with a number of disciplines. This approach, however, makes planning quite time-consuming due to the short duration of the workshop, the wide variety of subjects introduced and the number of unfamiliar hardware components included in the Protosnap Lilypad Development board.
- The hardware tools used did **not require any soldering or resistors**, making the activity particularly good for absolute beginners in electronics, yet due to the sheer number of components in the sewing kit it could be advisable to design a visual reference/glossary to hand-out to students, and a separate sheet illustrating basic circuits.

During the preparation of the workshop the issue of **gender stereotyping** was raised in several occasions. The following are some of the reflections generated by the experience with the workshop.

- Not necessarily a 'fashion' event. We wanted to **avoid turning the workshop into a 'fashion workshop'**, and were not so interested in stressing the aesthetics potential of the medium used, or in emphasizing the 'beauty' of the materials/outcomes. Instead, we decided to **focus on re-making and recycling** as opposed to passive consumerism, inviting participants to buy the t-shirts in second-hand stores. We encouraged students to **tinker and explore materials rather than producing perfect sewing stitches**: to this end we provided double sided tape which most students used to glue the conductive thread to the fabric instead of sewing. Besides, the Protosnap kit

allows for leaving sensors and microcontroller in place without the need to apply them with thread.

- Next time we will experiment with an introductory e-textiles event **open to both females and males.** While it is important to provide activities for girls only in order to create a more comfortable learning environment, especially in introductory courses within a field where males tend to be more likely to have previous hands-on experience acquired in informal settings [6], experimenting with wearables and e-textiles can successfully engage both males and females due to the number of fields students can design for: medicine, sport, art, theater etc.
- Creating activities for 'girls only' within the formal context of high school education, and in a scientific discipline such as computing, might wrongly suggest that females need separate learning activities from males, reinforcing gender stereotypes. The high school teacher of the girls also suggested to repeat the e-textiles workshop for both males and females in order to engage the class in its entirety.

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