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Inclusion of women to ICT engineering – lessons learned

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ABSTRACT

This paper address how we may understand inclusion strategies designed to reduce the gender gap in higher education in engineering and ICT engineering in particular. Based on a case study of a long-term inclusion effort and statistics on recruitment and retainment, we argue that inclusion initiatives which address important inclusion needs and put down a substantial effort are likely to be successful. However, such changes seem to be not very sustainable, and need continuous effort. Based on our findings and a review of previous research we argue that inclusion efforts are instrumental in gaining a higher share of women in ICT, but that the win may be short-lived. We suggest that there is a need also to work for a higher share of women faculty to obtain more sustainable recruitment and retainment of women in ICT. Moreover, we found that the probability of dropout among men students was systematically reduced with increased gender balance, which indicates that more gender-balanced programs are more attractive to remain in for both men and women.

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Gender balance; inclusion; recruitment; retention; engineering; ICT

Introduction

The persistent underrepresentation of women in higher education in the ICT field has often been referred to as the 'digital gender gap' (Mariscal et al. 2019) and raised political, economic and scientific concerns. The OECD states that 'greater inclusion of women in the digital economy and increased diversity bring value, both social and economic' (Borgonovi et al. 2018, 5). A report by the European Commission estimated that the annual European productivity loss generated by the digital gender gap was 16.2 billion Euros (SMART 2016/0025). Moreover, gender imbalance stifles innovative scientific outcomes since it reduces access to scientific talents (Nielsen al. 2017). Last but not least, the digital gender gap legitimises and supports hierarchical relations between men and women in society at large (Fox, Whittington, and Linkova 2017; Sonnert and Holton 1995a, 1995b; Xie and Shauman 2003).

This has spurred many efforts to increase the share of women in software engineering. However, gender imbalance remains a persistent problem in most countries and institutions, however, indicating that we need to better understand how to improve gender balances. There have been few evaluations of the effect of interventions targeting gender inclusion in STEM education (Mills 2011). There are few evaluations of interventions to recruit and retain women students in ICT (Siiman et al. 2014)

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or engineering programs in general (Mills 2011). There is a need for deeper insight into how to design strategies that effectively promote the inclusion of women in STEM fields.

In this paper, we examine and discuss the outcomes of a long-term project called Ada, aimed at recruiting and retaining women students in ICT engineering programs in one of the largest universities in Norway. Our aim is to identify possible factors and barriers for success in recruiting and retaining more women into ICT. We begin by reviewing the literature on what has been designated as the 'woman problem' in the literature on gender and ICT (Lagesen 2006). Next, we discuss the existing literature on inclusion strategies in similar programs believed to be successful. Then we examine the statistics on the recruitment and retainment to these engineering programs over 10 years, and discuss how we may interpret these in relation to inclusion strategies.

The 'woman problem' in ICT

The lack of women in ICT has been debated for decades, not only in policy contexts but also among scholars (Abbate 2012; Ahuja 2002; Cohoon and Aspray 2009; Johnson, Garcia, and Seppi 2019). The most prominent narrative of women in ICT has been one of exclusion (Lagesen 2006). Research has depicted ICT higher education as having unwelcoming and 'chilly' cultures for women and other minorities (Walton et al. 2015) and there have been frequent observations of sexism, sexual harassment and ridiculing (Beyer, Rynes, and Haller 2004; Dambrot et al. 1985; Spertus 1991; Jepson and Perl 2002; LaCosse, Sekaquaptewa, and Bennett 2016). Gender-related harassment and sexism have also been observed in other ICT-related areas such as gaming (Cameron 2019) and the ICT industry (Wynn and Correll 2018; Vardi 2018). Particularly in Silicon Valley has the exclusion of women been observed, as indicated in titles like 'Why is Silicon Valley so awful to women?' (Mundy 2017), and 'Brotopia – breaking up the boy's club of Silicon Valley' (Chang 2018). Moreover, women have been viewed as lacking self-efficacy (Galpin et al. 2003), playfulness (Yansen and Zukerfeld 2014), experience, (Brosnan 1998; Brosnan and Davidson 1996) or interest in computers (Siann 1997; Symmonds 2000). The stereotypical image of computer scientists as male, asocial hackers has been found to alienate women from the field (Gansmo, Lagesen, and Sørensen 2003). Thus, a dominant narrative of a multitude of barriers in the form of resistance, gender stereotyping, a hostile and off-putting culture combined with an unattractive image of computer scientists has led to a negative circle of exclusion of women in ICT (Lagesen 2006; Sørensen, Faulkner, and Rommes 2011).

In contrast, there has been a dominant narrative of men and ICT with an emphasis on inclusion. Literature has portrayed men as having a playful approach and deep fascination, even love, for computers (Oldenziel 1999; Faulkner 2000). Computers have been seen to play an important role in shaping masculine identities (Kleif and Faulkner 2003; Lie 1995; Murray 1993; Wright 1996) and as tools for bonding and forming relations between men (Chang 2018; Wajcman 1991, 2004; Mellström 1995, 2003). Thus, a symbolic link between masculinity, technology and ICT, as well as a culture permeated by gendered norms and ideologies together constitute what we may call a positive circle of inclusion of men to ICT (Sørensen, Faulkner, and Rommes 2011; Lagesen 2019).

Thus, circles of inclusion and exclusion are concepts to describe how forces create and reinforce either inclusion or exclusion and we will use these as main concepts for understanding recruitment and retainment strategies. A circle of exclusion, consisting of all these factors working together has led to a stabilised pattern of gender imbalance that has proven difficult to change. We thus propose that powerful efforts and initiatives are required to change what has proved to be stubborn patterns of gender imbalance. However, 'removing' the exclusion mechanisms described above is not easy. In the next, we shall review what we may consider efforts to create positive circles of inclusion.

Making positive circles of inclusion of women to ICT

In this section, we are reviewing what we consider other relevant attempts to recruit more women into STEM/ICT/engineering. In general, there are few systematic studies concluding what actually works (Mills 2011). Here, we briefly re-examine three previous studies of reported successful ICT inclusion projects as well as a larger study by Fox, Sonnert, and Nikiforova (2009) reviewing inclusion projects of women to STEM fields proposing some general success factors.

The first study is an analysis of a recruitment project in the US at the School if Computing at Carnegie Mellon (CM) (Margolis and Fisher 2002). Here, the share of women in the School of Computer Science improved from 7% in 1995 to 42% in 2000. This project consisted of several measures. One was to change the admission criteria to weaken preferences for highly experienced students, who were usually men. This led to a more diverse student body and increased the relative share of women, which made it possible to form peer communities for women, contributing to reduced dropout (Margolis and Fisher 2002). The CM project was built on a thorough investigation and analysis of the situation and the perceived problem at hand. The CM projected decided that educational efforts needed to be at the core of the project and aimed to improve the quality of the computer science program by utilising the best teaching resources at the undergraduate level and by tailoring the content in the courses to meet a greater diversity of interests among students. To counteract 'geek mythology' culture, the project supported social events and community building among women students. Carnegie Mellon has continued with inclusion efforts after the initial study in 2002 and has retained a relatively high share of women in their computer science program. According to Frieze and Quenesberry, who did a follow-up study of CM in 2009-2010, the most important strategy has been generating a more inclusive culture by recruiting a more diverse student population (Frieze and Quesenberry 2019).

Another example is a long-term project at the California Polytechnic University (CPU) which improved the percentage of women students in the software engineering program from 4% to 19% over the course of a decade (Janzen et al. 2018). The initiatives were multiple, including an introductory computing course for all students, a student group for women to provide a community of support, outreach initiatives toward girls in high school, bringing girls to the university for a day to learn about computer science, and sending students to the celebrating Grace Hopper conference. Moreover, a summer camp for middle and high school students gave high school students hands-on learning experiences with a variety of engineering disciplines. Also important was a capstone project where students worked for a real customer over time and decided whom to work with, reporting that women students appreciated the freedom to choose to work with other women students. According to Janzen et al. (2018), it is likely that these initiatives contributed to the rising share of women.

A third project, which was the predecessor of the Ada project (our case study here), was called 'The Women and Computing Initiative' (WCI) and lasted from 1997 to 2000. It aimed to recruit women to a computer science program and succeeded, increasing the share of women from 6% to 39% in one year. According to Lagesen (2007, 2011), the most important measure was a massive outreach initiative that increased awareness of the program among potential women applicants and made them feel invited and welcome. This was characterised as a 'Hawthorne'-effect, a positive effect of increased awareness and attention (Lagesen 2007). A second important measure was the establishment of a quota of extra study seats for women, which led to a rapid influx. Generating a critical mass of women students was important to facilitate a peer-community of women which reduced some of the problems women faced when they represented a very small minority in the program, like tokenism and unwanted attention (Lagesen 2007).

Finally, Fox, Sonnert, and Nikiforova (2009) analysed 49 projects for recruiting and retaining undergraduate women in science and engineering in the US to investigate what separated successful and non-successful programs. They found that the successful programs were characterised by structural rather than individual approaches to the gender balance issue. Thus, they recommend that projects should not be confined to individually oriented activities, such as peer mentoring and social events. Rather, they need to be firmly integrated in the institution, but at the same time connected to networks and externally funded partnerships which can be active and influential in shaping environments and outcomes for women (Fox, Sonnert, and Nikiforova 2009).

How may we understand the underlying inclusion strategies at work in such seemingly successful projects? Sørensen, Faulkner, and Rommes (2011, 226) identify three important 'inclusion needs' that should be addressed: access, motivation, and capability. Initiatives that manage to address these inclusions need have a higher probability of creating positive circles of inclusion. Such inclusion 'needs' may be used as an analytical framework to analyse the projects described above. First, we may observe that all the projects employed a range of different measures at the same time. This increased the possibility to address several of the inclusion needs, which allowed these projects to gain momentum. Second, the WCI and the CM project aimed for a diversification of the student body through the use of quotas in the WCI and changed admission criteria at the CM, while maintaining a high-quality student cohort. Second, outreach efforts and special invitations may also open access to underrepresented groups. Within a special invitation lies also a promise of accommodation and good treatment. The effect of such signals was particularly evident in the WCI (Lagesen 2007).

Quotas and broader admission criteria were also instrumental in attracting women into the programs in the WCI and CM. Achieving a critical mass is important to resolve a gender imbalance pattern because once a particular threshold level has been reached, a dynamic process will start that inevitably leads to further enrolment (Kanter 1977). It has been argued that increasing the proportion of women in places where they have been a minority can produce such threshold effects (see e.g. Etzkowitz, Kemelgor, and Uzzi 2000; Oliver and Marwell 2001). However, this theory has been criticised for incorrectly assuming that a critical mass prompts an accelerating enrolment of actors. Studlar and McCallister (2002) tested this theory in their longitudinal study of the political election of women and found that gains in women's political representation have been incremental rather than a critical mass accelerating the election of women to legislatures.

However, we may find other important effects related to achieving a critical mass. In the WCI, recruiting a higher share of women was crucial for enabling strong peer communities for women which, again, was crucial for well-being and preventing dropout (Lagesen 2007). Such an effect is undergirded by observations that when women are a small minority the risk of sexism, stereotyping and unwanted attention is much larger (Kanter 1977; Kelan 2007). Valian (1999) refers to several experiments where 'being in a minority increases a woman's likelihood of being judged in terms of her difference from the male majority, rather than in terms of her actual performance' (140). Lang, McKay, and Lewis (2007) found that the size of the women cohort in a study had a larger impact on women's learning outcomes than educational factors. This does not mean that educational factors are not important (see Siiman et al. 2014). Particularly regarding analysing dropouts in higher education ICT, educational reform has been shown to be an important instrument (Roberts, Kassiandou, and Irani 2002; Giannakos et al. 2017).

A larger share of women also affects gendered interpretations of computer science, making it more 'transgendered' and thus less masculine in the view of the students (Lagesen 2007). In Malaysia, for example, women outnumber men in computer science (Lagesen 2008; Mellström 2009; Othman and Latif 2006, 2019) and it is considered a 'feminine' occupation and study (Lagesen 2008). The relative proportion of men and women change gendered associations with a field (Lagesen 2007, 2010; Othman and Latif 2019; Frieze and Quesenberry 2019). Since gender constructions are fluid, the gendering of ICT varies across time and culture (Frieze and Quesenberry 2019; Lagesen 2008; Schinzel 2002). This makes for an amended critical mass theory, based on numbers as a basis for 'gendered symbolism', meaning that symbolic associations' gender changes (locally or more generally) with the numbers of men and women (Lagesen 2007, 2008).

Educational improvements are the third form of effective instrument in the CM and CPU projects. These include recruiting more inspiring teachers, tailoring courses to address a more diverse student population and providing introductory courses and hand-on workshops to first-year students. Tailoring the content of ICT works to recruit more CS students (Janzen et al. 2018) and prevent dropout (Margolis and Fisher 2002). Improving the quality of education benefits all, but those on the margins more (Sørensen, Faulkner, and Rommes 2011; Margolis and Fisher 2002).

Next, we will investigate a case study from our own university, called the Ada project (Ada). We begin by outlining the main measures in the project and then we examine statistically that was gathered as a way to evaluate effects of the project. Our main research question is; is it possible to detect potential long-term effects of the Ada on the recruitment and retainment of women? If so, how may we interpret these potential effects based on Ada's activities and what we know from previous research about inclusion strategies?

Method and data

The case university is one of the largest universities in Norway and has a strong science and technology profile but also includes humanities, social sciences, economics, medicine, health sciences, educational science, architecture, entrepreneurship, and art disciplines. The university has more than 40,000 students and more than 7000 employees and educates the bulk of engineers in Norway.

This paper is based on four sets of data. First, in order to investigate changes in the share of women between programs and probability of dropout, we collected statistical data from 'The Common Student System' (FS) which is a study administration system developed for universities, scientific colleges, and national university colleges in Norway. FS is developed by UNIT – The Norwegian Directorate for ICT and Joint Services in Higher Education and Research, and 'Coordinated Admission'.[1] Student status from study law data (FS265.001) is used to define dropout. Transitions between programs within the university are not defined as dropout. We have used data on grades from high school and the applicant's priority in the application. These data are public and openly accessible. Data was collected on an individual level. The proportion of women was calculated for each study program and start year. This variable does not vary within these dimensions so the standard error in the regression analyses is corrected for so-called Moulton bias.[2] Dropout is defined by student status in FS (status equal to withdrawal, terminated or expired).

Second, to substantiate some of our findings by comparing with other universities, we have collected data on women students in other ICT programs from the Database for Statistics on Higher Education (DBH), which is a data repository for a broad range of topics in the sector of higher education and research in Norway. Here we have collected figures for ICT programs at the three other large universities in Norway.

Third, we also conducted short telephone interviews with the department chairs of each of these ICT departments in these universities to learn what efforts have been made to recruit more women to their programs.

Fourth, we use findings from a survey conducted in 2020 of 188 women students in the Ada programs. This survey was conducted in-house by the Director of the Ada program (the third Lagesen). We will not analyse these data statistically but refer to some of the results from this survey that we deem relevant for this paper.

Finally, we would like to state that this paper is conducted independently from the case university, even if the authors work at the university. The first author is a researcher in a social science department. She has done the literature review and the main bulk of the writing. The second author has an administrative position as a statistician in the central administration of the university and has collected statistics for this paper and conducted the statistical analysis. The third author is the previous Director of Ada. Her position was funded by the university but was not part of the university organisation. The third author has contributed with inside knowledge about the activities of Ada and also with the results from the internal survey conducted on women in the Ada programs. The auhors have had close access to observe Ada and the case university in general. Thus, the paper also builds on some personal observations (auto-ethnography), and in those cases we refer to this as personal observation and personal information.

However, we stress that the main purpose of this study has been to investigate potential effects of Ada and discuss these findings critically in relation to research literature, to propose some ideas about effective strategies of inclusion of women to ICT higher education.

Analysis

In this section we will start by giving a description of Ada and its predecessor, the Women and Computing project (WCI) before we move on to analyse the statistics.

The WCI

The WCI project started in 1997 as a response to the gradually decreasing number of women students in the ICT program that had taken place since the mid-1980s. It was feminist vice-rector who initiated the project, which aimed to recruit more women students to the computer science program. The initiative started with a large national advertising campaign, made by a professional agency, which was considered unusual and innovative at the time (Lagesen 2003). Another initiative was the establishment of a quota for women-only which also meant an expansion of the ICT program with 45 extra student seats. This was controversial but led to de facto higher number of women to the program. Altogether, the marketing efforts and particularly the unusual use of a quota generated much debate and media attention locally as well as nationally. A consequence of all this was that young women were made aware that the program existed, and that the university really wanted more women. Even if many of the women applicants were critical of the use of a quota, they became interested and they felt specially invited (Lagesen 2007). Part of the WCI was also measured to support women students who were admitted into the program, like social events to foster community building and also a women-only computer-lab, funded by the industry. The idea was that women could have a space on their own. The faculty also funded a full-time position for a project leader to run the WCI project.

Overall, the WCI yielded quite notable results and the percentage of women students went from 6% to 36% in one year. The WCI continued in slightly different versions in the following years. Efforts to recruit women and increase the well-being of women students were sustained even if the measures varied. We do not have exact information on what measures were taken between the first version of the WCI and the second version in 2010, except that the WCI continued through marketing efforts to recruit women and social events to foster community building among women students. The quota for women was terminated after a couple of years. A lesson learned over these years was that then when the activities ceased, the proportion of women applicants went down. Also, the dot.com crises in 2001 led to a sudden drop of women applicants for some years. In 2010 the project was re-invented with a new director, one of the Lagesens of this paper, and with a new name, Ada (named after computer pioneer Ada Lovelace). In the following, we shall outline the key features of Ada in its current form.

Ada

In 2010, Ada was established and was expanded with six more engineering programs in Mathematics, Informatics, Cybernetics and Robotics, Electronic System Design and Innovation, Computer Technology, and Communication Technology. In the rest of the paper, we will refer to these as the Ada programs.

Ada has partly been funded by the ICT industry and partly by the university. One-third of the funding for Ada comes from 30 to 40 private ICT companies interested in recruiting women to their businesses and attracting good PR. The Ada team consists of a director (in a full position) and four to five students in paid part-time positions.

Ada's main activities have been outreach, recruitment and creating and maintaining a supportive social community for women students in the program.

The recruitment efforts have been targeting all young women in Norway who are taking the most advanced courses in mathematics in upper secondary school. Ada contacts science teachers who are asked to encourage girls with the best grades in mathematics to apply for participation in the

'Technology Week' which is an annual event taking place at the university campus. About four to five hundred young women applicants are then selected and invited to spend a week to get to know the university, the city and the Ada programs. These applicants have been selected based on three criteria: their grades in mathematics, geographical location, and the assessment of a motivation letter. The university covers travel and lodging for all the participants.

During Technology Week, women get to hear presentations about the study programs and about the industry from invited role models, who are emphasising that there is an interesting career and high demand for women in the industry with this kind of education. Ada tries to get woman presenters who can work as role models. The Technology Week also includes workshops where participants get hands-on experience with technology by building robots, learning to program, etc. Other important ways of 'alluring' women to apply, has been to present them for the student community and entertain and entice them with the opportunities for a great student life, through giving them concerts, arranging parties, etc.

A key goal with the Technology week is for the applicants get to know each other and form bonds during this week. The internal surveys Ada has conducted have shown that getting to know others is an important motivation to apply. Technology week represents a conscious effort to make women applicants feel especially invited and welcome and motivated to apply. A sub-goal is to get the participants to advertise the programs among their peers and friends when they return to their home place. Participants are thus encouraged to cover the event on their social media platforms. The internal survey showed that the percentage of women students entering the study after participating in the Technology Week was 72% (within one year), and 89% (within three years).

Once the women have entered the Ada programs, social events are put in motion to help build a strong women peer community. A prominent effort is the yearly networking event, where the women students travel to Oslo, the capital of Norway, to meet with relevant industries and businesses. Women students meet with industry representatives and other prominent figures such as politicians and ministers, who have often spurred attention and media cover. Other events include social evenings for women and classes in cooking, programming, etc. Such events was funded by the university in the beginning, but since this generated negative reactions about unfair treatment of men and women students, such events have since been funded by industry sponsors.

Ada has held a high public profile by giving presentations about ICT in upper secondary schools and participating regularly in events like industry seminars and conferences, Ada has been invited to many universities in other Nordic countries and received visits from universities here. Some of these have been inspired to make similar projects. Ada has also aimed to have a voice in the public debate submitting chronicles about women in ICT to newspapers and taking part in media debates. Ada has routinely made itself visible on campus, for example by having a tradition of organising 8th of March celebrating events. Ada also organises networking events with the industry and runs two career networks.

In the following, we investigate if we may observe any potential effects of Ada's work on long-term recruitment and retainment. We have gathered statistics on recruitment pattern and retainment in terms of figures the dropout rates during the last ten years. The practical work of Ada is not possible to operationalise in statistical models, but we investigated differences between the Ada programs and other engineering programs at the university.

The university has 17 engineering programs. The Ada programs constitute five of these. Thus, we chose to investigate whether there was a systematic difference between the number of women applicants to the Ada programs compared to the number of women applicants to the other 12 engineering programs. We hypothesised that if Ada has succeeded with their recruitment ambition, we would see an increase in the number of women applicants over time.

The results presented in Figure 1 show a trend towards an increased proportion of women applicants to the Ada programs, and we see that the growth in the Ada programs is significantly steeper than in the other programs. This is not evidence, but an indication that Ada has fuelled the

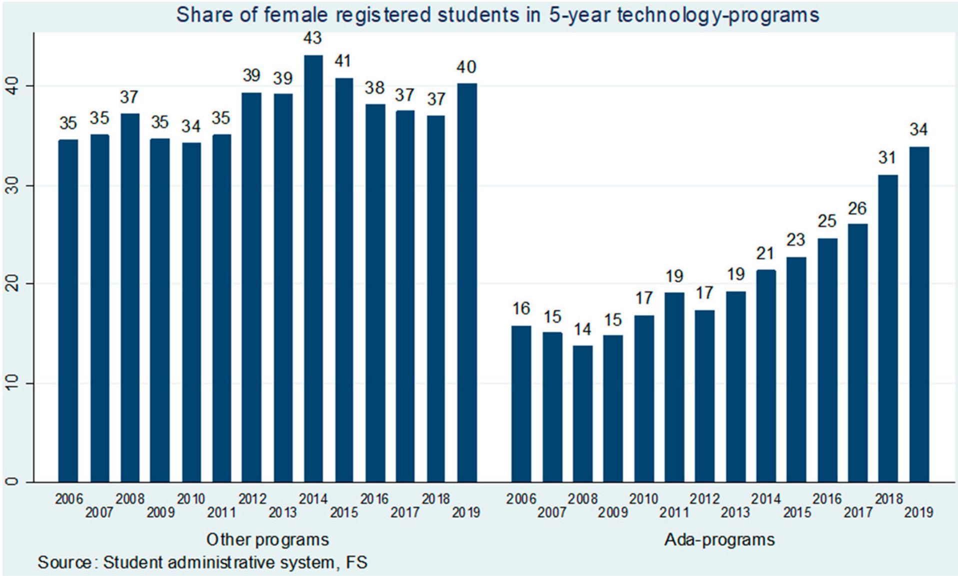

Figure 1. Share of women registered students in engineering programs.

recruitment of women students. While we cannot claim that the increased share of women applicants is an effect of Ada it is reasonable to assume that these efforts have had an effect, based on previous research and experiences (Lagesen 2007; Margolis and Fisher 2002). In 2002, the WCI reduced their recruitment efforts because they believed that it has become superfluous since a critical mass had been achieved. This led to an immediate drop in the numbers of women (personal information).

A comparison with the recruitment patterns of women in ICT programs in other universities shows that there has not been a general trend toward an increasing share of women in ICT programs. Figure 2 shows that there has been an uneven development in the other universities in the same period of time.

We see that University 2 had a sudden rise in the last years. In our interviews with the department heads, University 2 said they had worked 'steadily' since 2011 with recruitment efforts which included efforts similar to those of Ada, like an IT camp for girls in upper secondary school and 'a woman's day'. They had spent extra resources on these efforts. However, they could not explain the sudden influx of women in 2020. University 1 and 3 had not had any specific efforts to recruit women, except that university 3 had been conscious about not using only images of men in their advertising material. They had not spent extra resources on efforts toward women. Thus, the uneven pattern of recruitment across universities refutes that there is any national trend that could explain this increased recruitment to the Ada programs. Viewed together, these data suggest that efforts to recruit more women affect the share of women who apply to and are admitted to ICT programs. How and why we will return to in the discussion.

Next, we investigated the dropout rate among women students and whether it has changed over time and whether this change looks different between the Ada programs and the rest of the engineering programs.

We hypothesised that gender balance affected the dropout rate, particularly for women students. As shown above in the literature review, women may experience a lack of inclusion in higher education and even more so when they are a minority (Henwood 2000; Lagesen 2007). Thus, we anticipated that a higher share of women in the programs will reduce the probability of dropout among women students.

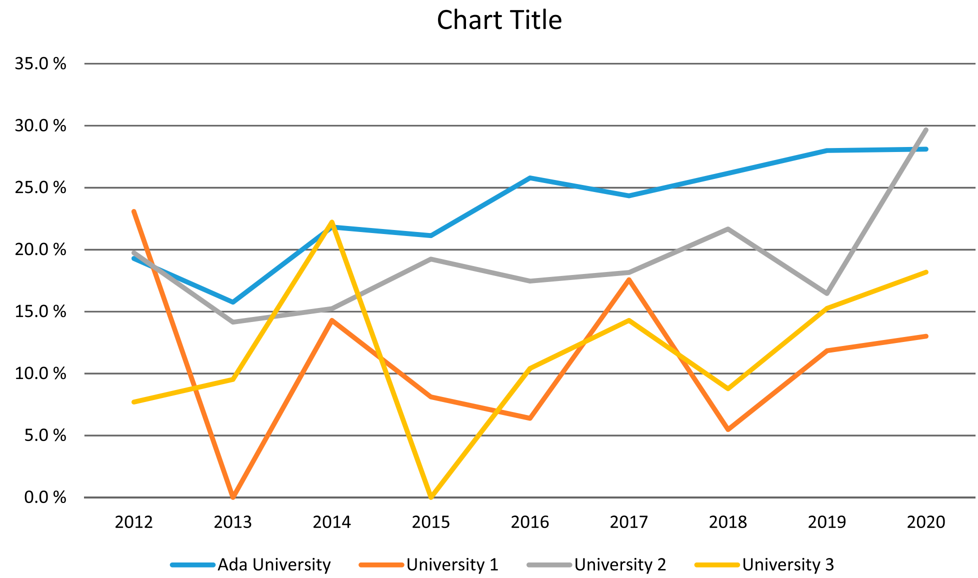

Figure 2. Share of women students in ICT programs. Source: DBH. Notes: Database for Statistics on Higher Education (DBH) is a data warehouse which holds data on a broad range of topics in the sector of higher education and research in Norway.

Using regression analyses, we modelled the probability of dropout in the Ada programs and other programs with a set of control variables. Although the focus of the analysis was to estimate the effect of the share of women students, we needed to control for other characteristics. We chose to control for age at admission, grades from high school, applicant priority, gender, and an indicator of whether the student is from the regional county. These control variables were selected based on demographics and accessible information as well as previous research on dropout. Studies on students' probability of dropout have shown that age is related to the probability of dropout, although with contradictory results. Giannakos et al. (2017) found that age reduced dropout for men and women students, while Stratton, O'Toole, and Wetzel (2008) found that age increased dropout, but only for men. Belloc, Maruotti, and Petrella (2011) found that students from the local area were less likely to dropout or transition into other programs. Average grades have been found to impact the probability of dropout (Chen 2012) and higher average grades have been found to reduce the risk of dropout (Belloc, Maruotti, and Petrella 2011). Applicant priority is based on an assumption that if you have the program as the priority, the risk for dropout reduces. Moreover, studies have shown that there is a tendency that men dropout more often than women in higher education (Meyer and Strauß 2019) and also in ICT studies (Giannakos et al. 2017; Belloc, Maruotti, and Petrella 2011). Still, these are aggregated numbers that should be considered with great care.

The coefficients were estimated using a linear probability model. The probability of dropping out is regressed against a set of independent variables. We have included so-called fixed effects at the study program level.[3] This means that we removed a good part of the variation between the study programs, which gives greater weight to variation over time. In the models, we did not include annual effects because we wanted to allow the proportion of women to explain some of the variations in the dropout rate. The fixed effects at the study program level mean the proportion of women can only explain changes over time, not time-invariant differences between study programs. This reinforces a causal interpretation of the estimated effects.

The results are reported in Tables 1 and 2. Table 1 shows estimated coefficients from a sample only with the Ada programs, while Table 2 shows the corresponding results for the other programs/all programs. Most selections are also estimated in gender-specific samples or with both (Figure 3).

Table 1. Regression analysis. Dependent variable: probability for dropout.

Variables	A	B	C
Share of women	−0.19***	−0.059	−0.25***
	(−2.96)	(−0.68)	(−4.20)
Age	0.022***	0.025***	0.022***
	(13.0)	(10.0)	(11.4)
High school average grade	−0.0074***	−0.0049***	−0.0081***
	(−5.82)	(−2.90)	(−6.95)
1. Priority	−0.036***	−0.071***	−0.023
	(−2.96)	(−3.59)	(−1.66)
2. Priority	−0.026*	−0.052**	−0.015
	(−1.77)	(−2.48)	(−0.93)
Woman	0.018***		
	(3.57)		
Local	0.042***	0.049***	0.039***
	(8.42)	(6.36)	(5.36)
Constant	0.092	−0.074	0.14
	(0.98)	(−0.68)	(1.50)
Sample	Both genders. All programs	Women. All programs	Men. All programs
Observations	27,168	8541	18,627
Adjusted R-squared	0.045	0.032	0.052

Robust t-statistics in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

How did the share of women affect the probability of dropout? In the Ada programs, we see that there is a systematic correlation between the proportion of women and the probability of dropout. We observe that an increased proportion of women lowers dropout rates. A coefficient of 0.3 means that the proportion of dropouts is reduced by three percentage points for an increase in the proportion of women by ten percentage points.

Consequently, we see that when the share of women in a program increases, the probability of dropout among women students reduces quite substantially. We also see that this effect is lower in the other programs than in the Ada programs. This may be attributed to Ada and its retainment efforts. However, another explanation could also be that increasing the share of women has a stronger effect in Ada programs because they started out with relatively fewer women.

Table 2. Results from regression analysis. Dependent variable: probability for dropout.

Variables	D	E	F
Share of women	−0.33**	−0.35*	−0.34***
	(−5.07)	(−2.66)	(−6.19)
Age	0.026***	0.034**	0.025***
	(30.7)	(4.47)	(17.5)
High school average grade	−0.010***	−0.0082**	−0.010***
	(−8.37)	(−5.14)	(−9.65)
1. Priority	0.0032	0.062	−0.012
	(0.28)	(1.89)	(−1.47)
2. Priority	0.015	0.060	0.0034
	(0.86)	(1.29)	(0.35)
Woman	0.022**		
	(3.86)		
Local	0.030**	0.032	0.029
	(3.20)	(0.74)	(1.62)
Constant	0.15	−0.076	0.19*
	(2.11)	(−0.47)	(2.43)
Sample	Both genders. Ada programs	Women. Ada-programs	Men. Ada-programs
Observations	6066	1226	4840
Adjusted R-squared	0.071	0.058	0.074

Robust t-statistics in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

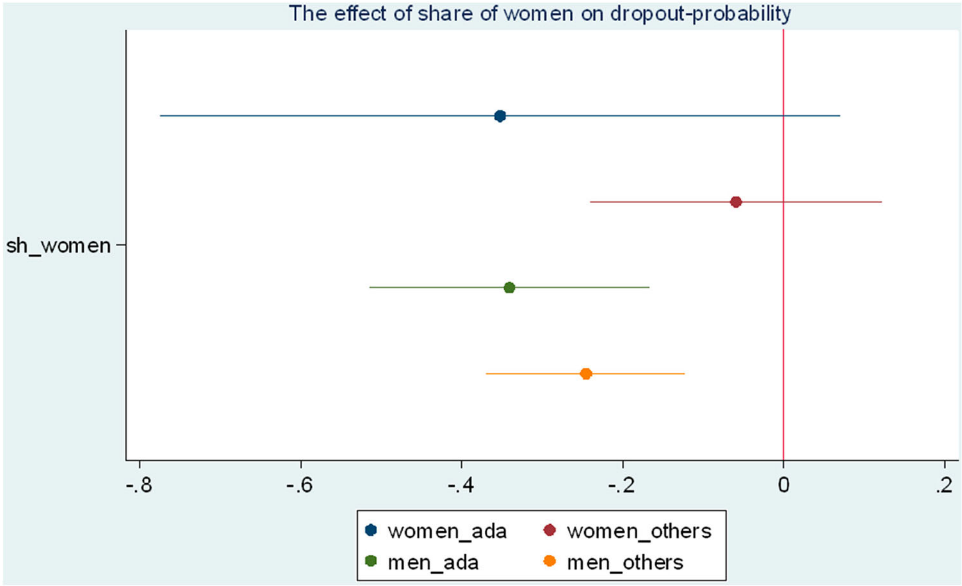

Figure 3. A graphical representation of the effect of share of women on dropout-probability.

That the dropout of women students reduces with an increase in the share of women is not very surprising, given what we know of how women have experienced being a minority in engineering programs (Beddoes 2011; Mills 2011). However, what is perhaps more interesting is that we see that the proportion of women is correlated with dropout rates for men students. We see that this effect is strongest in The Ada programs but appear to some extent also in the other study programs, where the effect is lower but still statistically significant. A tinier effect may be explained with the proportion of women students having a positive but decreasing effect on the dropout rate for men students.

To sum up our statistical findings; the recruitment to Ada programs has increased relatively more the last ten years, compared with other engineering programs in the university and other ICT programs in Norway. Further, we found that an increased proportion of women reduced the probability of dropout for women in the Ada programs, but not in the other programs. We also found that an increasing proportion of women had a significant negative effect on the probability of dropout among men students. This effect was the same in the Ada programs and the other programs. Next, we discuss how these findings might be interpreted.

Discussion

In our view, while we cannot prove causality between the Ada project and the increase in the share of women that we see during the last ten years, and the lower rates of dropout of women students in the Ada programs, our results strongly suggest that there is a relation between efforts made and these figures.

We believe this potential result is due to the continuous effort made over the years. Considerable resources have been spent and effort put down. Both the WCI and later Ada has been well anchored in the top leadership in the university and supported by among faculty in the engineering programs (Lagesen 2011). The allocation of funding to Ada has remained uncontroversial in the university organisation, because it has been believed to be instrumental in increasing the share of women in engineering programs.

What have been the inclusion strategies in Ada compared to previous research? Ada did not deploy measures that directly affect access, like changing admission criteria or quotas like we saw from other projects, like the CM and WCI. But Ada's measures did address important 'inclusion needs' such as access, motivation, and capability (Sørensen, Faulkner, and Rommes 2011). Inviting women and funding their visit is an important way to make women feel welcome and wanted was an indirect way of addressing access. We know that making potential applicants feel invited, welcome and appreciated is important (cf. the 'Hawthorne-effect' (Lagesen 2007)). Further, the presentations by women role models from the industry and hands-on workshops were initiatives that address capability and motivation (Sørensen, Faulkner, and Rommes 2011). The Technology Week aimed to motivate and to 'entice' women students with good prospects for interesting and fun jobs in the ICT industry, the allure of the student life of Trondheim, the opportunity to work with fun technology. Motivation is also spurred by familiarising potential applicants with each other in advance, facilitating the building of peer networks. Capability is addressed through hands-on workshops and initiatives (Siiman et al. 2014).

Clearly, to issue a special invitation to women spurs expectations that the university will take good care of women in the program and need therefore to be followed up in order to prevent dropout. Peer-community building starts in Technology Week and is continued through social events once women are in the study programs.

However, it is interesting to note that Ada is not focused on educational reform, which has been commonplace in many other recruitment efforts (Roberts, Kassiandou, and Irani 2002; Giannakos et al. 2017; Margolis and Fisher 2002). In Ada, the content of the program has remained the same, more or less, as opposed to projects that aimed for a diversification of the student body. If Ada succeeds with not addressing the content of the program, it may indicate that the content of the program itself is perhaps less important than the social and cultural factors surrounding it. Whether the content of the program changes with more women in it, or if addressing the content of the program could have led to a less resource-demanding and more sustainable way of recruiting women, is a question that would need further studies.

Second, we found that an increase in the share of women reduced the probability of dropout among women. This was not the case in the other engineering programs at the NTNU. There are two possible and related explanations. One is that the relatively low number of women students in the Ada programs in the first place enhances the effect of a critical mass. A critical mass of women has a significant impact, even if it does not promise sustainability in terms of enrolment. Second, it may be a result of Ada's retention efforts. Hence, the reduced drop-out rate may be both a direct and indirect result of Ada's retention activities. As argued in previous studies, the increase of women may lead to a form de-genderisation of an area or subject, which means that areas or disciplines are perceived differently and less gendered (Lagesen 2007, 2008). While we did not investigate whether this was the case with Ada, it is likely that the visibility of a higher share of women in the program makes it easier for more women to apply.

To conclude, the steady increase in the share of women during the last ten years could be explained by activities in Ada which have accommodated important inclusion needs. Does this mean a positive circle of inclusion has been created? When the WCI stopped its efforts, there was an immediate drop in the share of women applying to the programs. The dot.com crisis had a similar effect. This is in line with previous findings on similar projects, described above, showing seemingly success has consisted of persistent efforts. We propose that the increased proportion of women in the Ada programs is a possible outcome of a construed positive circle made up of initiatives addressing important inclusion needs, but which require continued support. In other words, Ada may reflect a *spiral* of inclusion work, rather than a positive circle of inclusion. This begs the question, what does it take to make a more sustainable change? Etzkowitz, Kemelgor, and Uzzi (2000) found that a critical mass of women faculty was pivotal to improving the situation of women students in science. This suggests that it is not necessarily enough to have a higher share of women students to spur a – with time hopefully – more self-sustaining circle of inclusion. Academic role models in ICT are crucial and women faculty remain a small minority even in programs that have managed to increase their share of women students. Thus, this suggests that recruitment and retainment projects should also attempt to address the recruitment of women into academic positions in science and not just in industry. Thus, clearly, there are elements in Ada that could be improved. Most of the women graduates are going to the ICT industry (which is eager to recruit them). Recruiting more women into academic positions is an important way of attempting a more sustainable inclusion of women to engineering. Also, the issue has been 'outsourced' to Ada, which means that the university is less engaged as it otherwise would have to be. Fox, Whittington, and Linkova (2017) found that it increased the success of initiatives if they were embedded in the university structure.

Finally, that the probability of men's dropout reduces when the share of women increases does not prove any causality, but it is reasonable to interpret this significant correlation as an indication that more gender-balanced programs are more attractive to remain into for both men and women and thus that gender balance make a more inclusive culture for everyone.

Notes

1. https://www.samordnaopptak.no/info/english/.
2. With robust cluster-function in Stata.
3. We include binary variables for all study programs (with a reference program). These variables detect differences between average dropout between study programs.

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