UNIVERSITY OF COPENHAGEN
FACULTY OF SCIENCE

MSc in Computer Science

Not Just a "Man In a Dress": Voicing the Invisible Women of Computer Science

Jenny-Margrethe Vej

Supervised by Pernille Bjørn and Valeria Borsotti

March 2022

Jenny-Margrethe Vej

Not Just a "Man In a Dress": Voicing the Invisible Women of Computer Science

MSc in Computer Science, March 2022

Supervisors: Pernille Bjørn and Valeria Borsotti

University of Copenhagen

Faculty of Science

Masters Degree in Computer Science

Universitetsparken 1

2100 Copenhagen Ø

Preface

Coming back to the University to finalise my thesis was not an easy decision. It has taken me years to process the feelings of failure from my last attempt and it has been nerve-racking applying to get back. There was a lot of what-ifs, but the only way to know was to try! To make sure I did not fall back into old habits or hit some triggers, I honestly shared every experience I could remember from being a student at Computer Science with my supervisor. This way, we could make a plan that would not only get me through it all, but would also make it a positive experience for me.

During these conversations, many memories surfaced about how I had experienced my previous time at DIKU, with the different courses, the interactions between students, and being part of a very small group of women.

And that is how this study saw the light of day.

Acknowledgements

I could not have completed this thesis, if not for my supervisor Professor Pernille Bjørn. She made it easy to open up and share my experiences, she was quick to shut down my inner saboteur when it reared its ugly head, and she has in general been really supportive. I have never doubted that she wanted me to finalise my Master's Thesis with success. Further, Professor Katarzyna Wac deserves a mention. She was my supervisor when I last attempted to complete my Master's Thesis, and has never been angry or disappointed with me for not seeing it through, years ago. Instead, she supported my return and helped me get back. Early on in the project, PhD student Valeria Borsotti joined as Co-Supervisor. She has been a pleasure to work with, always optimistic, happy and ready with good advice. Thank you, Pernille, Katarzyna and Valeria.

Besides my great supervisors I have had amazing support in my private life. Giving me courage, listening to my frustrations, cooking for me, helping me find articles, proofreading, and in general just being my amazing cheerleaders during some tough months; thank you Nana, Andreas, Thomas, Jessica, Anne and Willem-Jan. And a special thank you to my manager at work, who decided to take some of my workload off, so I had more time to focus on this thesis.

Last, but not least, I obviously could not have done any of this without the women who volunteered to share their experiences with me so openly and honestly. It has been truly interesting to listen to your stories. Both the ones similar to my own but definitely also the ones that differed. You are all amazing human beings and I wish you all the best. Thank you for helping me out.

Abstract

Denmark and other Western Countries is experiencing a wide gender gap when it comes to Computer Science and has been so for many years creating biases and exclusions when shaping the agenda for digital development, as well as challenging the industry in dire need of skilled individuals. In an effort to contribute to changing this narrative this thesis answers the research question: *"What are the embedded stereotyped attitudes and beliefs on gender and Computer Science encountered by women students and what complexities shape the experiences of social belonging?"*

To explore these embedded stereotyped beliefs and attitudes, ten former and current women students who started their Bachelor Program in the years between 2010 and 2015 were recruited for interviews. These ten women make up more than 12 % of the women who started at the Computer Science Bachelor Program during this period. The interviews were performed as Life Story Interviews with an interview guide based on the author's own experiences as a Computer Science student in that same period. Through coding and thorough analysis of the interviews, 5 themes emerged which has formed the basis of this study, covering significant gender stereotypes about women and attitudes towards different aspects of Computer Science as a field, as well as how the social groups played a significant role in the women's well-being.

What this thesis found was firstly that it is confirming that there are limited narratives about women that shape peoples experience, confirming existing research on this area, and we are extending this existing research by voicing these women's experiences. Secondly, we produce and propose a new concept called Relational Visibility to describe the challenge these women face, balancing how to be both visible and invisible at the same time. And finally, we propose a framework which describes the multilayered complexity which this gender minority needs to navigate when starting in Computer Science.

Contents

List of Figures

List of Tables

1 Introduction

It is commonly known that Computer Science in Denmark and other Western Countries is experiencing a wide gender gap and that it has been so for many years (Margolis and Fisher, 2002). The industry is in dire need of skilled individuals, which screams for this gap to be closed, but to address this challenge we need to recruit from the entire population, not just a single gender. A much needed further benefit from closing this gap is that it will help eliminate biases and exclusions when shaping the agenda for digital development (Margolis and Fisher, 2002; Frieze and Quesenberry, 2015; Bjørn and Menendez-Blanco, 2019; Albusays *et al.*, 2021). This gender gap exist throughout the Western World especially compared to countries like Dubai, Qatar and Malaysia, who do better than the countries in the European Union, which in general have low levels of diversity (Borsotti, 2018). When looking specifically at Denmark, it is evident that Denmark is placed very low in the statistics in comparison to the other countries in Europe which we normally compare ourselves with (Bendixen *et al.*, 2019).

Over the years, several initiatives have been made to strengthen the number of women students in the field of Computer Science. There has been some effect of these. As an example, the IT University doubled the admission of women into Software Development from 2016 to 2017 (Borsotti, 2018). And if we take a look at Table 1.1 we also see an increase in women students at Computer Science at University of Copenhagen since 2017.

In 2010, only 13 out of the 141 students who began at the Computer Science Bachelor program were women. Out of these 13 students, only a few stayed and finished the Bachelor program as well as the Master Program. In the years between 2010 and 2015, both years included, a total of 81 women started the Bachelor Program as students.

The author of this thesis was one of these few women. As a student, the author actually left the Master program in early 2016 and have since been working successfully in the IT industry. However, in 2020, an interest in returning to the University and completing the degree started to emerge, and in 2021, I returned to the University to do my Master's Thesis and finish the program.

	Men	Women	Total	Percentage is women
2010	128	13	141	10.16 %
2011	154	6	160	3.90 %
2012	147	15	162	10.20 %
2013	147	15	162	10.20 %
2014	150	12	162	8.00 %
2015	148	20	168	13.51 %
2016	165	14	179	8.48 %
2017	212	30	242	14.15 %
2018	197	45	242	22.84 %
2019	207	39	246	18.84 %
2020	207	43	250	20.77 %
2021	159	44	203	21.67 %

Table 1.1.: Number of admitted students from 2010 through 2021 based on gender from Uddannelses- og Forskningsministeriet, Accessed: 2021-12-05

At the same time, an increased interest in the low numbers of women in Computer Science - in both media and academia - had emerged and I was fascinated by it, diving into understanding how the Computer Science Program was experienced by the few women who entered into this field. Diving in and leaning a new vocabulary about the experiences of the few women in the profession, especially during the days where I was there, was interesting. Mostly, I wanted to understand why so many had left?

One proposed reason is the concept of Stereotype Threat. Literature has shown that people who experience Stereotype Threat also experience increased stress and risk of leaving the place where they experience it, as they do not feel a sense of belonging (J.Spencer *et al.*, 1999; Smyth and Nosek, 2015). So having the conceptual understanding of Stereotype Threat, I identified 10 of the 81 women who started at Computer Science between 2010 and 2015 and interviewed them using Life Story interviewing techniques. The research question which was investigated was "*What are the embedded stereotyped attitudes and beliefs on gender and Computer Science encountered by women students and what complexities shape the experiences of social belonging?*"

The collected data was transcribed and analysed, resulting in five themes related to the misconceptions about women in Computer Science. The misconceptions were about women's inferior technical skills, being invisible because of your gender and taking agency even when met with multilayered complexity such as Stereotype Threat. The five themes form the results of this study.

Research Background

2

When investigating the nature of embedded stereotyped attitudes and beliefs which exists in relation to the experiences of women students in Computer Science, there are some main conceptual works from literature that can help us understand the situation and context. Specifically, there are two main streams of Computer Science educational research that are important. These are *gender norms* (Bjorkman *et al.*, 1998) and *stereotype threat* (Kumar, 2012). However, before going into these concepts, a look at the historic nature of Computer Science, and how it has developed in the department where the empirical data was collected, is needed.

2.1 Computer Science at University of Copenhagen

When looking at the history of Computer Science, a natural first place to look is Britain. During the second World War, Britain was ahead in the computing area. Mar Hicks (Hicks, 2017) thoroughly researched the history of Computer Science in Britain and found that what has long been seen as a male-dominated world actually started out being dominated by women. Women developed punch cards and fed them to the computers, and they did the deciphering of messages during the war but were not allowed to speak about it until more than 50 years later (Hicks, 2017). As the war ended, more and more men joined the computing world and more and more decisions were made by the civil service and public sector which drove women out of the field. This lead to a shortage of people who had the skills to occupy the needed positions. There was a demand for men only for these positions, and women would not be accepted into any of them - even those positions without male candidates. Hicks goes on explaining how this loss of women in the field had major consequences for Britain, and further states that even in today's world, getting to the top as a women within Computer Science, you need more than just having great technical skills. (Hicks, 2017).

Another part of the world, but still within the Western World, where Computer Science started out early, was in the United States of America. In Nathan Ensmengers book "The Computer Boys Takes over", it is similarly stated that the first computer programmers were not men - they were women. Ensmenger explains that back in the 1940's and 1950's, coding was seen as more of a craft, hence a feminine art, than as a science which was seen as a masculine thing (Ensmenger, 2010). He goes on referring to the first textbooks published in the field "that clearly distinguished between the headwork of the (male) scientist or 'planner,' and the handwork of the (largely female) 'coder'" (Ensmenger, 2010, p. 15). It was assumed that programming was trivial, but it turned out to be complicated, far more time consuming than first thought and a lot more expensive. Over the years, just like in Britain, the Computer Science field turned into a male-dominated area with women being pushed out (Ensmenger, 2010).

Both in Britain and in the USA, Computer Science started out around the time of the second World War and the programming was primarily done by women. However, in Denmark it started out differently. During the war, Denmark was an occupied territory of Germany and the field of Computer Science in Denmark did not really start until after the war, with the establishment of the first Danish IT company called Regnecentralen in the mid-1950's. Regnecentralen consisted of a group of mathematicians, physicists and astronomers that built the very first computer together (Sveinsdottir and Frøkjær, 1988). However, early in the 1960's, the great opportunities of this computing was discovered and the field really started to manifest itself when the Department of Mathematics bought the second computer, GIER (Department of Computer Science, Accessed: 2022-01-12).

Over the years, the collaboration expanded, and it was decided to create a Master's Program combining Math and Computer Science (Sveinsdottir and Frøkjær, 1988). In 1970, the department of Computer Science at the University of Copenhagen was created - spearheaded by Peter Naur himself. Naur was, from the very beginning, a big part of Regnecentralen, and was also the main author behind ALGOL 60 (Department of Computer Science, Accessed: 2022-01-12 & Sveinsdottir and Frøkjær, 1988).

Going through the literature and documented history of the field of Computer Science in Denmark, not many, if any, women are mentioned. Furthermore, official data available on applicants and their gender is only dating back to 1997. However, in 2014, an article was published by the Danish version of the online magazine ComputerWorld, showing how the amount of women students in Computer Science in America drastically declined from the mid-1980s (Elkær, 2014). The article also have comments from

lecturer Torben Mogensen, who himself started as a student at Computer Science in 1979 and who estimates that there were considerably more women students when he was a student than there is now. So based on memories from former students and on the numbers from other western countries, it would seem to be a general trend that from the 1980's, the number of women admitted to the Computer Science program was declining. As seen in table 2.1 and illustrated in figure 2.1, the group of interviewees whose stories are presented in this thesis come from some of the last years before it seems to slightly trend upwards again. However, the slight positive trend in the admission statistics does not mean that there are no more challenges within the field in relation to this thesis' research, as there are no indications that the complexities shaping the women's experiences of social belonging has changed.

	Men	Women	Total	Percentage is women
1997	223	18	241	7.47 %
1998	153	16	169	9.47 %
1999	216	24	240	10.00 %
2000	250	49	299	16.39 %
2001	173	28	201	13.93 %
2002	213	22	235	9.36 %
2003	192	17	209	8.13 %
2004	158	6	164	3.66 %
2005	90	5	95	5.26 %
2006	76	6	82	7.32 %
2007	95	7	102	6.86 %
2008	76	12	88	13.64 %
2009	93	9	102	8.82 %
2010	128	13	141	10.16 %
2011	154	6	160	3.90 %
2012	147	15	162	10.20 %
2013	147	15	162	10.20 %
2014	150	12	162	8.00 %
2015	148	20	168	13.51 %
2016	165	14	179	8.48 %
2017	212	30	242	14.15 %
2018	197	45	242	22.84 %
2019	207	39	246	18.84 %
2020	207	43	250	20.77 %
2021	159	44	203	21.67 %

Table 2.1.: Number of admitted students from 1997 through 2021 based on gender from Uddannelses- og Forskningsministeriet, Accessed: 2021-12-05

The later start to the field of Computer Science together with being male dominated from the very beginning, are not the only areas where Denmark stands out, compared to

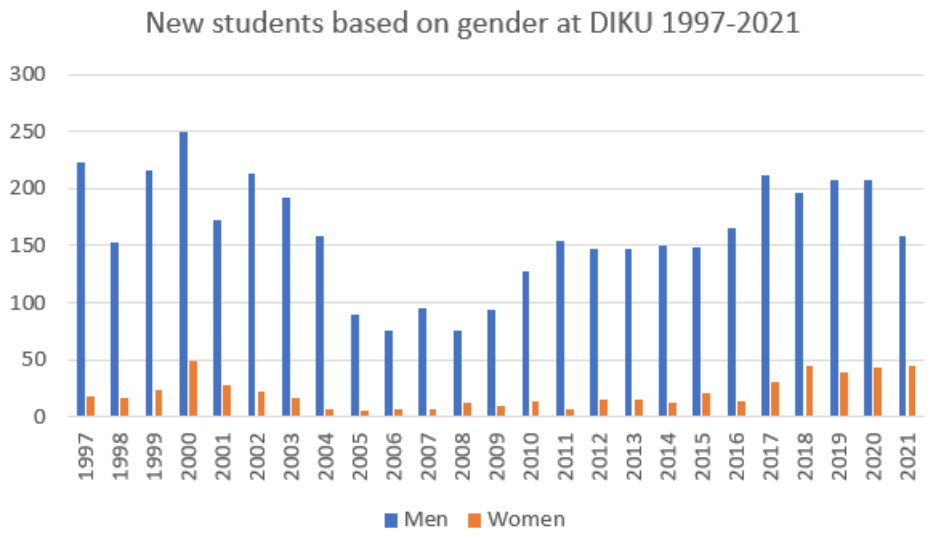

Figure 2.1.: Distribution of women versus men from 1997 through 2021

Britain and USA. The department of Computer Science at the University of Copenhagen was established in 1970 and about four years after the establishment, Peter Naur coined the term 'Datalogy' which translates to "the science of the nature and use of data" (Sveinsdottir and Frøkjær, 1988, p. 451). It is a term still used today when describing the field in Denmark, and it is also in the name of the department. Peter Naur had up until the establishment of the department focused a lot on programming languages, but in 1972 he changed focus to "how people work with programs" (Department of Computer Science, Accessed: 2022-01-12). Having this focus on data rather than on the computers later became known as The Copenhagen Tradition (Department of Computer Science, Accessed: 2022-01-12 & Sveinsdottir and Frøkjær, 1988). Naur was a "pioneer in his view that we cannot design IT systems in advance without including users and their practice. He believed that it was important always to remember that computers are a tool for people" (Department of Computer Science, Accessed: 2022-01-12).

Even though the foundation of Computer Science in Denmark is based on Peter Naur's term Datalogy, there seem to have been a development up until recent years where Computer Science is seemed to be more about programming than 'how people work with programs'. In 2016, Kinnunen *et al.*, 2018 published a study of first-year Computer Science students' expectations for what they was going to learn at the University and also what they expected to work with afterwards. The study used qualitative data from student surveys and essays from students in Finland, Sweden and UK. They highlight a few conclusions with some being "a potential mismatch between what incoming

students want to study and what they believe they have to study as part of Computer Science" (Kinnunen *et al.*, 2018, p. 215). Further they mention that "it appears that the image of CS as a multi-dimensional subject supporting many different paths of participation is failing to come across" (ibid, p. 214). Some of the reasons for these conclusions and subjects for further studies comes from the fact that a high number of the students participating in their study only mention programming as a Computer Science activity, and that programming was the area they expected to study.

Moving back to Computer Science in Denmark, a PhD study finalised just last year came across similar notions on what Computer Science is according to students. Katia Kromann Nielsen followed a group of students from their second year of the Bachelor Program in Chemistry, Computer Science and Natural Resources, and during her studies she learned which disciplines was considered part of Computer Science and which definitely were not. She explains that the heavier courses with programming and back-end related topics were considered Computer Science, and the less programming-heavy areas such as Human-Computer Interaction were not considered being part of the field (Nielsen, 2021).

These beliefs on what Computer Science is and is not leads back to the investigation into embedded beliefs which exist at the department today.

Since 2016, the Computer Science Department began to work towards increased diversity and inclusion through the FemTech initiatives (Bjørn and Menendez-Blanco, 2019). This work has in particular focused on changing the narratives about Computer Science through Design Artefacts and intervention approach (Menendez-Blanco *et al.*, 2018). Currently, the focus in the department has been towards more systemic changes for building inclusion such as Code of Conduct. However, it is very important that we understand the embedded cultural practices which defines the department if we want them to change - and most recently a study on humor have unpacked the challenged practices of creating inclusion in old rituals and traditions (Borsotti and Bjørn, to be published). This thesis seeks to help this work by zooming in on the experienced practices of women during this particular 6 year period - 2010 to 2015 - to understand where we can make changes today.

2.2 Normative Gender Stereotypes

Given that this study is about the experiences of women Computer Science students during a very unbalanced time at the Department gender-wise, it is important to consider research which can help in unpacking and understanding how gender norms and stereotypes impact people's experiences.

In 2012, Madeline E. Heilman defined stereotypes as "generalizations about groups that are applied to individual group members simply because they belong to that group" (Heilman, 2012 p. 114). She continues defining it further into gender stereotypes as "generalizations about the attributes of men and women" (ibid, p. 114) which have 2 properties; a descriptive and a prescriptive one. Heilman explains that "Descriptive gender stereotypes designate what women and men are like" where "Prescriptive gender stereotypes designate what women and men should be like." (ibid, p. 114) She continues stating that the "Descriptive stereotypes promote negative expectations about a women's performance by creating a perceived 'lack of fit' between the attributes women are thought to possess and the attributes thought necessary for success in traditionally male positions" (ibid, pp. 114-115).

In a review of interventions designed to change attitudes and behavior (Stewart *et al.*, 2021), traditional gendered stereotypes are defined with "traits such as ambition, power and competitiveness as inherent in men, and communal traits such as nurturing, empathy and concern for others as characteristics of women" (ibid, p. 2). Further, they define descriptive and prescriptive stereotypes as the first one being "beliefs about specific characteristics a person possesses based on their gender", and the second one being "beliefs about specific characteristics that a person should possess based on their gender" (ibid, p. 2). Steward *et al.* continues with a description of social norms being "informal (often unspoken) rules governing the behaviour of a group, emerging out of interactions with others and sanctioned by social networks" (ibid, p. 2). Further they elaborate that "stereotypes inform our assumptions about someone based on their gender" and "social norms govern the expected and accepted behavior of women and men, often perpetuating gendered stereotypes" (ibid, p. 2). This research helps us explain what gendered expectations society has, even outside of Computer Science.

In 1996, a study was started in Sweden to analyse and understand the culture at Computer Science at the University in Uppsala and the affect this culture had on women. The first part of the study focuses on this culture from a gender perspective,

and besides sexism, lack of role models and mentors, together with lack of support from family and teachers, they mention three obstacles for women in the academic world; The Unwritten Rules, Myths about the academic world, and a Catch-22 situation (Bjorkman *et al.*, 1998). The first of the three obstacles are the Unwritten Rules which are about power structures and blocking information to make it more difficult for minorities. The second of the three obstacles, the Myths, Bjorkman *et al.* describes as "views of academia as a democratic, objective, fair and open community, and the role of women in this community." (Bjorkman *et al.*, 1998, p. 65) They continue explaining that these Myths "also deal with the female essence: how women should act and how she should not act in order to be accepted, what women are like and what they are not" (ibid, p. 65). The last of the three obstacles, the Catch-22 situation, goes hand in hand with the Myths. Here Bjorkman *et al.* explains that "On the one hand women are expected to behave in a warm, caring and essentially "female" way to be socially accepted, while on the other hand, in order to reach success in their academic career they have to behave in a way typical for prominent individuals in their environment" (ibid, p. 65). Further, Bjorkman *et al.* states that "Femininity is often equaled with technological incompetence" (ibid, p. 65). This idea on how women should behave, and that being a woman means inferior technical skills, is something that the findings in this thesis also support, and it will be explored further in Chapter 4.

Lars Ulriksen, Professor at Department of Science Education, University of Copenhagen, proposes the term 'Implied Student' as a way to understand the assumptions and expectations which teachers have for their students. It is a concept that "relates to this complex of elements that students have to relate to and interpret, and aims at encapsulating the array of official and tacit expectations about what the student should be like and how" (Ulriksen, 2009, p. 521). Before defining this concept, he draws out studies that have shown "significant relationship between the students' feeling of being integrated into the discipline and the risk of dropping or opting out of the study" (ibid, p. 517) and continues explaining how being integrated is "one of the most important factors influencing the well-being of students" (ibid, p. 518). Ulriksen also talks about attitudes towards specific topics that where "considered hard, and in the discourse these are furthermore related to masculinity, and given more merit whereas others are regarded as soft, feminine and given less merit" (ibid, p. 519). This results in women students having to study differently than male students - simply "because their appearance as women suggests that they are 'less academic'." (ibid, p. 519) This way, to prove their worth, women students will then have to pursue excellence in these 'harder' topics or try "downplaying their gender by dressing in neutral clothing" (ibid, p. 519). These findings, namely that the lack of belonging can lead to students

dropping out, the perceived masculinity of technical subjects, and the downplaying of women's gender, rendering them invisible, are all topics that will be discussed further in Chapter 5 based on similar findings in this thesis.

Based on the above definitions and relations back to Computer Science (Bjorkman *et al.*, 1998), it seems to be highly important for Departments to be aware of these stereotypes, acknowledge them, and to implement initiatives to avoid these turning into stereotype threats and unnecessary complexity for the minority groups.

2.3 Stereotype Threat

In 1995, Claude Steele and Joshua Aronson came up with the term Stereotype Threat. They define the term as "being at risk of confirming, as self-characteristic, a negative stereotype about one's group" (Steele and Aronson, 1995, p. 797). Steele and Aronson performed four studies on stereotype threat in relation to African Americans during difficult verbal tests, and concluded that "Taken together these experiments show that stereotype threat - established by quite subtle instructional differences - can impair the intellectual test performance of Black students, and that lifting it can dramatically improve that performance" (ibid, p. 808).

A few years later, Steven J. Spencer published a paper with Steele and Diane M. Quinn about stereotype threat and women's performance on difficult math tests (J.Spencer *et al.*, 1999). They describe one of the consequences of stereotype threat "that women experience in math-related domains may cause them to feel that they do not belong in math classes" (ibid, p. 6). In the study, they performed three studies in relation to the stereotype that women are not as great at math as men are because of their gender. The studies shows that "when participants where explicitly told that the test yielded gender differences, women greatly underperformed in relation to men" (ibid, p. 12). However, the women performed at the exact same level as the men when no gender differences was mentioned. Furthermore, the studies showed a "nonsignificant tendency for men to perform slightly worse" (ibid, p. 17) when there was no indication of stereotypes in the tests "suggesting that characterizing the test as non producing gender differences has a negative effect on men's performance" (ibid, p. 17). While this study was not about Computer Science in particular, Math is well embedded into the Computer Science field, and it would seem likely that Stereotype Threat has exactly the same consequences regardless.

Interestingly, back in 2010 Amruth N. Kumar made a study suggesting that it is not only the group of people being part of the stereotype that might be negatively affected by stereotype threats. Kumar conducted a study to detect stereotype threat in some of the harder topics in Computer Science. In the studies, he found that reminding the students about stereotypes before their test by asking about demographic information that would then remind them of gender and gender stereotypes, would make them perform worse than if they were not reminded by these questions until after the test. The results showed that this was true for all the students, no matter gender or race (Kumar, 2012), which is in contrast to the math study by J.Spencer *et al.* that showed

a tendency for the majority group (men) to actually perform worse if no stereotypes where indicated before their test.

The study by J.Spencer *et al.* also showed that if you reminded the students about stereotypes before the test, everyone tended to answer the test questions slower than if you reminded them after the test. In relation to time, women and minority students based on race answered significantly slower than men and Caucasian students. Furthermore, less-prepared students scored lower in the tests if reminded of stereotypes before the test compared to the ones reminded after the test, no matter their race or gender.

Looking at this research background, it is clear that there exists several embedded stereotyped beliefs and attitudes which can complicate the experiences of women students in Computer Science. This thesis aims to explore the personal experiences of women students to shed some light on the nature of these issues and perhaps possible solutions, by asking the women themselves.

3 Methodology

To explore the embedded stereotyped beliefs and attitudes encountered by women as a minority group, ten former and current Computer Science students who started their Program in the years between 2010 and 2015 were recruited for interviews. Approximately twenty women were contacted in total. The contacts was primarily made through social media, and in a few instances some of the women knew another woman who then heard about the study, and offered to participate. When ten confirmed interview dates were made with ten different women who fulfilled the criteria, the search for women stopped. These ten women make up more than 12 % of the women who started at the Computer Science Bachelor Program in this time frame, as only 81 one women started in total in that 6 year time span (see Table 2.1 for a total overview of available admission statistics). Furthermore, no transgender women have been interviewed and nine of the ten interviewees are Caucasian.

Due to the COVID-19 pandemic, all ten interviews were conducted online. The interviews took place over a time span of fifteen days from December 20, 2021 through January 4, 2022. Table 3.1 shows which year the interviewed women started at Computer Science.

Year	Number of interviewed women
2010	2
2011	1
2012	1
2013	4
2014	1
2015	1

Table 3.1.: Number of interviewed women from each year

Out of the ten women interviewed, two dropped out of the Bachelor Program to study somewhere else, five completed their Bachelor in Computer Science, but did not complete their Master, and the remaining three completed both Bachelor and Master Program. In addition, two of the women had studied something else before starting at Computer Science.

3.1 Life Story Interviewing

An experience is a very subjective matter, and only the individual experiencing it can really share the story about it. That is why this study is built upon life story interviews. A life story interview is defined by Robert Atkinson as "a qualitative, ethnographic, and field research method for gathering information on the subjective essence of one person's entire life experience" (Atkinson, 2007, p. 225). This type of interviews is primarily guided by open-ended questions to support the interviewee in telling the specific story, and not by theory or any kind of research question - it is all about the story "this person want others to hear and what meaning does this story convey?" (ibid, p. 233).

An interview guide was made before the first interviews, based on the author's own experiences at the University, containing questions about potentially relevant areas, such as the introduction trips, the teachers (meaning both Teachers Assistants (TA's) and lecturers), the social groups, studying and everything in between. Additionally, the guide (see Appendix A) was slightly expanded along the way if an interviewee shared stories that were not initially covered by the guide. This was to make sure that the other women also had the opportunity to share something on the topic if they wanted to. These amendments were subsequently shared in messages to the earlier interviewees to make sure that I got their input on those topics as well.

All ten interviews were recorded. After each interview, initial thoughts and reflections were written down and already after the first few interviews, patterns and topics started to emerge during the transcriptions - and analysis was done iteratively. After these initial notes, the interviews were fully transcribed followed by a careful read-through. During this process, further thoughts and reflections would emerge, those would be added to the list and as the interviews went along, topics started to become more apparent.

Before moving on to defining topics for this study, initial coding was added to the transcripts. This coding was based on the different areas from the interview guide; one code related to practicalities such as when the women started, what they did before and why they chose Computer Science. Then another code for discussing the different courses, a code for social groups and so on (Eisenhardt, 1989).

After this initial coding was complete, a new set of codes were made based on the notes from the interviews. Among others, topics involving stress, (exam-)anxiety, the "no women" joke, different gender roles, stereotype threats and the bias against specific courses were recurring. These codes were applied to the transcriptions and six themes stood out; meaning that the topic came up either directly or indirectly in the majority of the interviews, or it somehow related to a theme that was mentioned by the majority. For example, 9 out of 10 talked about the bias/non-bias against some of the courses, 7 out of 10 touched upon each of the themes with "no women at Computer Science" and "women can't code" and 9 out of 10 mentioned the student revue. The different codes were added, no matter how the women talked about the topic. As long as it was mentioned, it got a code. It was clear when touching upon these topics that for most of the women, a lot of emotions were involved and some emotional scars had been left. It was not always easy to talk about, and it was definitely topics that took up a lot of the time in the interviews.

These six themes each got a headline, and every quote from the interviews that somehow related to these headlines were copied from the transcriptions into the paper and translated from Danish to English.

Anonymity has been a key aspect in this process, and it has been important to make sure all women were comfortable with the chosen quotes. This aspect also reduced the study from 6 to 5 themes, as we were not confident in our abilities to keep the anonymity on the last theme. Also, a small amount of quotes have been either shortened or even redacted, as identifiable information had to be removed. It was important to keep as many quotes as possible related to each chosen theme, but anonymity was always more important.

When all results from the interview process was finalized, each interviewee got the opportunity to read through the text. They were free to request changes, removal of quotes or other adjustments to make them feel 100 % comfortable.

3.2 Researcher's Role

The inspiration for this study, and also for the interview guide, came from my own personal experiences. I was myself a student of Computer Science, starting in 2010 and dropping out at the end of 2015, before finalising my Master's Thesis. I am now returning almost 6 years later to complete my Master's Program with this thesis. I did an extensive introspection on my experiences being a woman student at Computer Science, and through Reflective Conversations (Bjørn and Boulus, 2011), we decided to dig deeper into the experience of being a woman student. It would be a topic that would be highly relatable for me and maybe even therapeutic in a way. Additionally, the years I was a student at Computer Science also happens to be the last few years before a slight increase in women students at the Department is seen (see Table 2.1), making this time span especially interesting.

To avoid a study that only relied on one individual, also known as the *well-informed informant problem* (Bloomberg *et al.*, 1993), we decided to interview women who started during this specific time period. Due to the study having a time span of 4 months, and with not that many women starting Computer Science in the time frame of interest, we decided that 10 women would be a reasonable amount of interviews to conduct and analyse.

Based on the introspection I made in the beginning, I created an interview guide (see Appendix A) with open-ended questions, touching every aspect of my own experiences. This guide mainly served as a checklist through the interviews to make sure that we covered all topics, and if the conversation died out, I would have the guide to get the conversation going again.

It was definitely a benefit while conducting these interviews that I am part of the same minority group as the interviewees, an insider (Forsythe, 1999). It made the interviews flow quite easily from the very beginning, making it more conversational than feeling like a more formal interview. It was possible for me to connect with these women as I could relate and recognize many of the stories told - either by my own experiences or by observations made while I was a student myself. Furthermore, I was able to tell these women that they were not alone. I could tell them that other interviewees had shared similar stories, which in some cases seemed to be a relief for them.

However, being an insider also created some challenges, as I had to be in 2 different roles at the same time. On one hand, I was this insider, a part of the same group as these women, someone who has my own stories to share, and on the other hand, I was a researcher who gathered information for a study. I constantly had to make sure that my stories did not become the women's stories and that I kept the distance, so I could identify the relevant themes for me to base this study on. I had to be an outsider as well as being an insider - because as Diana E. Forsythe states "ethnography usually works best when conducted by an outsider with considerable inside experience" (Forsythe, 1999, p. 130). She explains that the reason is that "ethnography runs counter to common sense, since it requires one to identify and problematize things that insiders take for granted" (ibid, p. 130).

Nevertheless I am not the first to encounter this challenge. For example, back in 2011, Pernille Bjørn and Nina Boulus discussed how they overcame this exact challenge. Their study was running for a longer period of time and involved more people, but the challenge was the same. The observer in the study walked a fine line between being an insider that was trusted by the participants in the study, and an objective outsider (Bjørn and Boulus, 2011). Bjørn and Boulus explain how they take the challenges and uncertainties into an reflective approach; how their "reflective conversations gradually evolved into second-person inquiries" from starting out as first person inquiries (Bjørn and Boulus, 2011). Using reflective conversations became a key tool in this study as well, making me able to be both an insider as well as an outsider.

Results

4

This study investigated what kind of embedded stereotyped attitudes and beliefs women students at the Department encountered between 2010 and 2015, both years included. Through the techniques from life story interviewing we gathered these women's experiences, balancing the interviewer being both an insider and an outsider through reflective conversations. Five key themes from these interviews is being described here, covering significant gender stereotypes about women and attitudes towards different parts of the topic Computer Science as well as how the social groups played a significant role in the women's well-being.

4.1 "There are no women at Computer Science - only men in dresses"

One of the main themes which came from the data analysis, was that there was a joke embedded in many of the practices at the department (actually at the whole Science Faculty). The joke was that there are no women at Computer Science - only men in dresses.

This joke was part of the ways in which people would address or talk about women at Computer Science, to the point where women were sometimes referred to as "dress-men" in everyday speech. As discussed in Section 5.3, depending on how many facets of the multilayered complexity you are impacted by, artefacts such as the revue logo display this ambivalence by on the one hand reinforcing the imagery of the invisible women - there are only men in dresses here - and on the other hand showing a joyful dance where a man steps out of the ordinary stereotyped male clothes. The logo sends different signals and can be interpreted in different ways depending on the specific context which we will refer to as relational visibility and will be introduced in more details in Section 5.2. However, such mixed imagery leave little space for women – and the different ways of displaying gender outside stereotyped norms.

Figure 4.1.: Revue logo - was created back in 2010 and is still in use today

The revue is an important part of the Computer Science culture, which is explored in more details in Section 4.5. In figure 4.1 the revue logo depict an overweight man in a tutu (tutus being an iconic dress piece in the revue for men to show a women Computer Scientist). The revue logo came to light after a logo competition in late 2010 where everyone could submit suggestions for a logo for the revue.

During the interviews, many women explained how they experienced people's reactions when they mentioned that they were students at Computer Science. For example, one person said:

> "Ah yes, the 'there are no women at DIKU, only men in dresses' thing. You heard that comment a lot, when you told people what you studied." (Former student, 2021-12-30)

What we see with quotes like this is that from the day women start at Computer Science Department, they are told that they can not really be true, they can not exist, as there are no women at Computer Science. Interestingly, some women students experienced the joke about men in dresses as a way to belong; as a way to feel that everyone was equal. Especially in situations where the women were less interested in ordinary classified gender interests such as fashion. One of the women explains:

> "In the beginning I thought it was quite funny. I found a lot of the classic and ordinary 'girl stuff' a bit weird, so I kind of liked the joke. But it is also a bit... weird." (Former student, 2021-12-30)

While the quote shows that she at first found it fun, she did also find it strange. Further, a woman mentioned that:

> "But I also felt it was a way for us all to be equal. We were all the same - we were all having the same preconditions. (Former student, 2021-12-30)"

Exploring this further, even though it, on the surface, could make some women get the feeling of belonging, it becomes clear that the perspective on women as men in dresses actually create a toxic environment which has been experienced as problematic by other women, illustrated in the below three quotes:

> "But it is also a bit toxic that suddenly you can not like more feminine things, because you were a man in a dress and not a woman." (Former student, 2021-12-30)

> "You heard a lot that there were no women at DIKU. It was just men in dresses, which really triggered my Imposter Syndrome. I felt I had to be better than everyone else, because I did not want to be that woman who could not figure it out." (Former student, 2021-12-21)

> "It is a fucked up thing to say. We might not be many, but we are there." (Former student, 2022-01-04)

These quotes clearly show that as a woman student at Computer Science you are not really there. You are constantly told that you are different, and do not fit in. As one woman say:

> "You end up with a little bit of a chip on your shoulder, don't you." (Former student, 2022-01-04)

Perfectly illustrating that besides the pressure of studying at university, you also have to battle this view of your identity that you might not agree with. Some of the women even asked themselves if they, because of their gender, had to act in a specific way, as one woman states in the below quote:

> "Well, I have asked myself whether I have some kind of duty to be a certain way, or to be a role model or something. Since I am one of the few women. (Former student, 2022-01-04)

The joke about no women studying Computer Science is partly supported by the actual numbers of women admitted to the program. As Table 2.1 shows, in the years between 2010 and 2015, the women only counts for about 10 % of the students with 2011 being the worst year with only 3.90 % of the new students being women.

Being part of such a minority affect the students already from day one. Not only because of this joke that there are no women at the Institute, but also in general because there are so few women that no one seems to know how to handle the problem. As one woman explains:

> "In general the Intro-week was very chaotic. 160 new students starts with only 6 being women, and no one really seemed to have the capacity to make any special accommodations for that. In the name of equality it is fine that everyone is treated the same way. But the problem is just that when you are in such a minority, the lack of special treatment itself also becomes a problem." (Former student, 2021-12-20)

And she goes on explaining:

> "I would have appreciated if someone handled it somehow. Like, hey, we realise that it can be overwhelming to start at DIKU as a woman, because you're an extreme minority. As a woman, you're used to being a minority or majority in other situations, but rarely to this extent. It's rough to show up and be like, okay, apparently no one here looks like me. " (Former student, 2021-12-20)

This woman even started out by stating that she actually chose Computer Science over Biology because there is a big majority of women in Biology, and she felt less comfortable around other women. She felt she could more easily talk about her interests with men:

> "I had trouble deciding between Biology and Computer Science. But I was nervous about the gender distribution in Biology. I felt more comfortable

> with men. I could talk to them about video games and they didn't care so much about shoes. So I didn't feel like studying with too many girls." (Former student, 2021-12-20)

What these quotes suggests is that even though you are aware of the fact that you are going to be part of a minority, and even though you might even look forward to that - the difference between how many men versus how many women that begin at Computer Science is so big that it is still a shock for some women. Adding the joke about 'no women at Computer Science' just makes it extra rough for you.

The joke about men in dresses was also carried out in other situations, as it is a joke embedded into the traditional social activities at the Department. For example, one woman mentions that the theme for her introduction group was 'Princesses'. Every year, at least back then, the introduction week is planned and handled by a group of students in the tutor group called RusKursusGruppen (RKG). This group usually consists of about 30 older students, who are volunteering to make a good introduction for the new students. They divide themselves up into three smaller teams of 8-10 tutors. These smaller teams then create a theme that they are using for the entire introduction. They make costumes, theme based games, theme based information material and so on. The new students are divided out into these teams when they arrive on the first day, and follow their group for the entire introduction week - both the intro days at campus and the 3 day trip off campus.

So when this woman started, she was greeted by the Princess theme. A theme she found strange because she herself was not a big fan of wearing dresses.

> "The theme for my introduction was Princesses. I found that very odd. I mean, a lot of the guys found it funny that everyone had brought ballgowns. I hadn't. I never wore dresses, and I chose computer science so I wouldn't be expected to wear them." (Former student, 2021-12-20)

Back then it was custom to make sure that the few women that started and wanted to participate in the introduction events was put on the same team. However, as this woman states - maybe a princess theme would have been better if it had been a theme at one of the teams with only men, so that wearing a dress had been unusual for everyone:

> "As a girl, it was weird that wearing a dress was now supposed to be funny and different. Maybe it had been better if it had been on a trip only for men." (Former student, 2021-12-20)

Being one of very few women also means that your name is known very fast, even by people you have never talked to, because being part of a minority group, you stand out. This adds another layer of pressure. As one woman says:

> "It was a little intimidating to start, because I was very aware that I was one of very few women, and you get a lot of attention and everyone quickly knows your name even if you don't know them." (Former student, 2021-12-21)

As the above quotes shows, we have on one hand this joke about no women existing at Computer Science, that you should not really enjoy the more classical feminine things. But even if you are a woman who actually does not like the more classical feminine things, you are also 'wrong'. Because then you might not be comfortable with themes like the princess theme, and you would also still risk getting sexist comments like this woman experienced:

> "Hey, you should wear dresses more often. You'd be so pretty to look at." (Former student, 2022-01-04)

This quote shows that the women also experienced being objectified by their classmates. So on one hand they should not really be feminine as there "is no women at Computer Science", but on the other hand you are objectified and asked to be more feminine as that would make you 'prettier'.

Of course it is not all women who feel the same way. 7 out of the 10 women interviewed is represented in the above quotes, 1 did not mention anything specific, and the last 2 did not think much about it during their time at Computer Science. One of these two had studied English before starting at Computer Science, and mentions a more fun memory from when she started at Computer Science:

> "It was pretty interesting arriving at a place where you did not have to stand in line to use the ladies room. I was not used to that at the Institute for English." (Former student, 2022-01-02)

She continues with:

> "Impressively enough, I do not think I experienced something negative here. I know I generalise a lot now, but I think it was very clear, at least at my year, that many had been outsiders at previous schools themselves. So I think that made everyone have a great respect for all and that all should feel welcome. And that it is not about how you look. (Former student, 2022-01-02)

However, she does continue stating that:

> "It could of course make a difference that I was not single at the time - that, I do not know." (Former student, 2022-01-02)

So even though she did not really feel the negative aspects of being one of very few women and the joke about no women at Computer Science, she recognises that the fact that she was in a relationship might have made a difference, which would go in hand with a quote from another woman stating:

> "My experience as a woman at DIKU was, that either you were girlfriend-potential or you were the one that wrote the reports"(Former student, 2022-01-04)

This quote again shows how these women were being objectified and being reduced into the stereotype of women not being technically capable, which is also touched upon in section 4.2.

However, as mentioned, another woman did not think much about this joke either, and states she mostly thought about it when someone brought it up.

> "I actually haven't thought about it in everyday life besides when someone asked about it or just talked about it in general." (Former student, 2022-01-02)

What this section have shown is how a joke fundamentally impacts how the view on women is experienced, and how it also impact the feeling of belonging with their fellow students. Women at Computer Science have to follow some prescribed behavior to be

'right'. They can not be feminine, but also have to be feminine if they want to appear 'pretty'. They have to be a man in disguise.

Further, this joke or way of thinking might not only be a challenge at Computer Science and the Science Faculty. As one woman explain:

> "It was also a bit cool to stand out. When you went out, no one could guess what I was studying." (Former student, 2021-12-30)

So the assumption that women could not be studying something like Computer Science seems to be something of a more general thought in society, which would be worth exploring. This also indirectly shows in Section 4.2 where there seems to be a general understanding of women as not being able to code.

4.2 Women Can't Code

Another topic that is recurring throughout the interviews is the idea that "women can't code". It shows up in different ways in the interviews, for example, the below two quotes show that just because of their gender, these women had extra pressure added to their studies, as they felt that they had to work extra hard to prove themselves:

> "There was the feeling that women didn't understand IT, so you had to work extra hard. The courses themselves were difficult enough, and then you had that extra pressure." (Former student, 2021-12-21)

> "That thing, "women can't code", was a constant fear of mine. I didn't want to live up to the stereotype, and suddenly you feel like you're representing your entire gender. If you failed at something, your entire gender failed." (Former student, 2022-01-04)

These quotes shows, that instead of being able to focus on their studies like their male counterparts, they had to work extra hard to prove that they were not part of a stereotype.

This topic about women not being able to code changed the focus for these women. If they got a bad result in an exam, they started questioning if it was because of their gender instead of evaluating their personal situation as the following quotes shows:

> "If you were bad at something - was it just because you were a woman or was it a difficult course?" (Former student, 2021-12-21)

> "Failing a course was really tough. You felt that you were that girl who didn't know how to do anything. It was only in a few courses, where 70 % of the students failed, and where everyone knew that it was a deeply unfair exam and not your lack of skills, where it was okay." (Former student, 2021-12-20)

What the above quote shows is that failing a course in itself is not necessarily the worst thing. That happens. But because of stereotyped gender assumptions about women not being able to code, it turns out to be a very rough thing for you, because now you

feel like you are a bad representation of your entire gender. Only in cases where the course had a generally bad passing percentage, did the women feel that failing was okay - then it was not about them and their gender, but obviously the course itself.

Another woman also mention the 'failing an exam' culture as fairly decent in general - but like the others, she adds that because of your gender, the culture of acceptance, even if you happen to fail an exam for whatever reason tends to disappear.

> "The culture around failing in general was fine. But it was extra embarrassing when you were one of the girls, and people were like - of course you failed, you can't code. I'm a bit of a perfectionist so this was constantly on my mind." (Former student, 2021-12-20)

Feeling like a bad representative of your gender because of this attitude in the study environment, that women can not code, is also reflected in other situations. When talking to one woman about this topic, she said:

> "I ended up rarely asking for help, because I felt that everyone else knew everything already and didn't need to ask, so it would be weird if I asked." (Former student, 2021-12-21)

So besides having the burden of representing your entire gender, you also held back on your own learning, because you did not feel comfortable in asking for help - as you, being a part of such small minority, obviously had to be the only one who did not understand, so you did not want to be the reason that the rest of the class did not move on.

Another way this affected how the women then felt as a bad representation of their gender was that if they then ended up liking courses that did not have much programming in the curriculum like Human-Computer Interaction (HCI), a course many of the women actually liked and is being discussed further in section 4.4, they felt they simply confirmed that women could not code, as this woman explains:

> "You're already on the defensive because you're a girl. And if you are both a girl and someone who actually finds HCI interesting, then you feel like a bad representation for your gender because you're confirming that women

> can't code - just because you like some of the softer subjects." (Former student, 2021-12-20)

In section 4.1 above, a quote was stating that:

> "My experience as a woman at DIKU was, that either you were girlfriend-potential or you were the one that wrote the reports"(Former student, 2022-01-04)

This is also a relevant comment for this theme about women not being able to code, and goes very well with another quote from one of the other women:

> "Generally, with group assignments, it was assumed that the others had done the coding and I'd written the report." (Former student, 2022-01-04)

So the expectations to you as a women was often that you did not do any programming but you did write the reports.

Some women also mentioned that they met women who seemed to use this idea to avoid to code in group assignments as the below two quotes show:

> "A few women embraced it. Used the rhetoric to get extra help." (Former student, 2022-01-04)

> "Someone arranged a dinner for the women only. Very few women joined - maybe they had tried it before and knew to stay away. I was there once and never returned. I experienced a couple of women who were almost proud that they hadn't done any of the technical parts in their assignments. But then again, the problem with stereotypes is that they exist because some do live up to them." (Former student, 2021-12-20)

Of course it is not only women who write the reports at Computer Science. Male students also write reports, and there are also men who prefer to write reports rather than code.

9 out of the 10 interviewed women did not have any programming experience before they started as students at Computer Science. The one woman who did have experience

was already, before she started, a skilled Haskell developer and also knew JAVA and other languages. That meant her first year was going fairly easy for her, as she says:

> "I was way ahead. I already knew functional programming so I breezed through the first year." (Former student, 2022-01-04)

Her experience with the concept that women can not code stems from outside of Computer Science. When she was trying to decide what University to choose, it being Danmarks Tekniske Universitet (DTU), IT University (ITU) or Computer Science at University of Copenhagen, she went to an open house event at ITU - here she experienced, that just based on her and her friend's gender, they were perceived as coming students that were only interested in non-programming areas as she explains in the quote below:

> "I went to Open House at ITU with a female friend when we were picking a university. And we met with some sexism so we did just turned 180 degrees and left. They had a booth where you could hear more about software development. As soon as they spotted two girls approaching, they hid the Java book and said "Listen, it's about people." Great, but could you please not assume? I want to code and learn theory." (Former student, 2022-01-04)

Another woman also mentioned that she did not experience the concept at Computer Science, but she did receive comments from people outside of Computer Science, showing that it might not only be a challenge at Computer Science, but a more wide and general issue in society:

> "I don't think anyone at DIKU said anything about women and programming to me. But there has been comments outside DIKU, like 'you code well for a woman'." (Former student, 2022-01-04)

The woman with great programming experience did also mention that she did not herself experience the assumption of women not being able to code at university. Instead, she says:

> "I haven't experienced it explicitly. But I have been told a few times by other women that I was intimidating. Apparently I am loudly confident

> in my abilities. Maybe that prevented the whole thing about me being incompetent as a woman. It's hard to argue with my grades." (Former student, 2022-01-04)

What this shows is that if you, as a woman, want to avoid listening to comments about our gender not being able to perform this task, you have to show up with a huge skill set already on day one. And you have to be loud about it. You can not show up as a new learner like everyone else - not if you want to be judged on your skills rather than your gender.

4.3 "The Boyfriend Challenge"

During the interviews some of the women mentioned that they were in romantic relationships during their time at Computer Science. Some had relationships with people outside of Computer Science, but 3 women mentioned their relationship with a fellow (male) Computer Science student - relationships that caused them extra challenges in their student life. For example, one of these women says:

> "My boyfriend was a TA. To avoid that people would think he favored me, he made a big deal out of not wanting to help me at all. One thing was that he of course could not correct my assignments and stuff like that, but he chose to not wanting to help me at all, even though we lived together. At the same time, everyone assumed I got help from him when I did well, so I never really got any credit. It was more - 'of course you do well, you live with a TA." (Former student, 2021-12-20)

It is of course obvious that her boyfriend can not be her TA in her courses, but he is also in general unwilling to help, because he does not want people to think that she is being favoured. Further, she is not only struggling with not being able to get any help from her boyfriend who clearly knows the topic, but also having to handle rumours about her not doing her work herself when she does well. She continues with the following quote:

> "Because my boyfriend was a TA himself, he also decided to be tough on my actual TA. If I got good results or something, he would tease my TA, because he could not believe that my TA could not find anything to send me to re-submission on. That meant I ended up having to do re-submissions based on completely unreasonable minor details - just because my TA succumbed to the teasing." (Former student, 2021-12-20)

So besides her having to fight to prove she could do it herself, she also had to deal with the fact that her boyfriend was bullying another TA into being extra hard on her.

Another woman tells me that she actually got a great result on her bachelor project - a project which was pretty programming heavy. But the joy and pride disappeared fast when she started to get questions and comments about her boyfriends involvement:

> "Did very well on my Bachelor project which actually involved a lot of programming. I experienced being asked if it wasn't my boyfriend who had helped me since it had gone so well." (Former student, 2022-01-04)

These quotes shows that these women not only were battling an environment telling them they did not exist, as there is 'no women at Computer Science', and that they could not code - they were also 'lucky' enough to have a boyfriend, meaning that they also had to work extra hard to prove to everyone that they actually did their work themselves. That they did not get special treatment. One even explains how she had to plan where to sit physically to show that she did not receive help:

> "You ended up making a big thing out of placing yourself strategically when you were working to show that you actually did not get help from your boyfriend, but did the work yourself." (Former student, 2021-12-20)

Besides everyone assuming that you were not able to do your own homework, you also lost your identity as an individual if you became someones girlfriend.

> "If you had a boyfriend at DIKU you were just like an appendage. You were always someone else's. You were no longer seen as an independent individual." (Former student, 2022-01-04)

In general it seems that if you, as a woman, ended up being in a relationship with a man that also studied at Computer Science, you went from being your own individual person to this man's property, which also shows in the quote above. Another woman says almost the same thing when she explains how she for a long time just went under the description 'boyfriend's lady':

> "Well, I was for a long time known as <boyfriends name>'s[1] lady." (Former student, 2021-12-30)

Two of the three women also mention specific episodes that speak of this objectification, where you sort of become property when you become someones girlfriend. One mentioned a story where she got kissed by a man who was not her boyfriend - without her consent:

[1] Name removed for anonymity

> "We were at a party where another man asked my boyfriend if he could kiss me. My boyfriend thought it would be funny and said yes. And then this man goes right up to me, holds me, and then kisses me. It was super transgressive. Where was I in this? But I was just his lady, so he was in charge." (Former student, 2021-12-30)

The quote alone shows how violated she feels, and it also speaks to these women's feelings about not being looked at as individuals with their own will.

ANother woman mentions how a male student decided to try and trigger her insecurities just for fun by kissing her boyfriend in front of her:

> "I was at a party where my boyfriend thought it would be fun to let his friends know that I would be really upset if he ever kissed someone else. His friends thought they'd test that, so one of them went over and kissed my boyfriend in front of me just to see my reaction." (Former student, 2021-12-20)

This quote, together with several of the above, illustrates how difficult it can be for women to not become invisible. They are not only fighting a joke telling them they do not exist, but they also risk to loose their identity and agency if they end up in a romantic relationship.

4.4 But That's Not a "Real" Computer Science Course!

Another topic that came up in most of the interviews was the perception of what a 'real' Computer Science course was. For example, two women say:

> "There was this idea that Computer Science only counted the programming heavy things whereas becoming a teacher, going into management or user interaction wasn't real Computer Science." (Former student, 2022-01-04)

> "The more technical courses were put on a pedestal. I really enjoyed Human-Computer Interaction. But I had to listen to comments about how it did not have anything to do with IT. It was just easy ECTS. It was soft. Same thing with Project Management. If you were not programming, it didn't matter." (Former student, 2021-12-20)

These quotes shows that there seem to be a general idea that if you are not programming in the course, it is not 'real' Computer Science. It is 'something else' - which the quote below contributes to.

> "One of the courses I actually liked really well, and that I did very well in, was Human-Computer Interaction. But it felt like when you were finally good at something, it wasn't the right thing." (Former student, 2021-12-21)

Several women mention that this sort of bias against courses with no programming content actually made them choose a different path, even though they found the more interdisciplinary courses more interesting. For example, one says:

> "So yeah, even though I did well in Theory of Science, the first year project and other similar courses, it wasn't something you spoke about out loud. But if you did well in for example Operating Systems, you were more badass. It has definitely affected the direction I took at the University. Both because there wasn't that many courses within Project Management or similar and then I was affected by the atmosphere." (Former student, 2022-01-04)

Another woman also mention that she did not take Human-Computer Interaction, which she is actually regretting today:

> "In general, some courses was seen as less worthy than others. Meaning the programming-heavy courses were definitely the best ones. And that meant I never took Human-Computer Interaction because people said it was silly. But today I would have liked to have that theory with me." (Former student, 2022-01-04)

A third woman mentions that she thinks this pressure and bias comes from the students and not the institute - and recognises that there is a bias:

> "You get pressured a lot towards the tech-heavy courses rather than the more interdisciplinary ones, and I think that is a shame. I am also pretty sure it is coming from the students and not the Institute." (Former student, 2021-12-21)

This pressure on choosing programming-heavy courses made it difficult for students to choose elective courses:

> "It made it difficult to chose elective courses. Because you kind of knew it couldn't be too 'silly'. Preferably it had to be something very technical." (Former student, 2021-12-20)

One woman even describes it as elitist and describes it as you being less worth as a human, if you chose less programming-heavy courses:

> "It became almost elitist in some ways. The more programming work you do, the better it is, hence the more you are worth as a human almost." (Former student, 2021-12-20)

Another woman, while we talked about her exam anxiety, mentions that no one looked at her differently for having anxiety, but she was made fun of for being happy in getting a good grade in a non-programming course:

> "I can't remember that anyone reacted negatively to my exam anxiety, but I do remember that at one time I was very happy to have done well in

an exam - and then I was made fun of because it was Theory of Science." (Former student, 2022-01-04)

One woman, who had studied English before she started at Computer Science, recognises the bias against some courses, but was able to laugh at it:

> "It wasn't enough to be something that bothered me. But it did happen enough for me to kind of laugh at it because there was so much talk against people who studies humanities, and when you are one yourself..." (Former student, 2022-01-02)

She continues explaining how she was able to use her experiences from her previous studies to show that she might not have started at Computer Science with any programming experience, but she was still able to contribute:

> "I've studied something before, so even though I could not code when we started, I could feel that I could still contribute with something. And that was kind of a 'haha, told you it is not true - that it doesn't matter if we cannot communicate with each other'." (Former student, 2022-01-02)

She also mentions that she saw it more as sibling rivalry against humanities than anything else - she was however grateful when the Dean of ITU went out to the media stating, we should stop talking bad about humanities. That was an important message:

> "Experienced it more like sibling rivalry than I felt people were looking down at it. But I did get happy when Dean of ITU was out with a message for the media at one point, to ask that we should stop reducing the humanities. I thought that was important. But I have never experienced something at DIKU that I felt was personal or degrading." (Former student, 2022-01-02)

Finalising our talk about the topic, she also concludes that it was not exclusionary to her, but it was enough for her to think that people need to realise that they will also need soft skills when they go out into the real world after university:

> "I did not experience it as excluding but it was enough for me to think, that people had to remember, that when leaving DIKU it would not be enough to be able to talk to machines." (Former student, 2022-01-02)

Of course not all women enjoy the less programming-heavy courses. One woman enjoyed the programming a lot, and disliked courses like Human-Computer Interaction. She mentions that in that regard, she enjoyed Computer Science running a block structure instead of semester structure, because it was not for a long time, when she had to take a disliked course.

> "I wasn't that excited about Human-Computer Interaction so it was nice with block structure, because then it was over within 2 months." (Former student, 2022-01-04)

When asking more about why she did not like the course, she explains:

> "I wasn't happy with the course because of that book. It was very big and you really felt it was written by someone who got paid based on word count." (Former student, 2022-01-04)

She does, however, agree that there was a different vibe around the course and that it might actually have affected her, but she continues mentioning that she feels they could have 'done better'.

> "There was this vibe around the course that it was sort of fluffy - and yes, that vibe has most likely affected me a bit. All the people I spend time with had that vibe. But it must also be possible to do it better. I mean - make them read 'Design of everyday things' or something." (Former student, 2022-01-04)

Another woman, who did not let the bias against courses like Human-Computer Interaction affect her, mentions that she grew up surrounded by people who had Human-Computer Interaction as part of their professional life. She navigated around the topic by avoiding talking about the topic with the people complaining about the course:

> "Human-Computer Interaction, for example, is a course that many did not find interesting. But it was a course I liked. However, you could just avoid talking to the people who complained about the course." (Former student, 2022-01-02)

Lastly, one of the women mentions that she thinks it is problematic that one joke at Computer Science it that the slogan from the Institute is "IT is about people" because it is a true slogan, and she relates this joke to the bias against some courses that are more people-related.

> "I think it is problematic that people make fun of the slogan 'IT is about people'. Because it is a true slogan, and the mockery is the same as saying some courses are better than others." (Former student, 2021-12-21)

In contrast to the previous two topics, this topic is not purely based on gender. This reputation of some courses exists on course level, and gender does not matter, although there is a gendered component in whether you are allowed to like a certain course.

4.5 Let It Grow

Throughout the interviews, it became clear that the revue also played a huge role in these women's student life. Most of the women mentioned the social groups as being important, however the revue stood out as that was the only group mentioned by 9 out of 10 women. One woman mentions:

> "The revue was also a really, really cool thing in relation to the environment. I really had a feeling that if you wanted to be a part of it, you could. Everybody could join no matter your theater level - they would just make sure to find something that fit your skill. There was always a space for you. In fact, I found that to be a consistent thing throughout, also in other groups. If you wanted to try something out, the group would just take you in with a positive attitude and welcome you - which is in huge contrast to Århus University." (Former student, 2021-12-30)

This quote is not the only quote highlighting the revue together with other groups as a very positive thing for creating a feeling of social belonging. Another woman explains how the revue among other groups helped her stay at Computer Science for a longer period of time:

> "I was very active in the revue, both as a participant and later as a boss. I even worked with the revue after leaving DIKU. The revue was the first and the last thing I did at DIKU. I also think it was the reason I stayed for so long. I was also a mentor and in some other social groups, and the social part made a difference for how long you would last. If I hadn't been a part of the revue and such, I would probably have dropped out in my first year." (Former student, 2021-12-20)

When asking about what it is that makes the revue special, she continues:

> "For me it was most likely because I don't drink alcohol. And it wasn't really that funny to be at Caféen?, (the student bar, red.) if you did not drink alcohol. I've also always been very creative and enjoyed to sing. And with the revue it was possible to do that. It wasn't necessarily the revue itself, but just having a group of people who gathered to be creative instead of gathering to party and drink." (Former student, 2021-12-20)

This understanding of what the revue was and what it could contribute with in relation to belonging is backed up by another woman who states:

> "The revue was a place to be yourself. People didn't care if you drank or if you could code. You could just have a great experience with other people. It probably wasn't ideal that you had to take a week off from studying to do the revue itself, but it was really amazing." (Former student, 2022-01-04)

The revue at Computer Science was created back in 1973 and is a yearly event where students perform material in the form of sketches, songs and videos they have worked on during the previous year. It is a group for everyone who has a relation to Computer Science including professors who also often join on stage and in videos. The students create their own band every year, a tech-squad handling sound and light effects together with the videos, they create their own costumes and props, and they also work together with other student revues throughout the year.

Again continuing explaining how the revue and other social groups helped through the studies, and how she truly hope that this environment with social groups still exists as she deems it necessary for many to complete, a third woman explains:

> "In my first year I was really focused on my studies, but I later joined more social groups. I really tried focusing on being social. I often went to Caféen? (the student bar, red.) and also RKG and the revue. The social aspect was really important and it definitely carried me through. I hope it's still like that. It's the only way to get through it. You need someone to talk to - people who relate to your studies and assure you that you are not alone." (Former student, 2021-12-21)

These quotes show that the revue was seen as an open space for everyone. Here you could be part of a group without having to worry about your gender, if you were drinking, or if you were great at coding or not. These factors did not matter as the revue had a different set of values, creating a space of belonging. One of the factors that could support this welcoming feeling for these women was that the revue seemed very diverse. One woman mentions that it was probably one of the groups with most women present. Further, she hints at the revue also being a place where people could unfold. A place where you might find some of those students that were a bit more social. She describes them as butterflies:

> "The revue was nice, but that's probably also where you meet the most women. Or at least one of the places. It's where you meet the social butterflies with their colourful revue-wings. Those computer scientists who dare look at your shoes instead of just their own. Generally, the revue played a positive role for me, but so did the canteen and having my roleplaying group." (Former student, 2022-01-04)

It was not uncommon to see women occupy the roles of the revue boss (the 2-3 students who take upon them to lead the revue for the current year) as 1 out of 10 women in this study has been in that role, as well as the researcher behind this study, and there are artefacts from the years before with women in this position, such as the woman in the poster in Figure 4.2.

Figure 4.2.: Revue poster from 2007 taking a satirical view on a motto from a right-winged political party called Dansk Folkeparti.

As well as with the logo illustrated in Figure 4.1, depending on the specific context of relational visibility, this poster can be interpreted in different ways. On one hand it is

illustrating a strong woman leading the revue. She is in front of the poster with her two male peers behind her, but on the other hand it could come of as the woman being very masculine in this dark suit, suggesting that the way to have success at Computer Science is to be masculine.

Another poster artefact from the revue is the poster from 2009 illustrated in Figure 4.3. Here the Computer Science department building is displayed as a factory. It shows students of different physical appearance and gender enter the building and same-looking men leaving the building. So besides being inspired by the IT Factory scandal, this poster also seems to take a satirical view on how Computer Science have become sort of one-note with the focus on programming being the only true Computer Science, leaving everyone who finish very similar, compared to the diverse group entering the Department.

Figure 4.3.: Revue poster from 2009 inspired by the IT Factory scandal in 2008

The material for the revue is usually a reflection on the students' everyday life with a twist of humor and a sense of irony. One of the songs from 2014 is based on a song from Disney's animated movie Frozen, called 'Let It Go'. The satirical song, called 'Let

It Grow', plays into the gender stereotype of a Computer Scientist being a man with a beard and also touches upon the joke about no women at Computer Science together with the idea that women can not code, and thus can not be a Computer Scientist. The song was performed as a duet between 2 women Computer Science students - and is about how one woman really want to grow a beard so she can fit in and be a true Computer Scientist and the other sharing how she can accomplish that by buying a beard from the local costume store. Just like with all the other artefacts, depending on the context of relational visibility this song can be interpreted in different ways. One could argue that this song is confirming the joke that there is no women at Computer Science and that you have to be a man (with a beard) to be a real Computer Scientist. It is however, from the researchers perspective, seen as a song filled with irony, trying to make fun of these exact jokes and comments by ridiculing them to be about a beard - which, as should be obvious to most, does not make a difference to your skills as a Computer Scientist. The song is illustrated in Figure 4.4 and a recording from the show can be found on YouTube: `https://www.youtube.com/watch?v=zZqsmOnfl8o`.

Lad det gro
Frozen: "Let it go"
DIKUrevy 2014

Kantinen er tom, der er ingen at se
Og jeg drømmer for mig selv
Mit ønske er helt umuligt, jeg har håb alligevel

Du håber på at bli' en rigtig datalog
Jeg har prøvet alt
Men det vil ik' gro

Det kan ik' ske, jeg er en pig'
Det er det alle mennesker vil sig'
Men drømmen vil bar' ik' gå væk
Gi' mig et skæg!

Lad det gro
Lad det gro
Kan ik' holde det hem'ligt mer'
Lad det gro
Lad det gro
Det' på hagen det hele sker
Bare én stub, selv det ville ha' gjaldt
Lad dem bare glo
Uden skæg er en datalogs dage talt'

Dit kvindekøn dikterer
Alt det din krop ik' må
Men det er svært at acceptere
Alt det jeg ik' kan få

Men i mit ho'ed er en idé
Det bli'r fantastisk, prøv at se
En datalog kan jeg nu bli'
Endelig

Lad det gro
Lad det gro
Hvorfor har jeg ikk' tænkt det før?
Lad det gro
Lad det gro
Nu ved du hvad du gør
Det er den vej du nu har valgt
Lad dem bare glo

Mit skæg det snor sig som en slange mod mit bryst
De tykke lokker hvirvler sig i smukke cirklers lyst
Ved Nørrebros Runddel ligger min lykkens borg
Det' Fest og Farver, der har reddet os fra sorg

L[oa]d det gro
L[oa]d det gro
Nu kan ingen ting stoppe mig
L[oa]d det gro
L[oa]d det gro
Køn behåring bli'r en leg
Med vor's skæg kan vi klare alt
Lad dem bare glo
Uden skæg er en datalogs dage talt'

Figure 4.4.: Revue song from 2014

Not all of the women had much time for social groups for various reasons, but they still remember the revue as something positive. One even regrets that she did not have the time to participate on some level:

> "I had a pretty big social network before starting at DIKU, so I was only a part of the bigger events, like watching the revue. With work, studies, and boyfriend I was just too busy to join. But I really regret not being a part of it, maybe just to write the material. I would never dare be on stage." (Former student, 2022-01-02)

Others joined for a year or two and remember it as something special from their time as a student as the following 3 quotes shows:

> "I wasn't in that many social groups. I considered brewing beer (social group DQBrew, red.). But I only joined the revue once. It was really nice. But I also saw how much time people spent, doing cleanup after the shows and such. And I would rather spend my spare time outside my studies. It was important to me to have a social life outside DIKU as well." (Former student, 2021-12-20)

> "I used the canteen a lot as my social space. But I also once joined the party planning team for after the revue. It was really nice to meet a lot of people from other years. You got to know people better, it was really nice." (Former student, 2021-12-23)

> "I have been on stage in the revue once - it takes time which I didn't feel that I had in other years. But I have helped making props as well. I really liked the prop group. It really brings happiness to your studies to be in the social groups. And you get to know people that you can ask for help if you need it. It just adds to the experience to sit in the basement and write weird songs with other students." (Former student, 2021-01-02)

Two women mentioned how they knew about the revue before they started as students themselves because they had friends already studying Computer Science. One of these women even participated in the revue before she officially started as a student, really illustrating the openness and welcoming nature of the group whereas the other woman had learned the Computer Science 'anthem' before she started:

> "I knew a few people from DIKU who invited me to join the revue before I even started university. I think that the fact that I knew some people beforehand made it easier to start." (Former student, 2021-12-20)

> "I had cheated and knew a little about the revue before I started. So I knew our 'anthem' and the replies before I started." (Former student, 2022-01-02)

This shows that even before some of the students begin studying at Computer Science, they could, through their network, have a group they belong to - the revue. This is a group that creates this feeling of social belonging, as the group does not care about your gender, if you are drinking alcohol or not, or what your skills in programming are. This group works with different kind of values that have helped these women navigating and having agency.

5 Discussion

When this project was first initiated the main aim was to identify the embedded stereotyped attitudes and beliefs on gender and Computer Science encountered by women students and how these stereotypes created complexities and barriers for social belonging to the field and profession by these participants. Through the analysis of the empirical data we discovered three main stereotypical narratives which women students encountered while at the program. Firstly, women are told they do not exist through the joke about no women at Computer Science, and thus their bodies and existence at the program is rendered invisible. Secondly, women are constantly confronted with a narrative that they have inferior competences or maybe even can not code compared to men on the professional level of the field, and finally, women students are not understood as individual and independent people, but instead understood per association to others through their relations to romantic partners. Together, these three main stereotypical narratives complicate the fundamental experiences of belonging to the department, study, and profession - and seriously risk impacting women students self-esteem and ability to grow and impact the field of computing. Clearly, by encountering these narratives there is a high risk of stereotype threat (Steele and Aronson, 1995 and Kumar, 2012) to students who are not embodying certain characteristics of the implied students (Ulriksen, 2009), but instead stands out with different characteristics. This does not mean that women students cannot be successful within the department, and there are clearly many examples of excellent women students at Computer Science. What it does mean, however, is that to be successful, women students are required to battle not only the topics and subject matter - but also the community which they have joined.

5.1 The problematic narrative about women's inferior technical skills

The results clearly showed how the narrative about women being inferior in learning Computer Science was evident in the practices experienced by these women. One

example being the Open House event at ITU where the programming books were hidden when the women walked up to the booth (Section 4.2, p. 29). This experience alone made this woman decide against studying at ITU as she already knew she was not going to feel that she belonged. We can also see how this narrative affects these women in the quote about the complex experience of being in a romantic relationship with a fellow man student who was also a TA - not only did people assume she got a lot of help, she also had to deal with the fact that he would push another TA to be harder on her for no apparent reason besides her being a woman (Section 4.3, p. 31). This idea about women's inferior technical skills is very problematic as it adds an extra layer of pressure on these women. They do not want to live up to a stereotype they do not feel they belong to, and can feel that instead of just struggling for themselves to get better at their chosen profession, they are now struggling to not represent their entire gender in a negative way as explained in one of the quotes (Section 4.2, p. 26).

These narratives in education, in teaching, in the general environment at Computer Science, definitely confirm already existing research that the existence of stereotypes in a study environment creates unnecessary obstacles (J.Spencer *et al.*, 1999) and including them in teaching does not make an inclusive environment where the students thrive and get good results (Kumar, 2012 and Steele and Aronson, 1995). It is on the contrary making women choose somewhere else to study, and it is making it difficult to feel part of the environment which is one of the most important things to succeed (Ulriksen, 2009), and it is a problem in relation to stereotype threats.

Computer Science was originally thought out to be more of a interdisciplinary field, with the term "Datalogy" and an idea of how computers should be seen as a tool rather than the main object of interest in Computer Science (Sveinsdottir and Frøkjær, 1988). As this ideology unfortunately seems to have disappeared from the current understanding of what Computer Science is, and has changed to Computer Science being programming heavy, it intersects with this idea that women can not code. We see from the quotes that if these women found topics within Computer Science interesting that did not involve programming, it was simply confirming this problematic narrative (Section 4.2, p. 27). We see how this intersection between the narrative of women's inferior technical skills, and what topics real Computer Science consists off, take away some of the celebration when the women do well in courses, as it was cancelled out by those courses not being acknowledged, illustrated in several of the quotes from Section 4.4, p. 34. This narrow idea of what Computer Science is further limits the access and opportunities for everyone who would like to pursue these non-programming areas of the field, as it is a barrier for feeling a sense of belonging in general. Where it

gets highly problematic in relation to being a woman, is that it is yet another layer of complexity these women have to navigate.

There is no doubt that there exist an issue on this narrative, which both this study and former research shows. What this study further illustrates, is that Computer Science also experiences this problem to a high degree.

What this thesis argues is that to make real and effective changes that will keep women as students at Computer Science, it is necessary to take a serious look at the culture. It is imperative that these stereotypes and narratives on women's inferiority technical skills are handled and removed. Further, there is a need to revert the idea of what Computer Science is back to what it was in the very beginning.

5.2 Voicing Invisible Women

The result of this thesis shows that there are two connected narratives which fundamentally erase women as full members of Computer Science. One being the narrative about the existence of women at Computer Science - or the lack thereof. The other being the existence by relation, in this study illustrated by "the boyfriend challenge". There is a pattern in the environment that will make many women feel that they do not exist, they are not equally valued as their male counterparts, and this creates stereotype threats and imposter syndrome among other challenges. Erasing women from the department is problematic as it essentially takes away the opportunity for these women to participate in shaping the agenda for digital development as they only exist as peripheral members of the Computer Science field.

Current research shows that it is critical that the students feel like true members of the environment in which they study (Kumar, 2012 and Steele and Aronson, 1995), and the research in this thesis is extending the understanding from technical skills alone in relation to belonging to include and impact on the bodies and visibility of groups. Voicing invisible women also includes letting people be themselves. It is not about all women having to speak up and fighting these toxic narratives; some women have to speak up and some women will speak up, but it is more about creating equality of opportunity.

This thesis is further extending state of the art research such as the FemTech work (Bjørn and Menendez-Blanco, 2019) by voicing these invisible women, because by this voicing we do not just talk about changing the narrative - we add to the discussions a historic experience and perspective. It adds a different dimension, as one of the things is that in this voicing we hear about the experience of being silenced or being reduced to a relation of someone else, and how that adds on to the complexity of being a woman student at Computer Science.

Besides being invisible as a woman, there is yet another dimension, because when being a part of such a small minority group, you are, perhaps surprisingly, also quite visible, as the quote on how everyone quickly knew the women and their names illustrates (Section 4.1, p. 23). It is clear that there exists a deep frustration behind the stories for being very visible but at the same time no one really seems to see them. Being both invisible and visible at the same time depending on the state and perspective at that

specific moment gives analogy towards Quantum Physics with Schrödinger's Cat where the cat is both dead and alive - until you open the box to check.

With this thesis we propose a concept called Relational Visibility. For example, when you as a woman student are together with your boyfriend, your visibility is through that - the boundary of what makes you is you and your boyfriend. You become this accessory as the quote in Section 4.3, p. 32 also illustrates. But then, if you are just working by yourself, you are questioned on your technical skills which makes that the relation; and again if you are part of the revue, you are then physically in an environment where relational boundaries have been cut away as it no longer matters if you have a boyfriend, or if you can code or not (Section 4.5). You are still part of the Department of Computer Science and the culture there but these problematic boundaries have been removed. Further, as it seems that the revue in general had more diversity, it would feel less divisive, which, together with the previous statements, makes the women not only appear as their gender, but also as an individual, making the revue a free space for these women to take agency.

5.3 Taking agency navigating the multi-layered complexities

Throughout the empirical data combining the different findings from above, this thesis argues that being a woman in the Computer Science program adds additional complexities in how to be a student. Being told that you do not possess the technical skills, that your body is not there - that you are invisible or at least only standing on the periphery of the field. Looking across this data a picture of multiple complexities arise. As a woman student, you have to not only battle the regular complexities of being a student in a higher educational environment, but also have to battle these complexities consisting of invisibility, your skill-set being judged harder, and prejudiced against based on your gender alone, the risk of loosing your identity even higher if you end up in a romantic relationship with a fellow computer scientist.

This does not mean that women can not succeed within the field. There exists plenty of examples of successful women and even among the participants in this study we see women taking agency navigating these multi-layered complexities.

To describe this multi-layered complexity that the gender minority needs to navigate when they start at Computer Science, we propose a framework illustrated in Figure 5.1. To take agency you need a way to belong socially. Belonging can happen in different ways with one being the revue as shown in this study, but it is in general a matter of community building. Taking agency is also about pushing back the normative framework (Section 2.2), which relates to the Uppsala study where they explain the main three obstacles for women in Computer Science (Bjorkman *et al.*, 1998). We see that the women are expected to be feminine as the quote about the woman who was asked to wear dresses shows (Section 4.1, p. 23), but also that while being feminine, being a woman, you have to work harder to prove that your gender is not determining your technical skills.

Besides social belonging and gender expectations, as well as Relational Visibility that was discussed in Section 5.2, Figure 5.1 also have a petal containing the Nature of Computer Science. Having this idea that Computer Science is only programming heavy topics, instead of programming being a tool for people to understand data, the computer, and its interactions with humans (Section 2.1), is yet another complexity - a limiting narrative - students have to navigate. It creates a story that when you

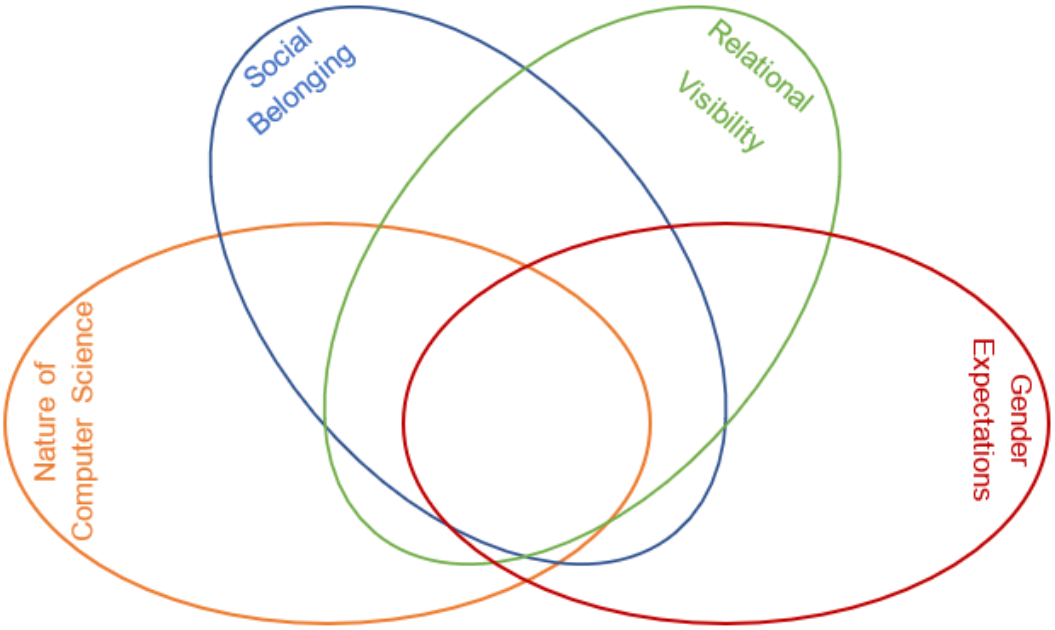

Figure 5.1.: Multi-layered complexity when taking agency as a gender minority in the Computer Science Department

are leaving Computer Science with a degree, you just come out into the world as programmers almost looking like robots as the artefact in Figure 4.3 illustrates. It also add to the complexity for women, as this idea of what Computer Science is makes some women either drop out or choose areas that they might not be interested in, as they do not want to confirm any stereotypes about women having inferior technical skills. Furthermore, this narrative makes it difficult for the students that do enjoy courses that is more in tune with how Computer Science was originally thought of, as we see in the quotes in Section 4.4, p. 34, where the women's pride of doing well in these courses was not respected. Their academic skills were not valued as much as the students who had chosen other parts of Computer Science as their topic, which obviously impacted their experience in a negative way.

Conclusion

6

This thesis is based upon 10 interviews of women who started as students at DIKU in the years 2010 through 2015. Through life story interviewing techniques, the stories from these women's student days has come to life and has formed the basis of this research.

In this thesis, we identified and explored the embedded stereotyped attitudes and beliefs which existed on gender and Computer Science encountered by these women students. Furthermore, we explored what complexities of these attitudes and beliefs shape the experiences of social belonging. We found three main stereotypical narratives that inflate this fundamental experience of belonging to the field. The narrative about women being inferior in technical skills compared to men was an embedded narrative which confirms already existing literature on this area. Secondly, we found that women were invisible through the narratives of no existence of women at DIKU together with existing by relation extending the understanding of technical skills alone in discussions about social belonging. Finally, we demonstrate how experiencing these problematic narratives did not mean that these women did not have agency and they still did engage in the culture of the department. However, the stereotype narratives impacted and added complexity for social belonging.

With these stereotypical narratives we confirm existing research stating there are limiting narratives about women that shape the students experience. Further, by voicing these invisible women's stories we extend current research as we add a historic perspective to the discussions. To describe the challenge of on the one hand being visible and on the other hand invisible, and how you as a women student need to balance that at the same time, we produce and suggest a new concept - Relational Visibility. Finally, we propose a framework which describes the multilayered complexity which the female gender minority needs to navigate when they study Computer Science.

7 Researcher's Perspectives

Writing this thesis has been a journey I did not expect it to be. I knew it was going to be hard. I knew that I did this for my own sake, as I have a great job that is independent of this final paper, so I did not need to do this as such. But ever since I dropped out, the fact that I did not finish after years of struggling with exam anxieties and difficult courses has still felt like a failure. And I have been terrified that I would stroll right back into this negative wheel of thoughts that would end up with me failing this time as well. This is also why I promised myself to be honest. Not only towards my supervisor, but also the people around me. I was going to do this, but I would need support. I would need people to help clear my head when it all became too much, and I would need to discuss the topic with others. Writing alone, you very easily get caught in your own train of thoughts.

What I did not expect was the therapeutic nature this work ended up having. Sharing my experiences with my supervisors made me realize how challenging it had actually been, being a woman at DIKU. How it is still affecting me in my everyday life now. How I have for so long played down my femininity and my gender to fit in. Furthermore, talking to these women somehow made it even more real. Objectively, I knew that there had been a lot of these challenges. I've had countless discussions myself about the importance of courses with no programming content, how inclusion of all students makes for a better environment thus making better students, and so on. But somehow, I realized I still felt a weird distance to it, which these interviews changed. I felt a connection to these women I have not felt before. Suddenly, there were other women. Women who had similar experiences. And I could see some of these women gaining this same connection. How it helped them to hear that they were not alone. We may not have been many women, but we were there and we could relate.

Working on this thesis means that I have grown as a human being. I have become a prouder person. I can look back at my time as a student, knowing that I actually made a difference - being a visible woman in countless social groups, not just as a peripheral member, but in the front, as responsible for the revue, chairman of the student bar, a mentor in RKG and a TA in both Introduction to Programming and less-programming

heavy courses, advocating for their importance, I know that I took agency even though it was not easy.

Further, I have reconnected with some women that I had not spoken to for a long time. I see friendships blossom and I feel stronger as a person. I feel closer to belonging in the world of Computer Science than I have ever done before, and I am ready to continuing taking agency, trying to make this field more inclusive.

Bibliography

8

Albusays, Khaled, Pernille Bjorn, Laura Dabbish, Denae Ford, Emerson Murphy-Hill, Alexander Serebrenik, and Margaret-Anne Storey (2021). „The Diversity Crisis in Software Development“. In: *IEEE Software* 38.2, pp. 19–25.

Atkinson, Robert (2007). *Handbook of Narrative Inquiry*. SAGE Publications, Inc.

Bendixen, Mette, Claire Meehan, Vanessa Jane Hall, and Ida Vogel (2019). „Denmark's examplary gender balance trips up in science“. In: *International Journal of Science* 572.178.

Bjorkman, Christina, Ivan Christoff, Fredrik Palm, and Anna Vallin (June 1998). „Exploring the Pipeline: Towards an Understanding of the Male Dominated Computing Culture and Its Influence on Women“. In: *SIGCSE Bull.* 30.2, pp. 64–69.

Bjørn, Pernille and Nina Boulus (2011). „Dissenting in reflective conversations: Critical components of doing action research“. In: *Action Research Journal* 9.3, pp. 282–302.

Bjørn, Pernille and Maria Menendez-Blanco (2019). „FemTech: Broadening Participation to Digital Technology Development“. In: *Proceedings of the 27th ACM International Conference on Multimedia*. MM '19. Nice, France: Association for Computing Machinery, pp. 510–511.

Bloomberg, Jeanette, Jean Giacomi, Andrea Mosher, and Pat Swenton-Wall (1993). *Ethnographic Field Methods and their Relation to Design. Participatory Design: Principles and Practices*. Lawrence Erlbaum Associates Publisher, pp. 123–155.

Borsotti, Valeria (2018). „Barriers to Gender Diversity in Software Development Education: Actionable Insights from a Danish Case Study“. In: *Proceedings of the 40th International Conference on Software Engineering: Software Engineering Education and Training*. ICSE-SEET '18. Gothenburg, Sweden: Association for Computing Machinery, pp. 146–152.

Borsotti, Valeria and Pernille Bjørn (to be published). „Humor and Stereotypes in Computing: An Equity-focused Approach to Institutional Accountability“. In: *Journal of Computer Supported Cooperative Work*.

Department of Computer Science (Accessed: 2022-01-12). *The history of DIKU – Denmark's first Department of Computer Science*. URL: `https://di.ku.dk/english/about/department_history/`.

Eisenhardt, Kathleen M. (1989). „Building Theories from Case Study Research“. In: *The Academy of Management Review* 14.4, pp. 532–550.

Elkær, Mads (2014). *Kvinder elskede engang de hårde it-fag - nu er kærligheden død*. ComputerWorld.

Ensmenger, Nathan (2010). *The Computer Boys Take Over*.

Forsythe, Diana E. (1999). „“It's Just a Matter of Common Sense”: Ethnography as Invisible Work“. In: *Computer Supported Cooperative Work (CSCW): An International Journal* 8, pp. 127–145.

Frieze, Carol and Jeria Quesenberry (2015). *Kicking Butt in Computer Science: Women in Computing at Carnegie Mellon University*. Indianapolis, US: Dog Ear Publishing.

Heilman, Madeline E. (2012). „Gender stereotypes and workplace bias“. In: *Research in Organizational Behavior* 32, pp. 113–135.

Hicks, Mar (2017). *Programmed Inequality: How Britain Discarded Women Technologists and Lost Its Edge in Computing*.

J.Spencer, Steven, Claude M.Steele, and Diane M.Quinnc (1999). „Stereotype Threat and Women's Math Performance“. In: *Journal of Experimental Social Psychology* 35.1, pp. 4–28.

Kinnunen, Päivi, Matthew Butler, Michael Morgan, Aletta Nylen, Anne-Kathrin Peters, Jane Sinclair, Sara Kalvala, and Erkki Pesonen (2018). „Understanding initial undergraduate expectations and identity in computing studies“. In: *European Journal of Engineering Education* 43.2, pp. 201–218. eprint: `https://doi.org/10.1080/03043797.2016.1146233`.

Kumar, Amruth N. (2012). „A Study of Stereotype Threat in Computer Science“. In: ITiCSE '12. Haifa, Israel: Association for Computing Machinery, pp. 273–278.

Margolis, Jane and Allan Fisher (2002). *Unlocking the Clubhouse, Women in Computing*. London, England: The MIT Press.

Menendez-Blanco, Maria, Pernille Bjørn, Naja M. Holten Møller, Jesper Bruun, Hans Dybkjær, and Kasper Lorentzen (2018). „GRACE: Broadening Narratives of Computing through History, Craft and Technology“. In: *Proceedings of the 2018 ACM Conference on Supporting Groupwork*. GROUP '18. Sanibel Island, Florida, USA: Association for Computing Machinery, pp. 397–400.

Nielsen, Katia Kromann (2021). „Science Students' Choises in Higher Education“. PhD thesis. University of Copenhagen.

Smyth, Frederick L. and Brian A. Nosek (2015). „On the gender–science stereotypes held by scientists: explicit accord with gender-ratios, implicit accord with scientific identity“. In: *Frontiers in Psychology* 6.

Steele, Claude and Joshua Aronson (Dec. 1995). „Stereotype Threat and The Intellectual Test-Performance of African-Americans“. In: *Journal of personality and social psychology* 69, pp. 797–811.

Stewart, Rebecca, Breanna Wright, Liam Smith, Steven Roberts, and Natalie Russell (2021). „Gendered stereotypes and norms: A systematic review of interventions designed to shift attitudes and behaviour“. In: *Heliyon* 7.4, e06660.

Sveinsdottir, Edda and Erik Frøkjær (Sept. 1988). „Datalogy - The Copenhagen Tradition of Computer Science.“ In: *BIT* 28, pp. 450–472.

Uddannelses- og Forskningsministeriet (Accessed: 2021-12-05). *Ansøgere og optagne fordelt på køn, alder og adgangsgrundlag*. URL: https://ufm.dk/uddannelse/statistik-og-analyser/sogning-og-optag-pa-videregaende-uddannelser/grundtal-om-sogning-og-optag/ansogere-og-optagne-fordelt-pa-kon-alder-og-adgangsgrundlag/ansogere-og-optagne-fordelt-pa-kon-alder-og-adgangsgrundlag.

Ulriksen, Lars (2009). „The Implied Student“. In: *Studies in Higher Education* 34.5, pp. 517–532.

Interview Guide

A

Start med at fortælle om specialet, at du gerne vil optage, at de får lov at se det inden aflevering osv.

Hvornår startede du på DIKU?
Hvor gammel var du, da du startede?
Hvorfor faldet valget på DIKU/Datalogi?
Hvad lavede du før, du startede på DIKU?

Hvordan var det at starte på DIKU?
Hvordan var de første dage, introdagene, hytteturen? Hvilke oplevelser husker du bedst? Hvorfor lige dem?

Hvordan oplevede du kurserne på DIKU?
Hvordan oplevede du øvelsesholdende? (Måske kommer vi ind på instruktorerne og TA miljøet her?)
Hvordan oplevede du forelæsningerne? Og professorerne?
Hvordan oplevede du afleveringerne? Hyppigheden? Omfanget? Nogle, du husker mere end andre? Hvorfor?
Hvordan oplevede du blok-strukturen i forhold til semesterstruktur? Hvilke udfordringer var der i forhold til kurser fra andre fakulteter? Tidspress?
Hvordan oplevede du eksamenssituationer på DIKU? Hvordan reagerede folk omkring dig på dine resultater?

Hvordan havde du det i det fysiske miljø på DIKU? Kantinen?
Hvis ikke TA's har været nævnt: Hvordan oplevede du instruktorerne? Var du selv instruktor? Hvordan interagerede man med dem uden for kurserne? Oplevelsen af dem i Kantinen?

Var du aktiv i de sociale foreninger? Hvilke? Hvorfor lige dem? Hvad betød de for dig igennem studietiden?
Hvad var din oplevelse af interaktionen mellem de studerende?

Hvor langt kom du på studiet?
Hvis du stoppede før tid, hvad fik dig til at stoppe?
Hvis du blev færdig, hvad tror du, fik dig til at blive og gennemføre?
Hvad laver du nu? Startede du på et andet studie?

Hvis du skulle nævne en ting, som DIKU kunne gøre bedre, hvad skulle det så være?
Hvis du skulle vælge noget at tale om, som vi ikke allerede har været igennem, hvad skulle det så være?

Extra spørgsmål til de 1-3, der ikke kom ind på dette automatisk
Hørte du noget til kommentarer som "der findes ikke kvinder på DIKU?" Og hvordan påvirkede de dig i så fald?
Stødte du nogensinde på udmeldinger som at "kvinder ikke kan kode", og hvordan påvirkede de dig i så fald?
Var der forskel på stemningen omkring kurserne? Altså, virkede det som om, nogle kurser var mere "rigtige" Datalogi kurser end andre? I så fald, hvilke, og hvordan påvirkede det dig?