NTNU
Norwegian University of
Science and Technology

Increasing IT Interest Among Girls in Secondary School: Lectures and Workshops

Sarah Serussi

Master of Science in Computer Science
Submission date: January 2018
Supervisor: Monica Divitini, IDI

Norwegian University of Science and Technology
Department of Computer Science

NTNU – Trondheim
Norwegian University of
Science and Technology

Increasing IT Interest Among Girls in Secondary School: Lectures and Workshops

Sarah Serussi

January 2018

Master Thesis

Department of Computer Science

Norwegian University of Science and Technology

Supervisor: Professor Monica Divitini

Preface

This master thesis was written at the Norwegian University of Science and Technology (NTNU) as part of the study program Computer Science. The master thesis was written in the fall of 2017. The idea for this master thesis was a result of previous research which discussed why girls were not interested in programming. The purpose of this report is to identify some characteristics of activities which can increase girls' interest in technology and programming.

Acknowledgment

I would like to thank the following persons for their great help during this master thesis:

Professor Monica Divitini for excellent guidance throughout the whole process of the research, for co-writing the paper *"GIRLS AND COMPUTING IN LOWER SECONDARY EDUCATION: The surprisingly unsurprising results of a Norwegian exploratory study"* which was published in November 2017, for supplying relevant material and opportunities to carry out the research, and for helping me shape the structure and contents of the report.

The Girl Project Ada by Line Berg for sharing their data from the Technology Camp at NTNU.

Researcher Anna Mavroudi for helping me with the statistical analysis of the data presented in this thesis.

Trondheim, 2018-01-26

Sarah Serussi

Abstract

It is a well-known fact that women are underrepresented in both technology education and in the professional technology sector. As the technology is rapidly evolving, the world has a need for more engineers in the future, and in order to fill all positions needed, women need to be recruited to the tech industry as well.

In this thesis, I have identified several workshops which have a focus on technology, with girls as their target group, and with the goal of increasing their interest in programming and STEM education. I have designed and analyzed initiatives which include both the informational aspect of a workshop, such as lectures about technology, and the practical aspect of a workshop, such as designing or programming something.

The outcome of this research is an analysis about whether girls become more interested in studying technology and programming through informational lectures and practical workshops. I have discussed the importance of lectures about technology versus the importance of experiencing practical activities of programming and technology. I have also found some characteristics of activities which could increase female secondary school students' interest in technology. These results could be used by teachers when designing programming activities or other activities to attract more girls to IT and programming studies.

Contents

List of Tables

List of Figures

Chapter 1

Introduction

1.1 Motivation

It is a well-known fact that women are underrepresented in both STEM (Science, Technology, Engineering and Mathematics) education and in the technology sector [1] [2]. As the technology is rapidly evolving, the world has a need for more engineers in the future [3], and in order to fill all positions needed, women need to be recruited to the tech industry as well.

Although the number of women applying to STEM studies and taking bachelor and master degrees in engineering continues to rise [4], it is progressing slowly. In 2004 there were 7% female students at the civil engineer studies Computer Science, Cybernetics and Robotics, Communication Technology, and Electronics Systems Design and Innovation at the Norwegian University of Science and Technology (NTNU), and in 2017 there were 29% [5].

In 2016, the Norwegian Ministry of Education introduced programming as an elective subject in 146 lower secondary schools [6], and in 2017 the subject was opened for all schools who wanted to teach it [7]. This research could possibly be of some help to the teachers of this subject, by supplying information about which type of activities can interest girls in programming, in order to avoid excluding girls from choosing this subject.

There are several upper secondary schools which provide IT (Information Technology) as an

elective subject, but even in upper secondary schools, there are very few girls in the IT classes, with an average percent of 32,9% from 2007-2009 in the introductory IT subject IT1, and 27,95% from 2008-2009 in the slightly more advanced IT subject IT2 [8].

1.2 Context

This research is done in the context of the Girl Project Ada (TGPA) at NTNU, as it evaluates one of their biggest events for recruiting girls to STEM studies at NTNU; the Technology Camp [9].

This research might also be useful for the elective programming subject for lower secondary school, by identifying some aspects of programming workshops which can increase girls' interest in studying IT later in life.

The UMI-Sci-Ed (Exploiting Ubiquitous Computing, Mobile Computing and the Internet of Things to promote Science Education) project [10], and the Centre for Excellent IT Education (ExcITEd) [11] at NTNU have also been involved in this research, as both UMI-Sci-Ed and ExcITEd works towards attracting more young pre-university students to the IT and STEM fields.

1.3 Problem definition

In my previous research about why girls are not interested in programming [12], I came to the conclusion that there were several factors which influenced the negative associations of programming for female lower secondary school students. Some of the reasons for not being interested in programming included that they (1) were not interested in programming because they did not know what it was, (2) they had the impression that programming was hard, (3) that programming was 'boyish' and 'nerdy', and (4) that they did not think programming could be useful to help the society. These factors have shown to be important in other studies as well [13] [14].

When interviewing the girls in lower secondary school during my previous research, many of the girls said that they thought programming was hard, even though they had not tried it. When

asked if they could describe what programming was, there were very few who had an idea of what it was and how it could be used.

This lack of information about programming, and lack of practical experience with programming, might be some of the reasons for why there are so few women choosing to study STEM studies, and as a result of that, why there are so few women in computing. Although the percentage of women working in the IT industry continues to rise, the percentage is still under 25% [15].

This is a world wide problem, and in many countries programming workshops are being organized in order to increase the interest for programming [16] [17] [18] [19] [20]. Some workshops are targeted specifically towards girls, and others for both genders.

In this thesis, I want to identify several workshops that have a focus on technology, with girls in secondary school as their target group, and with the goal of increasing their interest for programming and STEM education. I will look at initiatives which include both the informational aspect of a workshop, such as lectures about technology, and the practical aspect of a workshop, such as designing or programming something.

1.4 Research Questions

During this research I want to find out if secondary school girls will be more interested in technology and programming after having participated in an activity which involves technology. I want to see how informational and practical activities can increase their interest in technology and programming, and if there are certain activities that are scored higher than others.

RQ1: *Which activities can increase secondary school girls' interest to learn programming?*
RQ1.1: *Which type of activity (informational/practical) is more effective with regards to the increase in interest for IT?*
RQ1.2: *Which activity topics and contents are more interesting?*

1.5 Research Approach

In order to answer the research questions listed in the previous section, I have designed and organized an intervention which included three different activities for female lower secondary school students to examine their interest in IT throughout the intervention. I have also received data from the Technology Camp at NTNU, which is a three day camp where participants are experiencing several types of lectures and workshops with technology as a topic.

The two initiatives from which I collected data consisted of two different target groups; lower and upper secondary school girls. In the intervention with the lower secondary school students I wanted to see how their interest in technology and programming changed after each activity. From the data from the evaluation of the Technology Camp I wanted to compare the lectures and workshops to each other to identify whether there were some similarities in the activities which made them successful.

Both sources of data used digital questionnaires for data collection, with scoring systems and textual answers. The intervention for female lower secondary school students was designed based on previous research, while the Technology Camp was designed by the Girl Project Ada (TGPA) at NTNU.

As can be seen in table 1.1, RQ1 and RQ1.1 will be answered by analyzing data from the intervention and the Technology Camp. RQ1.2 will be answered by analyzing data from the Technology Camp.

1.6 Summary of results

The outcome of this research is a set of characteristics of activities which could increase female secondary school students' interest in technology, along with an analysis and discussion about whether girls become more interested in studying technology and programming through informational lectures and practical workshops. I have compared lectures about technology and practical activities of programming and technology, and presented results from the collected

Research Question	Description	Answered by
1	Which activities can increase secondary school girls' interest to learn programming?	Analyzing scores and comments from workshops in both intervention and Technology Camp
1.1	Which type of activity is more effective with regards to the increase in interest for IT?	Analyzing scores and comments from workshops in both intervention and Technology Camp
1.2	Which activity topics and contents are more interesting?	Analyzing scores and comments from the workshops at the Technology Camp

Table 1.1: Research questions and how they are answered

data which describes the girls' opinions of the lectures and activities. These results could be used by teachers when designing programming activities or other activities to attract more girls to IT and programming studies.

1.7 Outline of the report

Chapter 2 presents some technological workshops which showed a positive outcome with regards to girls' interest in learning programming or technology. Chapter 3 elaborates on the problem which is being discussed in this research, and introduces my previous research and how this research has been affected by it.

Chapter 4 introduces the intervention that was designed for female lower secondary school students, and presents analysis and results from that intervention. In chapter 5, the results from the Technology Camp is presented, and its content of lectures and workshops is analyzed.

Chapter 6 discusses and identifies some characteristics of activities which increase girls' interest in technology, and chapter 7 describes the conclusions of the research and suggests further work to be done on this problem.

Chapter 2

Previous research

The purpose of this chapter is to present some technological workshops that showed a positive outcome with regards to girls interest in learning programming/technology, and to identify some aspects which made the workshops successful.

2.1 Happy Girls Engaging with Technology: Assessing Emotions and Engagement Related to Programming Activities

The purpose of this research was to measure the effect of enjoyment, happiness, and anxiety on students' intention to participate in similar activities in the future [21]. This workshop used Scratch for Arduino (S4A) [22], and there were three groups participating in it; 12 year old girls and 17 year old girls. The workshop was based on creative activities for teaching youth how to program, and the goal was to find out whether female students' emotions affect their intent to adopt a similar activity in the future.

The workshop included activities such as creating physical characters, to make Scratch programs to animate characters, and a final presentation to present their work.The results showed positive effects of happiness, and negative effects on anxiety. It also showed that enjoyment has no relation with students' intention to re-participate in an activity.

2.2 Learning programming through fashion and design: A pilot summer course in wearable computing for middle school students

This summer course introduced technology through fashion and design, and focused on wearable computing [23]. The reason for this was that they perceived this topic as being more gender neutral than robotics. The target group were middle school students (7th-9th grade), and included both boys and girls. The duration of the camp was five days.

The content of the workshop included electronic circuit board theory, t-shirt circuit design, integrated circuits, and programming. They used the TeeBoard technology, which consisted of a t-shirt breadboard and a LilyPad Arduino [24]. They decided to split the participant into eight teams, where six teams were all-male, and two were all-female.

Even though most participants were exposed to computing before, most of them did not have much knowledge of programming concepts. The results showed that the girls liked t-shirt circuit design the best and that they learned the most from the programming module. Even though the girls thought it was quite difficult (but quite interesting also), the camp increased their interest to learn computer science a little. Two of the girls would want to take Computer Science (CS) courses in the future, one would maybe do it, while three did not want to take CS courses at all in the future.

The main difference between the boys and girls was that the boys were focused on finishing their tasks as quickly as possible without paying attention to the aesthetics, while girls worked more slowly and methodologically and focused a lot more on design, color, and patterns.

2.3 Scratching the surface of advanced topics in software engineering: A workshop module for middle school students

In this 3-hour workshop module, there were 30 8th grade girls participating [25]. The purpose of the workshop was to introduce both programming concepts and a programming environment. Scratch was used as the main technology for this workshop [26], and while the focus was laid on teaching programs, specifications, compositions, preconditions, and postconditions, it was also important to have fun.

The introductory lecture introduced an analogy that a computer acted as a chef, and that a program acted as a recipe. It was explained that the more constrained the final dish (the output) should be, the harder the recipe (the input) is to write.

The results of this workshop showed that the participants changed their views on CS more favorably, that they had fun while participating in the workshop, that they learned a lot about programming, and that it enabled continued engagement for CS and programming.

2.4 Design and evaluation of a computer science and engineering course for middle school girls

During a four-week summer camp in Orange County, USA, 53 girls participated in a computer science and engineering course designed with the purpose of attracting more girls to STEM [27]. The course lasted one hour a day twice a week and one half-day, and was designed for middle school girls.

In order to improve the attitudes towards computer science and engineering, they designed a course which was based on hands-on learning rather than lectures and explicit instructions. The technology that was used in this course was called PicoCricket Kit [28], which can be programmed to control lights, speakers, motors, sensors, and sounds.

The girls were split into smaller groups, and each group member were assigned roles such as software engineers, electrical engineers, civil engineers, and design engineers in order to highlight which types of tasks an engineer could have in their work life. Their tasks included making a musical instrument by conducting electricity through a pickle and creating a sculpture which reacted to sensors. There were mostly female students who guided the participants' work whom also acted as role models during the camp.

The results from this course showed that the participants received a greater understanding of what it means to be a programmer, and what it means to be an engineer. They gained more positive views on engineering and programming, and did no longer feel that programming was boring or that it entailed too much math.

2.5 Conclusion

The main take away from the study presented in section 2.1 to be used in this research, is that when female students feel happiness, they are more likely to want to participate in similar activities in the future, and that when they feel anxiety, their intent in participating in similar activities in the future is less likely.

Even though the study presented in section 2.2 showed different levels of interest in studying CS in the future, it tells us that learning programming through a practical workshop increases some girls' interest to learn CS in the future, and that it is possible to learn programming through participating in a practical workshop.

The workshop described in section 2.3 suggests a link between having fun while programming and a better impression of CS because of it. It explains programming well through using an analogy which is known to most students, and perhaps that made it easier for the participants to understand some programming concepts.

The course's design described in section 2.4 showed success with regards to increasing the participants' interest in studying STEM, and showed that learning through practical work can be both very fun and very educational.

All the workshops mentioned in this chapter succeeded in increasing girls' interest in programming and technology, and showed that it is important to have fun while learning. Practical work was used to teach programming, programming concepts, and engineering. The workshops used different technologies in order to teach programming, and all of them included some creative aspect of the workshop.

Chapter 3

Problem elaboration

3.1 General problem

In Norway today, female students receive the highest overall grades in secondary school [29] [30], and more women than men choose to take higher education. According to the Global Gender Gap Report from 2017, in Norway, 91.5% of women have been enrolled in tertiary education, while only 62,8% men have been enrolled in tertiary education [31].

Although there are many female students who graduate with a grade average which is high enough to get in to studies such as Computer Science, there are very few women who chooses to study it: According to SSB (the national statistical institute of Norway), there were 7 661 men who was enrolled in a master degree programme within STEM, while there were only 3 693 women enrolled [32]. In comparison, there were 2 498 women enrolled in the Medicine study, and only 1 200 men.

The effect of girls not choosing to take IT courses in lower secondary school, can lead to them not taking it in in upper secondary school, which could lead to them not studying IT related studies, which again could lead to the low percentage of women in technology, and especially the low percentage of female developers. Having such a small percentage of women in tech, can not only lead to missed inventions/improvements of technology, but also more severe consequences, such as medicine and technology not being tested properly on women [33].

3.2 Previous research

During my previous research I wanted to find out why girls were not interested in programming. I used several data collection methods, including questionnaires, Kahoot quizes [34], and interviews to uncover whether there were certain reasons for girls not wanting to take programming courses or studies. During the fall of 2017, while writing this thesis, I published the paper: *"GIRLS AND COMPUTING IN LOWER SECONDARY EDUCATION: The surprisingly unsurprising results of a Norwegian exploratory study"* from this research project (see full paper in appendix B) in cooperation with Professor Monica Divitini at NTNU.

The reasons for not choosing to study programming were many, but there were some reasons that were mentioned more than others. The main reasons not to choose IT education included: 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.

There were mainly three topics that there was little knowledge about, which affected their negative impressions of programming; (1) They did not have a clear idea of what technology was, (2) They did not know what programming was or how it could be used, (3) They did not know what an engineer was, or what an engineer does.

As this research is a continuation of the previous research, I seek to find out how we can increase the girls' interest in programming by having them participate in different activities which were designed to increase girls' interest in studying programming and technology.

While the previous research answered questions about why girls were not interested in programming, this research seeks to answer which kind of activities can increase their interest in programming.

3.3 Research rationale

In order to answer RQ1: *Which activities can increase secondary school girls' interest to learn programming?* I decided to collect data from two different initiatives; one intervention that I designed myself (chapter 4), and one initiative which was designed by the Girl Project Ada at NTNU - the Technology Camp (chapter 5) from which I was able to receive data.

I wanted to analyze data from both initiatives because I wanted to collect data from many workshops and lectures in the hopes of comparing them to each other, and to find out which ones were the most effective in order to increase girls' interest to learn programming and to study IT studies.

I wanted to collect data from younger girls (aged 13-15) and older girls (aged 16-18) in lower secondary school and upper secondary school to see if there are any similarities in their interest levels before and after an activity, and to compare data from girls who already are interested in science (which the participants at the Technology Camp were), and girls who did not have an initial interest in science (the participants at the intervention with lower secondary school girls), to see how their interest levels differs.

As table 3.1 shows, the two initiatives that were looked at for this research, differs in several aspects. The main difference is that one was designed specifically for the purpose of this research, while the other was designed by others.

Differences	**Intervention**	**Technology Camp**
Target group	Female lower secondary school students	Female upper secondary school students
Purpose	To increase interest for programming	To attract participants to STEM studies at NTNU
Existing motivation for participating	No	Yes
Designed by researcher	Yes	No
Amount of participants	8	158
Duration	One day	Three days
Data Collection	Four questionnaires, focus group	Questionnaire

Table 3.1: Differences of the two initiatives that were looked at for this research

Chapter 4

Intervention with female lower secondary school students

Previous research showed that girls are not motivated to study programming, because they do not know what it is, how it is used, and why it is useful for society [35]. It was therefore decided to recruit eight female lower secondary students to participate in an intervention to try out different activities in order to possibly identify some activities that would spark their interest for technology and programming.

The intervention consisted of an informational lecture about technology and programming, an idea generation workshop called Tiles [36], and a programming workshop with the Tiles toolkit for interactive objects [37].

4.1 Research method

In order to find answers to the research questions *"Which activities can increase secondary school girls' interest to learn programming?"* and *"Which type of activity (informational/practical) is more effective with regards to the increase in interest for IT?"* it was decided to design a workshop which consisted of an informational aspect and a practical aspect. The informational aspect which would give concrete general information about technology and programming, and the practical aspect, would give the participants experience of inventing an invention and pro-

gramming a program.

There were three different types of teaching activities included in the intervention; one informational lecture about programming and technology, one practical activity which introduced technology without explicitly using programming, and one programming activity.

4.1.1 Participants

To recruit participants for this intervention, an ad was placed at the Operation Day's Work (ODW) website [38], and the participants had to apply to the intervention by sending an email to the researcher. Eight girls were recruited via the website. All participants were female lower secondary school students from local schools in Trondheim. Two from 8th grade, two from 9th grade, and four from 10th grade. They came from three different schools in Trondheim. All participants were female due to the research question focusing on girls' motivation for studying technology and programming. As a compensation for participating in the intervention, the participants received a donation of 300NOK in their name which was paid to the ODW.

4.1.2 Purpose

The purpose of the intervention was to see how their motivation for studying technology and programming changed during the intervention's different activities. I also wanted to see how an informational lecture about technology compared to a practical activity, and how an activity including technology but not programming compared to an activity including programming tasks.

4.1.3 Procedure

The intervention started with information about the day's agenda, followed by a lecture about programming and technology, then a workshop of idea generation by using Tiles cards, and finally a workshop in programming. In between all of the different activities a questionnaire about how much they know and how motivated they were for studying programming was answered by the participants. The timeline of the intervention can be seen i table 4.1.

Time	Activity	Duration
09.15	Agenda of the day	15 min
09.30	Questionnaire	10 min
09.40	Lecture about programming and technology	20 min
10.00	Questionnaire	15 min
10.15	Tiles cards workshop	45 min
11.00	Break	15 min
11.15	Tiles cards workshop continued	30 min
11.45	Questionnaire	15 min
12.00	Lunch	30 min
12.30	Focus group	30 min
13.00	Tiles programming workshop including breaks	120 min
15.00	Questionnaire	15 min

Table 4.1: Timeline of the activities at the intervention

There were three students present during the intervention; me, and two other Informatics students. I was in charge of the intervention, one of the Informatics students had designed the programming workshop, and the other Informatics student wanted to observe and talk with the participants in between activities about her own master thesis concerning career counseling.

4.1.4 Intervention construct

I wanted to include a lecture about general information about programming and technology in order to give the participants an understanding of what it means and what it could be used for, before having them participate in practical activities.

Lecture

Because of the results from the previous research about why girls were not interested in programming (see section 3.2 and full paper in appendix B), a lecture giving general information about programming and technology was included at the beginning of the intervention. This was done in the hopes that by informing the participants about what programming means it could make the term less abstract, less scary and more exciting.

Idea generation workshop

Many girls think that studying computer science means writing code all the time, which is a false statement. By including an activity which focuses on the design of technology gadgets before implementation, the participants will experience how a computer scientist might think when developing new technologies, and how one might think when solving a specific problem. This could hopefully shed some more insight on how the work before the actual implementation is done.

Programming workshop

The last activity of the intervention consisted of concrete programming tasks. The participants were given physical Tiles that would be used to act as a pedometer by programming the Tiles [37] through JavaScript [39]. The purpose of including this activity was so the girls could experience how to write a program that could be executed to control a physical object.

4.2 The informational aspect

In light of previous research, and the request for more general information about programming from the girls, it was decided to start the intervention with a short lecture about information about programming and technology. The lecture lasted for 20 minutes, and included answers to some of the questions that some participants from previous research posed, such as *"What is technology?"*, *"What is programming?"*, and *"What is an engineer?"*.

4.2.1 Presentation form

The lecture consisted of a PowerPoint in conversational style with some illustrations and pictures, and few words. The lecture was decided to be held in conversational style in light of Mayer's personalization principle which suggests better transfer of learning when the material is presented conversationally instead of formally [40]. The lecture was also designed considering Mayer's Modality effect which suggests better transfer from animation and narration than from animation and on-screen text, and Mayer's Redundancy effect which suggests better transfer from animation and narration than from animation, narration, and on-screen text. The result of that meant that the PowerPoint design was minimal with little disturbance. Every topic had the same punchline of *"to put a long story short, it can be described as ..."*, in order to make it easier to understand the main point of the terms.

4.2.2 Topics

Specific topics that were mentioned during previous research revealed that the girls wanted more information about programming, what it is, how it is used, and why it is a useful skill to have. After the Kahoot quiz during the previous research, there were many students who were surprised that by studying science one can actually help make a difference, and help both people and society. It was therefore decided to include information about how programming can help society in the lecture as well.

What is technology?

Instead of using the formal definition of technology, which might be too advanced for 14 year old girls to understand, the term technology was explained by showing pictures of different types of technology such as music, computers, robots, phones, drones, cameras, and other objects that was assumed that 14 year old girls know about (see figure 4.1). The bottom line of the term technology was explained as *"objects or artifacts made by humans which solves problems and makes life easier"*.

Figure 4.1: *Illustration of technology*

What is programming?

In order to explain the term programming, I decided to use the same analogy as was used in the Scratch workshop module described in section 2.3 for middle school students which referred to a program as a recipe. In other words, it was explained that a computer is actually very unintelligent, and needs to know exactly what you want it to do, so you need to give the computer all the ingredients, and also a very detailed recipe of how to combine these ingredients in order to make a program.

Since programming is hard to explain without showing examples of how it looks like, I presented a scenario which introduced the concept of Internet of Things by looking at a smart refrigerator. The example consisted of an app on a smart phone communicating with a smart fridge, which would alert the user when food in the fridge was about to be expired. It was first described in pseudo-code and later shown how it could look like in the programming language Java. (see figure 4.2). The punchline of what programming is, was described as *"instructions to a computer which becomes a program that solves a specific problem"*.

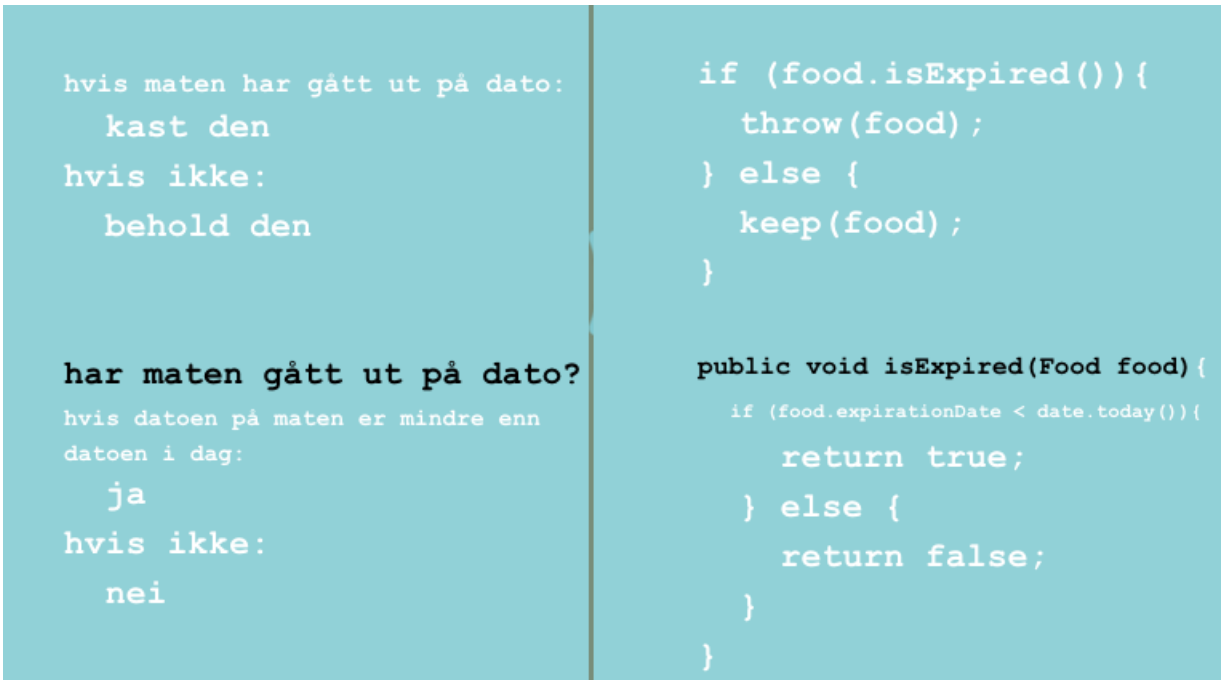

Figure 4.2: *Pseudo code vs. Java code*

What can one make with programming?

Pictures of different inventions were used to answer this question. For this question I wanted to address the uncertainties about not being able to help the society by programming which arose in the previous research. Therefore in addition to software, apps, and games, I also wanted to include medical equipment as an example of what one could make with programming. This was done to highlight that it is possible to work in medicine by studying technology.

I also included a slide of specific examples of how technology can help society, and talked about how technology plays a role in the medical field as well as in criminology (see figure 4.3). The main point of this slide was to illustrate that one can make almost anything with programming, and that many of the inventions made are not just for fun, but actually useful for the society.

What is an engineer?

During my previous research, there were very few girls who knew what an engineer was. As an engineer can do many things in various different fields, an engineer was described as *"a person which has a bachelor or master degree in science, who uses technology to solve specific problems"*.

Figure 4.3: *How one can help society by programming*

During this slide I also mentioned that the girls would act as engineers in the coming activities where they would design a new invention which could make their life easier, and that they would implement a program by using programming which would solve a specific problem.

4.3 The practical aspect

For the practical activities in this intervention, I wanted to use workshops which introduces aspects of an engineer's life, to show the participants what it could be like if they chose to study technology in the future. I wanted to underline that while programming is a big part of an IT engineers work life, it is not everything. I therefore decided to include one workshop about idea generation and product design, and one programming workshop.

4.3.1 Workshop form

A big part of the development process in engineering is to have a clear idea of what the team are developing. It was therefore decided that the Tiles cards workshop which is an idea generation tool should be the first practical activity of this intervention. This workshop introduces the Internet of Things (IoT) while allowing the participants to come up with an idea for a product and guiding them towards a specified idea.

The last practical activity that was run during this intervention, was the Tiles programming workshop. This programming workshop was designed by the inventors of the Tiles cards workshop, as a way to realize ideas which were developed by the Tiles cards workshop. Because of time limitation, we pre-selected a task to be implemented in the Tiles programming workshop. This programming workshop was chosen as a way to learn programming because it consists of physical elements as well as a cloud web portal, which could show the participants how writing code could affect physical objects.

4.3.2 Tiles idea generation workshop

The Tiles idea generation workshop was created by researchers at NTNU who wanted to create tools for end-users which enabled them to come up with their own IoT ideas more easily [36]. The workshop methodology is based on design thinking, and consists of several design thinking activities such as a storyboard and an elevator pitch.

The Tiles Workshop is a workshop that is designed for non-experts with a duration of approximately two hours. It consists mainly of a Tiles Idea Generator board, and Tiles cards, and are often supplemented with post-its and stationary kits. There are usually two or more users participating in the workshop.

The Tiles Idea Generator board is a board which has placeholder spots for the Tiles cards, a storyboard where users are asked to explain their problem and how their product solves it, as well as instructions on how to use the cards and where to put them.

The Tiles IoT cards is a deck of cards which consists of six different types of cards to ease the ideation: Data channel cards, Things cards, Human action cards, Feedback cards, Mission cards, and Criteria cards. Examples of these types of cards are the Mission cards which states goals and gives examples of how such a goal can solve certain human needs, the Things cards which consists of everyday things that can be used in the IoT context, and Feedback cards which presents different visual or auditory feedback that can be used when an action is done by a user of the IoT product.

For the purpose of this intervention, I decided to exclude the Criteria cards (which is a type of card which helps the user to reflect on their idea) because of time restriction, the Mission cards because I wanted the participants to think of a problem they had that they wanted to be solved, and also some of the Data channel cards such as Twitter and E-mail, because of the low use of these channels for 14 year old girls. Other than that, all the cards were available for the participants.

The workshop started with a PowerPoint presentation which introduced the Tiles Workshop and explained the procedure from selecting cards to use and how to use the Idea Generator board. After the participants were divided into two groups of four, they were asked to familiarize themselves with the board and the cards. They were given one hour to come up with an idea and to prepare a presentation of it.

4.3.3 Tiles programming workshop

The programming workshop tasks that were organized for this intervention were designed by a master student at Informatics at NTNU. The main task was to implement an activity monitor by using IoT squares, the Tiles cloud web portal [41], and an Android phone which had the Tiles application installed. The JavaScript programming language was to be used to program the application. The goal of the activity monitor was to record the amount of steps a user would take during one day, similar to a pedometer. The IoT squares represented one left shoe, one right shoe, and a controller, and were constructed with sensors and LED lights.

The participants were handed an instruction booklet with information about the IoT squares and how they could be programmed, as well as concrete sub tasks about what they should do in each step of implementing the activity monitor. The activity monitor consisted of three IoT squares which needed to be programmed in order to interpret specific inputs from the user. The sensors in the squares listened to events such as single tap, double tap, tilt, and shake. The output of the squares were haptic movement and shining lights.

This programming workshop was initially designed for a 3 hour workshop where the participants would be in charge of setting up the environment, installing the app, and programming all of the code necessary to run the application. Because of time constraint, we decided to do all the set-up needed for the workshop ahead of time, so that most of the time spent on this activity would include programming. A skeleton code base was also provided for this workshop activity.

The participants were divided into two groups of four. They were given 10 minutes to read through the instruction booklet, and then they received a short oral presentation from the designer of the workshop activity which would help them to get started with the activity.

Initially there were two different tasks available for implementation; one activity monitor and one music sharing application. The two groups were supposed to work on one task each, simultaneously. During the first 15 minutes of the activity we encountered some problems connecting one of the squares to the software, which meant that only one group could use the tiles at a time. We therefore decided to only implement the activity monitor, and found another activity for the group that could not work with the squares.

We did not plan any backup activity in case something went wrong, so we decided to use one of the activities from the Technology Camp at NTNU. This activity introduced the Python programming language by using the Turtle library [42]. There were no instructions or presentation of this activity ready for the workshop, so I introduced and explained how they could use the turtle library to make geographic figures. This activity was mostly an experimental activity per-

formed in order to give the participants something to do while waiting for the other group to finish the activity monitor task, and is therefore not evaluated by the participants.

After approximately 50 minutes the groups switched tasks, so that both groups could try out the implementation of the activity monitor. The planned duration for this programming activity was 90 minutes excluding breaks, so the implementation of the activity monitor was somewhat rushed by the organizer of the intervention. This could have affected the rating of this activity.

I observed that during the programming there were some participants who did not see the screen, and that they might have felt left out because of it. It was nice to see that there was one participant in the group who took charge and suggested that they switched between themselves when writing the code, so that all participants were able to do some of the programming.

4.4 Data collection

4.4.1 Questionnaire

It was decided to use Google Forms as the data collection tool to collect information about the participants [43]. Each participant was given a unique ID which had to be entered in the beginning of the questionnaire. There were several questions that were asked after each activity that were the same, in order to measure the excitement of the different activities and how it affected their wish to learn programming. All the questions asked can be found in appendix C.

A Likert scale of 1-5 was used for most of the questions, where 1 meant "strongly disagree" and 5 meant "strongly agree". The first questionnaire included questions about how much experience the participants had with programming, designing/inventing, and technology before, how interested they were in technology, and how likely it was that they would study science later in life.

The participants were asked to rate four concepts on how well they understood them or knew

what they meant. The concepts were 1) Technology, 2) Programming, 3) What an engineer is, and 4) What an engineer does. The participants were asked to rate these four concepts after each intervention activity to see whether they had learned something about them during the day.

4.4.2 Focus group

During lunch there was a focus group about which types of activities the participants would have liked to engage in. This discussion took place after the Tiles idea generation workshop and before the Tiles programming workshop.

Many of the girls would have liked to realize their ideas into real gadgets, and would have liked to know how that could be done. Although they understood that it would have been hard to implement their idea in such a short amount of time after the workshop was finished, they were interested in participating in a workshop at a later time where they could be part of implementing their invention.

When asked which types of technology they would have liked to learn how to make, most of the participants answered apps. They were fans of apps such as 9gag [44], gif-maker apps, picture editing apps, and games such as Flappy Bird [45] or Candy Crush [46].

The interest in making some type of technology that would help society or the environment were surprisingly low, and even though some of them expressed interest in those areas in general, they said that they would not want to download an app which would help the environment. They said that behavior change is hard and very individual, and that one needs to be motivated before wanting to change their behavior, and that an app would not make them change their minds about a certain topic.

They wanted to participate in an activity where they would have fun at the same time while learning something. They also said that it would be interesting to make apps that they would include gamification, since they have used such apps before. Apps need to be fun in order for

them to use it.

The bottom line from this discussion was that they wanted to learn how to make an app, and that the app should both be fun to make, and fun to use. Although they would have liked to realize their idea which came from the Tiles idea generation workshop, they would rather make an app that was a fun game than a more serious app which focused on serious topics.

4.5 Results

There were eight participants at the intervention. Because of the low number of participants, the individual trajectories of each participant is analyzed instead of all of them together as a group. All participants were given an ID, and for the purpose of this thesis they are marked with #1 for participant 1, #2 for participant 2, and so on.

4.5.1 Existing experience of and interest in technology

The initial questionnaire asked questions to uncover the participants' experience with programming and design, their interest in programming and technology, their likeliness to study technology, and their familiarity with certain science concepts.

All questions in the first questionnaire consisted of a Likert scale of 1-5 as the answer form, where 1 meant "nothing" and 5 meant "a lot" for the questions regarding their experience with programming and design and their familiarity with the science concepts, and where 1 meant "Not at all interested" and 5 meant "very interested" for the questions about their interest in technology, programming, and studying technology.

Q1: Have you programmed anything before?

(Likert scale: 1 = nothing, 2 = next to nothing, 3 = some, 4 = more than some, 5 = a lot)
Five participants answered "nothing" or "next to nothing" on this question, while two answered "some", and one answered "more than some". After discussing with some of the participants

in the following break, some mentioned that they had a small project at school which entailed some HTML programming and web design.

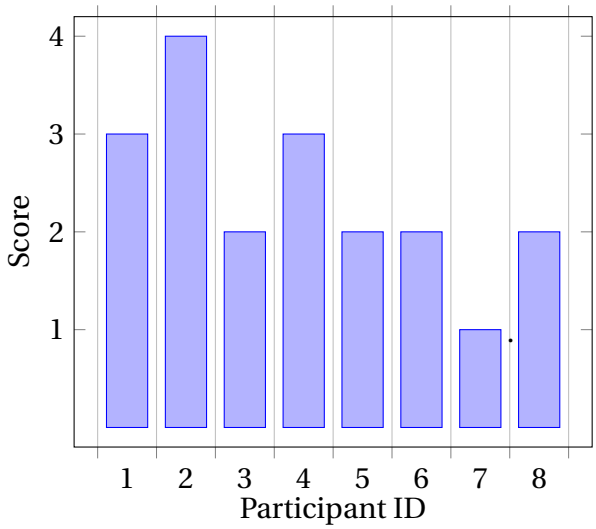

Figure 4.4: *"Q1: Have you programmed anything before?"*

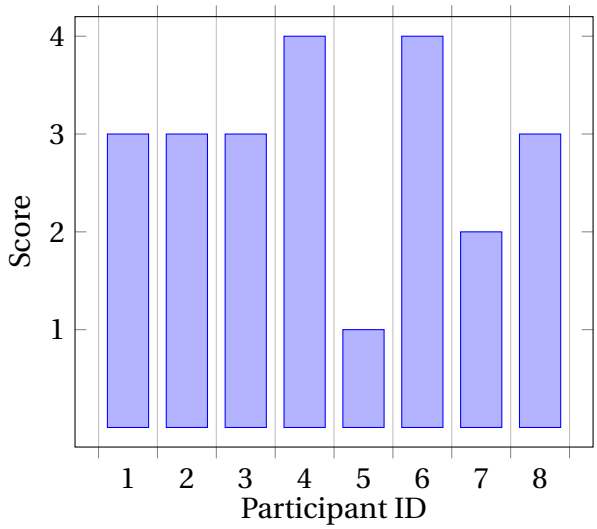

Figure 4.5: *"Q2: Have you designed anything/made an invention before?"*

Q2: Have you designed anything/made an invention before?

(Likert scale: 1 = nothing, 2 = next to nothing, 3 = some, 4 = more than some, 5 = a lot)

One participant answered "nothing", one answered "next to nothing", four answered "some", and two answered "more than some". During the discussion of this question with some of the participants later in the intervention, some did not think of this as a technological invention, but rather that they have come up with an idea that could be implemented in the future, or that they made an invention as a result of a school project.

Q3: To which degree are you interested in technology?

(Likert scale: 1 = not at all, 2 = a little, 3 = some, 4 = interested, 5 = very interested)

Two participants answered "a little", three answered "some", two answered "interested", and one answered "very interested".

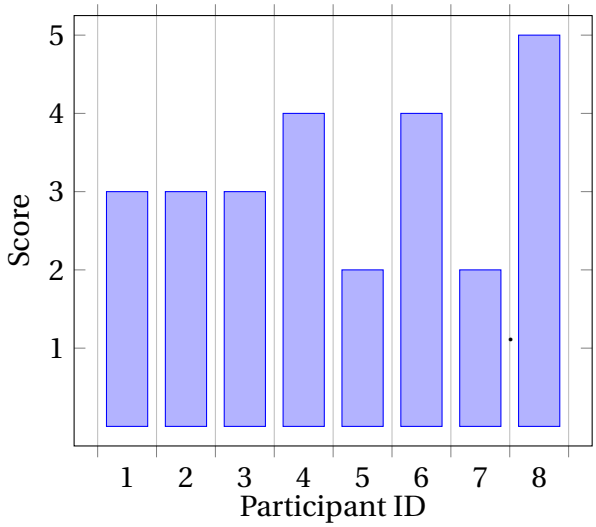

Figure 4.6: *"Q3: To which degree are you interested in technology?"*

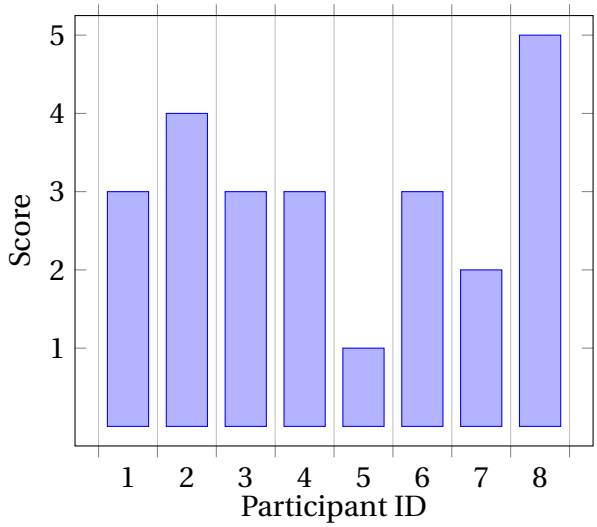

Figure 4.7: *"Q4: To which degree are you interested in programming?"*

Q4: To which degree are you interested in programming?

(Likert scale: 1 = not at all, 2 = a little, 3 = some, 4 = interested, 5 = very interested)

One participant answered "not at all", one answered "a little", four answered "some", one answered "interested", and one answered "very interested".

Q5: How likely is it that you will study technology?

(Likert scale: 1 = not at all, 2 = a little, 3 = somewhat likely, 4 = likely, 5 = very likely)

Most participants showed interest in studying technology. One participant answered "not at all", three answered "somewhat likely", three answered "likely", and one answered "very likely".

Q6: Familiarity with science concepts

(Likert scale: 1 = not at all, 2 = a little, 3 = somewhat familiar, 4 = familiar, 5 = very familiar)

The participants of the intervention had different levels of familiarity with different science concepts. As we can see, there are few girls who are very familiar with what an engineer is, and what one does. Most participants are somewhat familiar with the technology concept, and most are somewhat familiar with programming.

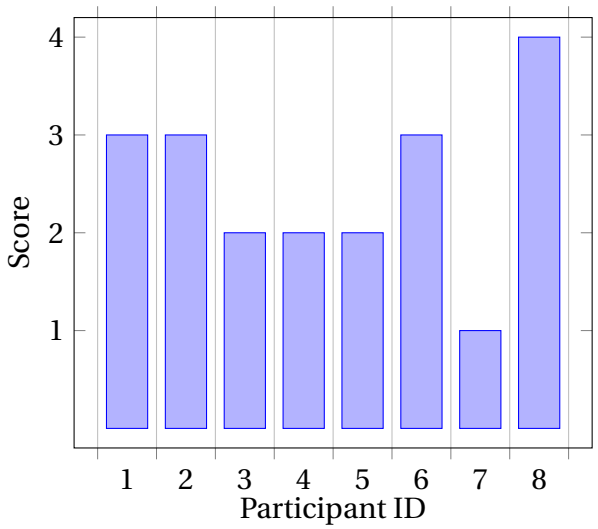

Figure 4.8: *"Q5: How likely is it that you will study technology?"*

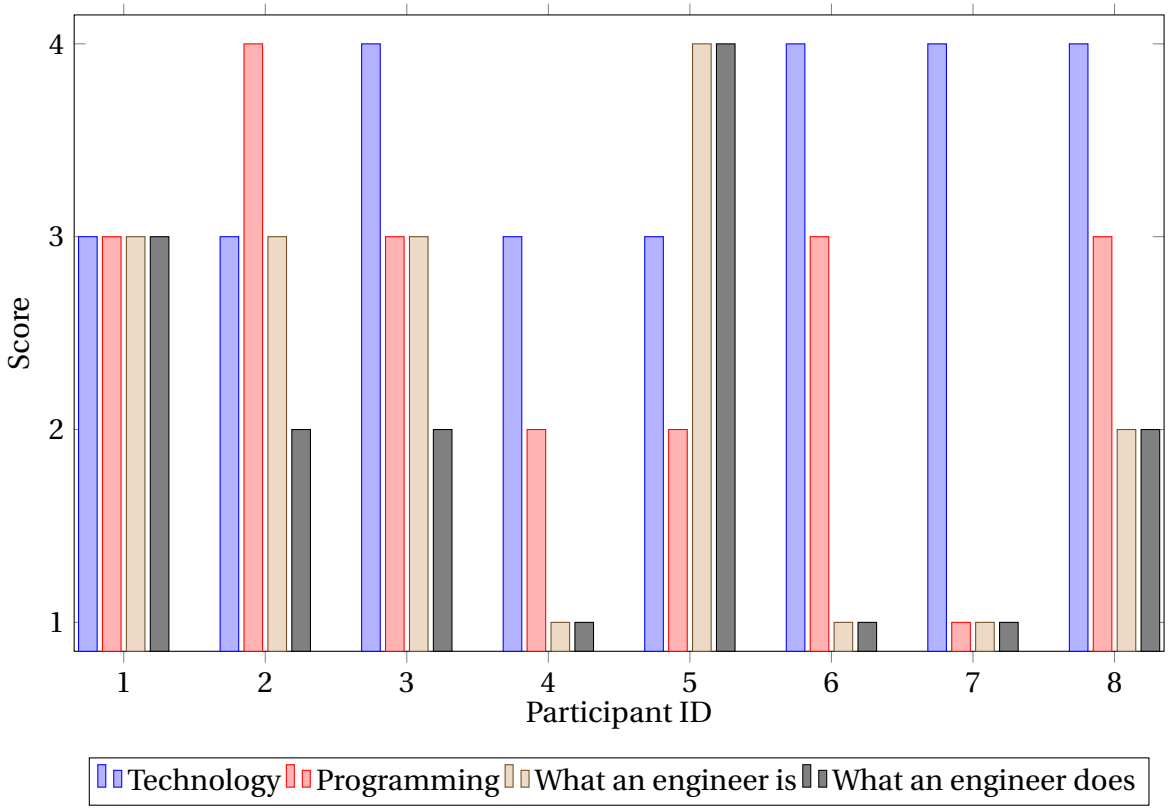

Figure 4.9: *"Q6: Familiarity with science concepts"*

4.5.2 After lecture about programming and technology

Learning outcomes

(Likert scale: 1 = not at all, 2 = a little, 3 = something, 4 = more than something, 5 = a lot)

All of the eight participants reported that they learned something about technology, six of them gave a score of 4 out of 5, and two participants gave the maximum score, 5.

Regarding their learning outcome of the term programming, two felt they learned something about programming, four reported that they learned more than something, and two reported that they learned a lot about programming.

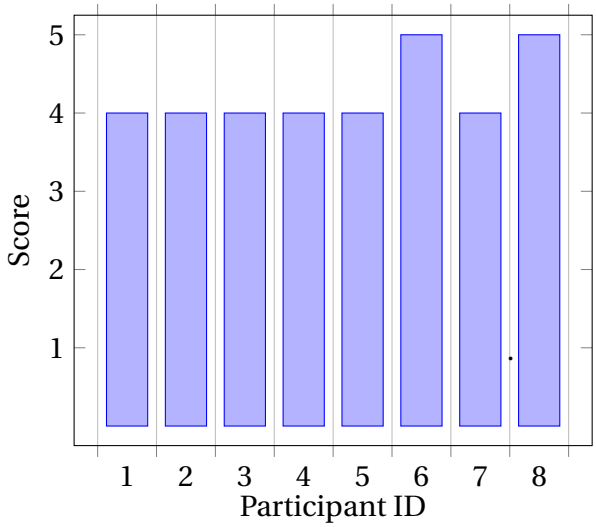

Figure 4.10: *"Q7: To which degree did you learn something about technology?"*

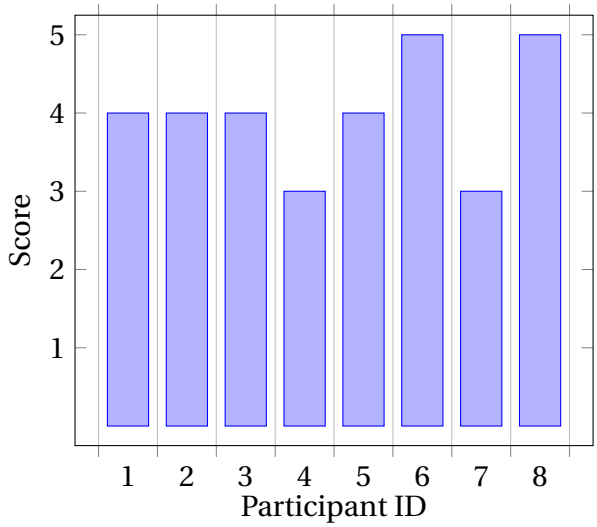

Figure 4.11: *"Q8: To which degree did you learn something about programming?"*

Interest in technology and programming

(Likert scale: 1 = not at all, 2 = a little, 3 = some, 4 = interested, 5 = very interested)

After the lecture about programming and technology, seven of the eight participants had the same interest or a higher interest in technology. Participant number 4 reported a lower interest in technology after the lecture.

All participants reported the same interest or a higher interest in programming after the lecture, and participant 3 went from being a little interested (a score of 2) to interested in programming (a score of 4).

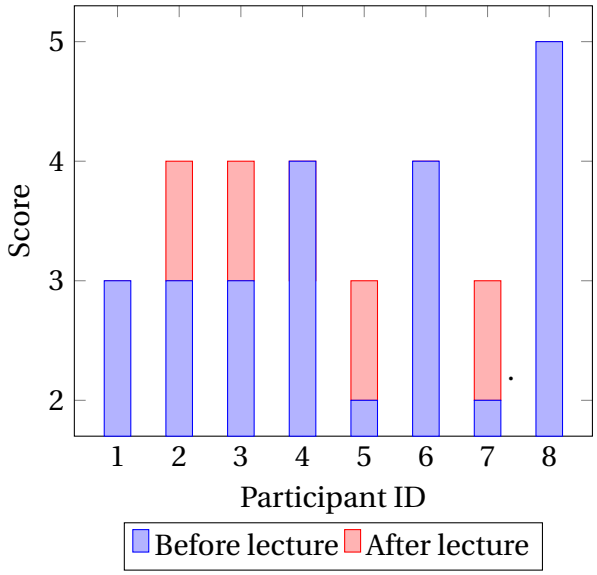

Figure 4.12: *"Q3.2: To which degree are you now interested in technology?"*

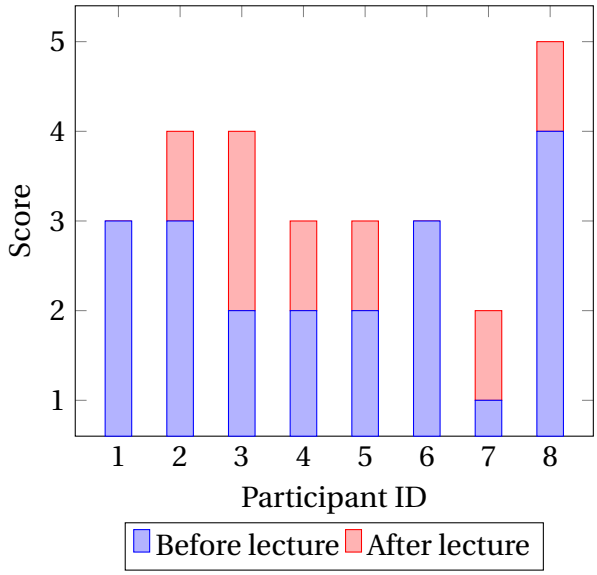

Figure 4.13: *"Q4.2: To which degree are you now interested in programming?"*

Likeliness to study technology

(Likert scale: 1 = not at all, 2 = a little, 3 = somewhat likely, 4 = likely, 5 = very likely)

All eight participants reported either the same level or a higher level of likeliness to study technology after the lecture. Participant number 4 reported that she was likely to study technology (a score of 4) after the lecture, compared to a score of 2 before the lecture.

Familiarity with science concepts

(Likert scale: 1 = not at all, 2 = a little, 3 = somewhat familiar, 4 = familiar, 5 = very familiar)

Seven out of eight participants reported the same familiarity or a higher score of familiarity of the term technology, while participant number 7 reported that they were less familiar with the term technology after the lecture. Participant number 1, 2, 5, and 8 scored their familiarity with technology one point more than they did before the lecture.

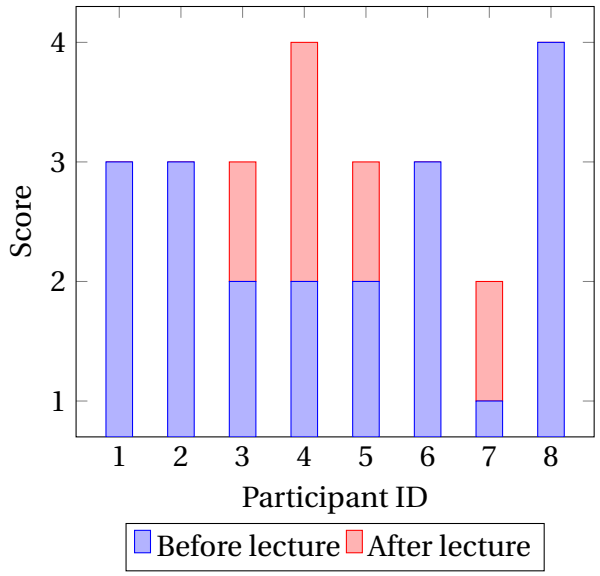

Figure 4.14: *"Q5.2: How likely is it that you will study technology?"*

The same score or a higher score of familiarity with programming were given by all of the participants, and participant number 7 went from scoring the familiarity of programming a 1 to a 3, and participant number 8 scored the familiarity with programming a 5 after the lecture, compared to a 3 before the lecture.

All of the participants gave a higher score after the lecture regarding the familiarity with what an engineer is. Participant number 6, scored her familiarity with what an engineer is four points more than before the lecture (going from a score of 1 to a score of 5). All of the participants reported a higher familiarity with what an engineer does after the lecture, and participant number 6 answered that she went from not being familiar with it at all (a score of 1) before the lecture, to answering that she was very familiar with it after the lecture (a score of 5).

4.5.3 After idea generation workshop

Learning outcomes

(Likert scale: 1 = nothing, 2 = a little, 3 = something, 4 = more than something, 5 = a lot)

All participants reported that they learned something about technology from the workshop, and

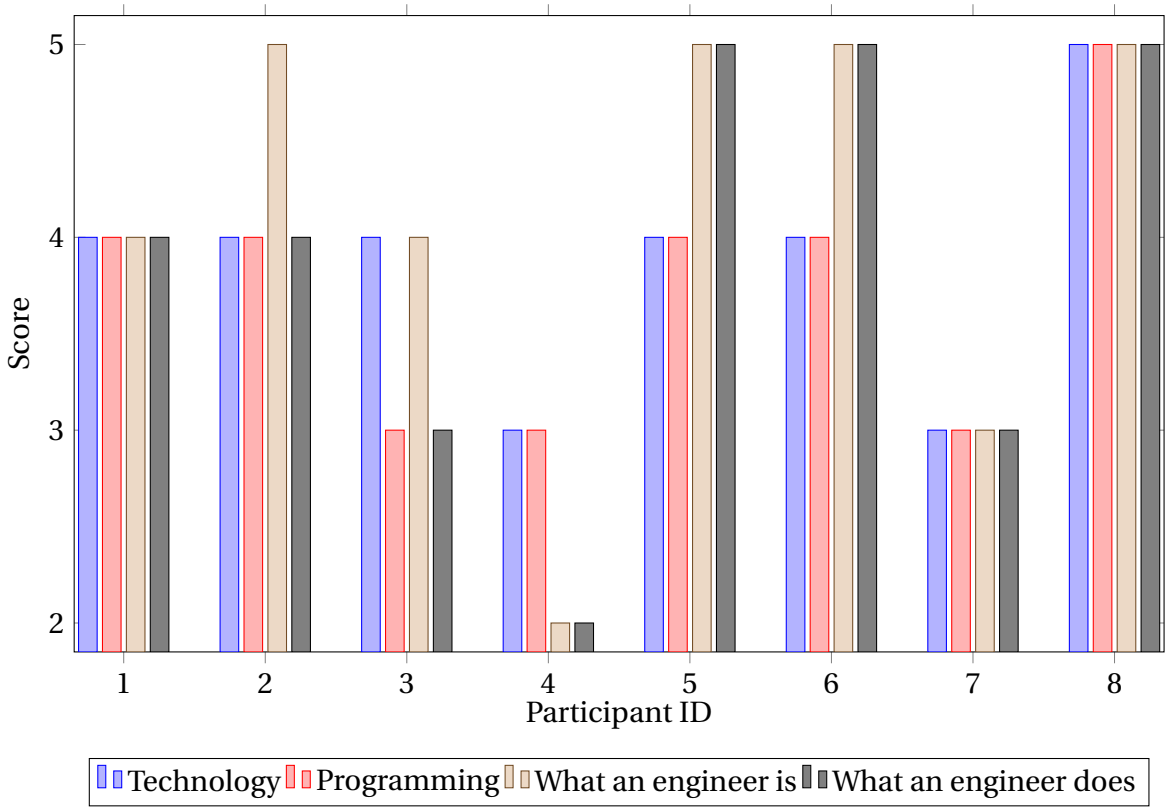

Figure 4.15: *"Q6.2: Familiarity with science concepts after lecture"*

participants 5, 6, and 8 reported they learned a lot (giving a score of 5). The participants did not learn as much about programming as they did about technology, but seven of the eight participants gave a score of 3 or higher, meaning that they learned something, more than something or a lot from the workshop. Participant 4 reported that she learned a little about programming from the workshop, giving a score of 2, which was the lowest score given by the participants.

Interest in technology and programming

Six participants reported the same interest in technology after the workshop, while participants 1 and 5 reported a higher interest for technology after the workshop. Five of the participants reported the same interest in programming before the workshop as after the workshop, participants 1 and 5 reported a higher interest in programming after the workshop, while participant number 3 reported a lower interest in programming after the workshop (going from a score of 4 to a 3).

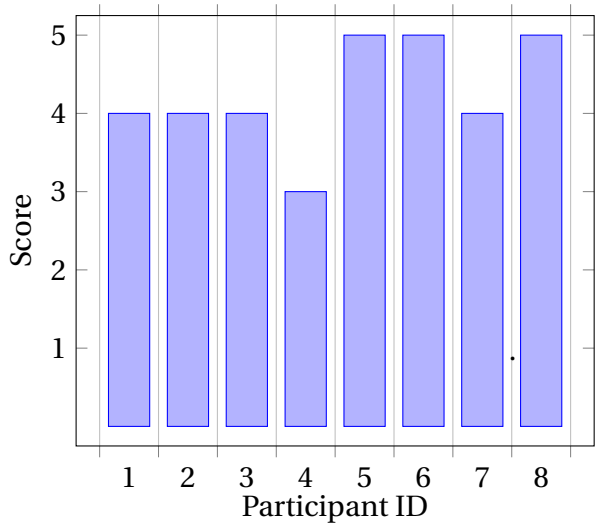

Figure 4.16: *"Q7.2: To which degree did you learn something about technology?"*

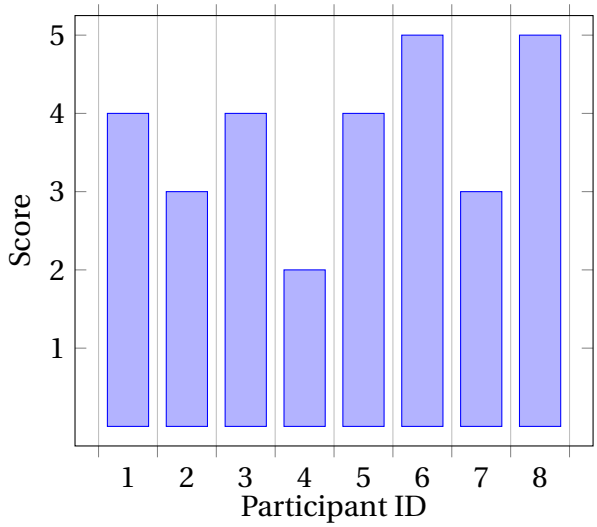

Figure 4.17: *"Q8.2: To which degree did you learn something about programming?"*

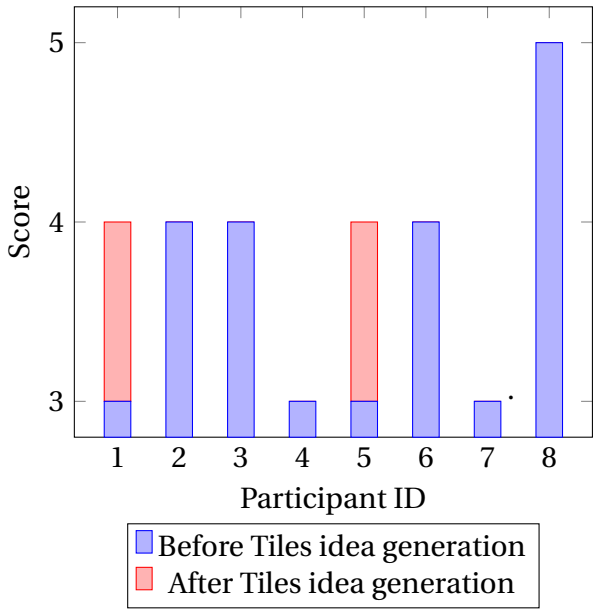

Figure 4.18: *"Q3.3: To which degree are you now interested in technology?"*

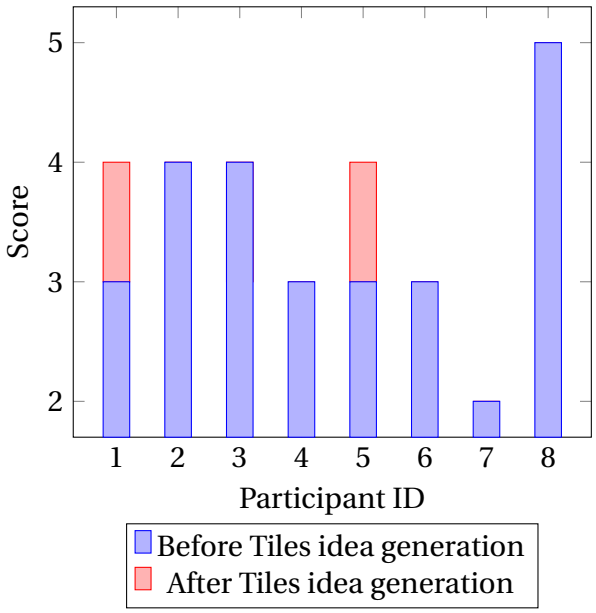

Figure 4.19: *"Q4.3: To which degree are you now interested in programming?"*

Likeliness to study technology

Four of the eight participants reported the same likeliness to study technology after the workshop, while participant 1, 3, and 8 reported a higher likeliness to study technology after the

workshop. Participant number 4 reported a lower likeliness of studying technology after the workshop.

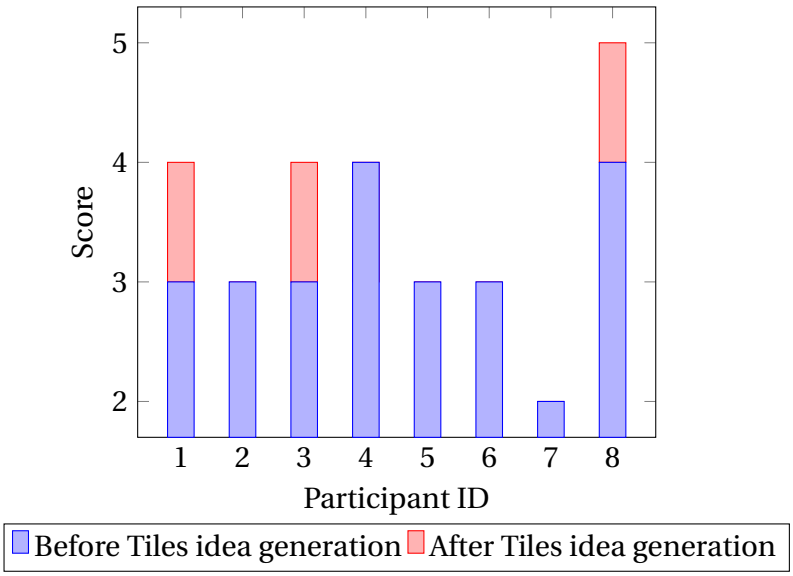

Figure 4.20: *"Q5.3: How likely is it that you will study technology?"*

Familiarity with science concepts

Six out of eight participants gave same score of familiarity with technology, and participant number 6 and 7 reported a higher score of familiarity with technology after the Tiles cards workshop. Six participants reported that they had the same familiarity with the programming concepts before the workshop compared to after, participant number 4 reported a lower familiarity with programming after the workshop, and participant number 6 reported a higher familiarity with programming.

Seven of the eight participants reported the same score of familiarity about what an engineer is, while participant number 5 reported a lower familiarity of it, going from a score of 5 to a score of 4. Six participants scored the familiarity of what an engineer does the same before the workshop compared to after. Participant number 5 gave a lower score (going from a score of 5 to a 4), and participant number 3 reported a higher score (going from 3 to a 4).

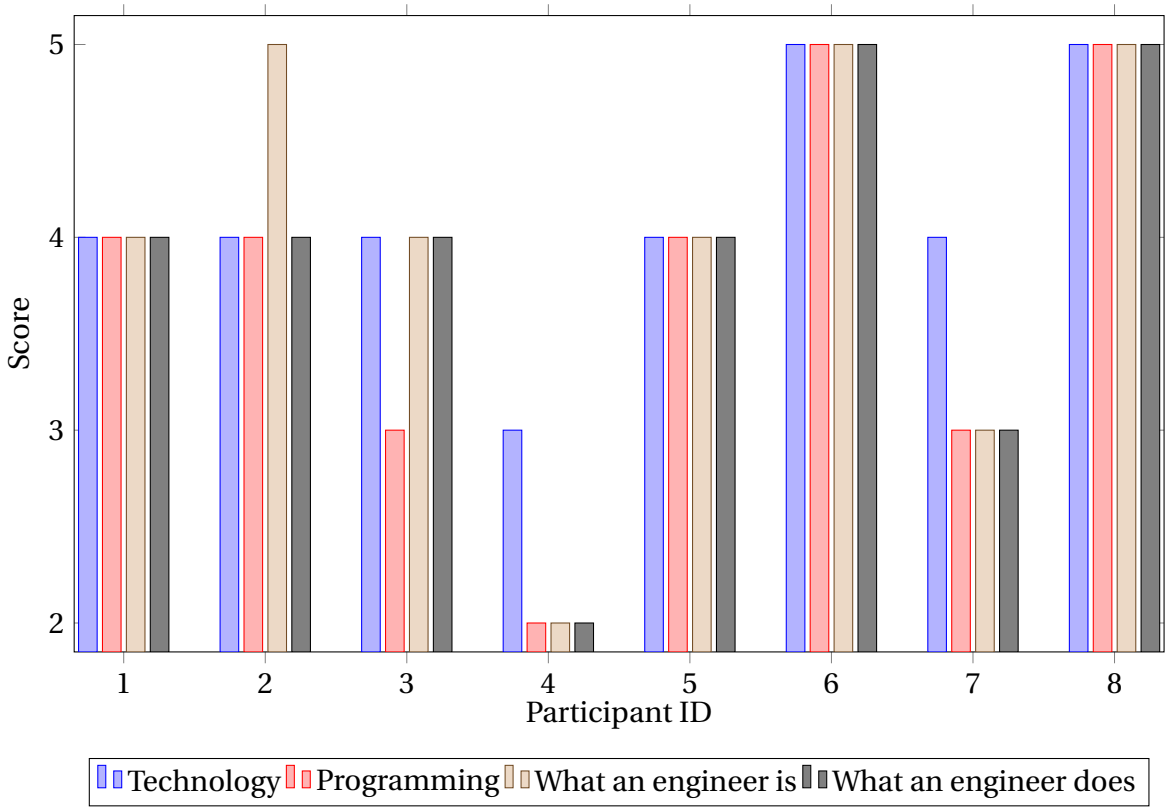

Figure 4.21: *"Q6.3: Familiarity with science concepts after Tiles cards workshop"*

4.5.4 After Tiles programming workshop

Learning outcomes

Participant number 4 reported that she learned something about technology after the programming workshop (giving a score of 3), three reported that they learned more than something, and four participants reported that they learned a lot about technology from this programming workshop. Five participants reported that they learned a lot about programming from this workshop, two reported that they learned more than something, and participant number 4 reported that she learned something about programming.

Interest in technology and programming

Seven of eight participants reported the same interest in technology and programming before the Tiles programming workshop compared to after. Participant number 7 expressed a higher interest in technology after the programming workshop, and participant number 3 gave a score

of 3 regarding her interest in programming before the workshop, and gave a score of 5 after having tried programming.

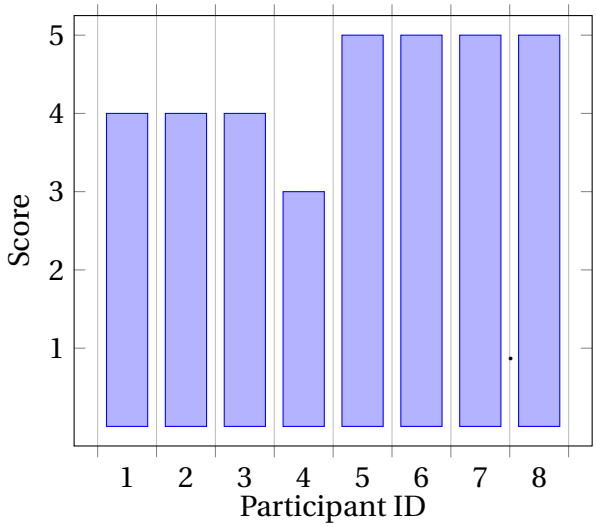

Figure 4.22: *"Q7.3: To which degree did you learn something about technology?"*

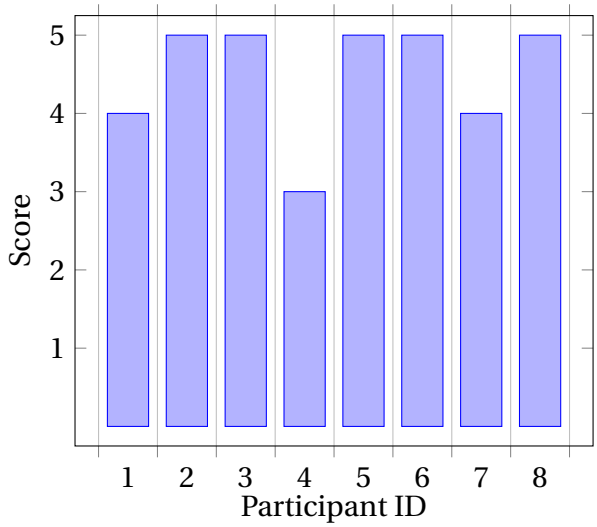

Figure 4.23: *"Q8.3: To which degree did you learn something about programming?"*

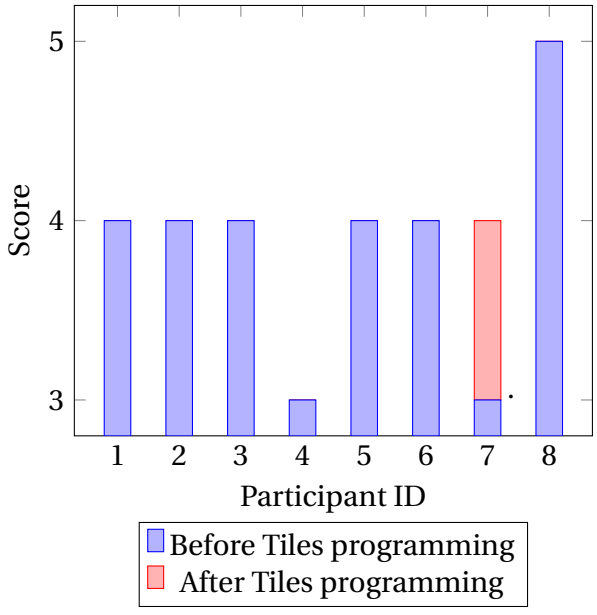

Figure 4.24: *"Q3.4: To which degree are you now interested in technology?"*

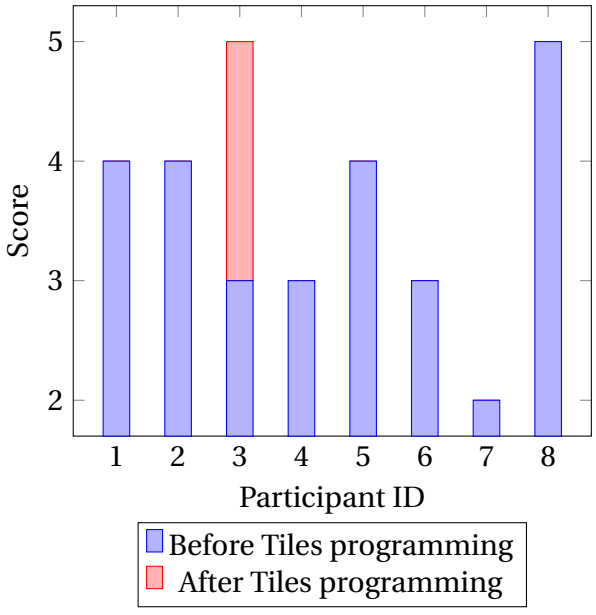

Figure 4.25: *"Q4.4: To which degree are you now interested in programming?"*

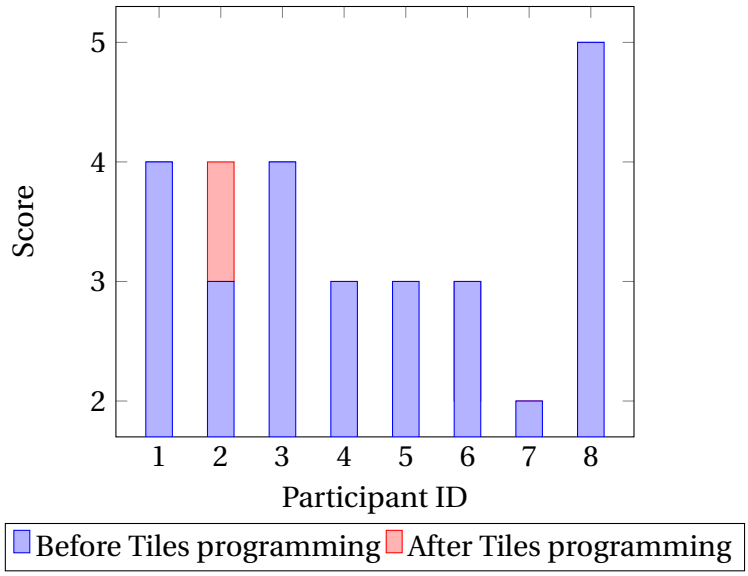

Figure 4.26: *"Q5.4: How likely is it that you will study technology?"*

Likeliness to study technology

Six participants expressed the same interest in studying technology before the programming workshop as after. Participant number 2 expressed higher interest in studying technology after programming, and participant number 6 reported a lower interest in studying technology after the programming workshop.

Familiarity with science concepts

Regarding the concept of technology, six participants rated the same familiarity with it before the programming workshop as after. Participant number 2 and 4 reported a lower familiarity with technology after the workshop. All participants reported the same familiarity with programming before the programming workshop compared to after.

All participants reported that they had the same familiarity with what an engineer is before the programming workshop, compared to after. Seven out of eight participants gave the same score of their familiarity with what an engineer does before the workshop as after, and participant number 3 reported a lower score of familiarity about it.

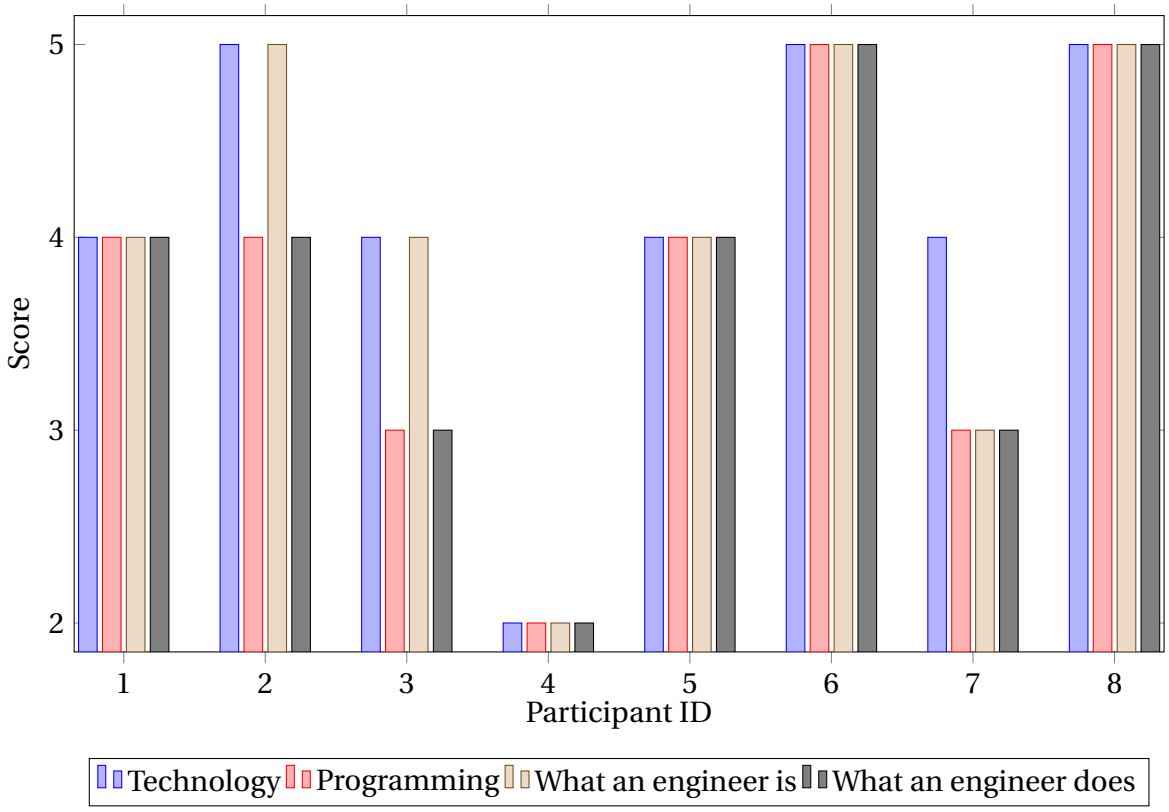

Figure 4.27: *"Q6.4: Familiarity with science concepts"*

4.5.5 Individual trajectory of interest of the participants

Participant number 1 scored her interest in technology one point higher after the intervention, compared to before (from 3 to 4). Her interest in programming also received one point more than before (from 3 to 4). Her interest in studying technology went from a score of 3 before the intervention, to a score of 4 after the intervention. The activity that she thought was the most informative/educational was the lecture about technology and programming. The activity that inspired/motivated her the most was the Tiles programming workshop.

Participant number 2 scored her interest in technology and her interest in studying technology one point higher after the intervention (from 3 to 4). Her interest in programming, which was a score of 4 was unchanged after the intervention. She thought the activity that was the most informative/educational was the lecture about technology and programming, and the activity that inspired/motivated her the most was the Tiles cards workshop.

Participant number 3 scored her interest in technology one point higher after the intervention (from a 3 to a 4). Her interest in programming increased from a score of 3 to a score of 5, and her interest in studying technology increased from a score of 2 to a score of 3. The activity that was the most informative/educational for her, was the lecture about technology and programming, and the activity that inspired/motivated her the most was the Tiles programming workshop.

Participant number 4 reported a lower score of interest in technology after the intervention (from a 4 to a 3). Her interest in programming remained the same (a score of 3), and her interest in studying technology increased from a score of 2 to a score of 3. She thought that the Tiles programming workshop was the activity that was both the most informative/educational and the most inspiring/motivating.

Participant number 5 scored her interest in technology two points higher than before the intervention (from a 2 to a 4), and her interest in programming three points higher (from a 1 to a 4). Her interest in studying technology increased from a score of 2 to a score of 3. The activity that was the most informative/educational for her was the Tiles programming workshop, and the activity that was the most motivating/inspiring was the lecture about technology and programming.

Participant number 6 reported an unchanged interest in technology (a score of 4), programming (a score of 3), and the interest in studying technology (a score of 3). The activity that was the most informative/educational for her was the Tiles programming workshop, and the activity that was the most inspirational/motivating was the lecture about technology and programming.

Participant number 7 increased her interest in technology after the intervention (from 2 to 4). Her interest in programming was unchanged at a score of 2, and her interest in studying technology increased from a score of 1 to a score of 2. The activity that was the most informative/educational for her was the Tiles programming workshop, and the activity that was the most motivating/inspiring for her was the Tiles cards workshop.

Participant number 8 had a very high interest in both programming, technology, and studying technology before the intervention (5, 5, and 4 respectively). She scored her interest in technology, programming, and studying technology a score of 5 after the intervention. The lecture about technology and programming was the activity that she thought was both the most informative/educational and the most motivating/inspiring.

4.5.6 Overall results

The average interest in technology increased during the intervention, going from a score of 3,25 to a score of 4. The interest in technology increased steadily after each activity, and the interest increased the most after the lecture. The average interest in programming also increased during the day, with a score of 3 before the intervention, and a score of 3,75 after. The interest in programming grew the most after the lecture.

The average interest in studying technology increased from a score of 2,5 to a score of 3,375 after the intervention. The increase in interest of studying technology grew the most after the lecture, and the average of the interest between the Tiles idea generation workshop and the Tiles programming workshop was unchanged.

Learning outcome

The average learning outcome of technology was given a score of 4,25 after the lecture, and a score of 4,375 after the Tiles programming workshop. The average learning outcome score between the lecture and the Tiles idea generation workshop did not change. The average learning outcome of programming was scored a 4 after the lecture, dropped to a score of 3,75 after the Tiles idea generation workshop, and increased to a score of 4,5 after the Tiles programming workshop. The drop in learning outcome of programming is not so strange, considering that there were no programming in the Tiles cards workshop.

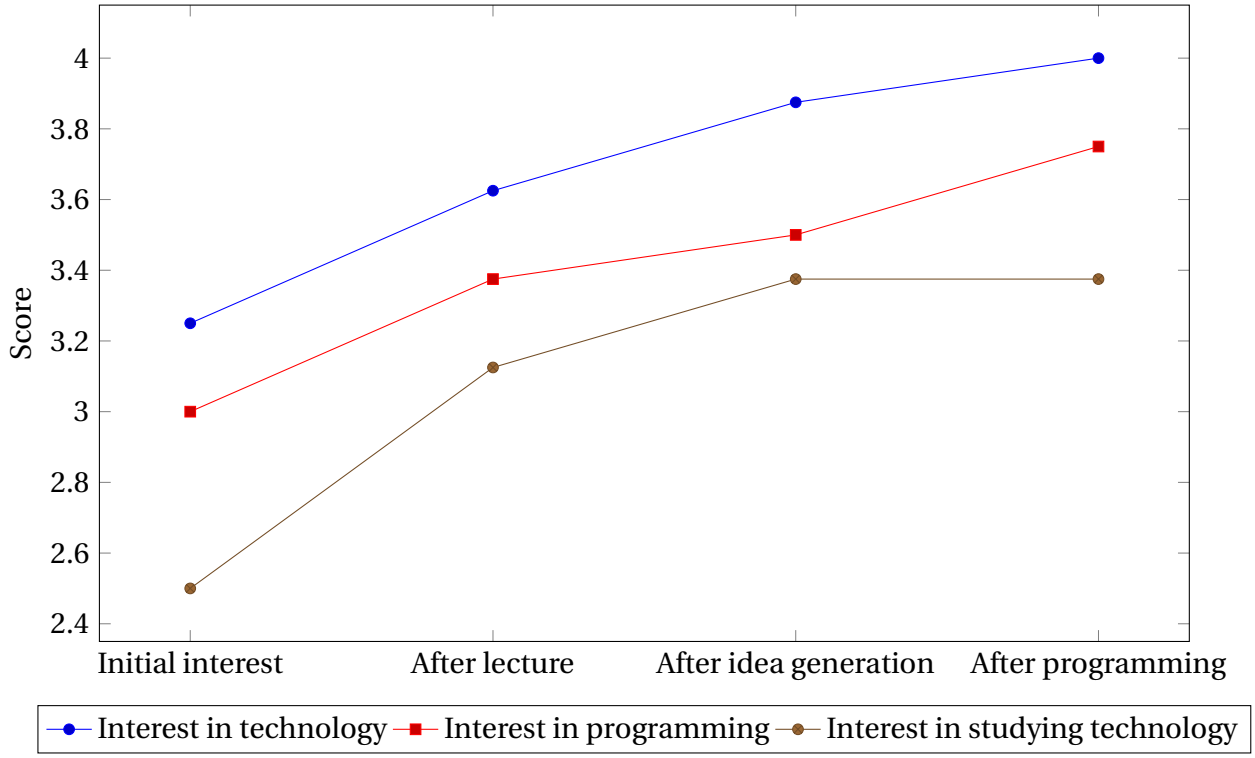

Figure 4.28: *Average interest in technology, programming, and in studying technology after each workshop activity*

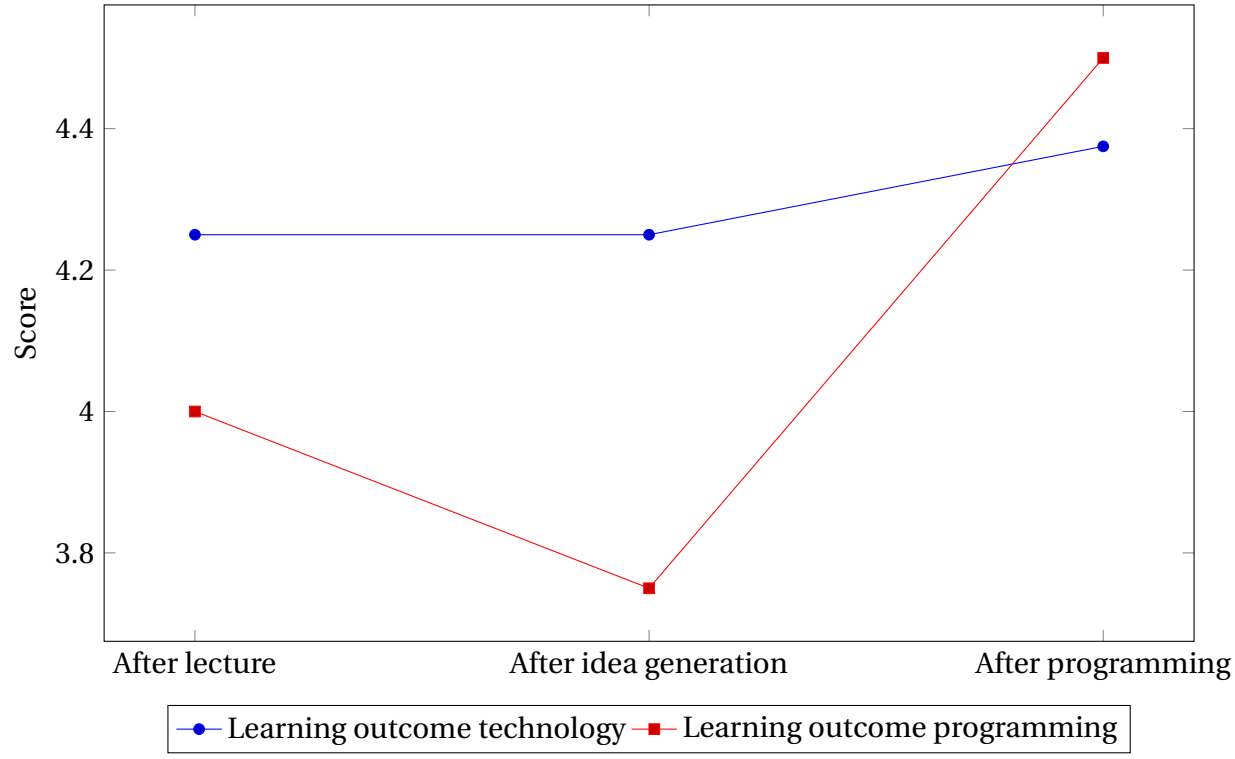

Figure 4.29: *Avg learning outcome in technology and programming after each workshop activity*

Familiarity with science concepts

The participants scored their average familiarity with technology quite high before the intervention, with an average score of 3,5. The average familiarity with technology increased after the lecture, and further after the Tiles idea generation, but was unchanged after the Tiles programming workshop, ending with a score of 4,125.

The participants had a low average familiarity with programming, with a score of 2,625. The average familiarity with programming increased after the lecture, and scored the same average after the following activities. At the end of the intervention the average familiarity with programming was given a score of 3,75.

The average familiarity with what an engineer is was quite low before the participants engaged in the activities, with a score of 2,625. The familiarity with the concept increased after the lecture to a score of 4,125, dropped slightly after the Tiles idea generation workshop to a score of 4, and dropped slightly further after the Tiles programming workshop, ending with a score of 3,875.

The concept of what an engineer does had the lowest score of all concepts initially, with an average score of 2. The average score of familiarity with this concept increased to almost the double of the initial score after the lecture, with a score of 3,875. The average score stayed the same after the Tiles idea generation workshop, and decreased slightly after the Tiles programming workshop, to a score of 3,75.

Evaluation of the most informative and motivating activity

At the end of the last questionnaire given to the participants of the intervention, they were asked which activity they found the most informative/educational. Four participants answered the lecture, and four answered the Tiles programming workshop.

When asked which activity they thought were the most inspiring/motivating, three answered the lecture, two answered the Tiles idea generation workshop, and three answered the Tiles pro-

gramming workshop.

4.6 Conclusion

With an exception of participant number 4 when scoring her interest in technology, all participants scored their interest in technology, programming, and studying science the same or higher after their intervention. Five participants reported a higher score of their interest in technology, three participants reported a higher score of their interest in programming, and seven participants reported a higher score of their interest in studying technology after the intervention.

It is clear that the participants were inspired by different activities during this intervention. The three different activities that were held during this intervention were all reported as the activity that inspired/motivated one or several participants the most. The lecture about technology and programming and the Tiles programming workshop were both deemed as the most informa-

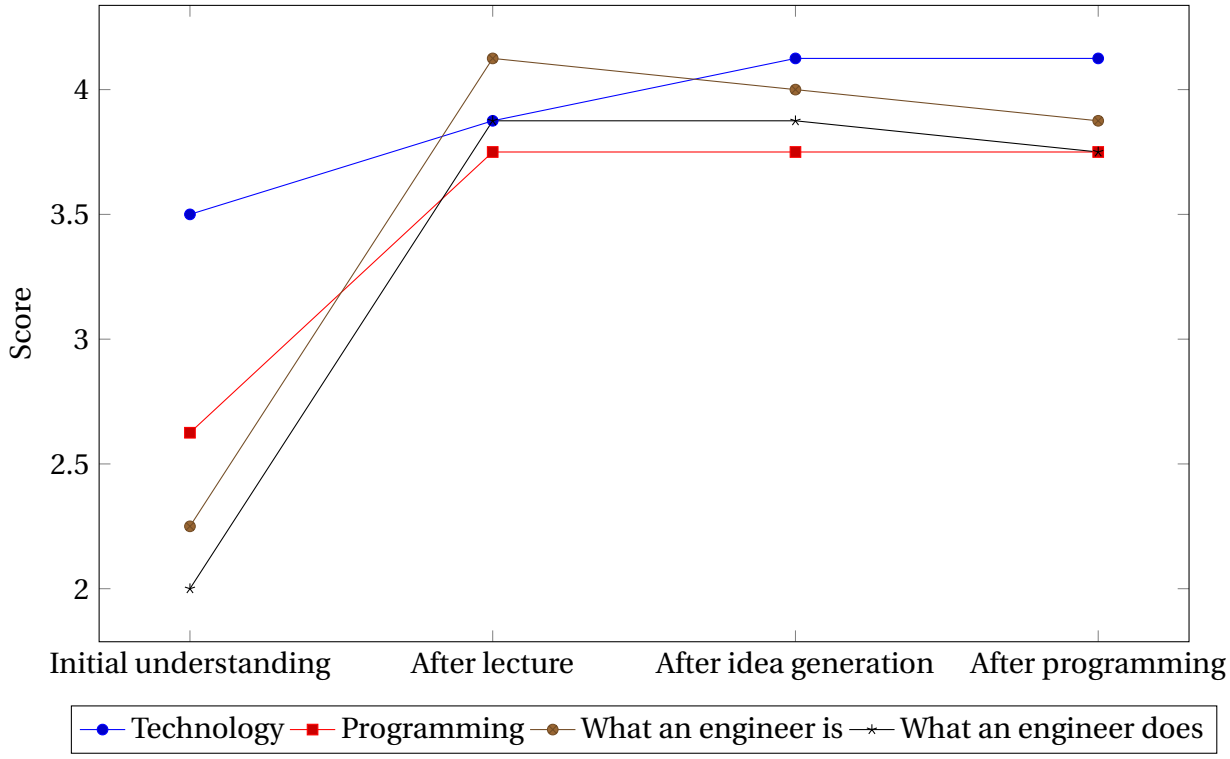

Figure 4.30: *Average understanding of some technology concepts after each workshop activity*

tive/educational by several of the participants.

The fact that the average perceived familiarity with what an engineer is and does dropped after the Tiles cards workshop and the Tiles programming workshop could be because it was not explicitly explained further what an engineer is in the following activities after the lecture. Perhaps it is important to introduce the activities of an intervention with an explanation of how the activities connect to the professional life of an engineer, in order for the participants to understand why they are doing what they are doing.

The increase in perceived interest of technology and programming, as well as the increase in interest in studying technology was the highest after the lecture. This could be because of how the intervention was designed with the lecture as the first activity. There might have been different scores if the intervention started with one of the two Tiles workshops instead.

It seems like the design of this intervention was appropriate when the purpose is to increase participants' interest in studying technology, as seven out of eight participants reported a higher interest in studying technology after the intervention.

It was somewhat surprising that there were several of the participants who thought that the lecture was the most inspiring/motivating activity of the intervention, considering that workshops which are designed to increase girls' interest in technology usually consist of practical activities (which we can see from chapter 2 for example). Perhaps it is important to include general information about technology and programming before introducing practical activities.

To conclude, we can see that the participants' levels of interest changed during the intervention. A lecture which includes general information about technology and programming can be both inspiring and informative for the participants. The Tiles cards workshop and the Tiles programming workshop can increase participants' interest in technology and programming, and also increase their interest in studying technology.

Chapter 5

Technology camp

The Technology Camp (TC) is a camp for female upper secondary school students who want to explore their possibilities to study STEM studies at NTNU [9]. Students all over Norway are invited to apply to attend the Technology Camp, and approximately 200 students are accepted.

The Technology Camp is organized by The Girl Project Ada (TGPA) [47], in cooperation with the Faculty of Information Technology and Electrical Engineering (IE faculty) at NTNU [48], whom works towards raising the percentage of female students in the STEM studies Mathematics, Computer Science, Communication Technology, Informatics, Electronics Systems Design and Innovation, and Cybernetics and Robotics.

This camp has proven to be a success with regards to recruiting female students to NTNU. Numbers from TGPA showed that of the participants who attended the Technology Camp in 2015, 89% of them started at NTNU by 2017 [49].

5.1 Research method

The Technology Camp was designed by TGPA with the purpose of attracting more female students to STEM studies at NTNU. I had no control over the activities that were held at the TC, I only designed and evaluated the evaluation form that was sent to the participants after this camp was finished. The evaluation form that I created was based on previous questionnaires

that were used in earlier Technology Camps.

5.1.1 Participants

All participants attending the Technology Camp are female students in upper secondary school, either in 2nd or 3rd grade. The participants are coming from schools located all over Norway. The girls must apply to participate at the Technology Camp by sending an application which includes their motivation for participating and their grades in math. All applicants must take mathematics for natural sciences, called R1, in order to be qualified for the participation at the camp, and only the girls with the highest grades in related subjects are selected to participate.

TGPA and members of the IE faculty are in charge of choosing which participants get to participate at the Technology Camp. They aim to include participants from all over Norway, and usually limits one or two participants from one school to join the camp. They try to have a balance between second and third grade upper secondary school students.

5.1.2 Purpose

The purpose of the Technology Camp is to recruit female applicants to STEM studies at NTNU. The studies that are in focus during this camp are Computer Science, Communication Technology, Informatics, Electronics Systems Design and Innovation, and Cybernetics and Robotics.

The goal of the camp is to increase the participants' motivation for studying science at NTNU. This is done by allowing the girls to experience NTNU's campus for technology - Gløshaugen, introducing them to various workshops which include technology in some way, and to listen to experienced professors and lecturers talking about different fields within Information and communication technology (ICT). In addition to the academic part of the camp, there is also a social part where the girls will experience Studentersamfundet [50], which is a popular gathering place for many students in Trondheim.

5.1.3 Procedure

The three day program for the Technology Camp is a mix between information about student life, inspirational talks, educational talks, workshops, and social happenings [51]. The first day of the camp consists of two informational lectures and two educational/inspirational lectures. After the lectures there is a dinner at a local restaurant in the city centre of Trondheim. The second day of the camp starts with workshops, then follows three educational/inspirational lectures, and finally a gala is hosted at Studentersamfundet in the evening. There is also a mingling session on the second day where the participants have the opportunity to visit several stands of different studies at NTNU and some technology companies. The last day of the camp starts with workshops and ends with two educational/inspirational lectures.

5.2 Lectures

In addition to students presenting various perspectives on student life and its possible activities, there are six lectures given by professionals which discusses several different topics within ICT (see table 5.1). The purpose of these lectures is to both give the participants information about the ICT field, and to inspire them to want to study ICT. Some lectures are more fact based, while others are more personal and describes their subjective experiences of a study or topic.

Table 5.1 shows the description of each lecture and which themes they include. Lecture number 2: *The road from student to professor in electronics*, and 3: *The journey from participant at the Technology camp, via Computer Science, to work life* are the most personal lectures given at the Technology Camp, where the lecturers talk about their experience with studying science. Lecture number 1: *Information and communication technology - what do we use it for?*, lecture number 4: *Online with hackers, scam artists, and spies*, lecture 5: *With lego pieces in nano format*, and 6: *Data driven person transport with magnetic hovering* are lectures which focuses on a specific theme, and do not include personal stories. Table 5.2 shows whether the lectures are personal or general, and whether they are held by a female or male lecturer.

Lecture ID	Lecture	Description
1	Information and communication technology - what do we use it for?	About ICT and its uses in daily life
2	The road from student to professor in electronics	About how one can start out as a mathematics and physics student to do research about medical technology
3	The journey from participant at the Technology camp, via Computer Science, to work life	About the inspiration from the Technology camp influencing study choices and the transition into the work life
4	Online with hackers, scam artists, and spies	About the importance of data security
5	With lego pieces in nano format	About Cybernetics and Robotics
6	Data driven person transport with magnetic hovering	About the future public transportation by using magnetic hovering

Table 5.1: Description of the Technology camp lectures

Lecture ID	Personal vs. General information	Female/Male lecturer
1	General	Female
2	Personal	Female
3	Personal	Female
4	General	Female
5	General	Male
6	General	Male

Table 5.2: Characteristics of the Technology camp lectures

5.3 Workshops

There are several workshops running simultaneously at the Technology Camp, with one session on day 2, and another one on day 3. A table of the workshops can be seen in table 5.3. The purpose of the workshops is to give the participants hands on experience with technology, while at the same time teaching them about a certain topic. Some workshops are more practical in others, in the way that the participants are working with physical objects, while others consist of mainly solving problems on a computer.

All workshops consisted of some programming. Workshop number 5: *Code your own game* and workshop number 8: *Programming in Python* were workshops which only included programming. Workshop number 3: *Hackerspace* and number 6: *Program your own traffic light* used Arduino to introduce programming. Workshop number 1: *Build your own computer* consisted mainly of soldering, workshop number 2: *A better tomorrow with IoT* introduced IoT through the littleBits building blocks, workshop number 4: *Introduction to hacking* consisted of lectures about internet security and small hacking tasks, workshop number 7: *Artificial intelligence in practice* consisted of learning how to program Pepper, the humanoid robot, and workshop number 9: *Program your own Lego robot* introduced Cybernetics through programming Lego robots.

5.4 Results from evaluation form

After the Technology camp was finished, the participants were asked to fill out an evaluation form of the activities that were held at the Technology camp. The evaluation form was made in Google Forms [43], and consisted of four parts; (1) the evaluation of the Technology camp in general, (2) about their desired study and place of study in the future, (3) about the lectures and the program as a whole at the Technology Camp, and (4) about the workshops at the Technology camp.

For the purpose of this research, part 3 and 4 are the most interesting, but results from part 2 are also included as it describes how the Technology Camp has affected their motivation for studying technology. Part 3 asks the participants to give a score from 1 to 5 of all the lectures

Workshop ID	Workshop	Description
1	Build your own computer	Soldering circuit boards
2	A better tomorrow with IoT	Connecting littleBits to make inventions
3	Hackerspace	Arduino, 3D-printing, VR game development
4	Introduction to hacking	Hacking databases, decrypting a text, modifying information online
5	Code your own game	Designing and programming a game in Scratch
6	Program your own traffic light	Programming an Arduino to function as a traffic light
7	Artificial intelligence in practice	Programming Pepper, the humanoid robot
8	Programming in Python	using the Turtle library in Python
9	Program your own Lego robot	Programming Lego Mindstorms robots

Table 5.3: Description of the Technology camp workshops

Workshop ID	Technologies used	Students vs. Professors responsible
1	Soldering, light programming	Both
2	littleBits	Both
3	Arduino, 3D-printing, game design, VR glasses	Students
4	Computer, Databases, Script programming	Both
5	Scratch	Students
6	Arduino, programming	Both
7	Programming Pepper robot	Both
8	Python	Students
9	Lego Mindstorms	Both

Table 5.4: Characteristics of the Technology camp workshops

being held at the camp, and part 4 asks the participants to rate the workshops they attended on a scale of 1 to 5, and also asks which activity they liked the most.

There were 158 participants who answered the evaluation form. It should be noted that by answering the evaluation form, the participants could join a contest to win two gift cards of a value of 500NOK.

5.4.1 Data collection

Google Forms was chosen as a data collection tool because of its easiness to create and use for participants. The form consisted of questions with linear scale answers and open questions with a corresponding textbox. A Likert scale of 1-5 was used for the rating scale questions, where 1 meant "strongly disagree" and 5 meant "strongly agree" when asked yes/no questions, and where 1 meant "very bad" and 5 meant "very good" when asked to rate lectures and workshops.

The questionnaire used for this data collection was based on an already existing questionnaire from earlier technology camps that have been organized previous years, in order for the data from this questionnaire to be able to be used in comparison with existing data. The only question that was added for the purpose of using it for this thesis was the question that asked which of the activities the participants enjoyed the most at the Technology camp. A list of questions asked in the questionnaire can be found in appendix D.

5.5 Analysis

The Mann-Whitney-Wilcoxon Test was used to distinguish statistical difference between lecture and workshop scores [52], by the use of the R programming framework [53]. This test can be used when the data does not follow the normal distribution to find out whether population distributions are identical or not.

When scoring the workshops the participants attended, a textbox of optional answering was followed after the linear scale scoring. The text written answers were analyzed by coding the

answers into two categories; what they liked about the workshop, and what they did not like.

5.5.1 Evaluation of the Technology camp's effect on study motivation

In addition to the participants scoring the statements *"The Technology Camp made me want to study technology or science"* and *"The Technology Camp made me want to study ICT"* on a scale of 1-5, there was also a question which asked in which way they think the Technology Camp did influence their study choices with a textual answer.

Figure 5.1 shows the scores given of the perceived desire to study technology before and after the Technology Camp. The average score of perceived desire to study technology or science increased after the Technology Camp, scoring a mean of 3,77 before the camp, and a mean of 4,42 after the camp.

Several participants said that they were more motivated to study science or technology at NTNU, even though they were almost certain that they wanted to study medicine or law before participating at the camp. Other participants said that they were sure they wanted to study science, but that they did not know which line of studies.

The average score of perceived desire to study ICT also increased after the Technology Camp, scoring a mean of 2,44 before the camp, and a mean of 3,89 after the camp. Figure 5.2 shows the distribution.

One participant said that she is now sure that she wants to study technology, and that she thought before that ICT was 'boring' and 'nerdy', but that the Technology Camp showed her that that was not the case. Several participants said that they had never thought of ICT as a possible future study, but that the camp had opened their eyes for it, and that they would consider it more seriously. Another participant said that she was now 100% sure that she was going to study Informatics.

A few students said that they were thankful for the experience of the Technology Camp, because

the camp made them more sure that they wanted to study something other than science.

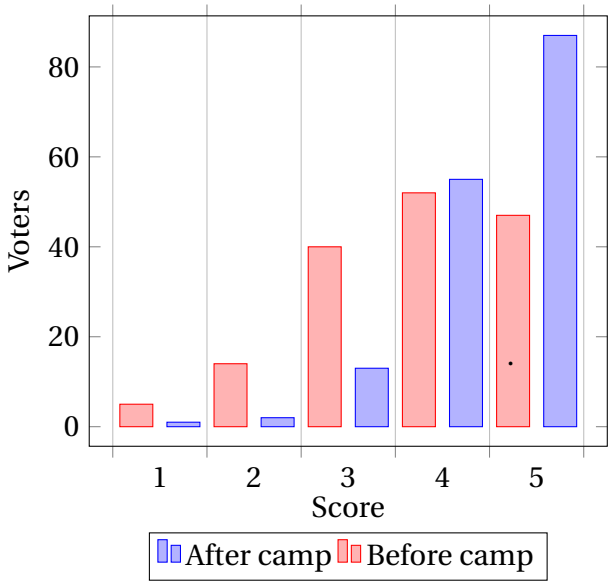

Figure 5.1: *The desire to study technology or science before and after the Technology Camp*

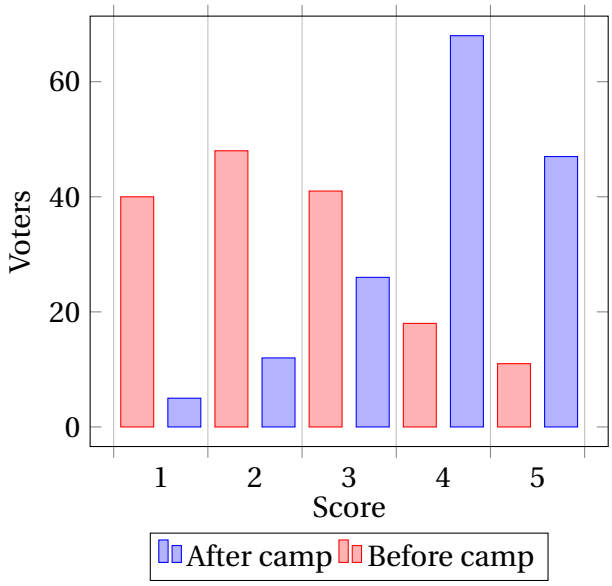

Figure 5.2: *The desire to study ICT before and after the Technology Camp*

5.5.2 Evaluation of the lectures

The participants of the Technology Camp were asked to rate the lectures on a score of 1-5. Table 5.5 shows the descriptive statistics for the lectures. As we can see from the table, lecture number 2 had the highest mean with a score of 4,866, and lecture 3 had the lowest mean with a score of 4,261.

In the final question of the questionnaire, the participants were able to leave additional comments to the Technology Camp. There were several participants who expressed gratefulness for the talented lecturers who were giving lectures at the camp. Lecturer number 2 was the only lecturer that was mentioned by name and pointed out as an inspiring lecturer; one participant pointed out that this lecturer had a very interesting and inspiring story. Another five participants mentioned that lecturer number 2 became a role model for them, and that she inspired and motivated them a lot. Lecture number 6 was also mentioned by some participants as a very inspiring lecture. It talked about future transportation methods, and made some participants

reflect on how important technology could be for the future.

Lecture ID	n	mean	sd	median	min	max
1	158	4.595	0.696	5	1	5
2	157	4.866	0.454	5	1	5
3	157	4.261	0.833	4	2	5
4	158	4.373	0.672	4	3	5
5	158	4.449	0.654	4	3	5
6	157	4.478	0.748	5	2	5

Table 5.5: *Descriptive statistics of lecture scores*

5.5.3 Mann-Whitney-Wilcoxon test of lectures

As we can see from table 5.6, not all lectures could be compared because of the pairs not being statistically different. The Mann-Whitney-Wilcoxon test showed that lecture 1 was significantly different than lecture 2,3,4, and 5, thus lecture 1 can be compared to those lectures. By looking at the mean of the lectures, we can say that since lecture 1 has a higher mean than lecture 3, 4, and 5, that lecture 1 was better than lecture 3, 4, and 5.

Lecture 2 was significantly different from all other lectures, and since lecture 2 has a greater mean than all other lectures, we can say that lecture 2 was the best lecture at the Technology Camp.

Lecture 3 was significantly different from lecture 1,2, and 6. We already know that lecture 1 was better than lecture 3, and since lecture 3 has a lower mean than lecture 6, we can say that lecture 6 was better than lecture 3.

In conclusion, we can say that lecture 2 was the best lecture at the Technology Camp. Lecture 1 was better than lecture 3, 4, and 5, and lecture 6 was better than lecture 3.

contrast	p.value	statistically significant difference
1 - 2	8.283e-06	yes
1 - 3	4.444e-05	yes
1 - 4	0.0004013	yes
1 - 5	0.01055	yes
1 - 6	0.1351	no
2 - 3	3.912e-16	yes
2 - 4	4.742e-15	yes
2 - 5	3.899e-12	yes
2 - 6	8.823e-09	yes
3 - 4	0.4402	no
3 - 5	0.08069	no
3 - 6	0.01102	yes
4 - 5	0.2992	no
4 - 6	0.05753	no
5 - 6	0.3493	no

Table 5.6: *Pairwise Mann-Whitney-Wilcoxon test of lecture scores*

Graphs of score distribution for the lectures

Figure 5.3 to figure 5.8 shows the distribution of scores for all the six lectures at the Technology Camp.

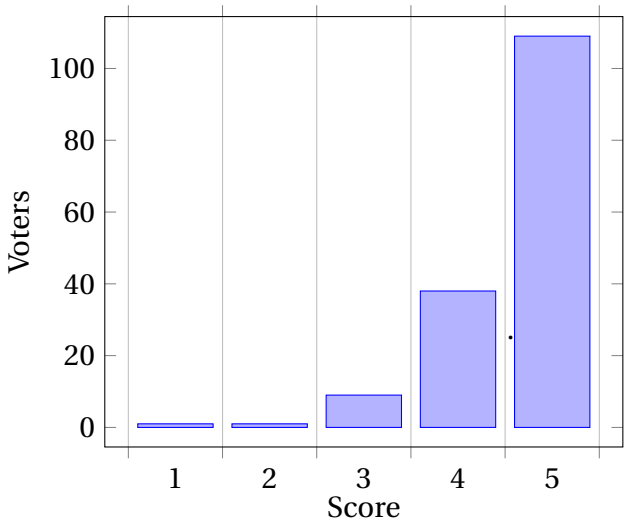

Figure 5.3: *"Lecture 1: Information and communication technology - what do we use it for?"*

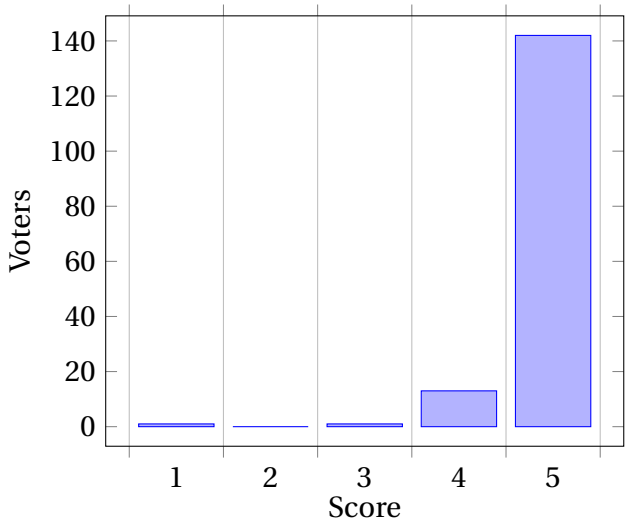

Figure 5.4: *"Lecture 2: The road from student to professor in electronics"*

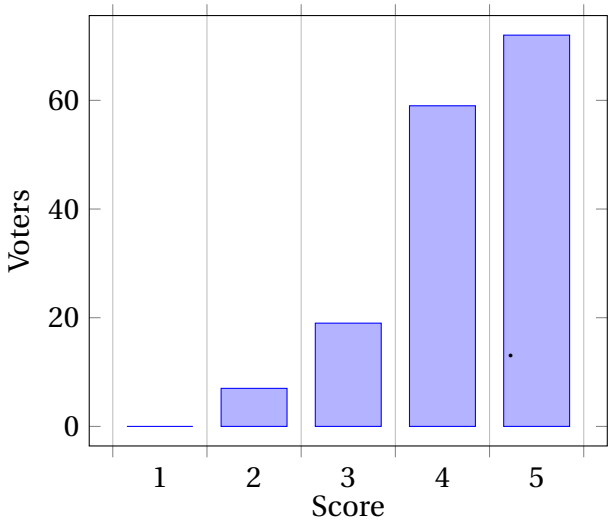

Figure 5.5: *"Lecture 3: The journey from participant at the Technology camp, via Computer Science, to work life"*

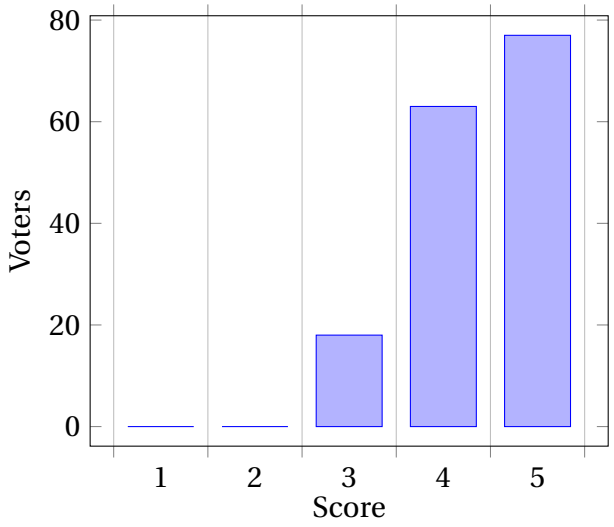

Figure 5.6: *"Lecture 4: Online with hackers, scam artists, and spies"*

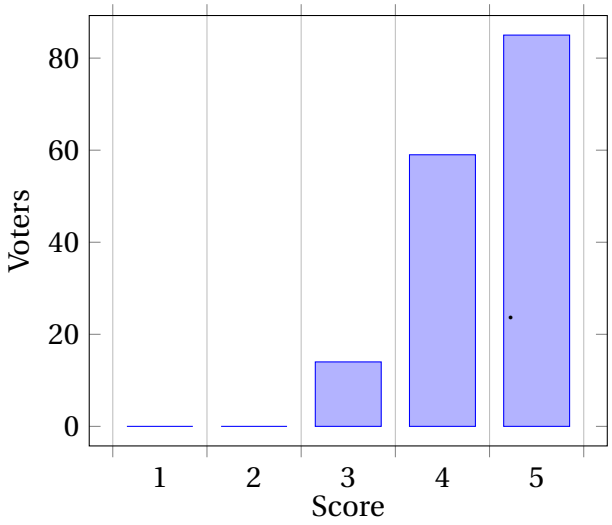

Figure 5.7: *"Lecture 5: With Lego pieces in nano format"*

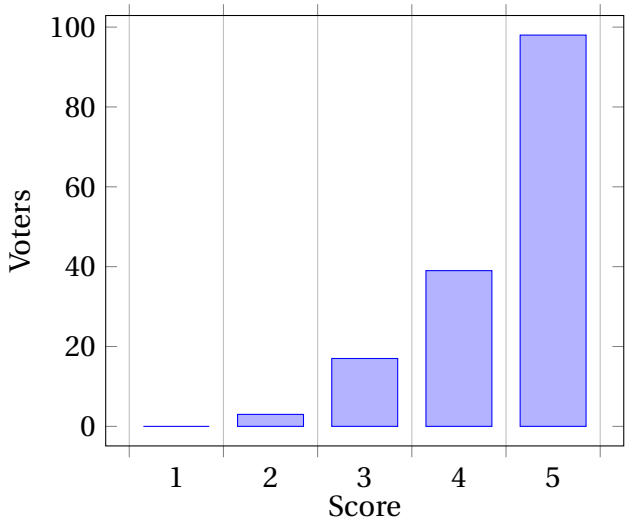

Figure 5.8: *"Lecture 6: Data driven person transport with magnetic hovering"*

5.5.4 Evaluation of the workshops

Each of the 158 participants at the Technology Camp took part in two workshops each. In addition to rating the workshops on a scale of 1-5, they were also asked to comment on how they liked the workshops. The data from the Likert scale answers were analyzed using the Mann-Whitney-Wilcoxon test, and the written answers were analyzed through coding.

Table 5.7 shows the descriptive statistics for the workshops at the Technology Camp. As we can see from the table, there were a different amount of participants for each workshop. Workshop number 3 had the highest mean of all workshops, and workshop number 9 had the lowest. The median of each of the workshops are either a 4 or a 5, which suggests many of the participants enjoyed the workshops.

Workshop ID	n	mean	sd	median	min	max
1	44	4.250	0.839	4	2	5
2	38	4.105	0.924	4	2	5
3	27	4.667	0.734	5	3	5
4	43	4.256	0.819	4	2	5
5	21	4.381	0.740	5	3	5
6	43	4.372	0.817	5	2	5
7	27	4.148	0.907	4	2	5
8	38	4.105	0.764	4	3	5
9	34	4.088	0.866	4	2	5

Table 5.7: *Descriptive statistics of workshop scores*

5.5.5 Mann-Whitney-Wilcoxon test of workshops

Due to the lower number of participants rating the workshops compared to the lectures, there were fewer workshops that could be compared by using the Mann-Whitney-Wilcoxon test. As we can see from table 5.8, the only workshop that had a statistically significant difference from other workshops, was workshop number 3.

Workshop number 3 was designed and organized by Hackerspace at NTNU [54], which is completely run by students. The workshop included Arduino programming, a crash course in 3D-printing, a short introduction to game design, and the testing of virtual reality (VR) glasses. They also showed the participants their newly built escape room for them to try out.

The Mann-Whitney-Wilcoxon test confirmes that workshop number 3 was the best workshop

at the Technology Camp, according to the participants. It cannot confirm which of the other workshops were better than others.

contrast	p.value	statistically different
1 - 2	0.5067	no
1 - 3	0.01555	yes
1 - 4	1	no
1 - 5	0.614	no
1 - 6	0.4564	no
1 - 7	0.6738	no
1 - 8	0.3239	no
1 - 9	0.39	no
2 - 3	0.003664	yes
2 - 4	0.5084	no
2 - 5	0.2978	no
2 - 6	0.1614	no
2 - 7	0.8759	no
2 - 8	0.7602	no
2 - 9	0.842	no
3 - 4	0.01401	yes
3 - 5	0.0771	no
3 - 6	0.04915	yes
3 - 7	0.01262	yes
3 - 8	0.001595	yes
3 - 9	0.002234	yes
4 - 5	0.6071	no
4 - 6	0.4428	no
4 - 7	0.6729	no
4 - 8	0.3148	no
4 - 9	0.3867	no
5 - 6	0.9177	no
5 - 7	0.418	no
5 - 8	0.1761	no
5 - 9	0.2211	no
6 - 7	0.2915	no
6 - 8	0.07213	no
6 - 9	0.1046	no
7 - 8	0.6965	no
7 - 9	0.751	no
8 - 9	0.9134	no

Table 5.8: *Pairwise Mann-Whitney-Wilcoxon test of workshop scores*

5.5.6 Detailed evaluation of workshops

Workshop 1: Build your own computer

After giving a lecture about the history of computers and a short crash course in soldering and electric circuits, soldering is the main part of this workshop. The girls were handed a circuit board with some components already attached, and are given the task of soldering resistors, a LED-display, transistors, and capacitors. The finished product is a circuit board powered by batteries, which shows a message in the LED-display.

The participants of this workshop thought it was fun and educational. They were happy about the students guiding them being helpful and nice, and appreciated the joy of practical work and that they were allowed to try and fail.

Several participants said that they would have wanted more information at the beginning of the course, and some said that the introduction with the history of computers was a little boring. Several participants said that they would have liked to try more programming and less soldering. They also said that they thought soldering was fun initially, but that it became a little repetitive after a while. Some participants felt that the professor in charge of the workshop was a little too absent during the workshop. Figure 5.9 shows the distribution of scores for this workshop.

Workshop 2: A better tomorrow with IoT

This workshop introduces the concept of Internet of Things by using littleBits [55]. The workshop starts with a short presentation of Communication Technology, and follows with a TED-talk about littleBits [56]. After this, a short introduction of Internet of Things is given, and the girls are given some tasks to be solved using littleBits. Towards the end of the workshop, after the participants have played around with the littleBits, they are asked to make their own invention using littleBits.

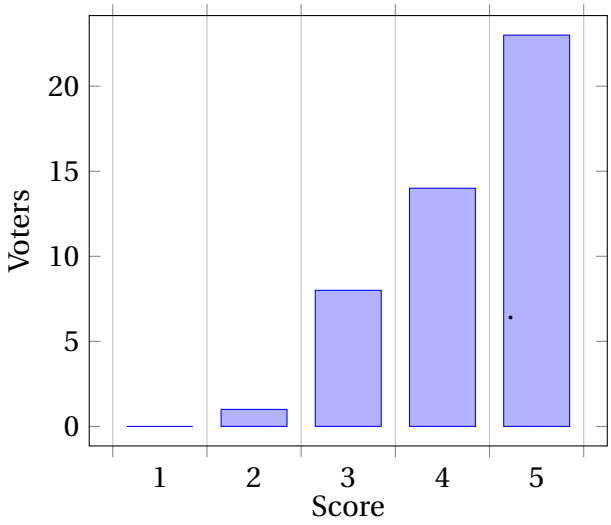

Figure 5.9: *"Workshop: Build your own computer"*

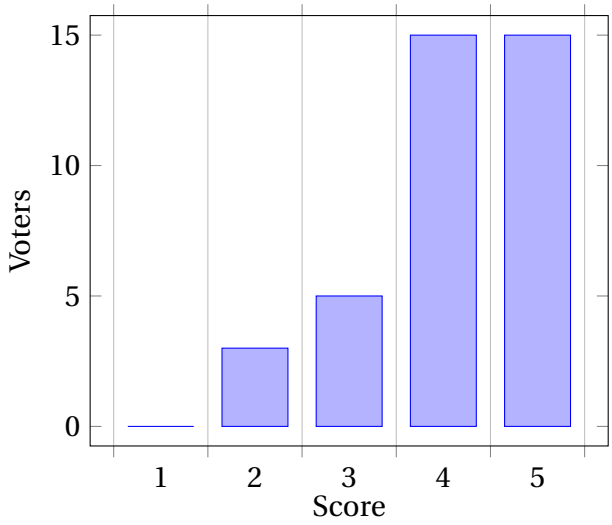

Figure 5.10: *"Workshop: A better tomorrow with IoT"*

This workshop was perceived as a good introduction to IoT and to the principles of building technology. It was described as fun, through several students pointed out that the most positive aspect of this workshop was that they got to talk to students about their studies.

Many participants said that they thought this workshop became a bit boring after a while. Some did not understand the point of the workshop, and some thought it was too easy and repetitive. Some mentioned that they would have liked to see real life examples of IoT, and others mentioned that the workshop did not seem relevant for the Communication Technology study. Figure 5.10 shows the distribution of scores for this workshop.

Workshop 3: Hackerspace

Hackerspace is a student driven organization which acts as a creative arena for students who wish to test out different technologies without buying them themselves [54]. In this workshop, the participants are able to test out how an Arduino works by making a small game, they get a short introduction to 3D-printing and game development, and they can also test out different VR games. Hackerspace also made an escape room which the girls were able to try out.

This was the best scored workshop at the Technology Camp, and there were few negative marks about this workshop. Some participants mentioned that they would have liked to make their own 3D models, some wanted more information about VR glasses and where one could buy them, and some thought the workshop was too easy. Some participants also mentioned that they would have liked to spend more time programming. There were also a few students who were unhappy with some of the student assistants as they seemed not interested in helping them.

The participants enjoyed that there were many varied tasks in this workshop. They said that they learned a lot, and that there were inspired to study technology. One participant even said that this workshop was the most influential event during the camp, which made her want to study technology in the future. Figure 5.11 shows the distribution of scores for this workshop.

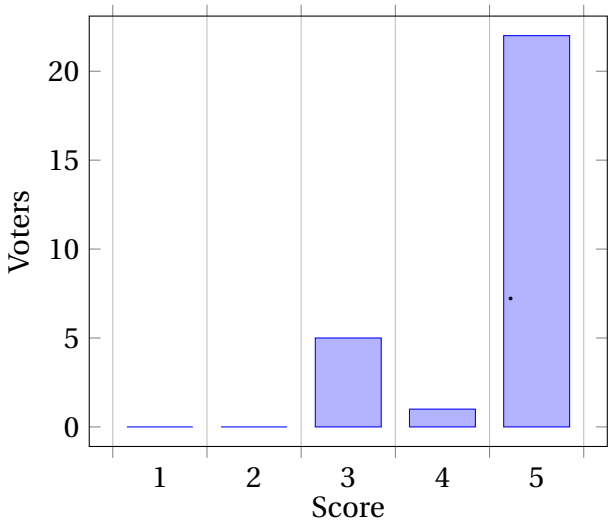

Figure 5.11: *"Workshop: Hackerspace"*

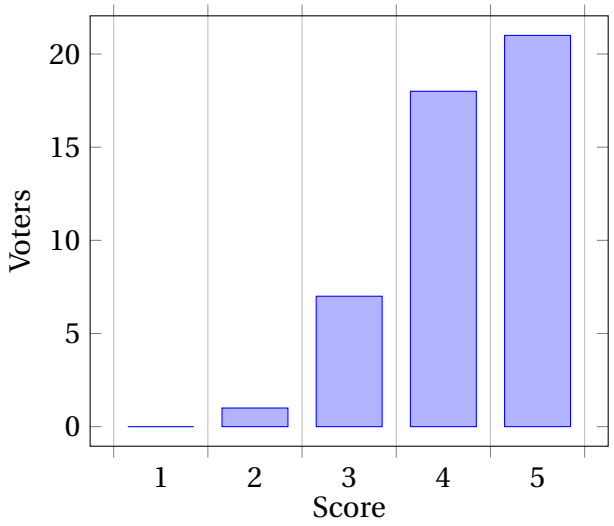

Figure 5.12: *"Workshop: Intro to hacking"*

Workshop 4: Introduction to hacking

Digital security and privacy is the main topic of this workshop. The girls are learning about how one can protect oneself from being hacked, by acting as hackers themselves. The girls are given

the task of hacking a password database, how to decrypt an encrypted text, and how to manipulate information on a website.

This workshop was described as boring by several participants, because of its lack of variation and its lack of challenging tasks. Some said that they wanted to write programs which could be used when hacking, and not only how it could be done. Some thought that the duration of the workshop was too long and that it became tiresome to sit in front of a computer for that long.

The workshop was also described as interesting, and several participants expressed that they learned a lot about hacking and internet security. Some complimented the organizers teaching method of switching between small lectures and practical work. One participant said that she became more aware of her need to protect herself from hackers after seeing how it could be done. Figure 5.12 shows the distribution of scores for this workshop.

Workshop 5: Code your own game

The participants are given an introduction to the Scratch programming language in this workshop by designing their own game [26]. The participants are placed in groups of 3, who will design and implement their game. At the end of the workshop, the girls are testing out each others games by playing them.

There were few things that the participants did not like about this workshop. Some commented that the workshop lacked a thorough introduction to the Scratch programming language, and that it was a little hard because of that. One participant said that she thought this workshop was just for fun, and did not see how it related to any science studies at NTNU.

This workshop was described as a fun introduction to programming. Some thought it was creative, and appreciated that they worked in groups to help each other come up with ideas. One participant enjoyed the workshop so much that she continued to make her own games in Scratch after the Technology Camp. Figure 5.13 shows the distribution of scores for this workshop.

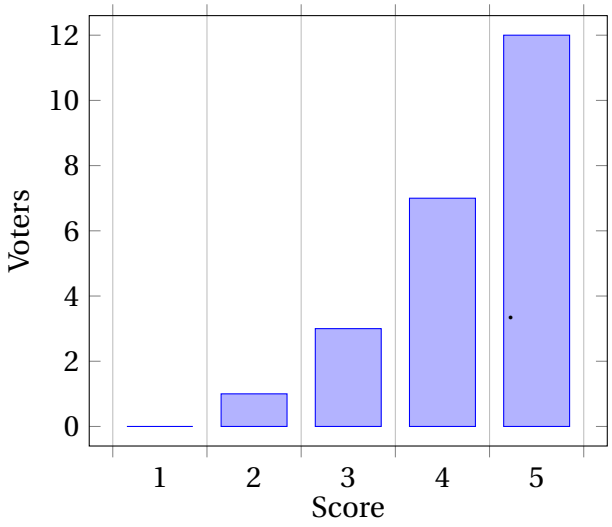

Figure 5.13: *"Workshop: Code your own game"*

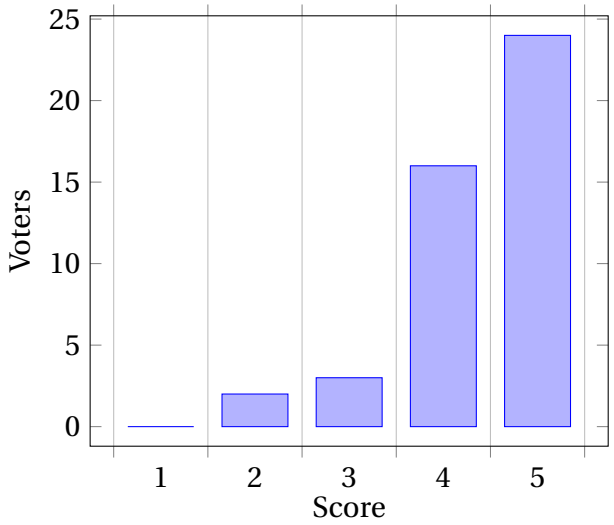

Figure 5.14: *"Workshop: Code your own traffic light"*

Workshop 6: Program your own traffic light

In this workshop, the participants are working in groups of two to make their Arduino act as traffic lights. The task includes connecting wires, LED lights, and resistors, as well as programming a short script which tells the Arduino what to do.

The workshop itself did not get much criticism from the participants, except that they thought it was somewhat monotonous. Several participants mentioned that they would have wanted more information about programming, others commented that they got the impression that the student assistants underestimated their skills, which made them feel less smart.

This workshop was describes as fun, exciting, and challenging. Some mentioned that they felt a sense of achievement after the workshop, and were proud of themselves for managing to get the program to run as it should. Figure 5.14 shows the distribution of scores for this workshop.

Workshop 7: Artificial intelligence in practice

Pepper, the humanoid robot, is in focus in this workshop. The girls are learning about how artificial intelligence actually works through programming Pepper to do specific tasks. They are grouped in groups of four, and among other small tasks, their goal is to make Pepper recognize specific objects through programming it.

There were several aspects of this workshop that the participants did not like; some felt that they were given too little information about what they were actually doing, some thought it was too hard, some were finished before the workshop ended and were bored because of it, while others could not finish the tasks in time. Some thought that there was too little variation in the workshop, and some wanted more tasks. Several participants said that they would have liked more information about artificial intelligence, how it is useful, and which job opportunities exist within that field.

The positive comments of the workshop included that the students that assisted the workshop were helpful, that it was fun to try programming, and that it was an exciting topic. Figure 5.15 shows the distribution of scores for this workshop.

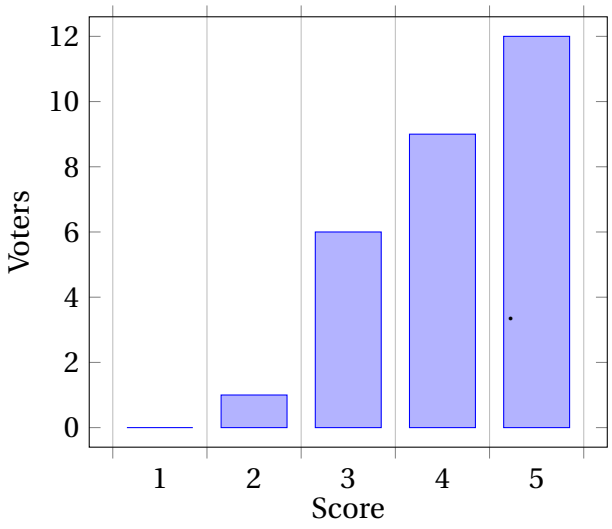

Figure 5.15: *"Workshop: Artificial intelligence in practice"*

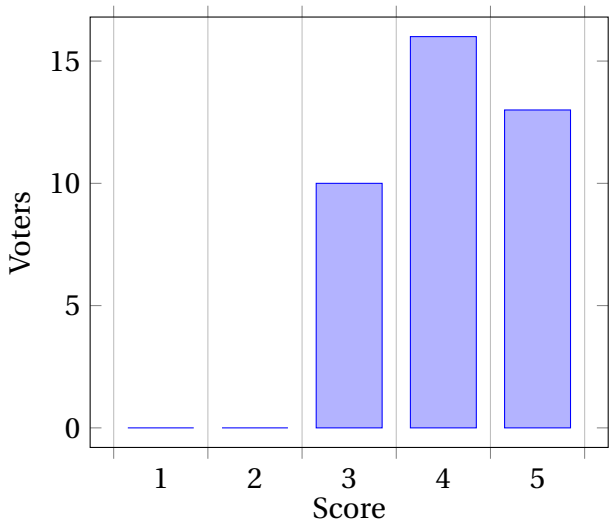

Figure 5.16: *"Workshop: Python"*

Workshop 8: Programming in Python

In this workshop the participants are introduced to the Python programming language by using the Turtle Graphics library [57] [42]. The workshop starts by introducing how Python's integrated development environment, IDLE, works by writing simple commands. After the basic commands are tried out by the girls, they are introduced to the concept of functions, loops, and conditionals. They are then given tasks with increasing difficulty. Examples of the tasks that are given are geometric figures which are asked to be recreated by writing code. Snippets of code are provided as examples. It is also encouraged to use Google as a tool to find more tasks or other solutions to a problem.

There were split opinions on the quality of this workshop. Some thought that the progression throughout the workshop went too fast, and some thought it went too slow. Several participants mentioned that they thought the tasks were too repetitive. Some participants stated that they did not understand what they were doing, and wanted a better introduction to why knowing Python could be useful for them. Some participants also mentioned that they did not feel that the student assistants were interested in helping them.

The workshop was also described as fun and challenging, and that it was exciting to visualize the programs they had written. Some thought there was a good explanation of programming concepts, and several participants stated that they learned a lot about programming. Figure 5.16 shows the distribution of scores for this workshop.

Workshop 9: Program your own Lego robot

In this workshop, the girls get an introduction to Cybernetics by programming their own Lego robots. The Lego robots are robots with wheels that can be programmed through an interface. The girls are introduced to basic programming concepts such as conditionals and loops, and their goal is to make the robot move by writing code.

Some thought this workshop was too hard, others thought it was too easy. Several participants

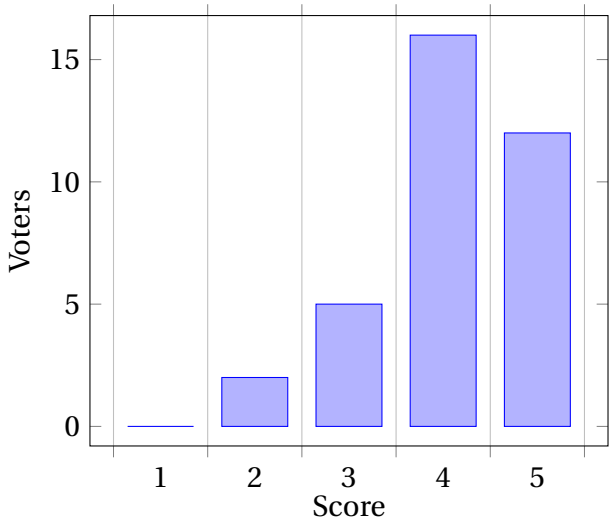

Figure 5.17: *"Workshop: Lego robot"*

mentioned that they did not understand the point of this workshop, and what this could be used for. One participant mentioned that she wanted information about why they were doing what they were doing, and not just instructions to do the tasks. Some participants said that they wanted more information about Cybernetics and Robotics throughout the workshop.

The participants said that it was fun to see that it was relatively easy to make the robot do whatever you wanted it to do. The workshop was described as challenging, but exciting, and the students that assisted the workshop were described as helpful. Figure 5.17 shows the distribution of scores for this workshop.

5.5.7 Evaluation of the best activity at the TC

The last question in the evaluation form of the Technology Camp asked which activity they enjoyed the most at the camp. 151 participants answered this question, and 69 participants thought one of the lectures or lectures in general was the best. 54 participants thought one specific workshop or workshops in general was the best activity, and 28 participants thought the lectures and workshops were equally good.

One participant said that *"The workshops were fun, but I got a lot more information from the lectures."*, and another participant said that *"I really enjoyed the lectures. There were several of*

them which were both educational and inspiring. I also appreciated the social activities which made us connect with students and other participants to hear their opinions.".

58 participants mentioned lecture number 2: *"The road from student to professor in electronics"* by name as the best, or one of the best activities at the Technology Camp.

5.6 Conclusion

All lectures and workshops received scores that were higher than 4 out of a score of maximum 5. This suggests that the participants at the TC were happy with the program at the camp. The Mann-Whitney-Wilcoxon test showed that lecture 2: *The road from student to professor in electronics* was the best lecture at the camp, and that workshop number 3: *Hackerspace* was the best workshop at the camp.

Lecture number 2 was held by a female professor which talked about her experience from being a student to becoming a professor in electronics. She shared personal information about her journey, and medicinal technology was in focus of this lecture. There were many students who explicitly thanked her for the lecture in the evaluation form, and stated that she became a role model for them.

Although there were one other lecture which was based on personal experience at the camp (which received the lowest mean score), it was clear from the evaluation form that the participants appreciated the lecturer from lecture number 2 sharing her personal stories. It suggests that a personal story could be very motivating if it includes interesting topics (such as medicine) and if the lecturer is good at conveying emotions during the lecture.

Workshop number 3 which received the highest mean score of all the workshops was the workshop which included the most activities; Arduino programming, game development, VR, 3D printing, and an escape room. The participants mentioned in the evaluation form that they appreciated the diversity of the workshop, and one participant even mentioned that this workshop

was the most inspiring workshop for her to want to study technology.

The last question of the evaluation form asked which activity they enjoyed the most at the camp. 69 participants thought one specific lecture or lectures in general were the best, 54 participants thought one specific workshop or workshops in general were the best, and 28 participants thought that the lectures and workshops were equally good. This result can indicate that lectures were more inspiring than workshops, especially when the lecturer is good at conveying a message at the audience.

From the evaluation form from the camp, it seemed like the girls appreciated the lecturer sharing personal stories, as it made several participants feel inspired to study technology. The topic of the lecture needs to be interesting, and the lecturer needs to be able to engage the students while lecturing.

The evaluation of the workshops showed that the participants of the TC appreciated when the workshops included varied tasks, and that they were bored when there were too repetitive tasks. The workshop should not be too hard or too easy, not too long, and not too short. Perhaps it would be beneficial for the organizers of the workshops to provide some tasks which are easier than others, so that the participants can choose their own level of difficulty. There were more participants who thought that a workshop lasting too long, was more dull than the workshops which had a too short duration. Perhaps it could be favorable to introduce similar activities or other activities if the organizer of the workshop notices that most participants are finished with their tasks, so they avoid being bored.

To conclude, we can see that the participants of the camp were more interested in studying technology and science after the camp. The desire to study technology or science increased from a mean score of 3,77 before the camp, to a mean score of 4,42 after the camp. The average score of desire to study ICT also increased with a mean of 2,44 before the camp, and a mean of 3,89 after the camp. Since this was the purpose of the Technology Camp, we can say that the camp was a success.

Chapter 6

Discussion

6.1 Characteristics of lectures which increases girls' interest in technology

From the data collected during this research, there were several similarities of the lectures being held which increased girls' interest in technology and in studying technology. In the intervention with the lower secondary school students there was only one lecture, but as it showed to be motivating for over one third of the participants, it is clear that there were some aspects of it which showed success in increasing the participants' interest in technology. At the Technology Camp there were six lectures, some who were higher rated than others, but they all scored a high score from the evaluation form of the camp. Table 6.1 lists the characteristics found in this research of lectures which increases girls' interest in technology.

Content of lecture

The content of the lectures which are analyzed in this research, all include technology in one way or another. The lecture from the intervention with lower secondary school girls entailed general information about programming and technology, how it can be used, and why it is useful for society. The six lectures from the Technology Camp included topics such as information security, studying technology, cybernetics, future public transportation, and ICT.

It is clear that in order to interest girls in technology or to inspire girls to want to study technology, the topic of the lectures need to include technology. The lecture which received the highest mean score at the Technology Camp consisted of talking about medical technology. The lecturer presented her personal story of how she went from being a student to becoming a professor, and talked about how her research has helped the medicinal community. From the evaluation form from the TC, there were several participants who mentioned that her story inspired them to want to study technology, and that she became a role model for them.

In my lecture at the intervention for lower secondary school girls, I talked about what technology and programming is, and spent a good amount of time talking about how it could be useful for society. I think there are many people who take technology for granted, without thinking about how technology can make their lives much easier and better. Even though this lecture was not very personal, it explained the relationship between programming and technology to the society, and highlighted the big role technology plays today.

There are many girls who attend the Technology Camp who have an initial thought that they want to study medicine in the future, because they want to help people. The lecturer from lecture number 2 talked about how technology can be helpful for society, and there were several participants who said that they would consider studying technology instead of becoming a doctor after participating at the camp. I think one of the reasons for that was because of this lecture talking about how technology can be used in the medical industry, and that one can actually help people by the use of technology.

Lecture number 6 talked about how technology can solve the future public transportation system by using magnetic hovering. This lecture was also mentioned by some participants as the best lecture of the camp. It made some participants reflect on the importance of technology in the future, and how public transportation could be made to reduce the time needed for getting from one point to another, and how it could be better for the environment.

I think it is important that the audience can relate to the topics being presented in the lectures.

By talking about how technology can be helpful for daily activities, how medical technology can save lives, and how technology can ease the future transportation methods, the audience can reflect on how technology has influenced or could influence their lives.

Lecturer

The lecturer of the lecture needs to be engaging when presenting. During the intervention with lower secondary school students I talked about a topic which was very interesting for me. I think it made me be engaging for the participants, and that they were able to understand my excitement. All the lecturers at the TC were experts in their fields. They talked about what they were interested in, and what they have researched for years.

The TC had both female and male lecturers during the camp. The results from the evaluation form showed no explicit preference for male or female lecturers, but it is worth noting that lecturer number 2 was described as a role model for some of the participants. It might be easier to relate to a woman when being a woman themselves, and that it is more natural to think of a role model which has the same gender as themselves.

I think it is important that the lecturer is present when performing, and that they try to engage the audience. They need to talk about a topic which they are excited about, and try to convey how interesting this topic actually could be for them also. Although the results did not show a preference for male or female lecturers, I think it might be easier for some girls to relate to women, and having female role models instead of male role models.

Personal vs. general information

Two of the lectures at the Technology Camp were based on personal stories (lecture number 2 and 3), while four were lectures with more general information. Lecture number 2 received the highest mean score of all the lectures, and lecture 3 received the lowest mean score of all the lectures. Although this suggests that there might not be a link between personal information and a high score, it was clear from the evaluation form that the participants appreciated lecturer number 2 sharing her personal experience.

It is hard to conclude whether girls prefer lectures which include personal information or lectures with general information, as the two lectures that were personal received the highest and lowest mean score. What can be drawn from the evaluation form from the TC is that some lecturers can become role models for the girls when they share personal stories.

Duration of lecture

The duration of the lecture I held at the intervention for lower secondary school students was 20 minutes, the duration of the lectures at the Technology Camp were between 30 and 40 minutes including time for questions. There were no comments about the lectures being too short or too long, so a duration of 20 minutes seemed appropriate for lower secondary school students, and a duration of 30-40 minutes seemed appropriate for upper secondary school students. There cannot be drawn any conclusions from the data in this research about which duration is the best for lectures inspiring girls to choose technology.

Visual presentation

The visual presentations which was used during the intervention and the TC consisted mainly of PowerPoints. Some lectures included props as well. As I did not analyze the contents of the lectures at the TC, it is hard to say something about the quality of the presentation. When I designed my presentation for the intervention I decided to use a minimal amount of text, and rather use pictures and illustrations to prove my points. It is hard to draw any conclusions about how the presentation should be designed, but what I can see from the lecture I held at the intervention is that the message was conveyed to the audience - that by using PowerPoint slides with minimal content worked. Since there was no negative comments from the evaluation form at the TC, one could assume that the participants were happy with PowerPoint presentations.

Characteristic ID	Characteristic	Description
CL1	Content	Provide content which the audience can relate to
CL2	Lecturer	Lecturer should be interested in topic to engage audience
CL3	Personal vs. general information	Personal stories can motivate audience
CL4	Duration	20-40 minutes seems suitable for secondary school girls
CL5	Visual presentation	PowerPoint seems suitable for secondary school girls

Table 6.1: Characteristics of lectures

6.2 Characteristics of workshops which increases girls' interest in technology

In total, there were 11 workshops that were analyzed during this research. Two workshops from the intervention with lower secondary school students and nine workshops from the Technology Camp. All workshops were focused on technology, and some included more programming than others. They all had the goal of making technology seem interesting for the participants, and the workshops at the TC were designed in order to attract more girls to the technology studies at NTNU. Table 6.2 lists the characteristics found in this research of workshops which increases girls' interest in technology.

Content of workshop

All workshops included different activities, and some workshops focused on more than one technology. The two workshops at the intervention with lower secondary school students consisted of the Tiles workshop with cards, and the Tiles programming workshop with Tiles squares. The workshops at the Technology Camp consisted of activities such as implementing their own games in Scratch, programming in Python, exploring the Arduino platform, and soldering.

Without considering the lecture in the intervention with lower secondary school students, the Tiles programming workshop with Tiles squares was the most inspiring for the participants of the two practical activities. Workshop number 3: *Hackerspace*, was rated as the best workshop at the TC.

The participants of the intervention received a short introduction to the programming of the Tiles squares before starting to program. They were also supplied with a set of instructions which was printed out. Most workshops at the TC also included an introduction to the activities before starting the actual activity. It was pointed out by several participants at the TC that some introductions could be shorter, and some could be longer.

At workshop number 1 at the TC which included an introduction of the history of computers, there were some participants who thought that the short lecture about computers was boring. Others thought that this workshop needed a longer introduction to the tasks that they would perform. Perhaps the connection between the history of computers and the soldering tasks was not explained thoroughly.

Most workshops focused on one specific task or one specific technology. From the evaluation form from the TC, there were several participants who mentioned that workshop number 1 which included soldering, workshop number 2 which consisted of playing with littleBits, and workshop number 4 which was about hacking, were all too monotonous. They thought that the tasks they were doing were too similar and repetitive, and became a little bored as a result of that.

Workshop number 3, which was rated as the best workshop at the Technology Camp, included five different activities; Arduino programming, 3D-printing, game design, VR games, and an escape room. The participants of this workshop appreciated the variety of activities, and stated that they thought the activities were very fun. As mentioned earlier, one participant even stated that this workshop was the activity at the TC which motivated her the most to want to study technology.

Some participants of workshop number 2 (which consisted of the littleBits technology) and number 9 (which consisted of making a Lego robot) mentioned that they did not see the point of the workshop. They wanted to know how this workshop is connected to the technology studies, and why having such skills could be useful for them. This was also stated during the intervention with the lower secondary school students when participating in the Tiles cards workshop. They did not understand how that was connected to an engineer's work life tasks.

In order for a workshop being successful at increasing the participants' interest in technology, the results from this research suggests that the tasks should be varied. If the tasks of the workshop are too repetitive or too similar, they might get bored more easily. Although it could be good to focus on one technology, I think it is important to include tasks which are not too similar, or maybe even include two or more activities.

I also think it is important to underline the reason for doing certain activities during the workshop. The participants need to understand why they are doing what they are doing, how it is useful, and to hear how participating in an activity is connected to either the technology studies or the professional life when working with technology. This was done in one of the workshops which is mentioned in section 2.4, by assigning specific roles to each participant and thereby underlining which tasks are associated with a software engineer, a civil engineer and an electrical engineer. Perhaps this could be implemented in some of the workshops at the TC to see whether they understand the link between engineers and the tasks they are doing better.

Topic of workshop

Different topics were introduced in different workshops; IoT, AI, traffic management, robot controlling, game design, and drawing, among others. There were not many comments about the topic itself from the evaluation forms, although there were some participants from the TC which mentioned that they thought traffic management seemed boring before attending workshop number 6: *Program your own traffic light*, but changed their minds after participating in the workshop.

Some participants of workshop number 8: *Programming in Python* said that they enjoyed writing code such that they could generate geometrical figures, but that it became somewhat repetitive. Some said that they would have liked to learn how Python could be used in other contexts.

Workshop number 4: *Introduction to hacking* was described as an interesting topic. Some participants of this workshop did not feel they were learning how to do the actual hacking, rather that they learned about how it could be done, which was disappointing for some of the participants.

Workshop number 7: *Artificial intelligence in practice* was also described as an exciting topic, but many participants stated that they did not understand what they were doing or why they were doing it. They wanted more information about AI itself and which job opportunities exist within this field. It might be useful to provide an analogy such as the researchers in section 2.3 did when explaining programming, if some concepts are hard to explain without being too technical.

I think most topics in a technological workshop could be interesting for participants who are somewhat interested in technology. What I think is the most important is that the technology used in the workshop is connected to the topic it concerns, and that the person responsible for the workshop assures that the participants of the workshop receive information about what they are doing and why they are doing it. It might be useful to talk a little about the topic itself, and possibly state how technology can affect this topic, for example how technology can influence the traffic when running a workshop about traffic management.

Organizers and assistants of workshop

During the intervention with lower secondary school students, I (a student) was in charge, and at the Technology Camp there were both students and professors in charge of the workshops. At the intervention I was presenting the lecture and introduced all activities. One of the other students which had designed the programming workshop, assisted me in helping the participants with any questions during the intervention. Although I do not know if this intervention

would have been different if there weren't only students present, I got the impression that the participants had a good time and that they appreciated talking with us.

Workshop number 1, 2, 4, 6, and 7 were organized by professors with students acting as assistants. The other workshops were organized by students and had additional students as assistants. All workshops had students as assistants, and results from the evaluation form showed that the participants appreciated that there were students present during the workshop who were able to answer questions about the workshop and about their studies.

Several participants of the TC mentioned that one of the best things of attending the workshops was that they were able to talk with the student assistants. Other participants had a poorer experience of a workshop because of a student or professor not seeming interested in helping them.

Regardless of students or professors being in charge of or assisting a workshop, they need to be polite and willing to help. As was found in the research mentioned in section 2.1, negative emotions during a workshop could influence the girls in a negative way such that they would not be interested in participating in a similar workshop in the future, and happy emotions suggests the opposite. If the participants of a workshop feel like they are asking stupid questions or if they feel like the assistants are uninterested in the workshop, then the participants of the workshop might get negative associations of the workshop itself. It is important to recruit engaging people who enjoy helping the participants when recruiting people to run the workshops.

Duration and difficulty of workshop

The duration of the workshops at the intervention were 1 hour and 15 minutes in total for the Tiles cards workshop, and 2 hours for the Tiles programming workshop. The duration of the workshops at the TC was 3,5 hours.

The two activities at the intervention were cut shorter than they would have been if we had followed the recommended time usage of the workshops. I did not get the impression that they participants of the intervention thought that the activities were too short. I think it was a suit-

able duration considering that the intervention consisted of three different activities, and I think that it might have become a little exhausting for the participants to engage in activities with a longer duration.

There were split opinions about whether the workshops at the TC were too short or too long; some participants had some experience in some of the technologies that were used in some of the workshop, and therefore were finished with their tasks before other groups. Other participants had no previous experience, and did not manage to finish their tasks before the workshop was finished.

Some participants of the TC workshops thought that the tasks given were too difficult, and some were discouraged because if this. Others thought the tasks were too easy, and became bored as a result of that. It is a hard balance of finding tasks which are not too easy and not too hard, and I think the solution is to have several tasks with a varied difficulty.

It is hard to design a workshop with a duration which suits all participants of the workshop, as the previous experience of each participant differs. Regardless of the duration of a workshop, I think it is important to design tasks with a varied difficulty such that the participants can choose which tasks they want to do, and so that they can move on to a more difficult task if they are finished with the easier ones, and so they can try an easier task if they found the first tasks to be too difficult.

Group work

Most workshops at the TC consisted of group work. As the Technology Camp wishes to create relations between the participants, group work in workshops is meant to work as a way for the participants to socialize as well as learning something. Some participants appreciated the group work as it made them talk to other participants, and maybe even make friends, while others who were a part of a bigger group felt left out.

Some workshops which include programming for example, could be harder to work on in groups,

Characteristic ID	Characteristic	Description
CW1	Content	Varied tasks and activities seem more motivating than one repetitive task
CW2	Topic	Technology used should be connected to topic and described why it is useful
CW3	Organizers and assistants	Assistants should be helpful and polite
CW4	Duration and difficulty	Duration needs to be connected to the difficulty of the activity. Introduce difficulty levels of tasks to avoid boredom or feeling of failure
CW5	Group work	Ensure that the amount of group members is proportional to the task

Table 6.2: Characteristics of workshops

as the keyboard usually is managed by one person, and because a computer screen usually is not big enough for all participants in a group to see (if there are many participants in a group). At the intervention during the programming workshop, I noticed that there were a few participants who could not see the screen and who might have felt somewhat left out because of it. It was nice to see that the participants of the intervention switched between themselves of who would write the code, and that there was one participant in the group who took charge and assured that every participant were able to try programming.

No matter which activity is carried out in a workshop, it is important to have a suitable amount of group members in a group. If there are too few members, it might become too difficult to complete the tasks, or even too scary to talk to each other, and if there are too many participants in a group, some might feel left out or become bored because of it. It is important to have groups that are big enough without it being awkward when not knowing someone, and small enough so that all group members can participate in the activity.

6.3 Discussion of data collection methods

Questionnaires were mainly used to collect data during this research. In hindsight there should have been textual answers in the questionnaires at the intervention with lower secondary school, to possibly identify which aspects of the lecture and workshops they liked and disliked, like the questionnaire from the evaluation form of the TC.

During the intervention, there were four questionnaires which the participants answered. These questionnaires contained many of the same questions and phrasings, in order to collect data more easily. Perhaps this structure became somewhat boring for the participants, and maybe direct contact with the participants would give better answers.

It could be that it might have been beneficial to run interviews with the participants at the intervention, in order to find out more about what interested them during the different activities. Interviews might have been useful to run with some participants from the Technology Camp as well.

During the intervention there was an informal focus group about which activities they would have liked to participate in. This was somewhat spontaneous, and could have been planned and organized better. I should have also planned an observation of the participants, or recruited someone to take notes. It was hard to observe and run the activities at the same time, and a standardized form might have been useful in order to note observations.

Chapter 7

Conclusions

7.1 Summary of intervention with female lower secondary school students

The intervention consisted of one lecture about general information about technology and programming, one idea generation workshop; Tiles workshop, and one programming activity with Tiles squares. Five of eight participants in the intervention scored their perceived interest in technology higher than before the intervention. Three participants reported a higher score in their perceived interest in programming, and seven participants scored a higher perceived interest in studying technology after the intervention.

Regarding the inspiration for these results, the participants were affected by different activities. Three participants said they were the most inspired by the lecture, three stated that they were the most inspired by the Tiles squares programming activity, and two reported that they were the most inspired by the Tiles cards idea generation activity.

All participants gained a higher perceived understanding of the concepts technology, programming, what an engineer is, and what an engineer does after the intervention. The understanding of what an engineer is, dropped slightly after the Tiles cards workshop. This could be because I did not specifically say how this type of idea generation workshop is related to an engineers'

work life.

It was surprising that there were so many participants who appreciated a lecture more than practical activities. I think there is a lot of focus today on inspiring students to study technology by allowing them to participate in practical activities, and too little focus on the effect that a lecture can have.

To sum up; the intervention showed that the participants were more interested in technology, programming, and studying technology after the intervention compared to their interest before the intervention. It showed that a lecture can be just as effective with regards to raising the participants' interest in technology.

7.2 Summary of Technology Camp results

In addition to smaller lectures which is not included in from the results of the Technology Camp evaluation form, the Technology Camp consisted mainly of six lectures and nine workshops. There were also social activities such as meals with students and a mingling session with stands.

The results from the Technology Camp evaluation form showed that the participants were more likely to study technology and science after the camp. The highest rated lecture was lecture 2: *The road from student to professor in electronics*, with a mean score of 4,866. The highest rated workshop was workshop number 3: *Hackerspace*, with a mean score of 4,667.

The participants of the TC were inspired by different activities, but the majority of participants were the most inspired by lecture 2 which was about a professor's journey from being a student to becoming a professor who among other things, researches medicinal problems.

Workshop number 3 was the workshop that was the most popular among the participants. It included several different technologies such as Arduino programming, VR, 3D-printing, game development, and an escape room. The participants appreciated the diversity of activities dur-

ing this workshop, and one participant said that this workshop was the biggest reason for her wanting to study technology in the future.

Lecture number 2 received a higher mean score than workshop number 3, and when asked which activity the participants of the camp enjoyed the most, 69 participants thought the lectures were the best, 54 participants thought the workshops were the best, and 28 participants thought they were equally good. This result is quite surprising, as the workshops are the biggest part of the Technology Camp (considering the amount of workshops, the duration of the workshops, and the people needed to be recruited for carrying out the workshops).

The results from this year's Technology Camp shows that a lecture can be more effective with regards to increasing upper secondary girls' interest in studying technology. It showed that the participants were more motivated to study technology in the future, even for those participants who did not initially think of it as an option for their future study choice.

7.3 Answers to research questions

From the results and analysis of the data collected in this research, the research question *Which activities can increase secondary school girls' interest to learn programming?*, can be answered by looking at table 6.1 and 6.2. Both lectures and workshops can increase secondary school girls' interest to learn programming, as long as the lectures include certain characteristics, and the workshops other characteristics.

Girls are motivated to study technology differently, but from the results of the intervention where the participants were equally inspired by the lecture and the programming workshop, and from the results from the Technology Camp which showed that most participants were inspired the most by one or several lectures, the second research question *Which type of activity (informational/practical) is more effective with regards to the increase in interest for IT?* can be answered (within the scope of this research) by stating that lectures were the most effective with regards to the increase in interest in IT for secondary school girls.

The last research question asks *Which activity topics and contents are more interesting?* and cannot be answered with a strict answer from the results of this research. It seemed like most topics were interesting for the participants. Regarding the contents of workshops, it could be stated that workshops which include varied tasks or several activities seemed the most interesting for the participants.

7.4 Limitations

There were several limitations of this research. Firstly, the intervention that was run with female lower secondary school students, had very few participants, and is thus not representative for female lower secondary school students in general.

Secondly, the target group of the intervention and the Technology Camp were different, as the intervention focused on lower secondary school students, while the TC focused on upper secondary school students. This connection might seem somewhat odd, but it was chosen because of availability of data; after running the intervention with lower secondary school students, and discovering that a lecture could be just as motivating as a workshop, the data from the Technology Camp which includes both data about several lectures and workshops was too attractive to ignore with regards to the research questions.

Third, the acquiring of data from the Technology Camp did not entail data about the design of workshops and lectures, and it is therefore hard to comment on the content and quality of it, without taking the participants comments into account. If I would have had more time, I would have liked to explore the contents of the lectures and workshops more thoroughly.

Lastly, it is hard to measure the interest and motivation of a person. The evaluation forms used in the intervention and from the TC only reports perceived interest. In order to find out whether these girls actually were inspired to study technology, one would possibly need to examine the girls' interest after a longer amount of time, and could then possibly state more certainly that a

participant was motivated/inspired if she actually did choose to study technology in the future.

I would also like to point out that there were several social happenings at the Technology Camp which could have affected the girls' motivation for studying technology as well. As the student life is a big part of studying, some participants might have been motivated to study technology because of the great impression of NTNU and the student environment.

7.5 Recommendations for further work

This topic should be examined further. I think there are many different factors which motivates girls to study technology which are not covered in this research.

This research could be continued by looking at interventions which include only workshops, only lectures, and both, to see which is more inspiring for secondary school girls. It would be interesting to see if one can run the best workshop from the Technology Camp, and organize the best lecture from the Technology Camp with a group of participants with an equal initial interest in technology, to see who are the most inspired/motivated.

It would also be interesting to see how a group of participants experience an introductory lecture with general information about programming and technology and then a practical workshop vs. just experiencing the practical activity. Perhaps they are more motivated to participate in a workshop if they know why they are doing what they are doing, and if they understand how it could be useful in the future.

When reflecting on the lectures that were held at the Technology Camp, I think it might be interesting to explore the aspect of a lecturer sharing personal stories vs. presenting general information about a topic, as there were so many participants at the TC who were very motivated to study technology because of one lecturer sharing her personal experiences.

It would also have been interesting to run the same program as the Technology Camp for lower

secondary school students. I think it would be very inspiring for younger students to experience the lectures and workshops that were held at the Technology Camp as well, and perhaps it would make more female students choose IT as an elective subject in upper secondary school.

Appendix A

Acronyms

CS Computer Science

ExcITEd Centre for Excellent IT Education

IDI Department of Computer and Information Science

IE Faculty Faculty of Information Technology and Electrical Engineering

IoT Internet of Things

ICT Information and Communication Technology

IT Information Technology

NTNU Norwegian University of Science and Technology

ODW Operation Day's Work

RQ Research Question

SSB Statistisk Sentralbyrå (Statistics Norway)

STEM Science, Technology, Engineering and Mathematics

S4A Scratch for Arduino

TC Technology Camp

TGPA The Girl Project Ada

UMI-Sci-Ed Exploiting Ubiquitous Computing, Mobile Computing and the Internet of Things to promote Science Education

VR Virtual Reality

Appendix B

Paper: Girls and Computing in Lower Secondary Education

B.1 Summary

In this research we wanted to find out why girls were not interested in programming. We used several data collection methods, including questionnaires, Kahoot quizes [34], and interviews to uncover whether there were certain reasons for girls not wanting to take programming courses or studies.

The reasons for not choosing to study programming were many, but there were some reasons that were mentioned more than others. The main reasons not to choose IT education included: 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.

There were mainly three topics that there was little knowledge about, which affected their negative impressions of programming; (1) They did not have a clear idea of what technology was, (2) They did not know what programming was or how it could be used, (3) They did not know what an engineer was, or what an engineer does.

GIRLS AND COMPUTING IN LOWER SECONDARY EDUCATION

The surprisingly unsurprising results of a Norwegian exploratory study

Sarah Serussi and Monica Divitini

Department of Computer Science, NTNU Trondheim, Norway
divitini@ntnu.no

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 study 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 9-36 (women-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 *ungdomskole* 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![1] 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, like, 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

[1] A Kahoot! is 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/*).

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 programs 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 flavour 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.

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.

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

3.1. 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 Kathoot! 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 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 4 we summarize the reasons that have been identified in the interviews for not choosing programming.

- **Motivation and interest** 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.

- **Lack of knowledge** 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.
- **Lack of information** 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.
- **External influences** 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.
- **Introduction to programming and technology** 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.
- **Misconceptions about programming** 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 to improve girls´ participation in programming courses.

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.

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

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 scaring".

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

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."*

ACKNOWLEDGMENT

We thank the teachers and the students for participating to our study; the Girl Project Ada (TGPA) for insight into activities for promoting educations and supporting data collection during their events; Anna Mavroudi and Sofia Papavlasopoulou for useful links to the literature. The research is partly funded by the European Union's Horizon2020 research and innovation programme under grant agreement No. 710583, project UMI-Sci-Ed and by NOKUT Centre for Excellence in IT Education (https://www.ntnu.edu/excited).

REFERENCES

Baller, S., Dutta, S., & Lanvin, B. (2016). *The Global Information Technology Report 2016. World Economic Forum*.

Baytak, A., & Land, S. M. (2011). CASE STUDY: Advancing Elementary-School Girls' Programming through Game Design. *International Journal of Gender, Science and Technology*, *3*(1).

Bigler, R. S. (1995). The role of classification skill in moderating environmental influences on children's gender stereotyping: A study of the functional use of gender in the classroom. *Child Development*, *66*(4), 1072–1087.

Demo, G. B., Marcianò, G., & Siega, S. (2008). Concrete programming: Using small robots in primary schools. In *Advanced Learning Technologies, 2008. ICALT'08. Eighth IEEE International Conference on* (pp. 301–302).

Ericson, B. J., Parker, M. C., & Engelman, S. (2016). Sisters Rise Up 4 CS: Helping Female Students Pass the Advanced Placement Computer Science A Exam. In *Proceedings of the 47th ACM Technical Symposium on Computing Science Education* (pp. 309–314). New York, NY, USA: ACM. https://doi.org/10.1145/2839509.2844623

Gibson, J. P. (2003). A noughts and crosses Java applet to teach programming to primary school children. In *Proceedings of the 2nd international conference on Principles and practice of programming in Java* (pp. 85–88).

Kelleher, C. (2006). *Motivating Programming: Using storytelling to make computer programming attractive to middle school girls*.

Leopold, T. A., Ratcheva, V., & Zahidi, S. (2016). *The global gender gap report 2016*. *World Economic Forum*.

Light, J. S. (1999). When Computers Were Women. *Technology and Culture*, *40*(3), 455–483. Retrieved from http://beforebefore.net/scima200/media/light.pdf

Rosenbloom, J. L., Ash, R. A., Dupont, B., & Coder, L. (2008). Why are there so few women in information technology? Assessing the role of personality in career choices. *Journal of Economic Psychology*, *29*(4), 543–554.

Sadker, M., & Sadker, D. (2010). *Failing at fairness: How America's schools cheat girls*. Simon and Schuster.

Sassler, S., Glass, J., Levitte, Y., & Michelmore, K. M. (2017). The missing women in STEM? Assessing gender differentials in the factors associated with transition to first jobs. *Social Science Research*, *63*, 192–208. https://doi.org/https://doi.org/10.1016/j.ssresearch.2016.09.014

Tyler-Wood, T., Ellison, A., Lim, O., & Periathiruvadi, S. (2012). Bringing up girls in science (BUGS): The effectiveness of an afterschool environmental science program for increasing female students' interest in science careers. *Journal of Science Education and Technology*, *21*(1), 46–55.

Wang, J., Hong, H., Ravitz, J., & Ivory, M. (2015). Gender Differences in Factors Influencing Pursuit of Computer Science and Related Fields. In *Proceedings of the 2015 ACM Conference on Innovation and Technology in Computer Science Education* (pp. 117–122). New York, NY, USA: ACM. https://doi.org/10.1145/2729094.2742611

Wilson, A., Hainey, T., & Connolly, T. (2012). Evaluation of computer games developed by primary school children to gauge understanding of programming concepts. In *European Conference on Games Based Learning* (p. 549).

Appendix C

Questionnaire from intervention with lower secondary girls

Note: All questions have been translated from Norwegian to English, for the purpose of this thesis. The questionnaire was originally in Norwegian.

Initial questionnaire

1. Have you programmed anything before? (1-5 score)
2. Have you designed/invented something before? (1-5 score)
3. To which degree are you interested in technology? (1-5 score)
4. To which degree are you interested in programming? (1-5 score)
5. How likely is it that you will study technology? (1-5 score)
6. How familiar are you with these concepts? (1-5 score)
    (a) Technology
    (b) Programming
    (c) What an engineer is
    (d) What an engineer does

Questionnaire after lecture

1. To which degree did you learn something about technology? (1-5 score)
2. To which degree did you learn something about programming? (1-5 score)
3. To which degree are you interested in technology? (1-5 score)
4. To which degree are you interested in programming? (1-5 score)
5. How likely is it that you will study technology? (1-5 score)
6. How familiar are you with these concepts? (1-5 score)
    (a) Technology
    (b) Programming
    (c) What an engineer is
    (d) What an engineer does

Questionnaire after Tiles cards workshop

1. To which degree did you learn something about technology? (1-5 score)
2. To which degree did you learn something about programming? (1-5 score)
3. To which degree did you learn something about idea generation? (1-5 score)
4. To which degree are you interested in technology? (1-5 score)
5. To which degree are you interested in programming? (1-5 score)
6. How likely is it that you will study technology? (1-5 score)
7. How familiar are you with these concepts? (1-5 score)
    (a) Technology
    (b) Programming
    (c) What an engineer is
    (d) What an engineer does

Final questionnaire after Tiles programming workshop

1. To which degree did you learn something about technology? (1-5 score)
2. To which degree did you learn something about programming? (1-5 score)
3. To which degree are you interested in technology? (1-5 score)
4. To which degree are you interested in programming? (1-5 score)
5. How likely is it that you will study technology? (1-5 score)
6. How familiar are you with these concepts? (1-5 score)
   (a) Technology
   (b) Programming
   (c) What an engineer is
   (d) What an engineer does
7. Which activity did you think were the most informative? (Lecture, Tiles cards workshop, or Tiles programming workshop)
8. Which activity did you think were the most inspiring/motivating? (Lecture, Tiles cards workshop, or Tiles programming workshop)

Appendix D

Questionnaire from the Technology Camp

Note: All questions have been translated from Norwegian to English, for the purpose of this thesis. The questionnaire was originally in Norwegian.

About the Technology Camp in general

1. How satisfied were you by the Technology Camp in general? (1-5 score)
2. How satisfied were you by the educational aspect of the camp? (1-5 score)
3. How satisfied were you by the social aspect of the camp? (1-5 score)
4. How satisfied were you with the information you received at the camp? (1-5 score)
5. How satisfied were you with the information given before the camp started? (1-5 score)
6. What did you like the most about the Technology Camp? (text answer)
7. Is there something you would have wanted more of at the camp? (text answer)

About future studies

1. The Technology Camp made me want to study at NTNU. (1-5 score)
2. I wanted to study at NTNU before I participated at the camp. (1-5 score)
3. The Technology Camp made me want to study technology or science. (1-5 score)

4. I wanted to study technology or science before participating at the camp. (1-5 score)
5. The Technology Camp made me want to study ICT. (1-5 score)
6. I wanted to study ICT before I participated at the camp. (1-5 score)
7. In which way do you think the camp had affected your choice of future studies? (text answer)

About the program at the Technology Camp

The participants were asked to range all the lectures, social events, and stands present on a scale of 1 to 5.

About the workshops at the Technology Camp

The participants were asked to range both workshops they attended on a scale of 1 to 5. They were also asked if they had any comments to the workshops. The second last question asked which activity they enjoyed the most at the camp, and the final question asked if there were anything else they would like to mention about the camp.

Bibliography

[1] David N Beede, Tiffany A Julian, David Langdon, George McKittrick, Beethika Khan, and Mark E Doms. Women in stem: A gender gap to innovation. 2011.

[2] Sharon Sassler, Jennifer Glass, Yael Levitte, and Katherine M. Michelmore. The missing women in stem? assessing gender differentials in the factors associated with transition to first jobs. *Social Science Research*, 63:192 – 208, 2017.

[3] Lacey Alan Fayer, Stella and Audrey Watson. Stem occupations: Past, present, and future. *STEM Occupations - Bureau of Labor Statistics*, 2017.

[4] Unesco. Cracking the code: girls' and women's education in science, technology, engineering and mathematics (stem). http://unesdoc.unesco.org/images/0025/002534/253479E.pdf.

[5] Antall kvinnelige primærsøkere til ntnu gjennom samordna opptak.

[6] Koding blir valgfag på 146 skoler (norwegian). https://www.regjeringen.no/no/aktuelt/koding-blir-valgfag-pa-146-skoler/id2481962/.

[7] Åpner for koding som valgfag ved alle skoler (norwegian). https://www.regjeringen.no/no/aktuelt/fra-hosten-kan-alle-ungdomskoler-tilby-programmering-som-valgfag-til-
id2552808/.

[8] Jenter og realfag i videregående opplæring (norwegian). https://www.ssb.no/utdanning/artikler-og-publikasjoner/jenter-og-realfag-i-videregaende-opplaering.

[9] Teknologicamp for jenter. https://www.ntnu.no/camp/.

[10] Umi-sci-ed (exploiting ubiquitous computing, mobile computing and the internet of things to promote science education). http://umi-sci-ed.eu/.

[11] Centre for excellent it education (excited). https://www.ntnu.edu/excited.

[12] Sarah Serussi. Girls and programming in lower secondary schools: a norwegian case.

[13] Shulamit Kahn and Donna Ginther. Women and stem. Technical report, National Bureau of Economic Research, 2017.

[14] Diane F. Halpern, Camilla P. Benbow, David C. Geary, Ruben C. Gur, Janet Shibley Hyde, and Morton Ann Gernsbacher. The science of sex differences in science and mathematics. *Psychol Sci Public Interest*, 8(1):1–51, Aug 2007. 25530726[pmid].

[15] Tns gallup survey - the amount of women in the it industry in norway (norwegian). https://odanettverk.no/images/Inspirasjonsdagen_2016/Kvinner_i_IT-bransjen_2016.pdf.

[16] Girls who code. https://girlswhocode.com/clubs/.

[17] Code with klossy. https://www.kodewithklossy.com/.

[18] 17 places where women can learn how to code. https://learntocodewith.me/posts/13-places-women-learn-code/.

[19] Kodeklubben. http://kodeklubben.no/.

[20] Code academy. https://www.codecademy.com/.

[21] Michail N. Giannakos, Letizia Jaccheri, and Ioannis Leftheriotis. *Happy Girls Engaging with Technology: Assessing Emotions and Engagement Related to Programming Activities*, pages 398–409. Springer International Publishing, Cham, 2014.

[22] S4a - scratch for arduino. http://s4a.cat/.

[23] Winnie W.Y. Lau, Grace Ngai, Stephen C.F. Chan, and Joey C.Y. Cheung. Learning programming through fashion and design: A pilot summer course in wearable computing for middle school students. *SIGCSE Bull.*, 41(1):504–508, March 2009.

[24] Lilypad arduino. https://www.arduino.cc/en/Main/ArduinoBoardLilyPad/.

[25] Paolo A. G. Sivilotti and Stacey A. Laugel. Scratching the surface of advanced topics in software engineering: A workshop module for middle school students. *SIGCSE Bull.*, 40(1):291–295, March 2008.

[26] Scratch. https://scratch.mit.edu/.

[27] Gabriela Marcu, Samuel J. Kaufman, Jaihee Kate Lee, Rebecca W. Black, Paul Dourish, Gillian R. Hayes, and Debra J. Richardson. Design and evaluation of a computer science and engineering course for middle school girls. In *Proceedings of the 41st ACM Technical Symposium on Computer Science Education*, SIGCSE '10, pages 234–238, New York, NY, USA, 2010. ACM.

[28] Picocricket kit. https://www.picocricket.com/.

[29] Utdanningsdirektoratet. Karakterer i videregående opplæring. https://www.udir.no/tall-og-forskning/finn-forskning/tema/karakterer/karakterer-i-videregaende/.

[30] Utdanningsdirektoratet. Karakterer i grunnskolen. https://www.udir.no/karakterer-i-grunnskolen.

[31] S. Zahidi T. A. Leopold, V. Ratcheva. The global gender gap report 2017. *World Economic Forum (2017)*.

[32] SSB. Studenter i høyere utdanning. https://www.ssb.no/utdanning/statistikker/utuvh.

[33] Why it's crucial to get more women into science. https://news.nationalgeographic.com/news/2014/11/141107-gender-studies-women-scientific-research-feminist/.

[34] Kahoot - how it works. https://getkahoot.com/how-it-works.

[35] Sarah Serussi and Monica Divitini. Girls and computing in lower secondary education. *Norsk konferanse for organisasjoners bruk av IT*, 25(1), 2017.

[36] Simone Mora, Francesco Gianni, and Monica Divitini. Tiles: A card-based ideation toolkit for the internet of things. In *Proceedings of the 2017 Conference on Designing Interactive Systems*, DIS '17, pages 587–598, New York, NY, USA, 2017. ACM.

[37] Simone Mora, Monica Divitini, and Francesco Gianni. Tiles: An inventor toolkit for interactive objects. In *Proceedings of the International Working Conference on Advanced Visual Interfaces*, AVI '16, pages 332–333, New York, NY, USA, 2016. ACM.

[38] Od-dagen (operation day's work). http://www.od.no/.

[39] Javascript. https://www.javascript.com/.

[40] Richard E. Mayer. Multimedia learning. volume 41 of *Psychology of Learning and Motivation*, pages 85 – 139. Academic Press, 2002.

[41] Tiles cloud web portal. http://178.62.99.218:3000/#/home.

[42] The turtle library for python. https://docs.python.org/2/library/turtle.html.

[43] Google forms. https://www.google.com/forms/about/.

[44] 9gag. https://9gag.com/.

[45] Flappy bird. http://flappybird.io/.

[46] Candy crush saga. http://candycrushsaga.com/en/.

[47] Jenteprosjektet ada. https://www.ntnu.no/jenter.

[48] Institutes at the ie faculty at ntnu. http://www.ntnu.edu/ie/.

[49] 9 av 10 søkte seg til ntnu. http://www.universitetsavisa.no/campus/2018/01/16/9-av-10-s%C3%B8kte-seg-til-NTNU-71356.ece.

[50] Studentersamfundet. https://www.samfundet.no/.

[51] Program, teknologicamp for jenter. https://www.ntnu.no/camp/program.

[52] Frank Wilcoxon. Individual comparisons by ranking methods. *Biometrics bulletin*, 1(6):80–83, 1945.

[53] The r project for statistical computing. https://www.r-project.org/.

[54] Hackerspace. https://www.hackerspace-ntnu.no/.

[55] littlebits. http://littlebits.cc/.

[56] Ted2012: Building blocks that blink, beep and teach. https://www.ted.com/talks/ayah_bdeir_building_blocks_that_blink_beep_and_teach.

[57] Welcome to python.org. https://www.python.org/.