GIRLS AND COMPUTING IN LOWER SECONDARY EDUCATION

The surprisingly unsurprising results of a Norwegian exploratory study

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Abstract. *The low percentage of women pursuing Information Technology (IT) education is a concern in many countries worldwide. This exploratory study is motivated by the experimental introduction of an elective programming course in a selected number of Norwegian Lower Secondary schools, now recently extended to include any interested school. Though there is a growing body of knowledge in the area, we believe this study is important to understand the situation in a moment of great change in the national curriculum. Given the nature of our investigation, we have adopted multiple methods to collect a variety of data and get an overview of the practice. The main reasons not to choose IT education include: the poor reputation of programming, lack of information about the course, lack of knowledge about programming and technology and what it could be used for, the impression that programming is not useful to help society, the negative influence of parents and friends, and the disinterest in programming. To a large extent, these results are not surprising in that they confirm results from similar studies worldwide. However, the results are unexpected considering the social and economic conditions of Norway. This paper mainly wants to act as a warning pointing out that despite the high gender balance in Norwegian society, this does not automatically solve the gender gap in IT education, with important consequences on the longer term for the job market.*

Keywords: Gender issues, Lower secondary education, Programming, Elective course

1. INTRODUCTION

During the second World war, most programmers were female (Light, 1999). Since then, the ratio of female engineers and technologists has decreased enormously. Today there are few women who choose to study STEM (Science, Technology, Engineering and Mathematics), and as a consequence there are fewer women than men working in the technology industry (Sassler, Glass, Levitte, & Michelmore, 2017). Approximately half of the users of today's technology are female, but most of the developers and engineers who create these technologies are men (Rosenbloom, Ash, Dupont, & Coder, 2008).

This gender gap exists also in Norway, despite the fact that the country is characterized by a high level of gender equality, ranking in the top three countries in the Global Gender Gap Report in 2016 (Leopold, Ratcheva, & Zahidi, 2016). According to the report, the gender gap in STEM studies is still relatively big, with a STEM graduate ratio of 9 to 36 (women to men). Even though the female ratio of Computer Science (CS) students at the Norwegian University of Science and Technology (NTNU) has increased since 2008, the increase is relatively small, and in 2016, only 13% of the applicants to the integrated master's programme CS at NTNU were female. The low number of girls studying STEM, and IT in particular, is a challenge also in lower and higher secondary education (in Norwegian, respectively *ungdomsskole* and *videregående*).

According to official data, while subjects like biology and chemistry are popular among girls, the percentage of girls taking IT courses is very low.

The concern that motivates the investigation presented in this paper is connected to the introduction of an elective course in programing in lower secondary education. In 2016, the Ministry of Education and Research in Norway introduced a pilot project of programming in some of the lower secondary schools around the country and the project has later been extended and all schools can now offer the subject (see Ministry of Education and Research, Press release Nr: 65 – 17; 10.05.2017). At the time of the study there were five schools in Trondheim offering the subject. In all five classes the percentage of girls who signed up for the course is very low, and since the start of 2017 some of the few girls have already dropped out. This is clearly a challenge since there is a risk to widen the gender gap in later years.

With this study, we want to explore the current situation in lower secondary schools with respect to participation to programming courses and reasons to study, or not, programming. Though there is a growing body of knowledge in the area, we believe this study is important to understand the situation in a moment of great change in the national curriculum. Given the nature of our investigation, we have adopted multiple methods to collect a variety of data and get an overview of the practice. We started with an analysis of existing activities to promote science education among girls. This analysis is mainly based on document analysis and on the personal experience of one of the authors with some of these activities. Second, to collect teachers´ perspective, we designed and distributed a questionnaire to teachers during an experience sharing conference. Third, to collect students´ perspective, we used Kahoot!, a multiple-choice quiz where one question is asked and the participants are given between two to four alternatives with minimum one of the alternatives being correct (*https://kahoot.it/*). This tool was chosen for its popularity among students, being regularly used in many classrooms. Kahoot! was used during six school visits to ask both male and female students about their understanding of programming. Fourth, the main empirical data is constituted by a total of 7 interviews, 2 with CS students at NTNU and 5 with younger girls to get their perspective of what programming is, how it can be used, and their interests in taking programming courses and studying programming related studies.

The paper is organized as follows. Section 2 provides an overview of ongoing activities in Norway to promote girls' participation in STEM education. Section 3 presents and discusses the results of the teachers' questionnaires. Section 4 presents the students' perspective, briefly reporting the results from Kahoot! and from the interviews. Section 5 discusses the results in light of the Norwegian context. Section 6 closes the paper with a call for action and for research to address the identified challenges.

2. ONGOING ACTIVITIES

One way of closing the gender gap in the STEM field is to introduce programming and other science studies to girls at an earlier stage of school life. Among other countries, programming has been introduced in elementary schools in the USA by storytelling (Kelleher, 2006) and game design (Baytak & Land, 2011), in Scotland by using Scratch (Wilson, Hainey, & Connolly, 2012), in Ireland by introducing a Java applet (Gibson, 2003), and in Italy by designing robots (Demo, Marcianò, & Siega, 2008). There are also a number of initiatives that are aiming worldwide to promote STEM education with focus on girls. Just to mention a few, the Women's Technology Program (wtp.mit.edu) and the Women's Initiative at the Massachusetts Institute of Technology (web.mit.edu/wi), Girls Who Code (girlswhocode.com), Girls in Tech (girlsintech.org), TechGirls, Google's Made with Code (www.madewitgcode.com), and Girls in Technology (womenintechnology.org/girls-in-technology), Bringing Up Girls in Science (BUGS) (Tyler-Wood, Ellison, Lim, & Periathiruvadi, 2012), and Sisters Rise Up 4 CS (Ericson, Parker, & Engelman, 2016).

In this section, we provide some examples at the national level. Most of the provided examples are focusing on activities involving NTNU and/or geographically located in Trondheim. This is not because they are better than others. Other universities and local organizations might also provide excellent initiatives. With this section,

we do not aim at selecting the best or most relevant initiatives, but rather to give an idea of the variety of initiatives that are available. In the following we provide a short list of initiatives.

- The Girl Project Ada (TGPA) is NTNU project to recruit and retain women in technology studies (www.ntnu.no/jenter) As part of its recruitment activities, TGPA organizes a number of events and activities targeting pre-university students of different age, most relevant are:
- *NTNU Technology Camp*, a 3-day event where girls from all over Norway are invited to experience education opportunities in STEM (www.ntnu.no/camp).
- *Ada Club*, upstarting in Fall 2017, is a project which aims to motivate girls from lower secondary schools to start technology studies later in the future (www.ntnu.no/jenter/adaklubben). The Ada Club will be a programming club for girls, where the tasks that are given are adjusted to the girls' interests.
- The Faculty of Information Technology and Electrical Engineering (IE) recruitment program at NTNU organizes two yearly events targeted to female students, including:
  - The Girl's Day **(***Jentedagen***),** similar to the Technology Camp but of shorter duration (www.ntnu.no/jentedag). In one and a half day, girls who are currently in their last year of upper secondary school are introduced to a variety of STEM studies at NTNU through stands and lectures.
  - The Technology Day **(***Teknologidagen***)** is similar to the Girl's Day, except both boys and girls are invited, and it is mainly for the students in 2nd grade in upper secondary school (www.ntnu.no/teknologidag).
- Code Clubs (*Kodeklubben*), coding clubs for children to learn programming (https://kidsakoder.no/kodeklubben/) They are coordinated by Lær Kidsa Koding, the largest voluntary organization in Norway for promoting computing education, with more than 100 clubs around the country. Although there is no set age limit, the children who participate in these courses are usually in between ages 8 to 14. The tutors in the classes are usually students who are either studying programming related studies or students who are interested in programming.
- *Kodeløypa***,** a one day event held at NTNU for children in 10th grade who are attending schools in the northern and southern Trøndelag region. It is part of a larger framework to promote STEM education that includes also activities in Mathematics, Energy, Physics, Chemistry, and Biology. The purpose of Kodeløypa is to introduce students to programming.
- *Girl Tech Fest* (GTF), a yearly one-day event held throughout Norway and organized by Jenter Koder (Girls Code) (www.jenterkoder.no) for girls attending elementary schools. The goal of GTF is to inspire more girls by exploring the possibilities there exists by the use of technology.
- The Girl Conference (*Jentekonferansen*), a yearly event for lower secondary school students in 9th and 10th grade and upper secondary school students from the Trøndelag region as part of the recruitment activities of Campus Kalvskinnet-NTNU in Trondheim.
- *National Centre for Science Recruitment*, a national arrangement supported by the Ministry of Education in Norway to increase recruitment to STEM education and professions. Two initiatives worth mentioning in this context are:
  - *The Role model* program, recruiting role models to visit elementary schools, lower and upper secondary schools all over Norway (www.rollemodell.no) and encourage students to study STEM.
  - *ENT3R***,** a nationwide after-school activity for students in 10th grade lower secondary school and for upper secondary school where university students who are studying science are tutoring the younger students in science related subjects (www.ent3r.no). ENT3R aims to create a sense of achievement for

the participants in order for the motivation of the students to increase and to reduce the dropout rate in upper secondary schools.

Table 1 compares these initiatives by specifying their target group, in terms of age and gender. For each initiative, the table also specifies if it is mainly intended to have a motivational impact or it also includes a strong educational component.

Table 1. Overview of national initiatives

Activity	Purpose of attracting both genders to STEM	Purpose of attracting girls to STEM	For a specific age group	Motivational/ Educational
TGPA	No	Yes	Secondary school and NTNU students	Both
Technology Camp	No	Yes	Upper secondary school	Both
The Ada Club	No	Yes	Lower secondary school	Both
The Girl's Day	No	Yes	Upper secondary school	Motivational
The Technology Day	Yes	Not specifically	Upper secondary school	Motivational
The Code Club Trondheim	Yes	Not specifically	Open for all, but primarily for elementary school	Both
Kodeløypa	Yes	Not specifically	10th grade	Both
Girl Tech Fest	No	Yes	Elementary school	Both
The Girl Conference	No	Yes	Lower secondary school	Motivational
NCSR: Role models	Yes	Not specifically	Pre-university	Motivational
NCSR: ENT3R	Yes	Not specifically	10th grade and upper secondary school	Both

Table 2 provides an overview of duration and methods that are used by each initiative to attract students. This, indeed partial, list of activities should give a flavor of the number and quality of ongoing activities in Norway. These activities, compared to the literature presented at the beginning of the section, can be considered as state of the art.

Table 2. Motivational methods in national initiatives

Activity	Duration	Methods used for attracting students to STEM
TGPA	Long-term	Role models, Social activities, Educational activities, Inspirational lectures, Campus tours, Information stands
Technology Camp	Short-term	Role models, Inspirational lectures, Educational activities, Social activities, Campus tours, Information stands
The Ada Club	Long-term	Role models, Educational activities, Social activities, Campus tours
The Girl's Day	Short-term	Role models, Inspirational lectures, Information stands, Campus tours
The Technology Day	Short-term	Role models, Inspirational lectures, Information stands, Campus tours
The Code Club Trondheim	Long-term	Role models, Educational activities
Kodeløypa	Short-term	Role models, Campus tours, Educational activities
Girl Tech Fest	Short-term	Role models, Educational activities
The Girl Conference	Short-term	Role models, Campus tours, Inspirational lectures, Information stands
NCSR: Role models	Short-term	Role models, Inspirational lectures
NCSR: ENT3R	Long-term	Role models, Educational activities

3. THE TEACHER PERSPECTIVE

In order to explore the perception of teachers, we distributed a questionnaire at a teacher experience sharing conference with circa 70 participants. Within a longer questionnaire, we added few questions to get the teachers' perspective on a) why there are generally fewer girls than boys taking programming courses in Norway, b) whether they were teaching programming in their schools, and c) if they had taken certain measures to encourage more girls to choose the subject. The questionnaire was answered by 34 teachers, 15 of whom had or were teaching programming. Before the questionnaire was handed out, there was a presentation of TGPA's views on what motivates girls to study STEM. Answers might therefore have been influenced by the presentation.

3.1 Participation

All the 15 teachers currently teaching programming, the only ones for which we report results in this section, reported a low percentage of girls taking programming. Only in two of the 15 schools the boy-girl ratio was 50%, while in 13 out of 15 schools the girl percentage was 33,3% or lower, including two schools with no girls in their programming class. Of the 15 teachers, only two reported that they tried to appeal to girls when presenting the programming course to the students, while six said that they would focus more on recruiting more girls to the course starting from next year's classes. Four of the teachers thought that it was unnecessary to appeal differently to girls.

One of the teachers, who had only two girls in the class out of 14 in total, answered that they had made the course more interesting for girls by focusing on function and design, and not only programming games, and that they would use girls and boys from this year's class to advertise for next year's class. Another teacher, who had one girl in the class out of 20 in total, reported that they had focused on including web design and 3D modelling when presenting the course for potential future students in order to appeal to girls.

3.2 Reasons for not attending

Six of the participants thought that one of the reasons for few girls is because of stereotypes of programming, and the fact that the IT industry is male dominated. One teacher suggested that it is because of programming being associated with algorithms and not design and creativity, another teacher thought that a reason for girls not choosing to study programming is because programming is associated with gaming. Two participants thought that it depends on which subjects their friends are choosing. One teacher thought that it was based on interest, and another connected it to the lack of knowledge about what programming actually is. One participant mentioned that from the time children are attending kindergarten, the girls are encouraged to care for their dolls and to draw, while boys play with Lego and building things, and this could be connected to their lack of interested in making things through programming.

3.3 Suggested solutions

Five participants thought that programming should be taught while the children are attending kindergarten or elementary school. Three teachers thought it would be useful to separate boys and girls in the programming classes, and other three that there should be more female role models. Three participants thought it was important to make the class relevant for girls' interests by including topics such as storage of information and social media. Two teachers suggested focusing on the creative aspect of programming, two suggested more information about the programming course, and two suggested to focus on the usefulness of programming. One teacher suggested that to include more girls, the progress of the course should be slowed down.

3.4 Discussion

When considering the answers of the teachers, it is important to underline that the subject is new, so teachers had had no time yet to adopt corrective measures or fully understand the phenomena and the implications on the long term of different pedagogical choices they might make. It is clear that there is no general agreement as to why there are so few girls in the programming classes. This is not surprising since there is also in international literature no agreement of reasons and measures to improve the situation. Although many of the participants had reasonable ideas to improve today's situation, it seemed like a few teachers had some misconceptions about the programming subject and suggested possibly problematic solutions to the problem. Three of the participants suggested to separate boys and girls in their programming classes. Even though it could be that girls would prefer to work together with other girls to avoid being a minority in e.g. a group project, splitting the class could give the impression that boys and girls cannot work on the same problems or

that some problems only can be solved by boys. This is turn might discourage girls to choose to take the class, and even lead to increase gender stereotypes in the classroom (Bigler, 1995).

One teacher suggested that a possible solution could be to slow down the course's progress to adjust to girls' pace. This could be interpreted as girls are 'less smart' than boys. If this attitude is conveyed in the teacher's presentation of the course, this in itself could be discouraging for girls. Unfortunately, sexism is still present in some of today's schools, and one should be careful when choosing teaching methods based on stereotypes (Sadker & Sadker, 2010). Though some teachers did not think they needed to change anything to recruit more girls, but most teachers did agree that they needed to change something to encourage more girls to take the programming class.

4. THE STUDENT PERSPECTIVE

4.1 General perspective on programming

To start our investigation, we conducted a Kahoot! quiz during 6 visits of TGPA to 3 schools in Trondheim, 2 of which offering the elective programming course. In total, 162 students answered (of which 95 girls). Reporting the full results is beyond the scope of this paper. Here we only want to underline some of them to contextualize the results from the interviews.

There were surprisingly many students who answered they know what programming is, with over 70% for both boys and girls in all three schools. However, it should also be underlined that, from the following discussion, it seems that some of the students might have a misconception, e.g. when they describe making a PowerPoint presentation as programming. There was little difference between the girls' and boys' answers in this question. In the non-programming school F, there was a higher percentage that answered that they knew what programming were, compared to the programming schools A and B. However, the gap between boys and girls increased when we asked if they had done some programming before. More boys in the non-programming school F answered that they had some experience with programming, compared to the other programming schools. Most students think they need no prerequisite to learn programming, though several of the students thought they need to know advanced mathematics and similar percentages logical thinking, while only a few selected gaming skills.

When asked which profession one can have if they want to help people, most students answered *Nurse*, preferred over the other three alternatives, all science related professions. It seemed that many students did not think studying or having science professions entails helping people. Both boys and girls from all three schools agreed that being a nurse was the profession that one should have if they want to help people. Even though most of the students from the programming schools answered *Nurse* to this question, there were some students who chose other answers, while in the non-programming school F all students except one answered *Nurse*.

One aspect that is worth to underline is the difficulty to extract any precise pattern from the data. This might of course be related to the method used for data collection, with students answering quickly to be first rather than reflecting in depth on the question. Additional data should be collected in a more systematic way, for example by using questionnaires with rating scales without any time limit, to detect any pattern.

4.2 Interviews with girls

A semi-structured interview with seven interviewees was performed during a period of one month: 2 first year students of Computer Science at NTNU and 5 girls, 4 attending 10th grade lower secondary school and one 7th grade, i.e. close to start lower secondary (used as pilot). The purpose of these interviews was to ask each interviewee individually about their opinions of programming and technology, and of programming as a subject in lower secondary school specifically. The goal of the interviews was to find specific reasons to why some

girls do not choose to study programming courses, and to find possible misconceptions of programming and technology. The interviews lasted circa an hour and were audio-recorded, then transcribed and coded to identify the emergence of common patterns. Participants to the study were selected through personal network (the first pilot interview) or during school visits and events at the university. Participants were compensated with a gift card of 200NOK.

There were several aspects and reasons that made the girls choose to take or not take programming courses. Some girls had more knowledge of programming and technology than others, but there was no strict correlation between knowing what it meant and the interest in it. In Table 3 we summarize the reasons that have been identified in the interviews for not choosing programming.

Table 3. Reasons not to choose programming courses

Reason	Description	Comment
1	Lack of information	Some girls did not choose the programming course because they did not get information about the course
2	Lack of knowledge	Some girls did not choose the programming course because they did not know what programming was
3	Influenced by friends and family	Some girls did not want to choose a subject which none of their friends chose, and some girls were advised by their parents to study other fields than CS
4	Interest and motivation	Some girls said they did not want to study programming simply because they had no interest in it
5	Bad reputation	Some girls considered programming as "nerdy" and "boyish" and did not feel that it fit their personalities
6	Programming linked with other science subjects	Some of the girls said they were not good at math and other science subjects, and therefore thought it would not be a good fit for them
7	Not a profession that could help people	A few girls said they wanted a profession where they could help other people, and did not think it would be possible with a profession within CS
8	Lack of time	Some girls said that they could be interested in taking the course, but that they did not have time to learn it by themselves
9	Other more appealing subjects	One girl who said she wanted to take the programming course said that she chose another subject simply because it meant more time off
10	Subject not offered at the school	The interviewee from School F said she would be interested in taking the course if it would be possible to choose it at her school

Most of the young girls that were interviewed said that they would be interested in learning programming, or at least trying it, but none of the girls would want to explore it on their own. Two of the girls said that they would consider taking IT courses at their upper secondary schools. Few of the girls expressed interest in

technology in general, but all the interviewees said that they used technology regularly. Of the two interviewees from the CS study at NTNU both expressed interest in technology before starting at NTNU, but only one of them expressed interest in and experience with programming before starting at NTNU.

Many of the interviewees reported little knowledge of what programming actually is. This was the case also for one of the interviewees studying at NTNU, before starting her study. Few girls knew what programming can be used for, and those who answered that they thought they knew what it could be used for mentioned mostly apps, web pages and blogs. Of the lower secondary school students, only one interviewee knew about the different career options after studying technology. The terms *IT*, *engineer*, *programming* and *coding* had different meanings for nearly all of the interviewees, and out of the five girls that did not study at NTNU, only one of them was aware of several career options of an engineer.

All of the interviewees, except one of the NTNU students, said that they would like or would have liked to have more information about programming in general at an earlier stage of their school life. Most of the interviewees did not really know what programming meant, what is taught in the programming classes, why it is useful, or why it could be relevant for their future. They said that they would have liked more information about programming and technology in general, and they would have liked the information to be given preferably some time before they were to choose subjects at their school. Some of the girls said that they would have liked information about programming and technology in elementary school. They would have also liked to know which types of tasks they would be given in the programming class and how it could be useful for them in the future.

Some of the girls valued the opinions of their friends and family when choosing subjects or studies, while others thought it was not that important what they thought. Three of the students in lower secondary school, and one of the NTNU students had a father that studied technology studies, and out of these four, two of the interviewees said that their father had influenced them into having a positive view of technology and programming. One of the female NTNU students said that one of her friends encouraged her to consider studying CS at NTNU, and even said that she might not have started studying CS if her friend did not mention it to her.

Two of the students at lower secondary school, and one of the NTNU students said that they were introduced to programming and technology through making their own blogs or websites when they were younger. The NTNU student expressed that because of the early interest in designing her own blog she became more interested in programming, and eventually decided to study CS at NTNU. The two students at lower secondary school did not really view their skills used when making a blog as programming. Only one of those two students said that she would probably choose programming courses at upper secondary school.

Many of the younger interviewees did not know what programming meant, but some of the girls had some idea of what they thought it was. It was described as consisting of numbers, letters, and symbols, and that one could make something by programming. In the words of one of the girls "*It seems very frustrating and that there's a lot to think about at the same time, and that's something I can't handle"* Most girls did not know how programming worked or what it was used for. Even though programming and technology was considered exciting, useful, and important for the future for most of the interviewees, it was also considered as a hard, cumbersome, boring, and a subject for boys, *gamers* or *nerds*. The areas of what programming can be used for were perceived as quite narrow, as most of the girls thought that programming was mostly used to make apps, phones, computers and web pages.

Table 4 summarizes some of the measures that have been suggested to improve girls´ participation in programming courses.

Table 4. Suggested solutions

Suggested solution	Description	Comment
1	Introduce programming earlier	Some girls mentioned that they enjoyed making websites when they were younger, and some of the girls were interested in programming because of this
2	Inform about programming courses outside of school	One girl said that she was interested in technology when she was younger, but lost interest as she grew up. If her parents encouraged her to take a course outside of school, then she might not have lost interest
3	Inform about the programming course at school	All of the interviewees requested more information about the subject. Some even said that they would take the course if they would have known that it would be useful for them in the future
4	Include programming tasks relevant to the girls' interests	Several of the interviewees said that they were interested in design, and others mentioned health. Perhaps making programming tasks where they could combine programming with their other interests would encourage them to take the programming course
5	Introduce role models to the girls	Non-stereotypical role models in STEM has shown a positive effect on girls opinions of science related studies

5. DISCUSSION

The motivations for choosing or not to learn programming emerging from our investigation are very similar to the ones reported in international studies. From the interviews that were done, there are several factors that affects the girls' choices in subjects and career choices in positive and negative ways. The identified factors include motivation and interest, lack of knowledge and information about the programming subject, external influences such as friends and family, and misconceptions about programming. Other reasons for not choosing the programming subject included lack of time, other subjects with more appealing benefits or contents, the fact that CS studies usually means that one needs to have taken other science classes before starting at university, and the impression that by studying technology it would be harder to help people.

The factors that influence the girls positively include if their friends or family had talked positively about programming, if they were aware of the work-life possibilities after finishing their studies, and if they had a genuine interest or motivation for studying it. The factors that influenced the girls in a negative way included factors such as; if their friends or family did not talk about programming, or if they discouraged them from studying it, the lack of information and knowledge of programming and technology, the bad reputation of

programming, the impression that programming is not linked with a profession that could help people, and the genuine disinterest in the subject.

These results are very similar to the ones identified, for example, in an online survey done by Google, consisting of 1090 young women, and 649 young men, aiming at identifying key factors for girls to decide to study CS or not (Wang, Hong, Ravitz, & Ivory, 2015). The study reported the importance of social encouragement and the influence of family and friends. Aspects connected with career misconceptions, e.g. as being a boy-job or with limited possibilities to have a positive impact on the world and taking care of people, are international issues that we identified also in our study, in the Kahoot! quiz as well as in the interviews. The issue of self-perception also emerged from both sources, with girls seeming worried of programming "not being for them", or "interesting but scary".

So, the results that we obtained are not surprising when we compare the gender gap in Norway with the situation in other countries, both in terms of number and reasons. However, they become interesting when we consider them in the wider social and economic context of Norway. As we already pointed out at the beginning, Norway is one of the countries in the world with the highest level of gender equality.

One could expect better results also when considering that, according to the Information Technology Report by the World Economic Forum (Baller, Dutta, & Lanvin, 2016), Norway is among the top 10 performers in the area of Information Technology. In particular, Norway has the world's best ICT infrastructure, ranks 2nd for individuals using the Internet, and the Norwegian Educational system is the 3rd for Internet access in schools. Norway has also a high ICT penetration in private and public sector.

On the overall, Norway has therefore the infrastructure to support innovative CS education, it has attractive and varied jobs that might benefit from IT skills, and it has private and public sectors who might provide different role models and career options. The initial analysis that we performed of relevant initiatives also shows that there are many initiatives outside schools that are addressing the gender gap.

Clearly, this is not enough to prevent the gender gap in programming education. The data that we collected from different sources points out the need to work more systematically on engaging girls with programming. In addition to the measures in Table 4, we also point out the need to increase teachers´ awareness about this challenge, providing appropriate teaching methods and material. The introduction of a new elective subject in programming offers an excellent opportunity to make a change, but it is critical that the issue is addressed immediately because if girls do not take advantage of this opportunity, there is a risk that this will create a cascade effect. As one of the participants to our study explained discussing why girls do not choose programming courses: *"Maybe they think that it is for boys, and that they need to know something before they start, and then think that they can't choose IT or programming because there are so many boys who have spent years in their room programming."*

If the elective subject in programming becomes a "boy-thing", it will become yet another reason for girls not to choose IT studies and careers later in life. As one of our interviewees said, *"It's a pity, because it is a profession and a career path that girls can choose in the same degree as boys, and there isn't really any advantage being a boy in that profession."*

We are aware of the limitations of this study. The research is based on a small number of schools and students. This clearly constitutes its main limitation. Also, the schools that we have visited are all in a relatively large university city. Schools in rural areas might be facing even more challenges. However, the use of multiple methods allowed to gain a rich picture and shed some light to the situation. This is a starting point for further, more systematic, studies.

6. CONCLUSIONS AND FUTURE WORK

As stated at the beginning, the research presented in this paper is intended as an exploratory study to identify a research roadmap and interventions to address the gender gap in IT education, with focus on lower secondary

schools and the elective course on programming. The results of this study present a list of reasons for why girls in lower secondary school do not choose to study programming, and a list of suggested solutions to the problem which the teachers of this subject could use to help recruiting more girls to these programming courses.

Our research will continue along two main directions. On one side, we are aiming at building a better picture of the current situation, capturing better teachers´ perspective and experiences. We also aim at collecting information about successful cases, i.e. school were the percentage of girls is higher than average to identify different success factors. The second research direction is more action based and aims at (co-) designing and running activities that can motivate girls to follow programming courses at the different educational levels.

We close this paper with:

- ***A call for action*** to the larger IT and educational community to get involved and contribute to address this important challenge. There are many interesting existing initiatives that can be supported in different ways. Companies might provide financial support, but also, and most importantly, meaningful and engaging activities and role models. Also, industry and schools need to cooperate to provide better career consultancy and help students to understand the role of IT education in the workplace, both as main career path and as auxiliary competence. To build on the existing experiences, there is a need for better coordination and experience sharing, e.g. more forums, physical or online events, to learn from each other.
- ***A call for research*** to the research and educational community at large. Previous research shows that there is not enough empirical evidence about the methods that work and why they do or don´t work, in particular in relation to specific context conditions and individual characteristics of individual students. A closer cooperation between the research community, schools, IT industry, and voluntary organizations might help to build a better understanding of the gender gap and define empirically validated educational and career consultancy methods.

As one of our interviewees said, "*Maybe it's because people are dividing genders so that girls are supposed to wear dresses and pink clothes and that boys are supposed to wear pants and play football. ... Maybe it's because they have divided technology to boys and arts and crafts to girls, but it's not supposed to be like that."*

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