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Bachelor in Computer Science

GENDER BALANCE IN COMPUTER SCIENCE
HOW DO WOMEN VIEW THE TRANSITION INTO A PHD?

(EN) COMPUTER SCIENCE
NOVA University Lisbon
September, 2022



DEPARTMENT OF
COMPUTER SCIENCE

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ABSTRACT

A doctoral degree is a fundamental step towards academia, but one that not many women take. It is one of the key stages of the so-called 'leaky pipeline' that exists in Computer Science, and results in a lack of female faculty that might serve as role models for younger women in the field. Previous studies have touched on the elements that influence attrition and retention rates in Computer Science courses, as well as in the industry itself. However, the transition from a master's degree to a doctoral degree requires further attention. With this dissertation, our goal was to understand the reason not many women go on to pursue a PhD in this area, and explore the emerging themes in an effort to attain useful data that might be used to 'patch' this leak of women from academia. This was weighed against the alternative path of leaving academia for industry, and through a series of interviews - conducted and analysed according to the Socio-Technical Grounded Theory methodology - we gauged the common reasons women choose not to persist in their studies. This led us to nine core themes which hold major relevance to women in the path of academia, and to the topics of confidence and security, which tie all of these together and may be an essential clue towards making Computer Science PhDs more appealing to women. With these findings, we hope to help build the much-needed critical mass of women in Computer Science that will go on to balance the scales when it comes to gender in the field.

Keywords: computer science, gender, doctorate students, inclusion and diversity, PhD

RESUMO

Um doutoramento é um passo fundamental na progressão académica, mas um que muitas mulheres não dão. É uma das etapas chave da conhecida *'leaky pipeline'* que existe em Engenharia Informática e que resulta numa falta de docentes e investigadoras, as quais poderiam servir como modelos para mulheres mais jovens dentro da área. Estudos anteriores abordaram os elementos que influenciam o atrito no percurso de mulheres e suas taxas de retenção, tanto em cursos de Engenharia Informática, como na própria indústria. No entanto, a transição do mestrado para um doutoramento requer mais estudo e atenção. Com esta dissertação, o nosso objetivo foi compreender as razões por que não há muitas mulheres a seguir um PhD nesta área, e explorar os temas emergentes num esforço para obter dados úteis para remendar esta fuga na *pipeline* académica. Estes dados foram ponderados contra o caminho alternativo de deixar o ambiente académico em favor da indústria, e através de uma série de entrevistas - conduzidas e analisadas de acordo com a metodologia de *Socio-Technical Grounded Theory* - aferimos as razões mais comuns pelas quais estas mulheres escolhem, ou não, persistir nos seus estudos. Isto levou-nos a nove temas centrais com grande relevância para as mulheres no caminho académico, e aos temas da confiança e segurança, que ligam todos eles e podem ser uma pista essencial para tornar os doutoramentos em Informática mais apelativos para as mulheres. Com estas descobertas, esperamos contribuir para a construção da necessária massa crítica de mulheres em Engenharia Informática, que poderá equilibrar a balança no que toca à igualdade de género nesta área.

Palavras-chave: engenharia informática, género, estudantes de doutoramento, inclusão e diversidade, PhD

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ACRONYMS

COST	European Cooperation in Science and Technology 12
CRA	Computer Research Association 8
EUGAIN	European Network For Gender Balance in Informatics 2, 4
GEP	Gender Equity Program 14
HSB	Hochschule Bremen 13
ICSE	International Conference on Software Engineering 2
IEEE	Institute of Electrical and Electronics Engineers 2
NSF	National Science Foundation 6
NTNU	Norwegian University of Science and Technology 14
STEM	Science, Technology, Engineering and Mathematics 1, 4, 6, 7
STGT	Socio-Technical Grounded Theory 3, 11, 21, 31, 36, 38, 41, 72
SWE	Society of Women Engineers 15

INTRODUCTION

1.1 Context and motivation

The topics of diversity and inclusion are ones that have long been studied and discussed, but in recent years they have gained renewed traction among scholars. As studies shine a light on minorities and their participation in different areas, the inequalities that still exist come into stark relief. One such area is that of the STEM field - [Science, Technology, Engineering and Mathematics \(STEM\)](#) - where women and ethnic minorities have long been underrepresented, and Computer Science is the prime example for this [25]. This representation gap is concerning, as less diversity means whole demographics are largely being ignored, and the industry misses out on the innovation and productivity that they would bring to the table. One of the largest and often overlooked sources of value in this sense is precisely the female gender.

Recently, more efforts have been made to encourage women to pursue Computer Science and, most importantly, persist in this area [7]. Considering most women's path in the field begins with formal education in an institute, universities offering a Computer Science degree have seen concentrated efforts in maintaining a necessary critical mass of young women among their ranks. These efforts have been largely based on studies regarding attrition in women's academic paths and factors that weigh positively on retention rates, and some have seen success.

Currently, the topic of gender diversity both in the Software Engineering industry and in academic environment is mostly being studied with respect to the so-called Leaky Pipeline metaphor [11]. This metaphor models the stages leading from the beginning of women's studies, through a master's and/or doctoral degree and into working in the industry, describing how women "leak" from the pipeline into alternative career paths, leaving Computer Science or the [STEM](#) field altogether.

Research targeting the doctoral degree in particular is more sparse and focuses on the dropout rates for women when compared to men. This type of research usually tries to gauge motivators and demotivators surrounding women's studies and the academic environment they're inserted in. In some cases, strategies to counteract the negative

aspects were devised and put in practice, which might allow for further studies of their success rates [7, 35].

The present analysis inserts itself into this paradigm by focusing on the transition from a master’s degree into a doctoral degree. With this, it aims to contribute to a more thorough understanding of all the pipeline’s stages, so that this “leak” from academia onto the industry may be patched. It mainly derives its value from being a systematic, yet human-centric, approach to an issue which is deep-rooted in the Computer Science field. This lack of women causes Software Engineering to lack a major source of value and innovation, and as such studying this phenomenon is of considerable interest within the field. This has only come to be confirmed by the number of recent studies and events focusing on the subject of gender balance in Informatics, in noteworthy scientific publications such as those promoted by the [Institute of Electrical and Electronics Engineers \(IEEE\)](#). The GE@ICSE, a Gender Equality, Diversity and Inclusion workshop at the [International Conference on Software Engineering \(ICSE\)](#) is a prime example of how addressing these topics at large scale events may encourage both research and reflection. One of the sources of funding for this event is the [European Network For Gender Balance in Informatics \(EU-GAIN\)](#), which is divided into working groups precisely dedicated to this type of research. This dissertation aims to add valuable information to their current knowledge basis and increase the body of research surrounding the topic, without diverting from the field of Computer Science, and using adequate methodologies for this type of study.

1.2 Objectives and research questions

The current research regarding women in academic environments in the Computer Science field mostly leans toward attracting women to this major and strategies that increase both their engagement in the subject and, by consequence, their retention rate. And though improvements have been noticed in areas studies have focused on, such as recruitment and attrition, with some success cases to show for it, a gap was noticed in the knowledge related to the transition from a master’s to a doctoral degree. Furthermore, a large percentual discrepancy can be observed between men’s and women’s enrolment in PhDs [9].

This transition is a key stage of the pipeline, and as such a prime subject for further research, as it is the one where most women leave academia [11]. In conjunction with previous studies, fixing or improving upon this stage will contribute to building the much-needed critical mass of women academics and faculty members. This will, in turn, provide role models for women to look up to in earlier stages of the pipeline, as well as contribute to a more diverse field in the long run.

This is precisely where this research fits. More specifically, it aims to fill in the knowledge of the reasoning behind women’s choice to pursue a PhD when compared to leaving academia for the industry, or abandoning Computer Science altogether. In order to achieve this, we undertook a series of interviews paired with data analysis, following the

Socio-Technical Grounded Theory (STGT) methodology to reveal emerging themes. These interviews were conducted both with women finishing their master's degree in Computer Science - in order to ascertain their perception and future plans regarding academia - and women who are currently in a doctoral degree or have previously attained one. By this definition, interviews also contemplated women currently conjugating work and PhD studies, as well as women in the industry who may have attained a PhD in the past. While the main research target was academia, the industry plays a role as the major alternative and as such was also given some spotlight.

Using the **STGT** methodology, explained further ahead, it was expected that the research questions would arise from the research, rather than be set in stone, as was indeed the case. However, the core of this dissertation may be captured in the following questions, which served as guides during this process and helped the researcher proceed with the correct focus:

Q1.: What are women's perceptions regarding a doctoral degree in Computer Science? How do they affect their choice to make the transition into one?

Q2.: Who are the women who choose the path of academia in Computer Science?

Q3.: Why do less women, percentually, enroll and persist in Computer Science PhDs than men?

1.3 Contributions

In the course of this research, the Socio-Technical Grounded Theory methodology was used as a basis for exploring themes which arose out of interviews. Upon gathering all codes mentioned by women and applying data analysis techniques specific to **STGT** and explained ahead, we arrived at nine core themes to our study. By establishing connections between these themes, possible new objects of study naturally manifested themselves. These were explored to their full extent, allowing us to converge on a final, main theme - confidence and security. Through these interviews and the elaborated theory, it was thus possible to gain a new insight on how women perceive pursuing a doctorate in Computer Science.

To the best of our knowledge, this approach is one that had not yet been explored for this instance, and heavily relied on women's personal experiences and the value these add to the discussion. It can thus prove more representative of their reality. By expanding the current understanding of how women view this transition, and the reasons they choose to make it or not, this study made it possible to combine its findings with previous knowledge and suggest new methods of dealing with this stage of the leaky pipeline.

This systematic approach also made it possible to identify what has worked in the past in encouraging women to pursue a PhD, by allowing us to delve further into topics where the studied literature intersected with our ten emergent themes. We were able to get a more informed insight on why these cases were successful and may be taken as learned lessons. These contributions can henceforth be transposed to make their application effective at a larger scale.

Further value can be derived from this dissertation's connection with **EUGAIN**'s goals regarding gender balance in Informatics. By aligning itself with the objectives of its second working group, which precisely targets the transition from Bachelor or Master studies to a PhD [18], it aims to contribute with its knowledge and revisit good practices in a new light and revised applicability. The chance for the obtained results to be considered at a departmental level also lends the research interest and significance. Furthermore, ways in which this theory can be expanded are proposed towards the end of the document, so that the contributions from this study and its scope may be broadened in the future.

1.4 Structure

This dissertation is structured into eight chapters, with the purpose of giving a complete overview of the subject matter at hand, laying the groundwork, and thoroughly laying out the research process and how the proposed theory was achieved. The chapters are structured as follows:

Chapter 2 - Background presents the current knowledge in the field at a greater depth, so that there is a clear understanding of the state of the art. It begins with an overarching analysis of women's presence in the **STEM** field, before making the specific case for women in Computer Science. It then presents the Leaky Pipeline metaphor, the basis for the analysis and as such an essential subject to understand. Finally, having established a more general view of the field, it goes into the detail of women in Computer Science doctoral degrees. This was the main focus of the research and as such some relevant figures are provided, which help grasp the present state of affairs. The final section includes background information on the Grounded Theory methodology, which supported research.

Chapter 3 - Related Work reviews specific bodies of work that relate to relevant concepts within the subject. Namely, the success case of Carnegie-Mellon University in patching stages of the leaky pipeline, as well as papers that focused on the retention of women in Computer Science PhDs. Studied factors affecting attrition, retention and engagement are given a spotlight here, since they were useful points to touch on during research and in the conducted interviews.

Chapter 4 - Data Collection gives an insight on how research was conducted and its population, specifying the strategy for recruitment, sampling and advantages of the chosen approach, as well as an outline for the interviews. Finally, it goes into the technical

aspect of recording and transcribing interviews. Possible threats to validity are also identified here.

Chapter 5 - Data Analysis goes into detail on how the data acquired from interviews was treated according to the Grounded Theory methodology, following its several coding stages. It also delineates how the theory began to arise from the collected data.

Chapter 6 - Theory lays out the findings of this research by delving into the codes and the relationships drawn between them, and exploring the emerging themes that were prevalent in the data, as well as how these came to be. This is the main body of knowledge acquired during this dissertation. The theory's validation and possible limitations are also discussed at the end of this chapter.

Chapter 7 - Theory Discussion serves as a moment of consideration over the presented theory, deliberating on its probable causes and effects, both in short and long term. It compares the acquired knowledge with the existing literature on this subject by revisiting the related work in a new light.

Chapter 8 - Conclusion captures the theory and results obtained through this research. It begins by revisiting the research questions set in the Introduction and how they may be answered with the attained knowledge. It then lays out possible ways in which future work may expand on current research, or how these results may be implemented in practice, at a larger scale.

BACKGROUND

2.1 Gender disparity in the STEM field

In order to fully grasp the gender disparity in Computer Science it is important to first paint the overarching picture for women in Science, Technology, Engineering and Mathematics ([Science, Technology, Engineering and Mathematics \(STEM\)](#)). This is a field where women have long been underrepresented, and continue to be outnumbered by men despite their growing numbers. Here, the areas of Physics, Engineering and Computer Science are where most disparity can be observed [25].

Looking at Bachelor's degrees earned in the United States in 2006, only around 20% were earned by women in each of these three fields. Even lower values are seen for the intention of first-year women in college to pursue a major in [STEM](#) fields. Only 15.1% express an intention to major in STEM, compared to almost 30% of men. And out of this percentage, a slight 0.4% planned to major in Computer Science [25].

Further, a look at PhD completion rates in the United States in 2018 showed that, although the difference between men and women was not significant across most fields, STEM presented itself as an outlier. In a study ran by the [National Science Foundation \(NSF\)](#), it is shown that despite almost 60% of degrees being held by women in fields like Biology, STEM fields such as Engineering and Computer Science see much lower rates. Looking at Computer Science alone, the percentage of women with PhDs has been increasing over time, although not by as much as expected, reaching only 21.58% of earned doctorates in 2018 [23]. Despite the rise in comparison to numbers from 1998, this increase is much too slow for gender parity to be reached soon. Combining a low number of women enrolling in STEM PhDs with the attrition in their path results in this lower number of earned doctorates in comparison to men.

Unsurprisingly so, looking past the university level and at the industry reveals that the gender gap extends itself. In 2013, women made up 26% of professionals in computing, around the same as almost 60 years ago [14]. This is especially significant considering the advances in both technology and equality so far, which do not seem to be matched by advances in the perception of Computer Science. As such, this remains a field with

little diversity. Evidence also suggests that even among women majoring in computing, fewer actually go on to work in computer-related jobs, 38% when compared to 53% in men [21].

More women are now entering the workforce in total numbers, but STEM shows prevalent prejudice and inequities. Less women in the field not only equates to less role models for other women to look up to, but also a worrying lack of diversity in teams. An important source of creativity and innovation is lost in the process, and the discussion of ideas becomes more one-sided. It also means a predominantly male environment that may not be as conducive for women, and a workplace culture that is more difficult to be integrated into. 50% of women in STEM claim to have felt discrimination at their workplace, a number which goes up to 74% in computer-related jobs [21].

It becomes obvious that men and women navigate STEM academic or work culture in very different ways, and develop different perceptions regarding them. Gauging the causes for these discrepancies becomes essential if institutions hope to dissipate them. One such suggested cause, in the case of Computer Science, is that the field has embedded cultural views which are not appealing for women [41]. This may be based on existing stereotypes, leading to implicit bias in the workplace or against female students.

Attempting to fix the numbers without fixing the underlying biases that cause disparities to surface will not, in the long term, be successful. The gap will persist as long as the source is left unchecked. What STEM and Computer Science in specific need at this time is concentrated efforts to mitigate the gender disparity at its origin. If this is indeed based on cultural views, then it is necessary to present girls with an earlier and more positive first contact with STEM. Research shows early practical experience helps build interest in the field later in life [10], and as such it should be made a goal to restore a positive perception of women's representation in STEM. It is important that younger girls feel that this field will welcome them and is one they can envision themselves in.

2.2 The 'Leaky Pipeline'

A commonplace metaphor in STEM is the existing pipeline, extending from the beginning of the academic path to graduation and a career in the area, or into research positions and tenure. Its stages are illustrative of an individual's academic progression, and its flow represents the amount of people, in this case students, going through the pipeline at any given time.

Nowadays, the pipeline is usually referred to when exposing its leaks. A leak at any stage means students are leaving the STEM field into other areas of work or study, and a funnel effect can clearly be observed from the beginning to the end of the pipeline [15]. The further along the pipeline a stage is located, the higher the number of students that are observed to be abandoning STEM.

While men more often go through the pipeline without hindrance, women and other minorities face added challenges along the way. These result in them leaking out of the

pipeline into other areas of study, sometimes leaving the STEM field altogether. And although they may have important contributions in other fields, this leak is still a worrying factor for Computer Science, and one that demands attention if equal opportunity and workplace diversity is to be achieved within it.

Although a constant natural trickle can be seen throughout the pipeline, it is in the transitions between phases that most women are lost. The first significant transition being that from high-school to university, then from a bachelor's degree to a master's, and from here to the PhD level. Even in academia itself, the shrinkage continues as women progress through academic ranks [11]. An important consequence of this is that not many women come out the other end of the pipeline, and as such younger women lack female role models in their own path. This means it is more difficult for them to envision themselves in such roles, and may constitute a mental blockage in their way.

It is worthy of note that a simple increase in the flow going into a pipeline does not necessarily mean there is a better flow by the end. Likewise, a simple increase in the number of women going into STEM courses will not fix what is essentially a flawed system structure. The question that remains regarding this pipeline is whether it is beneficial to just keep patching its leaks, or whether more energy should go into a revolution in the system that might fix the problem as a whole.

Computer Science is a particular case within STEM, where the pipeline shows more leaks and an even greater funneling effect when compared to other courses [15]. While there have been successful attempts at bringing and maintaining women in Computer Science courses, these have mostly focused on admission rates and graduate students. Despite men and women being given equal education and preparation going into a PhD, looking at this stage of the pipeline paints an altogether different picture than expected, and women continue to leave the field at a worrying rate.

2.3 Women in Computer Science doctorates

The transition from a master's to a doctoral degree is crucial in the Computer Science pipeline towards tenure-track or research positions. It is also the one where most women are lost, either in choosing to not further their studies or in not finishing their doctorate. As enrollments in academic institutions increase at all degree levels, so does representative faculty become increasingly important. Being a fundamental step towards academia, the PhD stage thus requires special focus and study.

According to the Taulbee Survey [9], ran every year by the [Computer Research Association \(CRA\)](#) on computing PhD-granting departments in the United States, the amount of enrolling female students has been rising in past years, if only slightly. In 2020, women amounted to between 23 and 25% of all enrolled PhD students, and around 20% of awarded PhDs. Here a comparison can be established with master's degrees, where women account for little over 30% of awarded degrees.

Looking at current faculty members, the CRA reports only 23.2% as being women, with a slight yet steady rise being observed in annual surveys since at least 2013, when the percentage was 19.2%. This is still quite far from equal representation, and may be the root of issues such as lack of role models for women enrolling in bachelor's or undergraduate degrees.

It is, however, difficult to gauge exactly the percentage of students that choose to pursue a PhD from these numbers alone. One could look at the number of students attaining a master's degree and compare it to the number of newly enrolled PhD students, but this would render it inaccurate, as many other factors play into these values. This makes this transition, and by consequence its analysis, less linear.

In choosing a specialization area for their doctoral degree from 2012-2018, both men and women most often opted for the Artificial Intelligence and Machine Learning field. However, this does not equate to women being percentually well represented [8]. When compared to men in the same area, those where women are better represented are Databases, Human-Computer Interaction, Information Science and Social Computing.

Studies that focus on accomplishment in doctorates are often ran over the course of a decade, since these span several years. As such, not much relevant information would be gleaned from singly considering a year's statistics. Through careful analysis of trends within this time frame, the Survey of Earned Doctorates in United States institutions reported that women spend up to a year longer in their studies than men [30], accounting for higher mean and median time enrolled. The majority of students involved in this study also expressed a preference for joining the industry over continuing their studies in the area. Regarding employment trends for those recently receiving a doctorate in computing, the industry has remained the preferred path, with around 30% going into academia [9].

This preference for the industry is yet understudied in the Computer Science field, and several questions may be raised from current studies, which could provide enlightening answers. The fact remains that those who are awarded a PhD in Computer Science exhibit an extremely low unemployment rate [11], and mostly work within the industry.

Current studies centered around women in Computer Science PhDs focus mainly on the aspects that lead to their successful completion of the degree, or on the reasons for higher dropout rates. Essentially, attrition and retention are given more attention in this stage. Factors that weigh into the decision of dropping out are analysed in institutional terms, since the aim is to understand what universities can change to increase their rates of retention. However, the question is left open as to why the alternatives are preferred by women.

Several factors could play into this preference, with varying origins. If the reason is indeed negative experiences in an academic environment in Computer Science, policies must be put in place to contravene this and create a space that promotes inclusivity. It may also be that the industry is deemed a more conducive environment, and personal reasons must be factored in along others.

An interesting take is to gauge why women are not making the choice to begin a doctorate in Computer Science, despite growing numbers of women with PhDs in STEM. What sets it apart from other courses in the field that makes it lag behind in this specific stage of the pipeline?

Another meaningful fact to analyse is the preference of industry over academia in the transition to a PhD. Although it is desirable for women to go into the industry as well as academia, the goal here would be to understand why they do not choose academia at the same rate as men do. As such, it is interesting to assess whether the leak at this stage of the pipeline is mostly by virtue of women's future career prospects or of specific discouragers in the path of academia. It can also be ascertained whether doctorates currently present themselves in a positive light, as a promotive environment for women's self or career development. There is not yet relevant information on the reasons behind this preference in the academic sense, and it would benefit institutions by providing a better understanding of a crucial step in their academic ladder. This would add on to the current knowledge about attrition, and aid universities in improving their efforts in building a critical mass of women in Computer Science. Conceivably, this would then lead to more women in tenure-track and research positions, once again contributing to a more diverse and positive image of Computer Science.

2.4 Grounded Theory

The grounded theory method is a qualitative and systematic approach to research created by Glaser and Strauss. It appeared foremost as a form of inductively generating a theory from data, without the need for research questions to be presented upfront [13]. It differs from most other research theories in the sense that there is no necessity of a hypothesis which the researcher will attempt to prove or disprove. Instead, its goal is for a new theory to emerge from the research process itself.

This method distinguishes itself by highlighting the importance of theory development over verification. While it works in a qualitative model, it also offers rigorous procedures and theoretical robustness, placing it on-par with popular quantitative research methods [26]. Its name derives from being grounded in practical evidence and the finding of patterns in phenomenon data, lending it real-world relevance.

Rather than separating data collection, analysis and theory derivation into different parts of the process' pipeline, these three steps are taken iteratively [27]. This means there is an interleaved bottom-up approach, starting from empirical evidence and increasing in abstraction as it forms into a theory.

The data collection stage of the process begins with theoretical sampling and involves contacting groups or communities to take part in the research. Semi-structured interviews are then conducted and recorded so they may be turned into transcripts. These will be the basis for analysis.

Analytical procedures for data start by the Open Coding of interview transcripts, which implicates breaking them into relevant excerpts that may be coded. Using the Constant Comparison method will result in emerging patterns and connections between pieces of data, which can be linked. This connective process is known as Axial Coding.

Here is where iteration comes into play - as the researcher finds common codes for the collected data, it may be pertinent to return to data collection and focus on the information newly acquired through analysis. By interleaving these two steps, a theory will be progressively fleshed out [28]. Given that more information is acquired in each cycle, pertaining to existing codes, it enables Selective Coding. This is defined as the act of finding a core category that connects all codes together, a central theory. It is worthy to note that a core category may not always be necessary, as it could be replaced by a number of key categories that are both coherent and cohesive. Special care should be taken to ensure these are significant enough to paint a bigger picture.

Throughout the iterative process there should be a conscious effort to stop to think about possible connections that may be emerging, and write memos or notes. This is an important aspect both in recording the process and in exploring any questions that might arise with potential interest to research. Once the data has been saturated into meaningful codes, the memos can begin to be sorted through to reveal the conceptual process behind the core. This is the unveiling of the theory itself, by means of logically organizing and composing the connections between concepts. The graph presented in Figure 2.1 gives a simplified overview of the stages here described.

This methodology causes theories to organically arise out of empirical observations, without de-emphasizing the importance of a solid logical foundation. Grounded theory thus allows for a theoretical and human-centered approach to software engineering, as will be explained further when specifying the details of [Socio-Technical Grounded Theory \(STGT\)](#) [26].

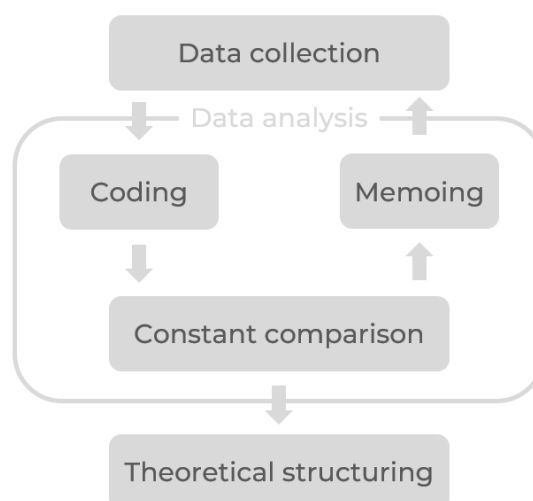


Figure 2.1: Simplified graph of the stages in Socio-Technical Grounded Theory

2.5 The EUGAIN COST Action

The [European Cooperation in Science and Technology \(COST\)](#), is an intergovernmental organization funded by the European Union [19]. Its main goal is to provide funding for research networks across Europe, thus effectively encouraging innovative and leading-edge studies in science and technology.

Scientists and innovators may come together in interdisciplinary groups with a common idea and research goal, and apply for funding by proposing a project or research plan. Once accepted by COST, this network becomes known as an Action, provided with four years of research funds. During this period more interested researchers may join the COST Action, expanding the collaborative network. Actions are divided into Working Groups, organizational units which work towards specific milestones of the project.

One such Action is EUGAIN, the European Network for Gender Balance in Informatics. Having been approved in 2020, its main goal is the active promotion of gender equality in this field, encompassing both the academic and research communities, industry workers, as well as trying to reach institutions' policymakers to generate a deeper impact. By establishing a diverse network it aims to gather knowledge of existing gender disparities, along with learned lessons on policies that have previously either worked or failed. Building upon this will then allow for the suggesting of effective institutional guidelines which may balance out the scales when it comes to gender in informatics.

The EUGAIN Action is divided into a core group and five working groups. The first deals with the transition of young women from school to higher education, with the goal of promoting recruitment and encouraging girls to choose the path of informatics. The second working group focuses on the transition from a bachelor or master's degree to a PhD, aiming to increase female participation and engagement in doctorate programs. Going further down the pipeline, the third working group is devoted to the progression to academia and professorship, in order to increase female role models at a high level within institutions. The fourth working group is related to the informatics industry and institutions, intending to gauge which guidelines are currently in place and whether they have seen success or positive impacts following their implementation. The fifth and final working group deals with raising awareness about the existing gender inequalities through events, workshops and meetings with policymakers, for a more widespread consciousness of the existing issue.

The present research is closely related to EUGAIN's Working Group 2 and its goals. Its focus is set on the transition into a PhD, and we intend to add value to the existing research body with insight gained from women's experiences.

RELATED WORK

3.1 Best practices in recruitment and retention

Affirmative action has been a tried and tested method for closing the existing gender gap, not only in STEM, but in the Computer Science field specifically [40]. Building upon previous studies that showed where universities were lacking in the enrollment and engagement of female students, several institutions put measures in place to counteract this, with varying degrees of success.

Here, affirmative action is characterized as temporary policies or special measures put in place with the purpose of improving opportunities for women and often other minorities. It is effectively a form of “positive discrimination”, usually offering these students an advantage in admissions or financial aid. Since minority quotas that had to be met were deemed unconstitutional in some places, institutions have focused on increasing recruitment through targeted campaigns and support programs [7]. This means focusing on engagement rather than admission numbers, and is a positive step towards dispelling some of the criticism surrounding this practice.

Some institutions choose to take affirmative action to a different level. One such example is the [Hochschule Bremen \(HSB\)](#), which created an International Women’s Degree Programme in Computer Science - a degree exclusively for women [29]. It is a paradigm shift for these degrees to begin being more strongly - or in this case, exclusively - marketed towards women. As such, this is a novelty and to the extent of our knowledge still an understudied phenomenon. Something similar was attempted and studied in the University of Applied Sciences Berlin (HTW Berlin) with the Computer Science and Business Administration degree created in 2009, as a partnership with the previously mentioned [HSB](#). This degree attracted students from a diversity of backgrounds, such as mothers, students in an older age-range, and migrants. In addition to this, many claimed they might not have studied computer science at all, were it not for the female-centric environment here created [38].

However, and perhaps surprisingly, some of the biggest critics of affirmative action

are the targeted minorities themselves. This was observed for the [Gender Equity Program \(GEP\)](#) put in place by the FMPS, where a quota of women at the top of the waiting list was given the opportunity to enroll. This caused feelings that their merit and individual achievements were being overlooked, and some even took this measure as being condescending towards their intelligence [40].

Several institutions thus decided to instead focus on making their Computer Science degrees more attractive overall, in an attempt to subvert any negative expectations regarding the course. This was a possibly more effective effort aimed at the root of the problem, rather than at trying to increase enrollment percentages by themselves. Campaigns of the sort usually focused on giving high-school students a positive first interaction with Computer Science through workshops, a method adopted by many universities worldwide to grow the interest of younger women in the field [7].

Other universities rely on implementing codes of conduct with a focus on tolerance and equality, or altogether reforming their educational programs to make them more appealing and accessible to all. One such case is the [Norwegian University of Science and Technology \(NTNU\)](#). This institution has implemented several strategies to encourage women in fields where they are underrepresented [22], namely awards to faculty or groups with a positive impact on gender diversity within NTNU, as well as funding programs and stipends for female researchers, or women who aim for professorship.

Another course of action taken by NTNU which has yielded results in several institutions is that of mentoring programs [7]. These may be put in place among faculty members or students, but more often than not a professor is chosen as a mentor for a student, serving as a role model and bridging the gap between students and faculty for bigger transparency. This gives young women a more solid vision of what they may achieve in the future, clearing and, most importantly, demystifying the path to the goal of becoming faculty members. Having these so-called “stepping-stone” role models at every step of this path is an increasingly popular practice, shown to increase women’s retention in Computer Science [34].

Stanford University is one that has put several strategies in practice in order to increase the number of women in Computer Science and Software Development degrees. Initially taking affirmative action in the enrollment procedure, with small yet positive effects observed, the institution then arrived at the conclusion that it was not only necessary to increase the percentage of women enrolling, but their overall number. Retention was another area that needed attention, as women still dropped out of the degree despite higher rates of enrollment.

As such, four major courses of action were devised, which would increase both Stanford’s recruitment of women and their retention rates, effectively building a critical mass. The first was the previously mentioned mentorship programs, and the showcasing of female role models that students might look up to in setting their goals.

The next two go hand-in-hand and relate to the creation of both introductory courses and bridge programs that, as the name suggests, attempt to bridge the existing gap in

women's enrollment. With these, the intention is both to make the Computer Science course more attractive for women, and to ease students into it with courses that provide them with the necessary foundations. These are important for all types of students, but may be especially helpful for women, who often lack the same confidence in their own skills that their male counterparts present [5, 10]. This is an important point to target due to it being one of the main reasons women are steered away from the field [24], and is known as the "confidence gap". It also heavily accentuates the need for introductory programs that help build confidence in women's own skills.

Finally, Stanford University created research internships that paired students with faculty members. This once again served as a bridge between students and faculty. It also combined the previously mentioned implemented measures by connecting the students to their role model figures in a program where they'd be fully involved in acquiring valuable experience [16].

Carnegie-Mellon is another institution that is often cited as a leader in equal opportunity for women in STEM. One of the focus points is the founding of the [Society of Women Engineers \(SWE\)](#), which constitutes of a network of people empowering women in the field and in developing their skills and careers [1].

Overall, in encouraging women to enroll in Computer Science courses, it is essential that frustrations steering them away from this field are addressed. This can be effectively done through non-discriminatory policies that target all stages of academic life. A positive first contact with and subsequent impression of Computer Science is important to subvert any stereotypes that might be associated with the course. The confidence gap can be narrowed by providing students with empowering introductory courses. Multidisciplinary and meaningful assignments are also key aspects that more often engage women in the subject [7]. And finally, by promoting contact between students and faculty, and among students, whilst ensuring diversity and upholding codes of conduct that facilitate this, it is possible to foster a greater sense of belonging for women.

3.2 Attrition and retention in PhDs

Going beyond recruitment and retention in Computer Science means delving further into the causes for attrition. This, as previously seen, is related to the gradual leaking of women out of the field. As such, it is an important phenomenon to understand, and in knowing the major causes for attrition institutions can begin to put measures in place to counteract them.

Existing research shows some of the frustrations faced by women in Computer Science courses or in the Software Engineering industry, which make them drop out at a higher rate than men [24]. The most noticeable are perhaps the previously mentioned stereotypes surrounding the field. There are cultural and societal views on Computer Science which are male-centric and have yet to be dispelled. This has led to several universities attempting to introduce the topic in a positive light at a younger age, since

lack of exposure is known to more often breed negative connotations in women's minds [10]. These are only perpetuated by discrimination and micro-aggressions suffered in an academic environment, and accumulated tension becomes a severe discourager, making women more prone to drop out[21].

Even where codes of conduct and anti-discriminatory policies are in place, an unfavourable climate may still be felt mostly due to women's perception of their male-dominated environment. Not seeing other women both at their own level and in positions of authority may cause women to feel more isolated. This means a more difficult social and academic integration [4], and could be a challenge in terms of motivation. Cultivating a sense of belonging begins by creating a support structure and connecting women across all academic levels.

Another potential reason that is both a source of lower enrollment, and higher attrition, is the previously mentioned confidence gap. While at time of enrollment it leads women to believe they would not be good at Computer Science, during the course itself it becomes a source of low self-esteem [4]. It has been observed that even when women and men in Software Engineering perform at the same level, women tend to rate their own progression and work lower. This self-assessment tends to improve as women are supported or mentored through their work and gain the necessary confidence in their proficiency [5]. This could be carried over to the academic level to decrease attrition, by providing women with additional mentoring and courses, and empowering them with better skills and consequent self-assurance.

Guidance is indeed another important aspect for women, especially those in PhDs. While women in undergraduate and graduate studies may need help navigating their education in a way that aids in envisioning their goals and laying out a defined path, those in PhDs more often feel lost due to a lack of support from faculty, which in turn instills doubts about their progress. Perceived achievement and success has been deemed the best predictor of attainment [20]. This requires clear direction and more transparent communication with faculty advisors.

Doctoral degrees require students to be more autonomous in their work and research. However, many of their measures of success are dependent on their professors and may feel covert. Transparent communication and expectation setting is thus found to be of great help to students, and crucial in increasing both motivation and participation [32]. Keeping a metaphorical wall between students and faculty reduces engagement, and a lack of knowledge of the criteria they are being evaluated by increases this distance further. Clarification sessions regarding academic standards may be beneficial in this sense, and give doctorate students a clearer view of their path. On account of this, some of the uncertainty surrounding their PhD is dissipated and women may feel more on par with their peers [20].

A lack of clear communication with mentors may lead to a feeling of isolation from the department the doctorate student is supposed to feel integrated into. Sparse feedback or less constructive critique may lead to dissatisfaction and often stress about perceived

progress and performance. It was reported that many Computer Science PhD students were dissatisfied with the support received from faculty during their studies, as well as from the scholarly community itself. This caused feelings of doubt and 43% of reporting students confessed to having given serious thought to dropping out altogether [2]. Women were more affected by this than men, as expected from the confidence gap between the two.

By adding external non-academic sources of stress to the aforementioned ones, a bleak picture is painted for motivators of retention. These sources of stress can come in the form of societal, financial or time pressures, among others. There may also be personal concerns about perceived achievement or performance, motivation regarding the research subject and future prospects.

Financial support is mentioned as one of the most important factors, and may come in the form of research grants, scholarships or internships, to name a few. Research also shows men tend to be at a financial advantage over women in Computer Science doctorates, and often take up more practical means of financial support such as trainingships, while women usually rely on fellowships and other types of grants [30].

Men and women tend to have the same type of concerns, though women are more affected by a few. One such concern that sets women apart from men in undertaking a PhD is that of balancing time between family and studies. The duration of a PhD can be of up to 6 years, on average [36], a prospect which many women wanting to start a family feel daunted by. There are yet societal expectations that burden women, making it harder for them to balance family with either a career or academic responsibilities.

The industry has done more to accommodate this than academic institutions, with paid maternal leave and the possibility of working from home. However, it is possible that the paradigm has shifted due to the 2019 pandemic. Remote working has become increasingly popular, and it could benefit women who do not wish to take on the financial weight of paying for a daycare. A study from 2016, though pre-pandemic, showed exactly this [31]. By having lectures, supervisor meetings and other proceedings online, women with access to limited resources were able to further their education thusly. The work-from-home model could therefore prove useful, and minimize women doctorates' concern for balancing competing responsibilities.

This biological inequality, paired with prevailing stereotypes at the work or study place, and gender-based discriminating attitudes felt by women, leads to a need of self-assertion. When surrounded by a competitive male culture they may not often be well integrated into, women face the added stress of feeling they must prove themselves. If women display what are seen as "feminine" strengths, these are viewed as less significant than typical "masculine" strengths. Even despite exhibiting equal technical expertise as men, they are still made to feel defensive about their skills. The belief is instilled that they must work harder than men in order to be valued [24], which may quickly lead to burnout.

Some women choose to deal with this by attempting to bridge the gap and downplaying their femininity. Although this should not be a length women must go to in order to be better accepted, it is shown to work in avoiding microaggressions from male colleagues [3]. White and Asian women who do not present as conventionally feminine have reported to feel better integrated with their male colleagues, but a different picture is painted for BIWOC (Black, Indigenous and women of colour), whose racialization is a further challenge in workplace acceptance. Negating one's own femininity is not only an unwelcome barrier, but an inadmissible one for some women, for whom the building feeling of isolation leads to them leaving the Computer Science field eventually.

This realization of further discrimination gives rise to an important question, that of how equality in treatment and opportunity leads to an equality of outcome [41]. This is especially significant for institutions striving to reduce inequality gaps, and should be studied regarding not only women but all other minorities. Understanding the difficulties that each of these groups faces rather than attempting a general solution that fits all may prove to be the best option. The expected result is a more inclusive and comprehensive policy elaboration in both industry and academia, fostering an environment where individuals may succeed in spite of their differences.

3.3 Encouragers for women in Computer Science doctorates

After going through the factors that cause attrition for women in the Computer Science course, it is important to take a look at the more positive side of the coin. Despite the inequality regime that is felt throughout the pipeline, it is necessary to point out the encouraging influences on a doctorate women's path - the factors that work in keeping them engaged. For this effect, one can take the previously mentioned discouraging factors, and target them to create positively reinforcing measures which will retain women in Computer Science PhDs. This is done in the hopes that institutions can better foster a supportive environment for women and other minority students.

The first factor to consider is how well integrated women feel in their department's environment. This not only means how they get along with their peers and whether they are socially accepted in mostly male circles, but also how they fit into the academic environment as a whole [42]. That can be related to their perception of own academic performance, which comprehends of and may be affected by several of the above mentioned factors, as well as interactions with faculty and even the structure of the department and PhD program themselves. Fostering a friendly environment for women begins with a place where they feel seen and heard, the dispelling of stereotypes, and transparency that allows them to better perceive their progress.

Some universities have already made progress in this sense by offering seminars and workshops which initiate the discussion on topics such as gender equality, inclusion and department diversity [33]. Having staff which is trained on diversity and bias, thus having a higher sensitivity toward these issues, as well as diversified conference panels, is

a common point to successful initiatives taken by institutions in accommodating women [7].

These events also help women build upon their networks and create communities. Research has shown having external supporting communities plays a major role in women's retention in Computer Science [32]. These not only include family or peers but other clubs and organizations women may belong to outside their course.

This transparency plays a role both in integrating women more fully into the department - creating a sense of belonging and stability - , and in the quality of their communication with mentors. In fact, it has been shown one of the biggest motivators for women is recognition and praise from their mentors, a clear and positive communication style, and receiving guidance and constructive feedback where needed [4]. This plays a part both in increasing confidence in their work, thus narrowing the confidence gap, and in gaining a positive view of their progress. Women tend to measure their success in terms of goals, and seeing them achieved and acknowledged is particularly important.

This underlines the importance of having mentors who are trained in communication skills and who can better support their mentees in their path. While in the previous section it was referenced that poor communication with mentors lead to feelings of isolation, here it is important to emphasize that a solid monitoring of doctorate students' progress is a pathway for their success [4]. This is especially true in the first stages of the doctorate, where much is yet undetermined and as such clearer guidance and more intensive supervision are needed. A good mentor will steer the student toward the right path and ensure they remain aligned with it throughout the whole process.

Several mentoring programs and initiatives already exist, with results for show. One such example is the Lamar University in Texas, where a mentoring and research program was put in place for undergraduate women in Computer Science [17]. Students thus had an opportunity to undertake a research activity with a female mentor's guidance. This not only helped motivated women thrive in their degree, but some claimed it built their confidence and desire to further their studies in the field. The mentorships fostered a sense of community among women and equally increased their confidence and expediency.

Despite external factors - such as departmental and environmental ones - being of great importance in encouraging study progression, it is also important to consider internal factors. These are often generalized as "motivation", although they may take different forms. One study identified some of the main drivers for students motivation [12], the first being personal fulfilment, which may come as an deeper interest in research, a wish for self-improvement or even a desire to challenge oneself. The remaining identified factors mainly related to the students' future prospects. Here, three paths were contemplated when it came to making the choice to pursue a PhD. The first driver was the possibility of a doctorate degree enhancing future career prospects in the industry. Other students aspired to a career in academia as a professor or lecturer, and as such saw a PhD as the next logical step in their academic path. The final motivator was the need some students felt for a new direction after working in the industry for a given time. Although

this group had no specific goals, they viewed a PhD as a way to broaden their horizons and employment possibilities.

Naturally, different students will display different motivation with regard to their studies, and as such their expectations regarding the course may vary. Aligning expectations to the reality of the degree they propose to undertake is therefore key in maintaining female doctorates' interest [20, 2]. By matching expectations to requirements as early as possible, with transparent programs and approachable mentors, it may be possible to further engage women in Computer Science doctorates, and encourage them in their path. It is also important to cater to their goals as individuals, and incite open communication of expectations.

This lends women a sense of self-government in their research, with the constant reassurance of a mentor to offer guidance where necessary, meaning their autonomy is not threatened but rather encouraged. In adding to this the closing of the confidence gap as mentioned above, and the cultivating of a sense of belonging in the department, the three bases for the Self-Determination Theory [37] are reunited. These are precisely autonomy, competence and relatedness, currently believed to be the leading causes for motivation. Further, a distinction is made between intrinsic and extrinsic motivators, which is particularly interesting as a possible point to target with women making the transition into a PhD.

DATA COLLECTION

This chapter describes the first essential stage of the Socio-Technical Grounded Theory methodology as seen in Figure 4.1 - data collection, in this case by means of semi-structured interviews. It is worthy of notice that the process of interviewing was an iterative one, always being interleaved with an analysis of the collected data - detailed on “ Chapter 5 - Data Analysis“ - as per *STGT* theoretical sampling conventions. The most important steps taken before and during data collection were the amassment of a relevant and diverse population, as well as the conception of an evocative interview structure and an approach to processing the gathered data. Below follow the insights on how this was achieved.

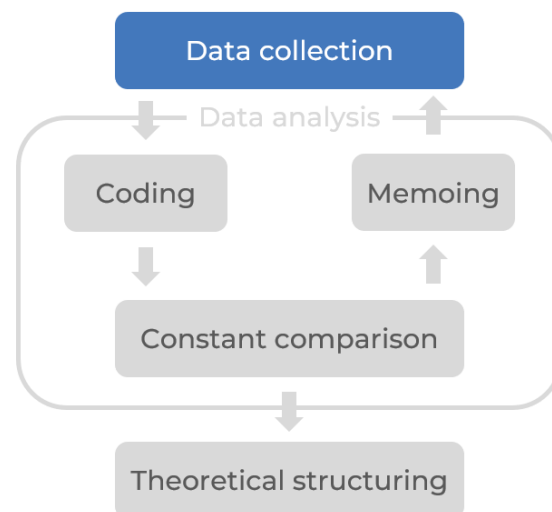


Figure 4.1: Simplified graph of the stages in Socio-Technical Grounded Theory, highlighting Data Collection

4.1 Recruitment methods

All participants were contacted individually via an email that informed them of the nature of the study. Upon receiving a response, availability for an interview was established and

one was scheduled with due brevity.

The recruitment for this study was done by combining different sampling types, with a first phase relying more heavily on convenience sampling. This technique involves contacting more readily available interview candidates from within the researcher's own network. This could, however, lead to a final pool of candidates that was much too homogeneous, and as such different sampling types were sought out.

One such method was snowball sampling, also known as chain-referral, where interview participants were encouraged to recommend potential candidates of interest from their own personal, professional or academic contacts. This yielded some results when contacting professors whose doctorates or masters students may be interested in participating.

Since the population was divided into three groups - specified ahead - it could also be argued that a measure of stratified sampling was used. In practice, this meant that the general population was divided by a defining characteristic into the three specified groups, and women were then picked at random from within the group they were inserted in. In this case, the defining characteristic that set women from the three groups apart was their current position in the academic path, in relation to a PhD.

4.2 Population

The sampling for this study was taken from one main source - the Computer Science academic environment - and effectively divided into three subgroups in order to attain higher coverage. The first group is composed of women who are currently undertaking a bachelor's or master's degree, with a focus on those finishing or having finished their master's in the same year as the interview was conducted. This means they are likely to be considering future options and as such the prospect of a PhD is one that presents itself more prominently than at other stages of their academic path. This allows for a better understanding of the factors that weigh into the decision, and of the perception women have of a PhD while looking in from the outside.

The second group with interest for this study is that of women currently undertaking their PhD. These women are actively involved in the stage of academia this dissertation intends to study, as such the group was given substantial consideration. Their input is valuable both in terms of their current experience while fully immersed in academia, and in terms of recalling the process and decisions that led up to them enrolling in a PhD.

The third and final group consists of women who have finished their PhD in recent years. The fact that we only targeted women who had recently attained a PhD somewhat restricted our recruitment, but was especially important in gathering information that is relevant to our current day and age, exposing the challenges that women in Computer Science face nowadays. Since this is a constantly evolving field, our goal was to capture and divulge the present state of affairs. This group comprises both of those working in academia, either in research or professorship - often both - and those who are now

working in the industry or have a research position at a company. This group is also valuable due to its hindsight on the full process of a doctorate's degree. Women in this group also have better insights on post-doctoral fellowships and the way the industry accommodates those with PhDs.

An effort was made to balance the amount of women in each category, so that these three different views of a PhD are equally represented in collected data. Candidates for these interviews were at first gathered from the researcher's university, and represent the core of the population with origin in Portugal. This pool was then expanded within the researcher's network in order to get candidates with different experiences from other European countries. Finally, a need for further heterogeneity called for candidates to be contacted from outside the researcher's own connections, and doctoral symposiums for international conferences were consulted.

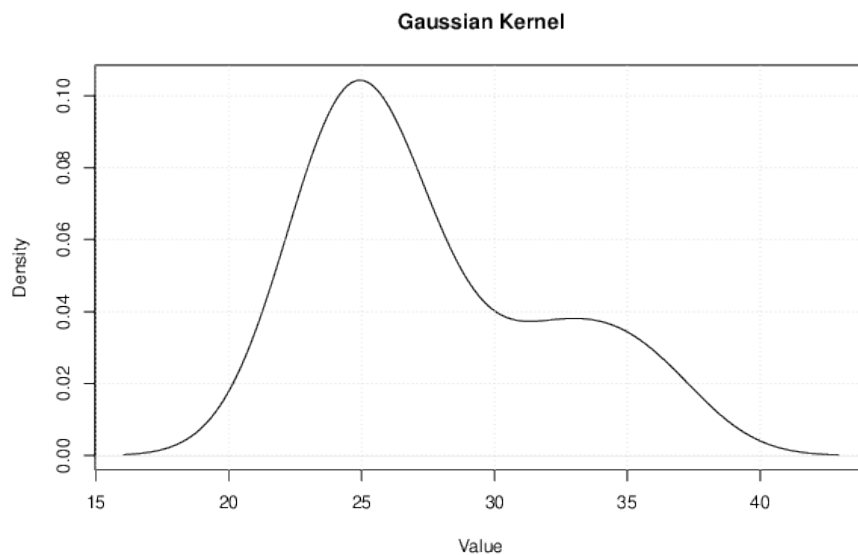


Figure 4.2: Gaussian kernel density plot of participants' age, in years

Regarding participants' age, we gathered that the range was between 23 and 36. This was expected, due to the population being divided into the above groups, with most participants falling within the first or second category, and a smaller population fitting into the third. These results were obtained from a pool of 14 total participants, with 6 having finished their master's degree, 6 currently being enrolled in a PhD, and 2 who have attained their doctorate's in recent years. This can be observed in Figure 4.2, which shows a higher density for ages 24 and 25. The average age for interviewees was around 27,6 and the median sat at 25,5 years.

4.3 Interview Structure

The goal with the interview questions was to gather useful information related to the research questions, but not restrict itself to this and allow the conversation to flow into other topics that may be of interest. The main topics which interviews touched on were the perception of a PhD, the environment for women in academia, comparison with the industry where relevant, and good practices in engaging women in Computer Science PhDs, or leading to the choice of pursuing one.

The overarching goal was to attempt to answer the question of why women are not pursuing doctorates in Computer Science despite the increase seen in female STEM doctorates. The comparison with industry was mostly made with the intent to gauge the cause for the leak out of the academia “branch“ of the pipeline, since industry is often seen as the alternative - although this is not necessarily a dichotomy. One intention here was to evaluate whether academia is a more conducive environment for men, or if the cause lies elsewhere. Finally, it was important to assess the source of different choices made by women in their academic path - whether these were mostly influenced by personal preference, the institution’s curriculum itself, or by discrimination suffered throughout their degree.

Regarding the interview structure itself, some variation was introduced in questions depending on the interviewee’s current situation. The three interviewed groups were women currently finishing their master’s degree, women currently in a PhD program, and women who have previously attained a doctoral degree.

A semi-structured approach was chosen, as there were several topics this research needed to touch on, but a conversational tone was preferred. As such, answers often needed different follow-up questions, and liberties were taken in altering question order or even questions themselves where needed. As new information arose from interviews, new topics also became relevant and were added to the loose script.

The questions presented below touch on several of the topics to be addressed by this research, and they were mostly designed to be open-ended and allow for the interviewee to elaborate on the topic as they see fit. There was an attempt for the questions to follow a certain flow, beginning by questions about factors in women’s academic path that may have made them consider pursuing a PhD. Following questions touched on the perceived environment for women in Computer Science, followed by an attempt to compare perceptions on academia and industry where relevant, and which perks one may have that makes it favoured over the other. This was also done with the intention of gauging what academia might need to improve in order to make itself more appealing for women. The final questions were more exploratory, allowing the resposdee to speculate on the reason for this lack of women in Computer Science academia.

The interviewee is currently in a master's degree or has recently graduated:

- Do you feel like the academic environment in Computer Science is friendly for women? Have you felt (negatively or positively) discriminated in any way throughout your degree? How so?
- Do you plan on taking a doctorate degree? Why or why not?
- Do you feel like you would have the ability to undertake a PhD? Why or why not?
- Have you had any previous industry experience, such as an internship? How did this change your view of the industry?
- Do you plan on joining the industry or academia after your degree? Why?
- What would you say the advantages of the industry are over a PhD, and vice versa?
- Which environment do you feel accommodates women best, academia or industry?
- How do you view the utility of having a doctorate degree, for future prospects? What paths does it open?
- What is your perception on how having a PhD is seen in the industry?
- Do you feel like the concept of a PhD is still somewhat abstract for undergraduate and masters' students?
- Do you feel having a research activity in your university curriculum might help you view a PhD in a new light? If you already had one, how did it change your perception regarding research in Computer Science?
- Do you believe there is a specific type of person that pursues a PhD? How would you describe them? Would you identify yourself with that description?
- Do you think it is possible to motivate more women to pursue a PhD? How so?
- How do you think motivating women differs from motivating men in the Computer Science field?

The interviewee is currently pursuing a PhD or has attained a doctorate:

- When in your academic path did you decide to pursue a PhD? Were there any specific events that lead to it?
- During your studies, did you have an internship or research activity in your university's curriculum (or by own choice)? Did this help you view academia/industry in a new light? In which way?
- When you were making the decision of proceeding to a PhD, what were the biggest factors you considered and weighed? What were the pros and cons for you at that time?
- What expectations did you have of a PhD, coming into it?
- Did your perception of a PhD in Computer Science change or did it live up to the expectations? In what way?

- Do you find yourself to keep a healthy balance between academic and personal life? Does your department facilitate this in any way? How has remote work changed this balance?
- Once you've attained your doctorate, do you intend to remain in academia, or join the industry? What are your goals moving forward?
- In what way will having a PhD set you apart in the workforce? **OR** What is your perception on how having a PhD is seen in the industry?
- How important of a factor do you think that constituting a family is for women planning to undertake a PhD? Does academia facilitate this?
- How important is the social factor of academia for women considering doing research work? What was your personal experience with this?
- Do you feel like the academic environment in Computer Science is friendly for women? Have you felt (negatively or positively) discriminated in any way throughout your degree? How so?
- How does being in a male-dominated environment affect you? What motivates and demotivates you?
- What would you say the advantages of a academia are over the industry, and vice versa?
- Do you think this decision of academia vs. industry is mostly dependent on someone's personality or their goals? Is there a specific archetype or woman that goes into academia, or is it something that can be made appealing to a more general audience of women?
- Do you think it is possible to motivate more women to pursue a PhD? How so?
- How do you think motivating women differs from motivating men in the Computer Science field?

There was an attempt made at balancing both technical and social questions. The followups to some may have been omitted and were intended to encourage the interviewee to elaborate on the topic if necessary. Some questions were added where found pertinent, such as questions regarding family plans and how this may affect future prospects, as well as the impact of the social environment on women. Another question that came up with international doctorate students was whether the need to move to a different country was an inhibiting factor in the decision to proceed to a PhD.

Interviews were also done with the intent to establish some "learned lessons", these being things that went right or wrong during the woman's academic path that led to their current position. These can be immensely helpful in tracing a successful linear path from the beginning of studies to attaining a PhD, as well as in identifying factors that work against the transition into one.

Despite some subjectivity and speculation being allowed in a few of the questions, these were mostly meant to encourage discourse. They also served as a point of interest for

analysis, since these questions condensate the previously discussed topics into a moment of reflection.

4.4 Recording and Transcripts

Due to the international nature of the study, and for the purpose of convenience, all interviews were conducted online using Zoom as the preferred platform. Those choosing to take part would be informed that their identity, any mentioned identifying features, as well as all shared information, would be fully anonymous. Respondees were reminded that their participation was fully voluntary and as such consent could be withdrawn at any moment, being free to refuse to answer any questions they might not be comfortable with. Further, candidates were informed they were free to request their interview's transcript, should they wish to clarify or void any part of it. All participating candidates gave their consent before recording started, and were asked to confirm it upon recording.

Recording was done using Zoom's inbuilt feature for this purpose, and OBS Studio (Open Broadcast Software) was used as a backup recording method to ensure quality transcripts in case the former failed. Both these softwares produced .mp4 files, with Zoom also producing a separate .m4a file containing only the audio for the interview. These were the files used for transcription purposes. Where needed, .mp4 files were converted to .mp3 using Adobe Premiere Pro CC.

For interviews conducted in Portuguese, options for online transcription that ensured quality and did not sit behind a paywall were scarce. As such, these transcripts were achieved manually by the researcher with high fidelity. To hasten the process, oTranscribe was used - an online open source web app where one may upload audio files, and which allows for hotkeys to pause, rewind and fast-forward while not interfering with the typing.

All other interviews were conducted in English, and as such more options were available. Otter.ai was chosen as the automatic transcription tool due to its inbuilt capability of differentiating between speakers. Due to its nature as a free trial, some longer interviews had to be split into audio files with a maximum duration of 30 minutes. Adobe Premiere was used in these instances, and files were exported in the .mp3 format. Upon completion of the automatic process, all transcriptions were manually reviewed and corrected wherever necessary. A lower microphone quality or connection issues might sometimes cut a few words from an audio. These were only filled in when there was no room for error, and otherwise left out of the transcription.

Interviews typically lasted between around 15 to 50 minutes, with the gaussian kernel density plot for their duration being presented in Figure 4.3. From the graph we can observe a majority of interviews fall at the 20 to 25 minute mark, with a considerable amount around the 40 minute mark. For consistency, interview duration started being counted at the beginning of recording - after the participant consented to the audio being recorded - and was stopped by the end of the participant's last answer.

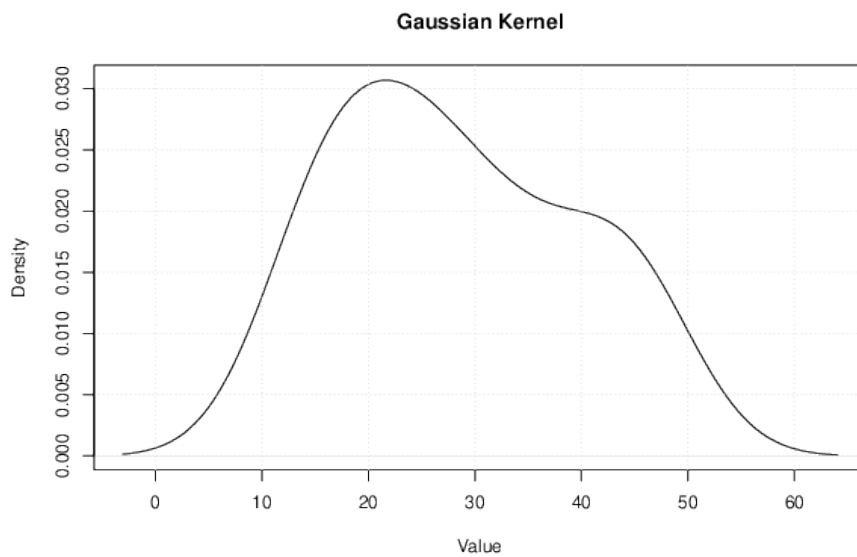


Figure 4.3: Gaussian kernel density plot of interview duration, in minutes

It is also worthy to note that in order to respect the participants' anonymity, the transcripts are not made available in their entirety. This is due to them potentially containing information that might facilitate the participants' identification. For this same reason, whenever any defining features are mentioned in the sentences chosen as illustrative for codes, these are redacted to protect their identity.

All transcribed sentences were also translated as closely as possible, wherever a translation was needed - in this case, all translations made were from Portuguese to English. To aid in automatizing this process we used DeepL, a fast and reliable translator which applies machine learning to its translation processes. The researcher, however, used their own judgement as final in reviewing all sentences produced by this tool.

4.5 Theoretical saturation

Theoretical saturation in grounded theory is a point in research which is reached once no new data seems to be arising from analysis, or data continues to confirm that which has already been asserted. A less diverse group usually means this point is reached faster.

In the case of this specific research, theoretical saturation was reached when answers received from candidates were no longer adding any new information to the existing knowledge base, and mostly confirmed codes that had already been attained in previous interviews. Both the candidate "categories" and the questions asked during interviews were varied enough to grant some divergence in answers, allowing the research to proceed further.

After interviews had been fully transcribed, the full script would be analyzed for relevant information, either pertaining to existing codes or with the possibility of constituting

a new code. Once new codes arose, there would be redoubled attention in following interviews to see whether it might be mentioned again. If this topic was deemed relevant enough, questions concerning it were added to the interview scripts and asked where appropriate.

This research also kept track of the number of new codes that appeared per interview, so that we would have a telling sign that theoretical saturation was close to being reached. In this case this would happen when the appearance of new codes tended towards zero. This aided in developing a more solid reasoning for the validation stage, and can be observed in the graphic below.

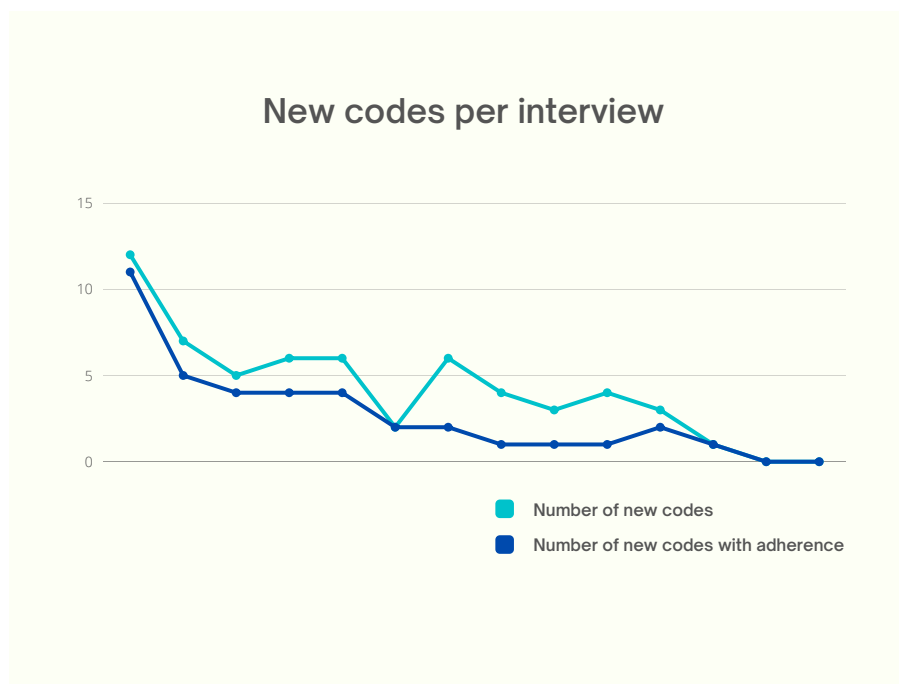


Figure 4.4: Line graph of new codes per interview

In elaborating the line graph in Figure 4.4 we found it interesting to not only look at the number of new codes arising from each interview, but also at what we labeled “adherence” to codes. Here, we refer to any code which was mentioned more than once - this means, any code mentioned by at least one more person other than the candidate who first caused the code to arise. This was deemed a significant number to present, as it more closely tracks codes which are relevant to a number of women, rather than unique occurrences. It also means that the closer the two lines on the graph are from each other, the higher the percentage of codes from that interview that had adherence.

One might argue that lower adherence over time is related to less follow-up interviews, however this is not the case, since at every new code that came up we would check all previous interviews for this same code. In case it had been mentioned previously, it was attributed to the first interview in which it had made an appearance.

We can observe there is a sharp drop between the first interviews, which is expected,

since a lot of themes were covered by our interview questions and as such it is only normal that a significant number of codes will arise in the first interview, only to be confirmed in further ones.

This graph is also essential in understanding theoretical saturation. Although the number of new codes per interview may fluctuate, by focusing on the new codes with adherence we have a more stable and reliable view of saturation. It is clear to see that there is a general tendency towards zero new codes, and a steady decline in number of new codes with adherence can be observed. As such, we can claim to have reached what is considered theoretical saturation - new data only added to that already recorded, and progressively showed less novelty information, until no new one was appearing.

5.1 Open coding

Open coding is one of the main stages in Grounded Theory, and is its key analytical procedure. Upon collecting the raw data, the researcher must employ constant comparison both between themes emerging from different interviews, and themes arising from within the same interview. This is where a pattern or key points may be noted, and a general conclusion is drawn by inductive means. As such, it is defined as a bottom-up approach - one that begins by looking at the concrete data, then increasing its level of abstraction through coding, broadening its scope. In Figure 5.1, we can see the stages in which data analysis is divided. It should be noted that the “Coding” label is purposely ambiguous so that it may refer to either open or targeted coding, by virtue of this method’s iterative nature.

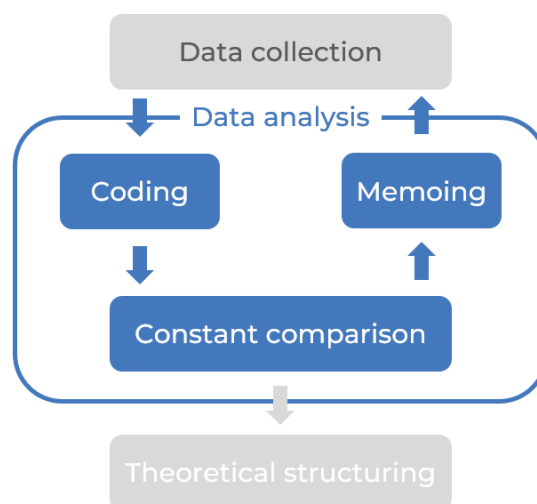


Figure 5.1: Simplified graph of the stages in STGT, highlighting Data Analysis

In the case of this specific research, this was achieved by a first careful analysis of the interview transcripts. Having employed active listening during interviews and reviewed the transcripts upon completion, the researcher had by this time already familiarized

themselves with the interviews. This was essential in getting a broader sense of the mentioned themes and in approaching the transcript with the purpose of open coding, as some clear key points had already materialized.

The first approach to a transcript - or first pass - would involve highlighting any points that might seem of relevance for research. Often two or three interviews would be read in a batch, so as to be more efficiently compared. Upon this first pass and comparison there would be a second pass over the highlighted areas, this time having the whole transcript, or transcripts, in mind. This made it easier to ascertain what was more pertinent to code.

The coding itself was achieved by taking the general sense of a chosen excerpt, along with its context, and giving it a more generalizing, single-sentence description. This description is what is indeed called the “code”, and elevates the passage - itself a specific or localised remark - by a level of abstraction. It was not uncommon for similar codes to arise from altogether different questions, as often these left space for the interviewee to steer the answer towards themes that were more meaningful for them, and as such these could arise at different times. However, for more close-ended questions, responses were expected to take similar paths.

All codes derived from interviews were stored in a coding table, composed of four columns, which served as a database for the open coding stage. The first column of this table includes the codes themselves - general single-sentence descriptors that capture a recurring theme. The second column features excerpts that support this code, the specific points in interviews where they occurred. The third column enumerates the interviews that code appeared. To maintain anonymity, all interviews were given a double-digit code, with which they are referred here. The fourth and final row is a simple count of occurrences, meaning the number of interviews a code appeared in. It is similar to the previous column, but does not discriminate in which interviews the code was featured. This was useful in quantitative terms, while the previous column was useful while assessing which group of women might have mentioned a theme more often than another. The table can be better visualized in [Appendix A](#).

Whenever it was determined that a certain passage was relevant or fit into a theme, the researcher would go over the already existing entries on the table and decide whether this matched with any of the established codes. Where appropriate, it would be added to the excerpts, with the appropriate changes to all other columns. On the other hand, if it was deemed to be a new code, a new entry would be added to the table, and there would be more awareness in the future for any new interviews that might mention something similar.

This table was mutable and dynamic while interviews took place and new transcripts brought more themes to light, which was especially common in the early stages of research, when theoretical saturation was the furthest from being reached. Sometimes, a certain theme might be overlooked, but be recalled as soon as another interview mentioned it. Backtracking was also more frequent in this initial stage. It was also the case that some codes were deemed to be too specific, when the researchers noticed these were

not getting many occurrences. However, by comparing them to similar codes and finding the common ground between them, it was possible to merge the two codes into a more general one, going a level further.

During this process it was also inevitable that very similar topics arose. Sometimes these would be similar enough or intrinsically related, so as to belong to one same category, but not be so identical that they might be merged. However, we could indubitably relate the two by drawing a link, and relations started to emerge. Patterns could also be noticed, where the appearance of one code would often lead to the appearance of another within the same interview, hinting that these might be strongly related, if not cause and effect.

To better visualize the process of open coding, an illustrative example of our process follows. In this case, the question focused on the moment that women had started considering going into a PhD as a viable option in their path. We asked the following:

"When in your academic path did you decide to pursue a PhD? Were there any specific events or encouragements that led to it?"

One woman, here coded as interview 06, gave the following answer, which we will consider as the raw data in this instance:

"I really liked doing research, I could see myself doing research especially in this topic, which I found particularly interesting. Then, of course, there was the invite, and from that moment on things became more serious and obviously from there on it was a more realistic analysis. (...) I had never seriously thought about [doing a PhD] until the invite arose."

At once, this seemed to be of great relevance to our research. Upon being asked for a defining moment in their decision to enroll in a PhD, or to consider it as a future option, this candidate chose to give a spotlight to the moment her Masters' thesis advisor personally invited her to enroll in a PhD. This underlines the importance of this particular event. Since we recalled other women previously mentioning that they were individually invited to do a PhD by their advisors, this was certainly a recurring theme and as such one that merited coding. By collating the raw data gathered from different interviews, we arrived at a more generalizing sentence to define the occurrence, our code: "A direct invite or challenge to do a PhD, coming from an advisor, is significant".

Here, we chose to give a positive weight to this event by calling it "significant", since learning what works both positively and negatively in encouraging women to do a PhD was essential. This was preferred over a neutral code such as "Direct invite or challenge to do a PhD, coming from an advisor", which does not make a balance of the women's feelings towards this event. Since this dissertation is primarily focused on how women view a PhD in Computer Science, providing this piece of context was deemed necessary.

In some cases, it also occurred that an excerpt was added to an existing code, but its context might be ambiguous, or its interpretation not clear. This would be carefully deliberated, ensuring that all codes could be logically induced from the given excerpts.

An example of this was interview code 07. From previous interviews we had come to the code “PhDs are not viewed as professional experience“, and in this interview we had asked the candidate:

"What do you feel are the advantages of remaining in the industry, rather than doing a PhD?"

Candidate 07 answered the following:

"I think [the advantage of remaining in the industry over academia] is gaining experience. Honestly, from a lot of what I've seen, (...) experience nowadays is more valuable than the degree. Some companies value the fact that you have a degree a lot; others prefer you to have more experience."

Here we could argue that what the candidate is saying correlates to the fact that PhDs are not viewed as professional experience. This woman mentions gaining professional experience as an advantage that is exclusive to the industry, and as such not something that can be gained in academia. On the other hand, however, they do not directly mention that this is indeed the way PhDs are viewed. It could be inferred, but a more direct correlation would be preferred for this excerpt to be added as illustrative of this code.

Given the iterative nature of the Grounded Theory methodology in conducting interviews, it wasn't uncommon for new codes or so far unnoticed relations between them to spark interest, generating some curiosity in the researcher. These were considered to require some sort of follow-up, and the dynamic of semi-scripted interviews gave researchers the freedom of altering or adding new questions that may target these curiosities. Often, this led to interesting results or brought up additional themes that had yet to be considered.

One such case was the interview with code 06. The question that had been asked was very open-ended, asking for the “pros and cons“ of taking a PhD. One thing that was mentioned as a con was the fact that it might be an isolating experience, which was an expected answer that fit with already existing codes. However, the candidate went on to state the following:

"I even talked about [the PhD possibly being isolating] with my teacher: what would it be like in a PhD, if I started one? Would I have a room just for myself? Would I be in a room with people? What is the day-to-day like, the social part of a PhD? Because after all it's not just about thinking in four years I'll have a PhD. No - I will have to live those four years, and so I have to think what my day-to-day will be like."

This went beyond what we were expecting, and caused some interest to rise. Surely other candidates had mentioned the possibly isolating nature of a PhD, but we had yet to consider prompting them about whether the social aspect of undertaking a PhD was a defining factor in the decision to enroll. This opened up a chance to further explore women's relation to the social environment in Computer Science academia. One of our questions for masters' students was whether the concept of a PhD might still feel too abstract. This data took us a step further in clearing up that it is important not only to make the process of a PhD transparent, but also - and maybe most importantly - to demystify the daily life of a PhD student. For all following interviews, we adapted our questions regarding the above topics so that we might explore and develop them further.

During the process of basic data analysis, memoing was therefore essential. This consisted in continually documenting any ideas or speculation about topics that might arise during interviews and their analysis, as well as possible links between codes. Situations such as the above, where something new appeared that brought about space for reflection, particularly highlighted the importance of this process. This was also a substantial aid for theory development.

5.2 Targeted Coding

Due to the broad nature of the phenomenon under study, once the coding stage was underway we opted for an emergent mode of theory development. Since the questions asked during interviews touched on a variety of subjects and were mostly prospective, obtained codes were also varied. As these were generalized into concepts, we found that some were stronger or more adequate than others which might not clearly tie into a well-defined theory structure. The emergent mode of theory development relies on targeted data collection and analysis. In practice, this meant later interviews would create some focus around areas that had previously been found to be of interest, and try to better establish and refine them and their relations to other concepts.

Targeted coding arises at the stage where a clearer analytic direction has been established, from continuous exposure to the codes and reflection on how they may tie into a theory. This also works as a way to go through large portions of collected data, using the most significant codes obtained during the open coding stage. This prompted us to first carefully analyse the existing codes and ensure they were harmoniously encapsulated in their attributed categories, going an abstraction level further where appropriate.

A comparison can be established with selective coding, where coding is geared towards the core category that has been identified. In this instance, however, a core category was not defined, and rather several important categories surfaced. STGT gives researchers the freedom to not establish a core category and as such we opted for this path, given that the matter of study is broad and presents itself in many facets that require equal consideration.

With the most significant codes having been given the spotlight, it then became easier to structure questions around these recurring themes, delving further into them. This was done with the intent of aiding the theory in emerging from the new relations being established. The targeted coding stage was where the theory's most important subcategories solidified themselves.

At first, this was done directly using the codes obtained in the open coding stage, as there was a variety that could yet be abstracted. We categorized the codes into several groups which were found appropriate, for better parsing the large amount of data. These were simple umbrella-terms such as "industry" or "academia" for codes relating to either, or more specific ones - "time" and "interpersonal connections", for example.

A practical example of this were the several codes regarding women's concerns towards the time a PhD consumes. Once this pattern was noticed, questions concerning time were given a stronger emphasis so that answers might prove useful and add to the already acquired knowledge in a way that would possibilitate a theory to rise. Different women would of course view this in different manners - while some found the commitment of a PhD to be too long, others saw it as a way to "gain time". Schedule flexibility and personal to work-life balance were other discussed themes within the topic of time. This stage of coding allowed for these sub-categories to begin forming noteworthy links between them. For instance, one code read the following:

PhDs are deemed more compatible with good time management

And upon reviewing all existing codes which we had categorized under the "time" topic, we found a very similar one:

Schedule flexibility and remote working are encouragers towards a PhD

The two were thus linked and might even be merged if deemed appropriate. Here, both codes relate to the flexibility that a PhD allows in terms of setting one's own schedule. This was often mentioned by women as a positive aspect of academia, but not only in terms of personal time - constituting a family was also a mentioned factor. We then managed to go a step further and relate the above codes with a third one:

Academia allows women to better manage family time

From this example we can see how the targeted coding phase was processed, and how connections began to form between codes. These bespoke topics of interest to be explored further ahead, in the development stage of the theory. In order to improve theory legibility, we opted to elaborate a graphic that would present this information in an easily digestible way.

This was done by giving each code or cluster of codes a designation and placing them in bounding boxes, allowing for it to be linked to other codes through an uninterrupted line. Codes that were similar, such as the ones above, were the first to be linked together, the line denoting that these codes are intrinsically related, with no specific orientation.

In other instances, rather than a bilateral connection or correlation, we would observe a unilateral one - possibly meaning we were in the presence of a cause-and-effect situation. In these instances we used an arrow from one code to the code containing its perceived consequence. These oriented links were especially useful when handling concepts that were considered to belong to either encouragements or deterrents from a PhD in Computer Science.

We also found it useful to label our links between codes where necessary. This allowed for some reflection on how and why codes were connected, and served as a form of memoing. It was also essential in the emergence of the theory from these relationships.

Once several categories or codes were connected and grouped, it was noted that sometimes a specific code from within this cluster would relate to a code from outside. In these cases it was necessary to review why it was that this code was only connected to one form within the cluster, or if it was perhaps the case that it might relate to all nodes within it. If several of these sorts of relationships chained together, the whole chain would have to be reviewed so as not to fall into the error of stringing together any codes that did not logically follow from the previous. If these formed a coherent and inferable chain, a positive step towards theory formation had thus been achieved.

In practice, and as the name suggests, during this stage both data collection - interview questions - and data analysis were targeted at the most relevant codes. During the process we sought to logically interconnect these relevant themes. Here, memoing proved useful once again, as sometimes these connections would be made more obvious during interviews or when a certain idea appeared, and it would be necessary to write it down for future theory constructing. The theory itself slowly materialised itself with help from these notes.

This stage proceeded until theoretical saturation was met, at which point no new information was being added to the knowledge base and no surprising new codes were arising from interviews. At this phase, codes were both well-established and had reached a satisfactory level of abstraction. Overarching topics were easily observed and the sub-topics within these could be related by identifiable and logically deducible paths.

5.3 Theoretical Structuring

Having previously established that arriving at a core category would not be the priority in the instance of this research, it was possible to work towards several categories that were deemed most important. This, as previously mentioned, was due to the broad nature of our theme and objective. In studying women’s perception of a PhD in Computer Science, we must first admit that many and varied factors are at play. As such, it was never expected that these would readily tie into a single core category, nor was it desirable. Taking this into consideration, while progressing with coding and further abstracting codes into concepts, we anticipated to observe several clusters, or strongly-bound groups of concepts, which may loosely tie with others. Any “orphaned” codes that did not fit with or relate to any others and were deemed irrelevant to the matter at study were put aside and disregarded unless deeper analysis caused them to re-emerge and regain interest.

When theoretical saturation had been reached and as such no new information was appearing, and the two above mentioned types of coding - open and targeted - had been applied, we considered the codes and their structure to be mostly solidified. This meant they were at a stage where, considering the memoing and documentation that had been done throughout all phases of the process, they could more freely be worked on and be molded into the final theory. This allowed us to move onto the next stage of *STGT*, as illustrated by Figure 5.2.

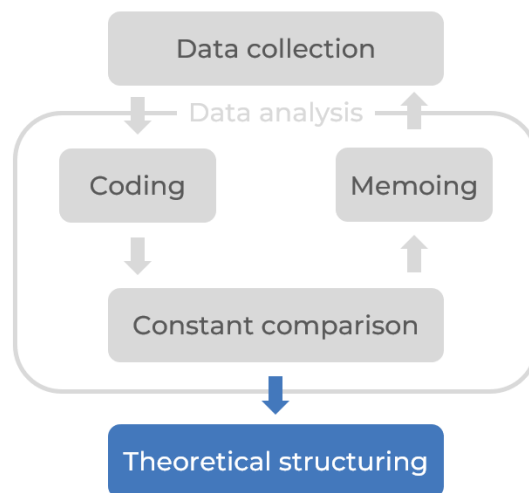


Figure 5.2: Simplified graph of the stages in *STGT*, highlighting Theoretical Structuring

For this effect, we reviewed the obtained data, relationships between codes or categories and their types, as well as the notes taken during interviews and data analysis. We took special care that at this point all connections in our graph logically followed from one another and left no room for speculation or vagueness. Here, we went so far as to check not only that the more abstract categories that had been devised had meaningful relations with others, but also whether codes within them might individually relate

strongly to another code or a whole category.

The emergent method for theory development suggests that after theoretical saturation is reached, the researcher should employ theoretical structuring. Despite this being a recommendation and not an obligation, we decided to employ it if possible, checking whether the theory seemingly fit with any existing structured templates. We did not, however, find a satisfying correspondence and as such it was decided that it would be best to present the theory in its emergent structure. This was found to better fit with the theme of the research and to allow for a less constrained analysis of the subject at hand. Having the freedom to weave the recurring themes together without being bound by one such template was thus a welcome scenario.

Having gone through the phases requiring mostly logic and inductive reasoning, for the theory to fully emerge it was necessary to move onto abductive reasoning. This involved looking at the data obtained from previous reasoning stages, as well as documented memos, and inferring what might have lead to these relationships and to the codes or categories themselves. In this instance, this meant regarding the codes as consequences and - through reasoning - attempting to reach their causes or antecedents. We were especially mindful during this stage not to incur in overly expansive interpretations, since the validity of our reasoning might more readily be questioned. As such, we carefully pondered the plausibility of our hypothesis at each part of the process and moved forward only when certain this was satisfactory and could withstand questioning as to its validity.

This stage of our research required another round of research to support any facts that arose out of intuition, so they could be confirmed and validated, lending this qualitative approach greater legitimacy. Wherever a given explanation seemed to fit with the observed consequences, it was kept. Once new explanations arose for the same or other codes, existing ones would be checked once again to ensure a coherent and consistent theory. In cases where two different explanations came up for one same code or connection, the most valid one would be ascertained and the other discarded - in the event that the latter offered no other value to the theory. When this was not the case, it would be reworked so as to still fit with the emerging information. If, upon suggesting a new antecedent, one of the others became obsolete or generated conflict, then both would be reviewed to determine the cause for this clash. The appropriate action would then be taken - which may once again involve reworking one or both, or even abandoning one of the two.

Having resolved these issues and arrived at a solid and sound theory, we went over its structure more at length. This involved rearranging the discussed themes into a palatable order and logically chaining them together to produce a more comprehensible and easy-to-follow string of thought. This way, any that read it may follow the logical deductions and abductive reasoning in a way that resembles that of the researcher originally. A "trail" such as this one was deemed indispensable, since it brought the reader and researcher closer in their understanding of the subject by letting the former into the thought process

of the latter, hopefully better elucidating them as to the choices made in helping the theory emerge. Such an approach was also considered necessary both in terms of having a more suitable and methodically organized theory, and in order to attain validity.

6.1 Development

Identification of the main themes or topics surrounding women's perception of a PhD in Computer Science was a continuous process that spanned the entirety of our research. While interviews were taking place and new codes were yet arising, resorting to memoing and constant comparison - both methods above defined - in iterative stages caused patterns to materialise more clearly. As an empirical method of gathering information, interviews brought to light data pertaining to women's concrete personal experiences. Precisely due to the concrete nature of such occurrences, the first codes and relations to arise were likewise concrete, or particular. These were the first and easiest to recognize, but yet required refining and abstracting if they were to form a more general and applicable theory.

As research proceeded, observations that might once have seemed new and meaningful in their own right, slowly became more prevalent and, as such, commonplace. We familiarized ourselves with the multiple and diversified expressions that one given theme might have across women from different backgrounds, and with their varied consequences and oftentimes perceived causes. This was crucial in theory development, as it progressively presented us with a better painted picture of the overarching themes.

With more codes arising and refining into new or existing concepts, our theory solidified. The connections and categories became clearer, and our major themes discernable at a glance. Having always given reasonable priority to theory legibility, this was one of our main goals. Seeing it achieved, alongside theoretical saturation, meant we had reached a stage in research where we could begin to present out findings in a treated way.

Our narrative was thusly developed. Sometimes, this process called for minute alterations to the already analysed and treated data upon review, which was expected. As an ever-dynamic and iterative process, this allowed the theory to show itself to its full extent, sometimes in surprising ways, yet never stagnant. We considered this to be a valuable point of *STGT*, not easily replicated by other research methods.

We arrived at several core themes, which are fully detailed below. The codes pertaining to each are contained within, and where relations were established with different themes, this connection was explained in detail in the appropriate section. We can further group codes from individual themes into three categories, namely encouragers, detractors and aspects of consideration - the latter for those which might cause women to feel either encouraged or discouraged from attaining a PhD in Computer Science, depending on their evaluation of said factor, or possibly on personal factors.

There are ten main themes to this research, given that one - confidence and security - is an overarching theme which can be used as a means to categorise all others, as shown in Figure 6.1. The remaining themes are PhD theme and impact, the industry’s perception of doctorates, faculty, maternity, time, male-dominated environment, transparency in PhDs, financial precariousness and social support. While some of these themes play an essential role in this theory, others serve mostly as an insight that may help us comprehend the rest, and are a welcome addition to the knowledge base.

The theme of confidence was not one that was initially contemplated in the gathered codes, however it became evident as the theory progressed that it deserved a spotlight. It was indeed directly mentioned by a few of the women interviewed, and upon taking it into consideration, it was found to actually be a main theme that connected itself to several concepts from other topics.

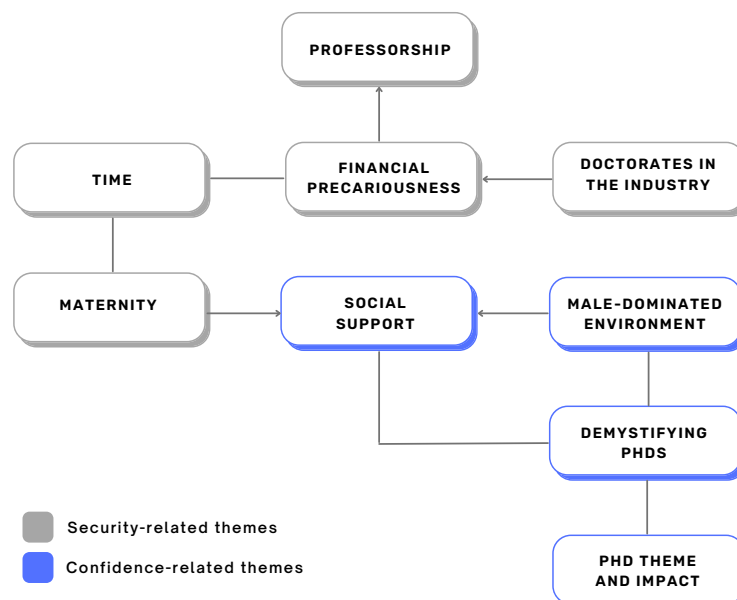


Figure 6.1: Simplified view of the nine encountered themes and their connections, divided into two categories (confidence and security-related)

6.2 Themes

Within the variety of codes that arose out of interviews and women’s personal experiences with a doctorate degree in Computer Science, we distinguished some overarching patterns, which we labeled as the main themes. These were deemed to be a quintessential part of the perception women have of a PhD, and connections between these themes oftentimes appear in illuminative ways. In Figure 6.2, we get an overall idea of how often these themes came up.

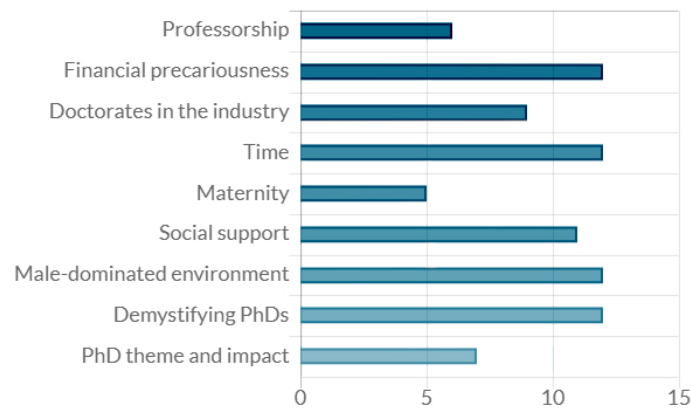


Figure 6.2: Bar chart of emerging themes, by number of women who mentioned them in interviews

6.2.1 PhD theme and impact

As a long and in-depth research process on a niche subject, a doctorate requires the alumnus to carefully consider and settle on a topic for their doctoral thesis before making the commitment to enroll. Several considerations are at play in this stage which can veer the candidate one way or the other. While for some, research activity is rewarding in itself and seeing its impact is a welcome culmination of their efforts, for others, committing to a single theme may feel restricting, and lack of progress in research can be stifling.

One of the core themes for this theory is therefore the topic and perceived impact of a PhD. The first thing that is worthy of mention is the fact that most of the women going into a PhD did so as a result of particularly identifying with a specific topic of research. This interest was usually something acquired during their master’s degree and which they expressed interest in developing further. In this sense, doctoral degrees are seen as a way to further one’s learning, and allow women to follow their curiosity for a topic or desire for knowledge. Evolving in something that is already close to them therefore feels more motivating throughout their path.

For some, research also presents itself as a chance to develop one’s soft skills and writing, which may not have been given proper attention in classic Computer Science

courses, due to their heavily technical nature. The writing of the thesis itself appeals to those who enjoy the activity and can even be seen as a creative pursuit.

It was also not an uncommon occurrence for women to mention having interest in developing projects or research that might have an impact on society, and whenever mentioned, this impact was always perceived as something positive and encouraging in their work. The below quotes by candidate 06 are prime examples of this:

"I want to do something for the world and I see technology as a means to do that"

"The girls I met (...) wanted to somehow have a job that had an impact on society, which allowed them to have the power to do things for the better, to be able to help, to be able to contribute"

Not only this, but this desire also came up as a reason for choosing academia over industry, with the latter not corresponding to this need for impactful action. Some claimed that conducting research work that has societal relevance might be rated as a priority, and others still that visible results are considered a necessity in maintaining motivation and an interest in research. Even when projects yield results, if their effect is not obvious, it can cause some disconnection or disinterest in progressing with research. It is clear to see that a need for instant results can be detrimental to the prospective doctorate student, however it is possible to maintain their engagement with the chosen topic if it is deemed to be practically relevant.

Concerns about research work were expressed by participant 04, who considers that research can end up being a blockage at the practical level:

"I get [to a software development project] and I see that I am doing something, I am creating something that people will use. And at the research level (...) you get results, but then the project ends and it was no use, most of the time"

However it is also of interest to note that for those who have chosen to go into a doctorate, or have expressed interest in such, this is not mentioned as a problem. This may indicate that the necessity for immediate gratification from research results is not expected from those better acquainted with it, and is not a deal breaker when it comes to going into a PhD in Computer Science, but it may be a negative factor considered by those who do not enjoy research activity.

The aspiration for research with impact on the world may come from a place of altruism in some women, but it is also a fact that a need for validation is preeminent in the path of some, which may be related to the confidence gap existing between men and women. Seeing their research validated, approved and recognized by others in their field

is therefore essential in maintaining the confidence in the impact of their work, and once again encouraging in further research. This is akin to having visible results in terms of importance - not only do results need to be evident to the researcher, they should also be made visible for others, so that they feel more rewarding and palpable for the researcher.

Participant 09 expressed exactly this, claiming that one the most stimulating parts of research is indeed being able to present your results and having them acknowledged by others. Exposure is thus a great motivator of research:

“To see your work out there (...) it’s like ‘Oh, your work has been read! Somebody is actually interested’ (...) You’re disseminating your research. This is the most enjoyable.”

But downsides to picking a doctoral dissertation theme also exist: from those that considered a PhD as a future possibility, a few eventually disregarded it due to the required specificity. They saw mastery of a single theme in depth as a potentially negative choice, which might limit them in the future, and even close doors to other areas. Candidate 02 summed this up well:

“This fear of committing myself to an area (...) is related (...) to the fact that I think it will restrict the remainder of my path”

For these candidates, the industry appears as the most favourable choice. It seems less restrictive in terms of area of work or study, and changing career paths is simpler. A PhD is a suitable choice for those wanting to learn more about a specific topic, but the industry still presents itself as a place where one may learn and work on a variety of themes. It appears to be the old debate between “jack of all trades” and “master of none”, still relevant in this instance. One’s personal traits and preferences, and their view on seeking knowledge may be the first key to understand why some women view a PhD as a generator of opportunity and others see it as a narrowing of possibilities.

6.2.2 Doctorates in the industry

Although a dichotomy between academia and industry does not necessarily exist, it is important to take the business world into account when studying women’s relationship with a doctoral degree, as the most popular and often more straight-forward alternative. As such, we found it important to have a theme that expresses just this. It was also brought to light in the previous topic, “6.2.1 PhD theme and impact”, that women partly judge their decision of getting a PhD in regard to future industry prospects.

As mentioned above, a PhD can be seen as opening doors both in academia and in the industry, giving women a wider panoply of future choice. With a doctorate, women are not restricted to research fellowship or professorship positions: the industry offers

research positions in an environment that may be more appealing to some. And it is also possible to conjugate the two, as candidate 10 mentions:

“A lot of people juggle industry and academia and do a bit of back and forth - they aren’t that separated because academia is playing a lot into the industry as well.”

This “back and forth” is mentioned by several candidates and seen as something beneficial. As a technological field, Computer Science sees many advances in short periods of time and is a constantly advancing field. Staying away from the industry for too long may cause one to fall out of touch with the most recent practices. Women also mention that the industry-academia dynamic can be interesting for professional development. Research gives them a chance to learn a subject more in depth, and the industry the chance to apply it and see it working in practice. It is also always a chance to get a change of pace, and maybe the benefits that come with one or the other, which will be unraveled throughout this chapter.

But despite offering a wider range of possibilities according to some, doctorates are still not widely recognized and valued in the industry as a whole. This may be strongly connected to the fact that PhDs are not regarded as professional experience, by itself a product of them being misunderstood by outsiders. One candidate suggested that a company’s view on doctorates is very dependent on whether doctorates occupy the company’s higher boards, since this means there is a better appreciation of the skills a doctorate brings to the table. This is not only in terms of the specific topic they study in depth, but all the smaller competences developed in academia. As candidate code 10 puts it:

“There are some companies that see [doctorates] as an added value, they know that you can work independently, they know that you don’t give up easily, but normally they are people who have gone through the process themselves, because those who haven’t don’t really understand what the advantage and growth are from it.”

It is therefore worth to think why it is that companies do not value a PhD, and how this could be solved in those that do not have doctorate degree holders in their boards. One thing that was also commonly mentioned by several participants was the fact that PhDs are not considered work experience. This means a doctorate student wanting to go into the industry has a “handicap” of around four to five years when compared to someone fresh out of a master’s degree who went straight into the industry, despite having been actively engaged in Computer Science research for those years. This can be a great deterrent for those considering a doctorate, as they will not see it as advantageous in this sense and might even see it as a hindrance in their career progress. But not only is it a worry for

those wanting to get into a PhD, it is especially concerning for doctorate students who might see a future for themselves in the industry, as candidate 13 puts it:

“Here in Portugal - and this really keeps me up at night - I don’t think they value a doctorate at all.”

With Portuguese candidates making up a reasonable part of the studied population, this was something that came up quite often, sometimes paired with observations on how this might differ in some other European countries. But upon looking at answers from other European candidates, we can see that the worry is generalized, and that women perceive the industry as not valuing doctorates as a whole. Participant 09, who worked in the industry and may therefore hold some insider knowledge, claimed the following:

“From my experience in the industry, [a PhD] makes no difference. It doesn’t matter. (...) If you’re good enough at the technical part, nobody questions your research degrees.”

However, even with good technical capabilities, there is yet another worry on doctorate students’ minds: that of over-qualification. Many women claim that going into the industry with a PhD is not only undervalued in some cases, it might be considered too high of a degree in others. They fear that companies will unhesitatingly reject them due to holding a PhD, since they might require a higher salary which the company is not willing to pay. Participant with code 06 perfectly put her concern into words:

“There is no advantage in having a doctorate in Computer Science and going into the industry (...) you are not more valued (...) in fact you become so qualified that no one can pay you what you are worth.”

As such, it does not come as a surprise that some women do not view a PhD as a solid basis for their future. Not being able to visualize themselves in the industry somewhat limits their options, and prospects of remaining in academia are not always compatible with women’s aspirations. Several even went so far as suggesting that you should have separate curricula - one where you display your highest qualifications such as your PhD, and one where you do not, for companies where they believe it will not be well regarded, or which may outright discard them as a candidate for it.

6.2.3 Financial precariousness

One of the major concerns for women who plan to undertake research work as a doctorate student in Computer Science is their support network. As previously mentioned, we can divide support into two topics: personal or social support, and financial support. Both play an important role in women’s well-being and in soothing their concerns for the

future, and they tie in with several of the other topics, as expected from something that encompasses so much and is so closely tied with one's livelihood. As something that affects several other aspects of life, finances were given great predominance, and came up more often than any other topic or code.

If we take a look at the previous topic, "6.2.2 Doctorates in the industry", we find one of the main concerns regarding finances has already started to be uncovered. Given that a PhD in Computer Science is not seen as valuable for the industry, doctorates will often not be paid what their qualification is worth, making the four or five years spent in academia seem unsalable. This leads us to one of the main topics within the financial precariousness created by PhDs: scholarship values. Most interviewed women claimed they would never have considered going into a PhD if there was no scholarship and that even then, the value of a doctorate's scholarship is not in the least appealing, especially when compared to what is offered in the industry.

Woman inevitably will compare themselves to their colleagues who have taken the alternative path of joining the industry, and the difference is glaring. While the latter gain years of professional experience, have salary increases and bonus, and possibly even company-specific perks, the doctorate student will be presented with salary stagnation. Furthermore, once their research is over, they will not get these years worth of experience to show in the business world - due to the aforementioned issues with doctorates in the industry - and their counterparts will have five years of pay raises on them, or possibly even a senior position. Candidate with code 03 summarizes these points, which make academia a less appealing choice:

"The industry definitely beats academia. Both in terms of entry salary, and in terms of career progression and salary progression. (...) Scholarship values are not competitive with the offered salaries, besides there being four, five years of salary stagnation."

But the stigma does not just come from the industry. Some women also mentioned the government itself, as well as big institutions such as banks, seem to overlook or underrate doctorates. Not only do women feel like they are in a position of financial precariousness due to undervaluing by the industry and low scholarships, but the government only furthers this cycle by viewing them as precarious workers and as such presenting them with worse conditions when it comes to taking a loan for a house - a step which may be crucial towards independence. Interviewee with code 05 compares this to what happens in the industry in an eye-opening way:

"You get into a company and, if you're in Computer Science, in around six months you'll have an open-ended contract. Through the eyes of the government, you're much more stable this way than as a scholarship fellow."

Candidate 03 completes this by saying:

“You want to take a loan and having a scholarship from a foundation, you don’t have stability, so they’ll give you much worse conditions, if they even accept you.”

It is clear to see that scholarships and fellowships need to be made more competitive if women are to be drawn to a PhD. As they stand at the moment, scholarships do not create the condition for financial independence that women desire, deeply affecting other areas of their life. One such area is maternity, which will be mentioned ahead. Without a salary that is comparable to that earned in the industry, and the near impossibility of getting a loan on good conditions, doctorate women find it hard to gain independence, move out, and above all start a family.

This lack of stability is at the root of a lot of doubts women have regarding a PhD in Computer Science. And this is not purely at short term - not having any kind of subsidies or social security deductions means women in a doctoral degree are missing at least four years of deductions that could be going towards their retirement. This type of long term thinking does nothing to assuage women’s fears, and the prospects are not positive. It may be so discouraging in fact, that some give up on the idea altogether, as candidate 13 tells us:

“Some of my female colleagues dropped out of the PhD because they looked and thought “I’m 28, I’m in a PhD, I have no [social security] deductions for example, what’s it going to be like? How will I retire?”

This can only be seen as a fair reaction when all things are considered. Volatile work conditions meet societal misunderstanding of a doctorate’s value to make for an overall lack of security. In the face of this, some women are only reassured with a backup plan or some sort of external financial support. This may come in the form of an assured place in the industry that will serve as a safety net should academia prove unreliable, or in direct aid from family or a significant other.

If the goal is to make PhDs more appealing for women, providing them with financial stability is something that needs to be considered at depth. Some of the above mentioned factors - such as the government’s view of doctorates as precarious workers - are systematically ingrained in society and need to be deconstructed. The value of foundations’ scholarships or fellowships must also eventually be made more competitive in relation to the alternative, if this cycle is to be broken. A revision on doctorate students’ status should also be revised, lest they hang in a limbo between worker and student, while not quite fitting into just one of these definitions.

6.2.4 Professorship

When going into a doctoral degree, many women's interest is first and foremost that of research work. A career in professorship may not be in the minds of many at first, and is not often the main motivator towards getting a PhD. A few women view it as more of an obligation - something that must be done in order to support themselves during research or, as a participant mentions in interview 03:

“You find it very difficult to have any progression at research level (...) without having a career in professorship associated with it. So you can have professors who don't want to be professors.”

This is, in a way, related to the need for extra security, which research does not correspond to, as seen in the previous sub-chapter. And even considering professorship, which may be an undesired added responsibility, this security may still not be achieved.

Although this may be their initial view, during our interviews most women who had to give lectures throughout their academic path - either by own choice or necessity - ended up with a newfound interest in professorship. Upon discovering this was something they enjoyed, a few regarded a PhD in a new light, as a means to reach an end - giving lectures. Others still, see the opportunity to teach as one of the benefits of a PhD. Such is the case of participant 11:

“Another thing is you get to teach, which I like very much. Being among the students (...) you get a lot of ideas (...) Sometimes someone asks a question and it sticks in your mind, like "Oh this is interesting, something can happen out of this"(...) You get to learn a lot by teaching. I really believe that.”

So even when professorship is not the initial intention behind a PhD, it can become a welcome addition, and a beneficial one that brings an extra layer of security to the equation of being a doctorate student. But this is far from being the ideal solution, and is at best a partial one. This can be justified by the precariousness that still exists even among lecturers, as interviewee 13 describes:

“Doctoral work and university teaching work, only when you're a cathedratric professor or exclusive to the university do you have security. Because until then, it's a very precarious job.”

Here, a cathedratric professor is defined as the highest rank of professorship, or one with full tenure, above assistant and associate professor. The main takeaway from this observation is how giving lectures may not come as a comfort until a tenure track position is achieved, and even then it might not be enough to secure the desired future for these women.

This topic was deemed to be of importance due to being an option within academia that often requires consideration, despite women's varied feelings towards tenure. Its connection with feelings of security in their job and for the future brings it even larger significance.

6.2.5 Time

The topic of time is a complex one, and it can be argued that it is connected to most other approached topics, as the primal human concern it presents. The two topics that were found to most closely connect with time were finances - as illustrated in "6.2.3 Financial precariousness" - and "6.2.6 Maternity", as a representative of biological time that can be a major consideration for some women. Before approaching this theme however, it is necessary to paint the overall picture of how women perceive the time spent in a Computer Science doctorate degree. As expected from a diverse population, there is no general consensus, but some themes arise more often than others, and we can thus assume they are of importance to a large audience of women.

If we begin by taking a look at those belonging to the first defined group of the population - who are currently finishing their master's degree or did so recently - we can gauge what the external perception is on the duration of a PhD. Unsurprisingly, for someone who is coming to a close on five years of higher education, the prospect of four or five more years is not an appealing one. A bachelor and master's degree are already seen as strenuous work for some, making a "change of air" somewhat necessary if burnout is to be avoided - often meaning the industry presents itself as a more tempting choice, if not only for the difference and variety it suggests when compared to five more years in the same environment of academia. Candidate 05 tells us how this particularly affects the outlook of those who are finishing this part of their higher education:

"When someone is finishing their master's, maybe it's something they longed to finish, to close the cycle. Considering four more years (...) for someone who is 23/24 when they finish, is a bit scary"

Above all, a PhD is seen as too big of a commitment in terms of time, and one that is especially difficult to make at the end of a bachelor and master's - in themselves compromises. But as often happens with a diverse population, the opposing view also exists. Some women perceive this extended research time as something positive, giving them more leverage to carefully organize the research they plan to undertake and allowing for a deeper dive into their subject matter. When compared to a master's thesis, which some find to be "rushed", this can lead to more satisfying results.

However, and perhaps more rarely, for some women who may yet feel some uncertainty about the future, this time can be seen as a way to prolong a "state of grace". It allows them to remain in the familiar environment of academia and adjourn the process

of joining the workforce, which can be daunting for some. Candidate 13 puts this into perspective, and touches on a new point of interest:

“Maybe it is also the fear of going into the industry already and having to look for work and all that stress (...) Maybe doctorates are more appealing to those people who are lost.”

This candidate introduced an interesting topic by mentioning some women may be “lost” not only in terms of uncertainty towards the future, but in terms of the subject they want to pursue in itself. From the interviews we conducted in the course of this research, although most women had followed mostly linear paths through classic Computer Science courses, some had also come from different backgrounds and eventually settled in a Computer Science PhD. In this sense, a doctoral degree can be a way to specialize in a topic of interest whilst keeping a diverse tool belt from other areas of study, without necessarily compromising for one.

For those belonging to the second and third groups of our population, who are more personal with what the process of a doctorate entails, time still makes up a great part of their considerations. Time management is of the essence in such work as research, and flexibility in scheduling plays a big role in this. Women in a PhD are given more freedom to organize their time and tasks, and most of this is left up to the best of their judgement. This freedom is often welcome, as participant 09 tells us from her personal experience:

“You work a lot but you work flexibly. I’m a night owl, (...) my active hours start after four. And this is something that the corporate world doesn’t support. (...) It’s all about your personal time management, so if you’re good at it, a PhD will be a better choice for you”

Indeed, schedule flexibilization was something most interviewed women pointed out as the major advantage of academia, both in itself and when compared to the industry. Some even went as far as suggesting that allowing for a higher degree of flexibility in work and study hours might be the key to encouraging more women to go into a doctorate in Computer Science.

Remote work, popularized during the COVID-19 pandemic, has certainly had a lasting effect on these women’s perception, especially when it comes to research work, which does not require *in loco* activity. It not only allows them to devote the time that works best for them to research, but it gives them more power over their own time, and a capacity to plan around their priorities, rather than having their priorities set for them. Participant 08 compared time flexibility in academia and the industry, illustrating this well:

“I think [academia] is sort of a calmer work, and I think it’s more interesting than maybe working at a company. (...) At the same time we also don’t have the pressure of working for a client and meeting deadlines. (...) It has to do with (...) what we prefer: to have things defined for us or to define them ourselves”

Allowing women to set their own priorities is not only beneficial in terms of research - it is imperative that it is also perceived in terms of personal time. A work-life balance is essential in keeping people productive and above all motivated, with imbalances in this area possibly leading to a decrease in mental health that can go on to permeate all areas of life. In this sense, academia was often mentioned as the superior option for those seeking a better balance, with a PhD being most compatible with good personal time management.

One of the aspects of this work or study to personal life balance that was also rightfully brought up by women was that of a clear separation between the two. Although remote work has facilitated time management, its perceived effects are not all seen in a positive light - women feel it may have blurred the lines between personal time and working time. Candidate with code 08 expresses that clear separation is needed, and how she implemented it in her own living space:

“To ‘separate the waters’ (...) we have our work area and our relaxing area. I think that quarantine showed us that having a workplace, a place where you go to do something specific, is beneficial.”

Working from home means more comfort and freedom but there is also an unwelcome continuity from work to personal life. These two planes of living would be better isolated from each other if remote work were not the norm. The living space blends with the office space and it is more difficult for women to leave the working headspace when the physical location they occupy remains the same. Since companies have stipulated office hours, work does not often bleed out of its allotted times, and as such some women feel like the industry is better in maintaining a good separation - despite not being the best option in terms of time management. Interviewee coded 05 reflects on how the industry may be a better option in this sense:

“In a company you enter at one hour and leave at another - although remote working has those problems of people being able to contact you at any hour. Things are limited, you can separate your personal time from your working time.”

To confirm this view, candidate 04 expresses how academia may yet need some improvements when it comes to creating this separation:

“Sometimes I think there’s a bit too much ‘at ease’ in the research and academic part. I think maybe they should limit it more. And with all the remote part that exists now with the pandemic, it’s even worse.”

This ties in with time management in relevant ways, one being the fact that as a woman, some responsibilities are felt to be innate or embedded in society, and these may take priority when scheduling. Consciously or not, and despite the advancements that have been made in this sense, gender still permeates several aspects of our daily lives. Some of the interviewed women feel as if the female gender is more often guided by their responsibilities and priorities, while men have more openness to focus on their preferences. This is not only biologically so, as we will see ahead in the “6.2.6 Maternity” topic, but possibly also in terms of one’s own confidence.

Some of the interviewed women felt as if they were less in control of their own time when compared to their male counterparts. This might come in the form of feeling overloaded by responsibilities that some consider to be feminine, despite these having no inherent gender attribution. It appears that being a woman implies spending extra time outside of one’s studies, and this is a recurrent consideration when undertaking a new task - in this case, a PhD. Candidate with code 01 found this to be so significant she went so far as to labeling it as a “third workload”:

“Men can dedicate more to work and the academic part at the same time because they are not concerned with other activities that are considered feminine. Women (...) have the academic part and the professional part and the home part (...) it’s like a third workload.”

This additional workload that weighs on women may take on several forms, the most common one being a responsibility for taking care of their family. Once again, as society evolves this is expected to become a less gendered role, but interviewed women often mentioned it and as such it is clear that it makes itself felt to this day, its weight perhaps reduced when shared with a partner, but not yet in an entirely balanced way. Adding this weight to that of ongoing research means doctorate women need constant and careful consideration of their own time. It also implies making a choice between the better time management offered by academia and the better separation offered by the industry.

And, as anticipated, for some women a big part of this added workload stems from the desire to constitute a family - maternity thus arises as a topic that many contemplate before or during a PhD.

6.2.6 Maternity

When considering the main distinction between men and women’s journey through a doctoral degree, it is inevitable that the biological difference between the two will eventually be mentioned. Many a time during our research, maternity appeared linked to

time management, as was foreseeable - juggling research, personal time and raising a family is a demanding and time-consuming endeavour. This can clearly be observed in the previous section - “6.2.5 Time” - where we go in-depth over how women perceive academia’s aptitude for accommodating their time needs.

For this topic to come up so often during our research, many times unprompted, it is clearly still relevant for a number of women. And for those who plan on starting a family, it is not only a priority but a highly-ranked one, as candidate 09 brings forward in concrete terms:

“Family is probably still the most important thing for a woman (...) This will dictate my choice.”

For those intending to start a family, academia was seen as the better alternative in terms of managing concurrent responsibilities, but this was not deemed to be enough to make it appealing. So where is academia lacking in terms of attracting family-oriented women to PhDs? Taking a look at what the industry is doing may be the key to understanding this.

As mentioned before, in the “6.2.3 Financial precariousness” section, women in academia still do not have a similar status to those working in the business world. This means legislation regarding both is widely different, and those in academia still lack an amount of laws that might otherwise protect and safeguard their interests. With this said, there is one crucial point where the industry beats academia: maternity leaves. This citation from candidate 12 perfectly encompasses this:

“Government rules regarding maternity and paternity support women and men in order to have a chance to still raise a family and keep working. That’s something that is important because women don’t have to choose between having a family or having a career. Here [in Europe], you can have both.”

In the industry, and mostly with respect to European countries, both women and men have the right to a paid maternity, paternity, and/or parental leave at the time of a child’s birth, and in some cases even preceding it. This means the two can share this time and the caring responsibilities, as well as helping women balance work and family life. Most countries even make the maternity leave mandatory, and over time these directives have been modernized to encourage equality, not just in the workplace, but as a whole.

Meanwhile in academia, the picture that is painted is more bleak. Several of the women who were interviewed mentioned that starting a family during their doctorate was not a promising prospect. The lack of support that is felt extends from the lack of maternity leaves to the possibility of losing their funding if they choose to pause their research. Raising a child becomes above all a financial struggle in an already not favourable environment.

It stands to reason that this is one of the main points where academia needs to focus potential improvements, and a possible way for Computer Science to mend its leaky pipeline. It is time for long-standing institutions to adapt their regulations to a growing female population and meet their specific needs.

“[Women’s] time is a bit more accounted for, especially on a biological level, and as long as they don’t worry much about that, there’s not going to be a specific appeal for women to go for PhDs.”

6.2.7 Social support

In previous sections we have seen how it is fundamental for women to receive support both in terms of finances - as seen on “6.2.3 Financial precariousness” - and in terms of a status that protects their interests when it comes to maternity - “6.2.6 Maternity”. However, a third and essential source of support exists: women’s own network of friends and family, who may offer them what he here label as “social support”.

Several women mentioned that the prospect of going into a PhD may be daunting, and that having interpersonal support is therefore both a way of maintaining their motivation and cultivating a feeling of security. This plays such a major role in their venture in higher education that several claimed it would not have been possible without this support, or it would have been made quite difficult. Unlike the previously discussed topics, this is not quite something that universities can intervene in or get success cases from, however it is a critical piece in building a full understanding of women’s perception of a Computer Science PhD.

Interpersonal or social support can at times closely relate to financial support. Several were the candidates who mentioned that the lack of stability which a doctorate offers meant they did not have enough financial independence to move out of their parents home. This, in turn, caused them to have to rely on their parents for longer, which was undesirable for most. Others claimed their parents’ support was essential in allowing them to further their studies. These women claimed to be lucky in having parents, close relatives or significant others who aided them financially and lent them a security net to fall back on. A lack of social support can snowball into a lack of financial stability, which in turn affects women’s ability to start a family, as candidate 09 tells us:

“If you’re really growing into your society, if your family is against you going into academia, which means obviously you’re not earning the money anymore, you’re dependent on this tiny scholarship, you can’t really start a family unless you have a lot of support - all these things could prevent women [from going into a PhD].”

But some of the support women require is within universities’ departments’ reach. While doing their master’s degrees, some women take a special liking for research work,

but perhaps never consider it as a valid option for their future. But one thing in common, that many of the current doctorate students mentioned, was the direct invite or challenge from an adviser to progress into a PhD.

This invite is important for two central reasons. The first has to do with the confidence gap - hearing this type of praise from an adviser makes women feel more empowered and confident in their capabilities. In the face of the unknown that is a PhD, which some perceive as being only for the top students, having an external vote of confidence from a figure of authority can be just the missing incentive. The second has to do with pulling back the curtain on a doctorate degree. Either due to viewing it as an abstract or distant reality, or having no female representation or stepping-stone role models to look up to, some women have never given a PhD any consideration as a possible path.

A revealing insight on this was given by candidate 06, for whom an invite from a thesis advisor was decisive in her serious consideration of advancing to a doctoral degree:

“There was an invite, and from that moment on, things became more serious (...) I had never seriously considered [doing a PhD] until the invite came along.”

What this tells us is first and foremost that despite having other encouragements to do a PhD, having a direct invite from a trusted thesis adviser may be a determinant first step. It can open the door to a more serious deliberation on the subject and allow for previously unexplored factors to begin to be weighed as real possibilities.

This interpersonal support however, does not limit itself to being an encourager for a PhD, rather being a necessary constant throughout the process. This can be especially important when we take a look at how women perceive the social aspect of a PhD and its importance. One thing that often came up during our interviews was the view of a doctorate, or research work in general, as a lonesome or isolating activity. Several things may play into this, the pandemic possibly being one that has exacerbated these feelings. The second is the fact that doctoral research is, as previously mentioned, very heavily focused on a niche subject which not a lot of people explore. This makes idea exchange with colleagues and discussing their findings difficult, and contributes to a feeling of being alone in their work. This can be further worsened by a lack of colleagues who share the same physical space, or who do similar work and who might thus relate to their plies. Finally, the male environment that makes itself evident in Computer Science - further explored in “6.2.8 Male-dominated environment” - can also contribute to segregating women. A lack of female colleagues may make it more difficult for a doctorate woman to feel integrated in academia, and the predominance of men makes itself felt.

Candidate 08 better illustrates how feeling supported and accompanied in the research process matters to women:

“Most things are not done alone. A PhD is one of them. (...) The social environment and feeling at ease help people a lot to in fact enjoy what they’re doing, feeling like they’re evolving and learning. (...) It’s completely necessary, that more social aspect, and being surrounded by people who are doing the same as we are.”

The interviewee with code 10 complements this by presenting us with an inside view of what it can be like to have several doctorate students working in a shared space:

“I do have people to bounce ideas off of, so that’s very promising for me. (...) I can just speak to people and learn about things that apply to my topic, but for the people that can’t do that it might be even more isolating, because then it’s just you and the book, or you and the Youtube video.”

From these two testimonies we gather that it might be a rewarding idea to pursue an environment in academia which is more stimulating for women undertaking research. This will be explored at a bigger depth in further chapters, but it is important to first lay out this knowledge base that asserts the importance of the social factor for women in academia. The surrounding environment is something Computer Science departments have a degree of power over, and as such it is enlightening to first understand the effect it has on women, before change can be enacted.

For the sake of having a term of comparison, we asked women with experience in both the business world and academia how they felt that the social factor was treated in each, and how one may learn from the other. Here, the industry was seen as favouring the social aspect of Computer Science, as was possibly expected from the previous observations. In the industry, it is more common for people to be inserted in teams and work towards similar goals, or be grouped into areas of expertise where their experience more closely relates to that of their colleagues. With the return to work in loco, at the office, this not only means women are less isolated in their physical workplace, but also in their social sphere. We take another look at the experience of candidate coded 08, which confirms exactly this:

“In the industry we usually have a team that we are actually working with. In PhDs you have the colleagues that are also doing it with you, but they are not all doing exactly the same project. So in that part, working in a company should be more interesting in terms of discussing ideas.”

But workplace exchanges may not all appear as positive, engaging discussions. The environment in academia is found to be too competitive by some women, which is an undesirable feature. This may be related to a need for people to assert themselves in the field, once again as a result of the instability that a position in academia entails. And

when you consider the male predominance in the field, we can see there might be other types of setbacks and even discouragers in women's path. We look further into this in the following chapter.

6.2.8 Male-dominated environment

Despite the efforts that have been made to mend the several stages of the leaky pipeline that exists in Computer Science, it remains a fact that this field is dominated by the male gender, not only in terms of sheer numbers. The male presence makes itself felt at all points of the pipeline, and this can be observed both in the industry and in academia. And even though there have been advancements in society and people's perception over the years to quell the gender stigma - which cause plenty of women nowadays to no longer feel as discriminated in their academic journey - some issues still rise from this situation.

Most of the interviewed women mentioned the big discrepancy that was felt in terms of male-to-female ratio in their courses, or even in their experience in the business world. This difference in numbers is, by itself, not necessarily something that has a direct effect on women - but there is something to be said about the fact that most, if not all women took notice of this, lending it some significance. If we take a look at the previous topic, "6.2.7 Social support", we realize that this number disadvantage may have social consequences and make women feel more isolated, as candidate 09 indicates:

"Sometimes it's just a bit lonely. If you try to explain a problem about your physical feeling or you're getting a little bit more emotional (...) you're like "oh, maybe it's just me, because I'm a woman". (...) You see all the other men sitting in the room, and they're fine, and nothing affects them, and they just want to get the job done and go home. (...) So, it would have been nice to have women around to just talk to."

Once again, a stronger female presence in Computer Science is pointed as a desirable future. Interviewed women who conducted their doctorate's research in more female-centric environments also gave them praise, affirming it made for a more balanced and positive setting. This is not only related to a need for more relatable interpersonal connections, owing to the importance of the social aspect of academia, but also to a topic that will be approached ahead - that of creating more female role models and representation.

As more women enter academia, the more exposure their particular struggles in this environment gain. By getting more exposure and becoming more visible, women's presence is naturally and progressively normalized in this area. But the leaks in the pipeline mean there are fewer and fewer women, the further along academia you are. This means that even if they attain better representation, younger women still lack the role models to look up to - women who may mentor them or show them the path they are on is viable and that they too can thrive in academia. Candidate with code 00 expresses how important this was for her:

“It was very beneficial for me to see women in positions of power within the department, (...) having role models to follow and being able to aspire to reach a certain level.”

Candidate 13 goes further into the reasons why it is so positive for more women to be entering academia now than they were a few years ago:

“There are a lot more girls in the course now, that helps (...) a lot because [men] start to get used to the idea. If [these girls] got in with the same or better grades than them, then they are also just as good or better.”

So we see that a bigger gender conscience is naturally being created just by having more women enrolling in Computer Science courses. One may then fall under the false assumption that the problem will fix itself: the more women enroll, the more men will get accustomed to the idea and the less obstacles will be put in women’s path. Is this gender conscience really needed if things seem to be improving? The answer is yes: a vicious circle such as the one we are presented with does not fix itself by pure chance. Focused action needs to be taken if this is to be fixed, and a great part of the problem is the discrimination that is yet felt in Computer Science.

Before getting further into the topic of discrimination, we must first note that it may be felt differently by different women, and can thus affect them in varying ways. At first glance, several women claimed to not have felt any gender discrimination throughout their path, but some of them eventually went on to describe particular situations in which they had indeed been treated different for reasons they felt were related to their gender. It is also true that a few of these women may have considered these comments or situations to not have contained more serious insinuations, and claim they did not go on to affect them. But the fact remains that these microaggressions are present, and some women are more sensitive to their buildup. Candidate with code 10 retells her experience in academia in regard to this:

“There’s a lot of microaggressions, and some people just stop because they can’t see themselves doing that for the rest of their lives, or even for three to five years. I think that’s also because we have so many men in academia now. (...) It is still seen as a hostile environment.”

A “hostile environment“, as it is described by this participant, is far from being the appealing depiction that Computer Science needs to become a more favorable option for women. Since problems are best fixed by their root, we attempted to gauge the origin of these microaggressions or all-out discriminatory comments and behaviours. What we found was that these came not only from women’s classmates and peers, but in some cases also from professors. This was especially appalling and when it came up in interviews, it

was usually in a way related to gatekeeping knowledge and not aiding female students in the same way they did others. The following situations were respectively reported by candidates 06, 07 and 08:

“I spoke to two [female] friends at the time who told me exactly the same thing: that they couldn’t learn to program because they felt that their doubts weren’t answered, and that no teacher wasted time with them.”

“I could have exactly the same question as a male classmate, but just because I was a girl they were not clarified in the same way.”

“My classmate and I went to solve some questions. And this teacher only spoke to my classmate. He practically didn’t look at me, and asked questions(...) only from my classmate. I ended up not answering anything, because he wasn’t even looking at or talking to me.”

It must be noted that these may have been isolated occurrences or not having been related to gender, but this study heavily focuses on women’s perception of academia. What is here presented are women’s personal experiences, and it is therefore valid that if women felt these occurrences to be related to their gender at the time, it will be relevant to the study.

On the other hand, one situation of positive discrimination from professors was also reported - one candidate claimed that during her course, professors noticed that women were more prone to worrying about their performance. In seeing them as more sensitive, they took the time to sit down with them and aid them in solving any doubts, which in turn gave them reassurance.

But the daily interactions of women in academia are more often in relation to their classmates. The following three excerpts come from interviews to candidates 06, 13 and 10 respectively, and are illustrative of the types of comments that women heard from their classmates, or situations they encountered with enough frequency or enough impact that they stuck with these candidates and were worthy of mention:

“I started to hear things I had never heard before in my life, such as ‘You got a good grade because you batted your eyelashes at the teacher’.”

“There was much more of that ‘Ah, you’re a girl, it would suit you better to go to chemistry, or bio-engineering’.”

“I felt like I had a lot of things explained to me by my classmates that didn’t need to be explained to me. (...) It’s definitely a double take a lot of the time that they need to do on me.”

These are a select few of the comments that women mentioned during interviews. Add to this a bigger effort being required for them to be heard among men, and it is blatant that this type of discrimination yet lives in academia. We see that creating and maintaining a gender conscience is necessary, and a few of the women who were interviewed suggested equality programs that aim to educate students and departments alike, so that they may become more inclusive in both their language and their treatment of others. These initiatives will no doubt be a necessary step in achieving a more equal space in academia.

While for some of these women these types of comments might have been disregarded as questionable “banter”, many are the cases where an accumulation of negative comments instilled some doubt. One candidate mentioned that the more introspective one becomes, analysing the situations they have been through, the more they will come to realize that certain comments or events might have had more to them than what meets the eye. For women more prone to this kind of thinking, feelings of inadequacy can easily start to form, which will lead to a lack of confidence in themselves in the Computer Science field. According to the sensitivity of each one, this could be the breaking point that causes them to leave Computer Science academia. This is especially worrying because women seem to be more affected by a lack of confidence, as has been previously studied - and labeled as the “confidence gap” - and as candidate 10 puts into perspective with a comparison to the perceived confidence of some men:

“When you speak to men, they’re very confident to be where they are. And that’s phenomenal, I think we should get there! (...) For us it’s a lot of questioning, like ‘Is this my place? Is this where I should be?’”

We’ve previously approached a few ways that women’s doubts may be assuaged and their confidence boosted - a direct invite from a professor or advisor to do a PhD, for example, or seeing their research work praised and its impact. But what else can be done at an interpersonal level? Something that often came up was that women felt there was no one they were comfortable asking questions to - preferably a woman who had walked the same path. This brings us to the next topic, where we go over what might yet be needed to clear up women’s expectations towards a PhD.

6.2.9 Demystifying PhDs

For those not acquainted with the research process, a doctorate in Computer Science may yet seem like an abstract concept. It comes as no surprise then that women entering a bachelor’s may not have any future prospect of becoming a doctorate, and even those who are doing their master’s degree and are more familiar with research do not know what a doctoral degree entails. It seems that this information needs to be sought, rather than being offered to women. And without disregarding the importance of proactivity, some women mentioned that this information could be made more easily accessible. This

transparency would provide women with a better notion of what a doctorate actually is, and help in setting their expectations of a PhD. By clearing this up sooner in women's paths through academia, it would allow a PhD into their imaginary, making it a realistic option with a defined set of responsibilities. Making a PhD into a future possibility earlier may be a key to having more women make this choice.

Candidate with code 07 - who finished her master's degree but did not choose to go on to do a PhD - touched on this subject during her interview, allowing us into her thought process and introducing another important topic:

“Even the [master's] thesis is a bit abstract, because I was never told what it was supposed to be. (...) Maybe if I had had more knowledge about what was (...) the life of a doctorate, it would have weighed more heavily on my decision.”

An important piece of information that arose during this interview was the fact that women are not just interested in knowing what a PhD entails in technical terms or in terms of milestones to be achieved. It is equally important for them to have a window into the daily life of a doctorate student, making them privy to what this type of research activity implies, and helping them in visualizing what their next four to five years may be like. This was perfectly put by candidate 06, who also shows just how important the social aspect of a PhD is, and how it ties in with several other concerns:

“What would it be like now if I started [a PhD]? Would I have a room just for me? Would I be in a room with people? How is the daily life, the social part of the doctorate? Because at the end of the day, it's not just about thinking "In four years I'll have a PhD- no, I'll have to live those four years, so I have to think about what my daily life is going to be like.”

Institutions specifying the implications and objectives of a PhD and making this information widely available is only the first step, and for some not enough. Given the specificity of expectations for each university, and how they may vary from one institution to the next or even between departments, this is made even more important.

But the issues candidate 06 mentions above are exactly where contact with doctorate students comes in, and especially that with women who have gone through this same path. Several of the interviewed women expressed the need for contact with PhD students, either personally or in the form of talks where they might learn more about their activities. Some of them preferred closer or personal contact with these students and actually conveyed some mistrust towards talks, as they are often organized by the university itself and as such might be skewed to meet their preferred view of a doctorate's degree. Women showed to be more interested in realism and in actually being presented with the unabridged “pros and cons” of a PhD. Candidate 08 put this into her own words:

“I think that this is something that is necessary: (...) talks by doctoral students about what they did and what the experience is like, but of course (...) they sprinkle a lot of flowers on top, so actually seeing the day to day and actually seeing the meetings and the things they do is completely different from just listening to their opinion (...) once everything is done.”

Having gathered what helps demystify a PhD for outsiders - women who have had no previous personal contact with it, or who might consider it as an option in the future - it is important not to neglect the needs of women who are currently doing their doctorate's. For these women, doctorate research is part of their daily life and most of the process is, as such, fully disclosed to them. But it is still not uncommon for these women to have some doubts regarding their path. Some of these questions tie with their research and may be asked of their supervisors, advisors, or people in the department. But a PhD is a facet of academia that differs from those they may be accustomed to, and as such it can feel new and may bring about different types of questions - not necessarily with respect to research, but to academia in general, or even to women's own struggles in this environment.

For these types of inquiries, a supervisor is not always available, nor may they be the desired recipient for them. Having someone to ask these to is therefore of great importance to these women, and relates to several of the topics we have previously discussed. Towards the end of the previous theme - “6.2.8 Male-dominated environment” - we approached the topic of confidence. One thing that may provide women with the confidence they require in their position is allowing them a safe space to ask questions so that they may feel secure and like they have a better grasp on things. Interviewee with code 10 expressed why this is especially important for women who do not come from a background in academia, for whom everything is a novelty:

“I don't come from an environment where people have PhDs so especially at the beginning there was a lot of ‘Is this normal for a PhD or is it something that's happening just to me?’ (...) Representation is important but for me it was more than seeing somebody to aspire to - it was more of having somebody to ask ‘How is this supposed to be?’ (...) There's nobody to ask these questions. A lot of the things I've learned about PhDs, I learned from YouTube. Things about structures of papers or things about grants. (...) This is massive and it can be extremely isolating.”

The question of social isolation is once again brought up, this time with regard to the necessity for someone who will serve as a support for women fresh into academia. This places women in a more encouraging position, and can help in eliminating some of the worries that might otherwise be constants in their mind. Having role models in

the department such as female professors can be one way of creating this presence and network, but it is also possible that having younger women they can relate to may be a path towards success. As we have previously mentioned, this can only be achieved by maintaining a critical mass of women in academia, its renovation dependent on this balance. By giving women the tools and assistance they require to prosper in the field, we will have taken a step closer to our goal.

6.2.10 Confidence and security

An overarching theme that we came across during our interviews and research was that of women's confidence and how central it is to their success. It is a fact that the self-assurance of women both in academia and the industry still does not match that of men, oftentimes due to the perceived differences between the two. These differences, however, are prolonged mostly due to the male predominance in the Computer Science field. This has indirect consequences, such as those seen in policies that do not protect women in this environment.

Confidence both causes an effect and is affected by several of the themes that we explored in this dissertation. It is first and foremost an interpersonal issue, but its consequences stretch over several domains and can affect women's persistence in a Computer Science PhD. It has repercussions in how women view their future in an academic path, and even how they perceive the significance of their research and contributions.

The second key factor for women is security, which differs from confidence in the sense that it does not only imply interpersonal connections, despite also encompassing them. It originates in things like legislative support and financial stability, although having a social safety net they can fall back on or rely on when necessary also gives women a sense of safety. This was oftentimes brought up as being of the utmost necessity when endeavouring in the unfamiliar and precarious field that women perceive a Computer Science doctorate to be.

Safety appeared to us as the missing component that incorporated all remaining themes not covered by confidence - though it is not uncommon for the two to overlap. When considering mending the stage of the leaky pipeline that focuses on the transition into a doctoral degree, these two overarching themes need to be given due consideration. Creating the conditions for women to go into a PhD and persist in one is a many-headed affair and as such, the solution could not be simple. Action is necessary at several levels, as will be discussed ahead.

To better illustrate the ways in which the aforementioned themes interconnect, and having gone through the topics within each, a graph that builds upon Figure 6.1 is presented below, in Figure 6.3. Here, it is possible to see more minute connections between themes, as well as their categorisation into confidence or security-related. This may be helpful in finding where exactly improvements may be needed for the two to become balanced.

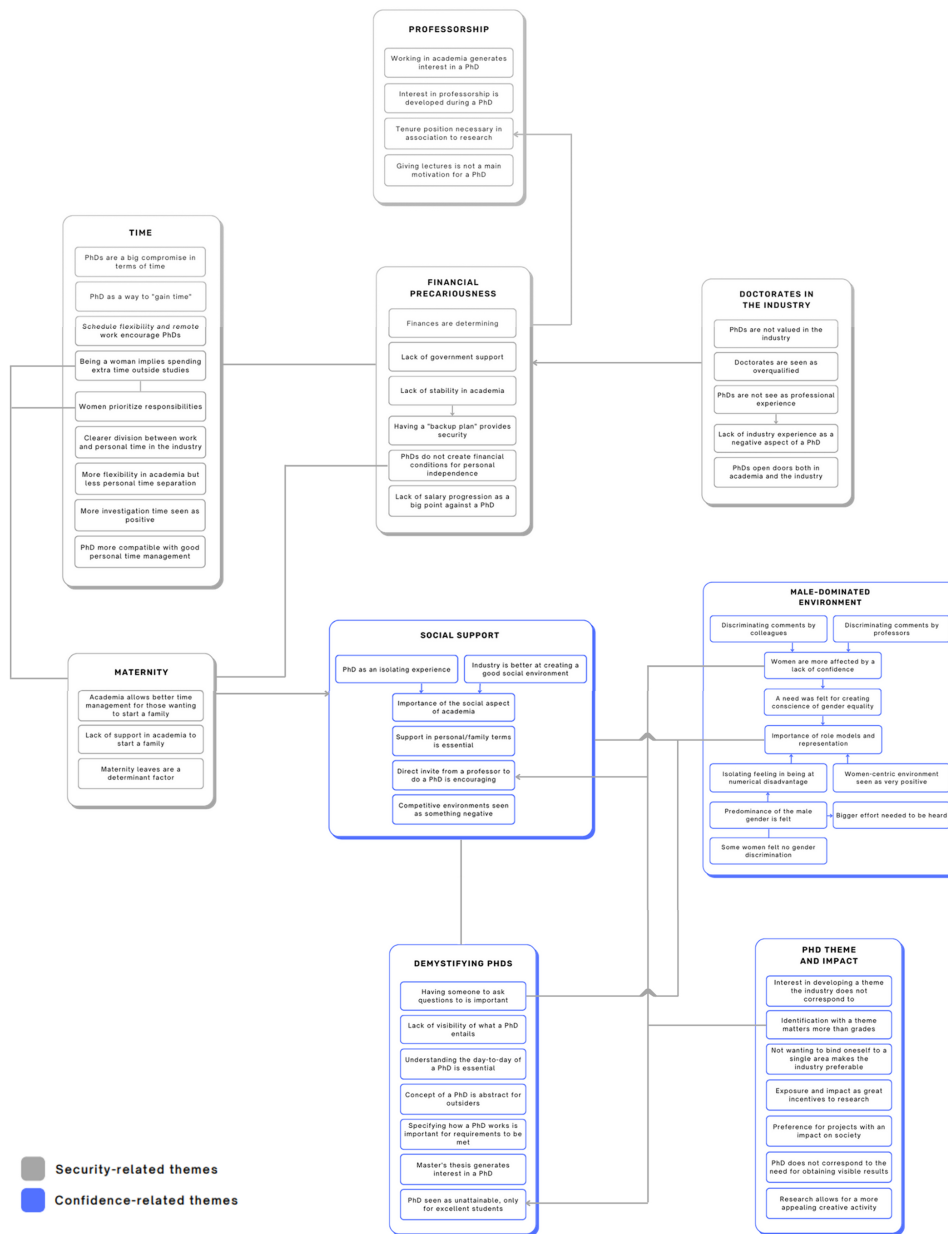


Figure 6.3: Complete view of the nine encountered themes and their connections, divided into two categories (confidence and security-related)

6.3 Validation

Given that this research paper relies on grounded theory, the sampling of interviewees is a major factor towards validity. The first concern was gathering a representative sample. Having divided the population into three major groups lent the study some basis of representativeness. However, there were yet other factors to consider, individual to the interviewed women. These ranged from socio-economic status to age, nationality and

even personality. These factors will be taken into account when considering the applicability of the study at a larger scale, as a lack of representativeness might threaten external validity by making the study lose relevancy in the face of a bigger and more diverse target audience.

With concern to the acquired data, another aspect that deserves attention is theoretical saturation. This occurs when the sampling of data - in this case, information acquired from interviews - does not further add to the already gathered knowledge. This is strongly related to the above mentioned representativeness of the sample, as it is expected that a more diverse study population will yield more diverse answers. Reaching saturation too fast means the chosen group was not representative enough, but a very diverse group may also produce more disparate answers and take longer to fully study and code. Given the chosen population sample, a balance was reached in this sense.

Still regarding grounded theory, the open coding phase was crucial for internal validity, as it required an effort in finding key patterns which may be argued if not done correctly. As such, a clear and logical path was carefully established from raw transcript data to the derived categories or codes, so that anyone wishing to follow this chain of thought would be able to do so without trouble. This was done with the intention of leaving as little open to subjectivity as possible, despite the necessary abstraction.

The process of assessing whether the standards for grounded theory validity are met was a careful one, as thorough guidelines exist to ensure researchers' methodology is adequate. In its quality of an empirical qualitative research method, grounded theory is particularly strict to assure it is up to par with popular quantitative methodologies.

One of the validation methods suggested for our chosen theory development, which was the emergent method, is that of abductive validation, since our data analysis had a facet of abductive reasoning. This type of validation claims that a hypothesis is considered valid if it is a simple and elegant explanation for that which we are attempting to explain. Given that we arrived at causes for given consequences, then it must be clear that these consequences did indeed follow from them, in order for validity to be achieved.

6.4 Limitations

Regarding our first limitation, we found it important to add a disclaimer with respect to gender identity. Despite there being more gender identities and expressions than the ones here studied, in discussing the topic we realized it was impossible to provide full coverage in the relatively short time we were allotted for this dissertation. As such, we chose to specifically target cisgender people identifying as women, and get an account of their experience in academia, which would certainly differ from others.

Secondly, in only interviewing women, we did not gain insight on men's experience in academia for comparison. However, the main goal for this dissertation was to add to the knowledge base of how women perceive a PhD. Perception is, by definition, unilateral,

and as such we found this focus to be justified. It allowed us to target struggles which are specific for women, as well as those that may be common to men as well.

Having chosen convenience sampling as our first and main method of attaining interview candidates lead to two different limitations. The first was that candidates closer to the researcher might have come from a more similar background and as such had more similar experiences in their academic path. These candidates were mostly Portuguese, but may not be representative of the reality of Portuguese academia as a whole. This relates to the second limitation that convenience sampling led to, which was converging mostly on Portuguese candidates. This made the research scope less broad, and as such it is possible that it became less representative. However, we attempted to mitigate both of these limitations by resorting to different sampling methods and reaching out to women outside our own networks. This had a positive effect in diversifying our studied population and as such the breadth of research itself.

With respect to limitations concerning the researcher, it is possible that unconscious personal bias might have been present in the tone and wording chosen for interview questions, and how these were posed to candidates. This might have influenced their answers, but an effort was made to employ neutral vocabulary while devising the interview questions. Open-ended questions were also the more frequent type, so as to allow candidates to freely state their personal observations and reduce the researcher's potentially biased participation.

THEORY DISCUSSION

7.1 Revisiting related work

Having laid out the core of our findings in the previous chapter, it is important to create an understanding of how they tie in with the literature reviewed in “Chapter 3 - Related Work”, or improve upon it with new insights. As such we will revise the main gathered concepts and how exactly they matter in engaging and maintaining women in Computer Science PhDs.

Regarding good practices in terms of recruitment and retention, it would appear that the creation of strong codes of conduct in universities is of great importance in reducing the impact of a male-dominated environment on women, especially in terms of any segregation [22]. Ideally, this would also target microaggressions that women might suffer on their path, although it can be difficult to have a full control of these types of interpersonal behaviours at the institutional level. However, it stands to reason that having clear regulations in place against discrimination would lessen this source of attrition to a degree. Pairing this with programs that create more gender awareness, suggested by some of the interviewed women as being highly beneficial, would only add to this. With these efforts, it might be possible to reduce the impact on women’s confidence and allow them to view a PhD as an option where their interests will be protected.

In terms of the women’s-only degrees that have arisen in recent years [38][29], it might be particularly interesting to study how eliminating one of our core themes from women’s concerns - the male-dominated environment - might impact their academic and career prospects. Since this overarching theme negatively affects their confidence, it may be that women’s degrees allow them to feel more assured in their path, and as such be more conducive of women progressing into a PhD. It would be interesting to compare the perceived “pros and cons” of the two environments and assert what positive aspects may be carried over to mixed degrees - which, once again, would surely have to be combined with gender equality awareness and possibly policies.

When focusing on retention, mentorship programs have been shown to be essential, either in approaching younger women and those more advanced on their degrees, or in

bridging the gap that is felt between students and faculty [17]. This touches on our topics of demystifying a PhD and on the importance of having role models or women in higher positions to ask questions to, which can help women feel less isolated in a predominantly male environment, as well as helping them visualize themselves further along their path. During our research, several women mentioned a closer contact with PhD students as something that might have - or had indeed - encouraged them on their path. As more women join Computer Science courses, so does the representation increase at a base level, but the leaky pipeline persists in decreasing their numbers along the academic path [35]. As mentioned by some, this increase in representation may naturally lead to a more encouraging environment overall, but it is not expected that the leaky pipeline is a self-solving issue. The structures that enable it continue to exist, both at the societal and institutional levels, and only by allowing women to feel confident and secure in their positions and future will it be mended.

Introductory courses help build women's confidence that they belong in Computer Science by providing them with the tools to more comfortably get through their studies [16]. Adding research internships to the curriculum - where these are not yet implemented - will have the similar effect of helping women in realizing the extent of their capabilities. It also generates earlier interest in research, somewhat unveiling what the process entails and possibly even creating interest in a topic they may want to pursue further ahead - now with some knowledge on the inner workings of a research activity. This is especially significant when we consider that growing up, most women do not consider Computer Science as a possibility - even if no specific deterrents are put in their path, this is still quite a long way from having an encouragement to explore this option.

One interesting thing to note is that most - if not all - of the above mentioned practices have only touched on women's confidence, but few are those that relate to their security as well. It can, however, be argued that having societies of women in Computer Science and Engineering creates networking opportunities that translate to career opportunities [1]. Still, it may be that institutions need to shift their focus so they might balance the scales of confidence and security. This could mean improving research grants and revising policies on maternity leaves, so that women feel more supported and a PhD is made a viable option and solid alternative to the industry.

In regard to security, however, it has been shown that women take financial support into great consideration when compared to men, and this was one of the emergent themes in our research - perhaps even the most significant one. Stable finances allow women the freedom and independence that they require to tend to personal responsibilities such as family, which is an additional worry that men are not so often directly afflicted by. As such, this topic touches on both the financial precariousness that is felt in a PhD, the weight of maternity in their choices, and time-related concerns. As previously mentioned, in degrees where women were given the chance to do their research remotely, the flexibility was appreciated. Going forward, it might therefore be worthy to consider some type of hybrid regime that opens up the possibility of remote work for those who require it, yet

also still allows for the much-needed connection to other doctorate women in a shared workspace.

Having touched upon institutional policies and the influence and support created by having female mentors and role models to aspire to within the department, one paper suggests there are yet two other categories that influence women's recruitment and retention in academia - pedagogy, and promotion and engagement [6]. The two may relate to our theme of security, with the second deserving a special focus in this sense, while the first is mostly tied with the topic of confidence.

Regarding teaching methods, women have been more shown to enjoy hands-on and active learning [39]. A good comprehension of study materials, as well as an openness to clear up any doubts that may arise with a professor, are essential in giving women the confidence they need in their own skills. Should these professors be doctorate students in some cases, and especially if women, this closeness could be another step towards demystifying a doctorate's degree and allowing younger women to envision themselves in this position.

Women's visibility in engaging with the industry is also particularly relevant, and feeling like the university or institution caters to their future prospects may be another source of security. If we consider the precariousness with which women in academia perceive a PhD, something similar could be achieved in creating more networking opportunities for them or, as one of our participants mentioned, having research projects where they may closely work with the industry. Seeing how their degree may be put to use in both academia and industry may lend these women a sense of assurance and stability.

CONCLUSION

8.1 Revisiting research questions

Having presented the main body of knowledge we acquired during this research and laid out the main themes that arose from interviews, we can now revisit the questions that were set in the “1 Introduction” chapter. Once again, however, it is important to be reminded that the utilized research method, *STGT*, does not heavily rely on these and the theory is expected to arise from research itself. However, these questions served as an important support, and when devising the interview questions they were always kept in mind. As such, we present below a summarized version of our findings, geared towards the questions that we set out to answer.

Q1.: What are women’s perceptions regarding a doctoral degree in Computer Science? How do they affect their choice to make the transition into one?

A1: Women see a doctoral degree as an opportunity that may open doors in both academia and the industry, but this is often overshadowed by the big time commitment that it is perceived to be. This can be daunting for women who are yet deciding on whether to make the transition into one, and can be the most jarring setback in this choice, or the one that comes up first in their deliberation. On comparing it further to the industry, we come across the second key aspect in understanding women’s perception of a doctoral degree - its precariousness. Women see doctorates as not being as socially understood or supported, and as such this can be daunting and deter some from progressing into one. This is largely related to a wish for independence - financial or otherwise - which makes a precarious position less favorable in their eyes and causes them to seek alternatives. Research is also seen as isolating work, even for those who have enjoyment for it, but this may not be enough to discourage some women. Nevertheless, there is a need to demystify the day-to-day of a doctorate student, with a focus on the social factor, if more women are to be inclined to become one. In terms of time management and freedom to set their own

schedules around their priorities or responsibilities, women view the doctorate degree as being more permissive, making it an ideal choice for those who value this aspect.

Q2.: Who are the women who choose the path of academia in Computer Science?

A2: Unsurprisingly so, women in Computer Science academia are very diverse, both in terms of their backgrounds and in terms of personal interests, chosen research topics, and the reasons they chose to go into academia. But there were still some prevalent remarks that allowed us to glean what these women had in common. Although it may seem like a given, it is still important to mention that all these women first and foremost truly enjoy the act of research and all that it entails - its autonomy in some cases, the possibility to contribute to a topic they are passionate about in others. Most of these women also only realized this aptness for research work during their master's thesis, which for most is the first real taste of more in-depth academic work in their university's curriculum. Something about these women that stood out was also that - perhaps calling back to the theme of precariousness discussed in the above answer regarding how women perceive a PhD - they all had some sort of support network that allowed them to feel the confidence and security they needed to proceed to a doctorate's. But above all, we saw women who want to make an impact with their learnings.

Q3.: Why do less women, percentually, enroll and persist in Computer Science PhDs than men?

A3: Despite not fully delving into a comparison with men's perception of a PhD in Computer Science in this dissertation, we can yet gather the reasons that less women decide to go into one by eliminating factors which are not specific to the female gender. The first, a phenomenon that has seen previous studies, is the confidence gap between women and men - women are less likely to feel confident and secure or even deserving of their position, while men more easily feel comfortable in their achievements. Women constantly have to prove to themselves and others that they belong. Secondly, Computer Science academia is still seen as an environment where the male gender is predominant, and the microaggressions that accumulate as a result of this during a woman's path through a bachelor's and master's degree may mean that they will be less encouraged to pursue a PhD that might imply four or five more years of this. Due to the leaky pipeline, there are also less female role models for women to look up or ask questions to, contributing to a sense of isolation. Women not only have the responsibilities that come from academia and their personal life, they also have the added weight of fighting to remove the barriers to their own progress.

8.2 Future Work

With this dissertation, our goal was to add to the existing knowledge base by studying and reporting the perception that women have of a PhD in Computer Science. We managed to do just so, but it is interesting to consider future work that may stem from this and other researches. Firstly, it is natural to want to see how representative the obtained results are at a wider scale, and as such it would be interesting to have the scope broadened, both geographically and in terms of gender. The latter would be particularly interesting in gauging the experience of those with different gender identities - here not just in terms of having men as a term of comparison, but non-binary persons and others who might have lived a different reality in academia. Expanding the research to a broader selection of countries, across continents, would also be of interest.

Another target of interest would be those who are enrolled in Computer Science degrees exclusively for women. This being a somewhat recent phenomenon, and to the best of our knowledge still understudied, makes it a prime topic for future research. It may also be used for comparison with the experiences of women in classic mixed Computer Science courses, assessing what is working in their favour, and whether it can be implemented at a wider scale.

Throughout this study we also gauged the perception that women in PhDs - or those who have attained one - have of the industry, and how they in turn perceive doctorate women. It would be compelling to inquire with companies about this same topic and clarify whether these perceptions match. This could involve gauging their views on hiring doctorates, any apprehension on their part if justified, and judging whether these companies' views stem from having doctorates in their higher boards, or lack thereof.

And finally, it would be valuable to review the applicability of the uncovered themes in this dissertation at a larger scale. This could come in the form of programs partnering women with others in their degree that might help guide them, or demystifying the daily lives of PhD students by having undergraduate and graduate students engage with them more closely, for example. It could also come in the form of good practices that were confirmed and solidified through these women's testimonies. Along with other tried and tested methods of retaining women in the Computer Science academic path, implementing these at a departmental level could wield positive results.

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APPENDIX 1 - TRANSCRIPT CODING

Transcript Coding

Code	Sentences	Occurrences	Count
<p>Research during masters' generates interest in a PhD</p>	<p>00 "When I got to my thesis I fell in love with research"</p> <p>01 "It was more out of personal enjoyment that I realized, as a researcher during my master's, it was something I identified myself with"</p> <p>02 "Meanwhile I managed to change the course of my thesis and realized I'm enjoying the theme a lot, and would like to continue to learn more"</p> <p>03 "When I was doing my master's I really liked doing my thesis, it was an experience I loved"</p> <p>06 "I had the opportunity to cover a theme which I love and above all - and I really mean this - I fell in love with research"</p> <p>13 "When doing my master's I felt like I wanted to know a bit more and went on to do a PhD" + "I enjoyed my master's so much, the thesis and all that, that I wanted to do a PhD"</p>	<p>00, 01, 02, 03, 13</p>	<p>5</p>
<p>Bad experience in the industry</p>	<p>00 "I knew I didn't like working in the industry because I had an internship (...) and that experience, for me, was really bad"</p> <p>11 "I interviewed for one IT company. And I got rejected honestly. And then I swear to myself, I would never sit on another interview"</p>	<p>00, 11</p>	<p>2</p>
<p>Finances are determining / Lack of government support</p>	<p>00 "A doctoral degree is something really expensive (...) I didn't want to go into one without having a scholarship"</p> <p>01 "In Brasil it wasn't possible to obtain a scholarship (...) It's a factor that worried me in the beginning (...)"</p> <p>+</p> <p>"My fiancée also works in technology (...) I work with him in some projects (...) so we saw that it wouldn't be a problem"</p>	<p>00, 01, 02, 03, 05, 06, 09, 10, 11, 13</p>	<p>10</p>

	<p>02 “Four years living from a scholarship, with no deductions or vacation subsidies, nor salary increases is annoying”</p> <p>03 “You begin to want your independence, begin to want your own house, to have your own space and in some cases to start a family, etc. and that becomes really complicated in your current conditions” + “The industry definitely beats academia. Both in terms of entry salary, and in terms of career progression and salary progression + “Scholarship values are not competitive with the offered salaries, besides there being 4 / 5 years of salary stagnation” + “You want to take a loan, and having a scholarship from a foundation you don’t have stability, so they’ll give you much worse conditions, if they even accept you”</p> <p>05 “For four years you don’t have the same salary evolution you would see in a company” + “You get into a company and, if you’re in Computer Science, in around six months you’ll have an open-ended contract. Through the eyes of the government, you’re much more stable this way than as a scholarship fellow” + “Stigma from the government, for loans and those sorts of things”</p> <p>06 “I’m a very independent person. And at this moment I’m living at my parents’ house, but I don’t see myself doing that in the future, I want to build my own future. And a PhD would imply four years where I’m dependent on my parents (...) and this was a big con”</p> <p>09 (...)</p> <p>10 “It just feels good to be in the corporate environment for the pay, definitely, which is substantially more than in the academic world”</p> <p>11 “The cons, definitely the money. You have to choose what you want to prioritize. So I prioritize research and what I feel like</p>		
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	<p>gives me peace of mind”</p> <p>13 “The income at the end of the month is also a bit tight” + “Some of my female colleagues dropped out of the PhD because they looked and thought “I’m 28, I’m in a PhD, I have no [social security] deductions for example, what’s it going to be like? How will I retire?”</p>		
<p>Research is an isolating experience</p>	<p>00 “A bit of a lonesome task (...) Besides you and your mentor, very little people are looking into this niche topic”</p> <p>05 “The PhD is too isolated (...) also a bit of a strain at the social level, feeling alone, feeling like you’re the only one working for that” + “As interesting as the project may be, you’re doing it alone”</p> <p>06 “A negative aspect for me was that I really believe social life is really important, when undertaking demanding intellectual work (...) It’s important to take a break, it’s important to talk to other people, it’s important that your head gets out of the research mental space”</p> <p>08 “Most things are not done alone. A PhD is one of them (...) That social environment and feeling at ease help people a lot to in fact enjoy what they’re doing, feeling like they’re evolving and learning (...) It’s completely necessary, that more social aspect and being surrounded by people who are doing the same as we are”</p> <p>12 “You could feel a little bit isolated because of the cultural differences and also because you’re working by yourself”</p> <p>13 “A PhD is very lonely work (...) In the beginning it’s amusing to be there and write some scientific papers, but after you write 4, 5, 6, 7, it gets a little dull” + “I’m at my little cubicle at home looking at the computer all day, and for me that breaks my spirit a bit”</p>	<p>00, 05, 06, 08, 12, 13</p>	<p>6</p>
<p>PhD is too big of a compromise in terms of time</p>	<p>00 “The fact that it’s a lot of time scares most people off, because it’s a four to five year compromise”</p> <p>05 “A person is finishing their master’s,</p>	<p>00, 05, 06, 08, 09</p>	<p>5</p>

	<p>maybe it's something they longed to finish, to close the cycle. Considering four more years (...) for someone who is 23/24 when they finish, is a bit scary (...) so, another negative aspect"</p> <p>06 "I was sincerely getting a bit tired of studying, and just wanted to finish the course as fast as possible"</p> <p>08 "It's between three to five more years of my life, in the same place"</p> <p>09 "It's also a very long commitment for a lot of people (...) they think it's probably gonna be like undergrad but only twice as long"</p>		
<p>Time management and flexible scheduling are important</p>	<p>00 "The fact that I have the freedom to be at home and do things when I feel like, helps (...) As long as things show up done, we're flexible"</p> <p>01 "All my research can be done online (...) All of a sudden if it were any other type of job, having to commute and everything would be more complicated" + "The question of schedule flexibilization would encourage many, many women to consider doing a PhD further ahead, because it would make their load a little lighter"</p> <p>02 "Scheduling flexibility, being able to more easily choose what I work on without being limited to the technologies each company uses (...) the possibility to travel to several places to attend conferences, the possibility to work remotely and the dynamic environment"</p> <p>05 "Despite having a lot of free time, things were not well stipulated" + "Doing a PhD - I would have more free time but maybe not as separate [from working time]"</p> <p>08 "It's to 'separate the waters'. We have our work area and our relaxing area. I think that quarantine showed us that having a workplace, a place where you go to do something specific, is beneficial." + "I think it's sort of a calmer work, and I</p>	<p>00, 01, 02, 05, 08, 09, 10, 11</p>	<p>8</p>

	<p>think it's more interesting than maybe working at a company" + "At the same time we also don't have the pressure of working for a client and meeting deadlines" + "It has to do with (...) what we prefer: to have things defined for us or to define them ourselves"</p> <p>09 "You work a lot but you work flexibly. I'm a night owl (...) my active hours starts after four. And this is something that corporate world doesn't support" + "The work-life balance, I think, got better since I started my PhD" + "It's all about your personal time management so if you're good at it, a PhD will be a better choice for you than the corporate world, because in the corporate world, you will be kind of ordered to do whatever you have to do"</p> <p>10 "As long as you get your work done, nobody's going to ask if you come in at 9:30, if you come in at 10, if you don't come one day and you say you're working from home or taking a day off"</p> <p>11 "When we're writing papers or doing research, it doesn't matter if I do it in a day or a night. The timing is completely up to me, which I always liked very much"</p>		
Male-dominated environment is felt	<p>00 "The internship I did was at a company with 19 employees, all software developers and I was the only woman. So that was more complicated"</p> <p>05 "I think I could say in a company it would be worse. Not in a negative sense, just speaking in terms of quantity [of men]"</p> <p>01 "Obviously since graduation, the classroom, most are (...) men there, and few women"</p> <p>06 "When I saw we were such few women I was a bit surprised and from there on began a path of discovery of this situation"</p> <p>09 "I was working in an IT department. And I was the only woman in the department, all the six years"</p> <p>+ "Sometimes it's just a bit lonely. If you try to explain a problem about your physical</p>	00, 05, 01, 06, 09, 10, 13	7

	<p>feeling or you're getting a little bit more emotional (...) and you're like "oh, maybe it's just me, because I'm a woman (...) You see all the other men sitting in the room, and they're fine, and nothing affects them, and they just want to get the job done and go home. And you're overthinking (...) So, it would have been nice to have women around to just talk to"</p> <p>10 "IT departments are generally very male dominated. So it is a bit intimidating"</p> <p>13 "We were 17 girls to 100 guys at that time. It was a giant discrepancy. Now we're like 4 or 5 girls to 20 guys, the discrepancy continues"</p>		
Bigger effort necessary to be heard is demotivating	<p>00 "I don't know if it's due to being a woman or because of being too young - sometimes I have to try a little harder to get the idea across, and for them to believe what I'm saying indeed happens the way I'm saying"</p> <p>10 "I did work with three men in the same lab. And that meant I was interrupted a lot, spoke over a lot, and there was a bit of apprehensiveness over 'Is this how it's going to be?'" + "It is demotivating in the way of there's small things but when you think of it long term 'Am I going to have to deal with this forever? Will I ever gain the credibility in which you stop talking over me? Or in which you stop questioning my ideas and actually understand that I'm not talking out of my imagination" + "I was in meeting rooms where I would ask a competent question and I would be told that's a very good question and then the man explaining would turn around and explain it to my coworker instead of me (...) That was very demoralizing"</p>	00, 10	2
Academia accommodates women better	<p>00 "In the industry the fact that I'm a woman has a lot more weight than in academia"</p> <p>01 "Due to still being a heavily male environment, they end up expecting the same of you: for you to dedicate that extra time outside the workload" + "In academia I can control the scheduling question"</p>	00, 01, 03	3

	<p>better, the time I dedicate to work, without affecting my personal life”</p> <p>03 “At the industry level I think [female] representation is a bit smaller. This will surely vary from company to company. (...) It also depends on job position a lot”</p>		
PhD seen as being only for excellent students	00 “Before I got into a PhD (...) I thought PhDs were just for exceptional students, for those students with out-of-this-world grades (...) Throughout my academic path I never saw myself as a doctorate student”	00	1
Importance of role models and representation	<p>00 “It was very beneficial for me to see women in positions of power, also within the department (...) Having role models to follow and being able to aspire to reach a certain level”</p> <p>01 “We also see in those mirrors (...) where we can get and that it is possible to follow that path, having that support, showing ‘Look, yes, it can be done’”</p> <p>07 “I think it’s also a positive thing: our department has a lot of female professors”</p> <p>11 “It’s motivating to have female professor, there are female PhD students, they are all doing the same work”</p> <p>13 “It would also help to have some female representation in the department. There are female professor, sure, but there’s still few”</p> <p>+ “There’s a whole life. And female representation helps us to also understand our own future, we see what it’s going to be like too, how we’ll be able to manage the next few years”</p> <p>+ “There’s a lot more girls in the course now, that helps (...) a lot more because they [men] start to get used to the idea. If they got in with the same or better grades than them, then they are also just as good or better”</p>	00, 01, 07, 11, 13	5
Direct invite from a mentor to do a PhD is determining	00 “My professor made me an invite at the end, I pondered for a bit and decided to accept because I really liked it”	00, 03, 05, 06, 07, 08, 10	7

	<p>03 “My mentors (...) asked me if I wanted to remain and do a PhD”</p> <p>05 “No invite to do a PhD was made for me, I can definitely name that as a factor. So I couldn’t even do the comparison of ‘I have a company offer and a PhD offer, which one will I do?’”</p> <p>06 “There was the invite, and from that moment things became more serious” + “I had never seriously considered it until the invite came along”</p> <p>07 “It was really something I thought for myself. Maybe if I had a professor who would give me some incentive in that sense, maybe I would have considered it more in-depth”</p> <p>08 “An incentive is also something that always inflates someone’s ego (...) it’s good to be seen and gives us more to ponder. I know people who have had that invite, even if vaguely spoken about and it always leaves some interest”</p> <p>10 “I was having some discussions with a professor and she was telling me it would be a great environment for you, and you could definitely find a place, and then I started to think maybe this is an option” + “A professor told me there’s definitely space if you want to start into research and that gave me an extra push (...) It started growing as a possibility” + “When you get encouragement it does mean a lot”</p>		
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01

<p>Doing a PhD was not an initial intention / Seen as a natural academic progression</p>	<p>00 “My initial idea always was to get a master’s”</p> <p>01 “I had no intention of doing a PhD, I always wanted to do a master’s”</p> <p>03 “My idea always was to do a master’s then proceed to the industry”</p> <p>04 “I had decided that when I’d finished my thesis, I was going to enter the job market”</p> <p>05 “I had no plans of following academia. I</p>	<p>00, 01, 03, 04, 05, 07, 10, 12</p>	<p>8</p>
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	<p>always thought about joining a company”</p> <p>07 “For me it wasn’t so obvious that the right choice was to go straight into the job market. So yes, I considered that possibility [of going into a PhD]”</p> <p>10 “I felt like it was quite a natural progression” + “Honestly I kind of went through my education as a ‘why not?’”</p> <p>12 “It happened by chance because I was working in the industry at that time. And it was not my purpose at that specific moment to start a PhD”</p> <p>+ “It was something that I could do. It was not mandatory. At that moment I wasn’t feeling like I need a PhD in order to feel myself complete”</p>		
Professorship experience serves as an encourager to get a PhD	<p>01 “I really enjoyed giving lectures (...) if I want to continue in that path, I need a doctoral degree”</p> <p>03 “If I finish my PhD my plan will then be to remain in academia and try to stay here and give lectures”</p> <p>05 “I considered it (...) since I enjoyed giving lectures, if [a PhD] could make sense for me”</p> <p>11 “Another thing is you get to teach, which I like very much. Being among the students, you get to teach the subjects, and you get a lot of ideas from that. Sometimes someone asks a question and it sticks in your mind, like Oh this is interesting, something can happen out of this” + “You get to learn a lot by teaching. I really believe that. So it was always helpful”</p> <p>12 “I thought I wouldn’t enjoy to have the chance to teach, but I have. I’m basically a teaching assistant right now”</p>	01, 03 05, 11, 12	5
Interest in developing a specific topic to which the industry does not correspond	<p>01 “When I decided to do a PhD, I already had in mind to continue that work (...) little talked about, little understood, little of the interest of those working in the industry”</p>	01	1

<p>No gender discrimination was felt</p>	<p>01 "I had no issues, no obstacles, I felt no difference in progressing in my research, or even my work"</p> <p>02 "I never felt that it was the fact that I was a woman that was impeding me from getting something or blocking opportunities, nor do I feel disdain or disbelief"</p> <p>03 "I always felt very welcome in both environments. I never felt any level of discrimination."</p> <p>04 "I always felt that the university was extremely inclusive. I always felt that if at any time I needed anything, either from colleagues or from teachers, they were available and I didn't feel that there was a difference between boys and girls"</p> <p>05 "I don't think I felt any stigma (...) neither in a company or in college, in relation to being a woman versus being a man"</p> <p>07 "In terms of (...) relations with colleagues, I don't think I felt much [discrimination]"</p> <p>08 "Otherwise I think I never necessarily felt the difference. Sometimes there are social comments in general, not necessarily in relation to the course itself, but nothing that is serious or contains serious insinuations (...) It has always passed by, as those kinds of opinions for me really don't make any kind of sense. And I have also always been in activities where there were more boys than girls".</p> <p>11 "We all eat together, we all work together. We never discriminate" + "Never crossed my mind that it should be intimidating"</p>	<p>01, 02, 03, 04, 05, 07, 08</p>	<p>7</p>
<p>Decision to do a PhD is related to a type of person</p>	<p>01 "It has a lot to do with profile. Because the academic area is not for everyone" + "Those who already have that propensity to go for a doctorate, then they will better weigh those personal characteristics of what they want in life"</p>	<p>01</p>	<p>1</p>
<p>Being a woman implies spending extra time outside</p>	<p>01 "Men can dedicate more to work and the academic part at the same time because they are not concerned with other activities"</p>	<p>01, 09, 13</p>	<p>3</p>

studies	<p>that are considered feminine" + "Women (...) have the academic part and the professional part and the home part (...) it is like a third workload"</p> <p>09 "Going back into academia is more common for women if they look at family, flexibility and things like that (...) A lot more with family and caring responsibilities, and for men it's more about their own preferences" + "There might be slightly different motivators for men, maybe it's more about being exposed to innovative research (...) rather than priorities (...) Whereas for women you have to consider everything. You have to make impact in the world but you have to think also "ok, what am I gonna do if I have a family?"</p> <p>13 "We are there doing our PhD, and we still go home, we still cook, we still probably travel by transport and some of [the men] don't".</p>		
Interest in a PhD comes from identification with a specific theme	<p>01 "You find your path, what you like to do, what you identify with, and then you'll be very good" + "I think it's more important that we can get to 'this is for me', 'this is not for me'"</p> <p>09 "There was never a woman apart from me. And that kind of got me thinking about other education and research about "how do I change that", that there were no women, all of a sudden"</p> <p>10 "I wanted to do a PhD because it's something required if you want to stay in academia or would be interested in research (...) but in Denmark, I did not have the grades for it" + "You don't have to be a good student to be a good researcher"</p>	01, 09, 10	3

02

Bad experience with research causes a PhD to be discarded as an option	02 "I realised that I didn't like what I was working on. The same thing happened at the beginning of my thesis. And in a way that made me reject the possibility to continue for a PhD"	02, 07	2
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	07 "I didn't finish my thesis (...) I had to change themes so that things could work" + "The situation of having had the "failed" thesis, the first theme, I think it massacred me a little at a psychological level and then I didn't have the capacity to continue for a doctorate"		
Lack of industry experience as a negative aspect of a PhD	02 "Since I never did a Computer Science internship in the industry and it was all at an academic level, I feel I can't choose a PhD without experiencing the other side first" 10 "It might stunt me if I don't have any connection with the industry in these three years. So I'm pushing my supervisor and I'm pushing myself to do a lot of projects with the industry"	02, 10	2
Not limiting self to one theme makes the industry preferable	02 "In the industry I can more easily change areas if I do not like one or want to try another, while in a doctorate, from the moment I choose the area, I cannot change without losing funding" + "This fear of committing myself to an area (...) is related (...) to the fact that I think it will restrict the remainder of my path". 08 "The problem with the PhD is that it's also super specific, so it closes doors to other things that are more general or are from another area"	02, 08	2
PhD as an option being considered	02 "If I don't like the industry I can always terminate a contract and come for a PhD later, but stopping a PhD in the middle doesn't seem like an elegant solution to me"	02	1
Doctorates are overqualified when entering the industry	02 "I get the idea that in the industry they avoid doctorates a bit because they think they are too qualified" 03 "What I think sometimes happens is that whole overqualification thing. Some companies see it that way". 06 "There is no advantage in having a doctorate in computer science and going into the industry in Portugal (...) you are not more valued (...) in fact you become so qualified that no one can pay you what you are worth". 07 "Some say it might even hinder you, in	02, 03, 06, 07, 09, 13	6

	<p>the sense that they don't want to hire people with PhDs because it's not necessary, it's kind of over-qualified"</p> <p>09 "You probably shouldn't even mention [having a PhD] in your CV because they might think you're overqualified"</p> <p>13 "When you go to look for a job you have a CV saying 'I have a PhD' and then you should have another CV saying 'I have a Master's degree'"</p>		
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03

<p>Demystifying the PhD is essential - still abstract, so transparency and accessibility matter</p>	<p>03 "When we enter your bachelor's degree, very few people know what a doctorate is"</p> <p>04 "I think there is a lack of information (...) what do you get out of it? There is no information about it. That's why I felt the need to talk to a professor."</p> <p>06 "What would it be like now if I started [a PhD]? Would I have a room just for me? Would I be in a room with people? How is the daily life, the social part of the doctorate? Because at the end of the day, it's not just about thinking "in four years I'll have a PhD", no, I'll have to live those four years, so I have to think about what my daily life is going to be like."</p> <p>07 "Even the thesis is a bit abstract, because I was never told what it was supposed to be"</p> <p>+</p> <p>"Maybe if I had had more knowledge about what was (...) the life of a doctorate, it would have weighed more heavily on my decision."</p> <p>08 "I have colleagues (...) who are doing doctoral studies and I also like what they are doing (...) It has been interesting to see and have some notion of how it actually works"</p> <p>+ "I think that this is something that is necessary (...) talks by doctoral students about what they did and what the experience is like, but of course (...) they sprinkle a lot of flowers on top, so actually seeing the day to day and actually seeing</p>	<p>03, 04, 06, 07, 08, 10, 12</p>	<p>7</p>
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	<p>the meetings and the things they do is completely different than just listening to their opinion (...) once everything is done".</p> <p>10 "I don't come from an environment where people have PhDs so especially at the beginning there was a lot of 'Is this normal for a PhD or is it something that's happening just to me?'"</p> <p>+</p> <p>"Representation is important but for me it was more than seeing somebody to aspire to - it was more of having somebody to ask 'How is this supposed to be?'"</p> <p>+</p> <p>"There's nobody to ask these questions. A lot of the things I've learned about PhDs, I learned from Youtube. Things about structures of papers or things about grants"</p> <p>+</p> <p>"This is massive and it can be extremely isolating, especially if you come from a background that doesn't have anything to do with these things"</p> <p>12 "My oldest brother has a PhD and he is kind of an inspiration to me. So it's something that was not completely new, neither for me or my family. So it was on the table"</p> <p>+</p> <p>"It would be good to have some guidance for those that have not lived for all our lives in academia" + "It was been a really nice experience so far and a huge part of it is because my supervisors are really supportive (...) always willing to help with anything, not only things that are related with research"</p> <p>+</p> <p>"You arrive with some idea of what you need to do or what you need to accomplish to get the degree. But then you discover that it's completely different and you are not mentally prepared for that" + "Too many universities, and every university does things differently"</p>		
<p>Importance of choosing good mentors, more than the research topic itself</p>	<p>03 "A very important thing at the level of academia is to be with the right people (...) when I chose the thesis, I chose for the advisors (...) I already knew it was going to be very interesting exactly because of the type of people I was working with"</p>	<p>03</p>	<p>1</p>

<p>PhDs are not valued in the industry</p>	<p>03 "This duality is a little difficult for outsiders to understand because, yes, you are studying but you are working" + "Those who haven't been through the process don't really understand what the advantage and growth is there"</p> <p>04 "There are some courses where a doctorate is really important. And I always had this perception that (...) in computer engineering, at a business level, it wasn't something very relevant"</p> <p>07 "I didn't see any great advantages in terms of the future, for example, if I wanted to enter the business environment, I don't know to what extent having a doctorate would be advantageous or not".</p> <p>09 "From my experience in the industry, it makes no difference. It doesn't matter (...) If you're good enough at the technical part, nobody questions your research degrees"</p> <p>13 "Here in Portugal - and this really keeps me up at night - I don't think they value a doctorate at all".</p>	<p>03, 04, 07, 09, 13</p>	<p>5</p>
<p>Need to associate professorship with a career in research</p>	<p>03 "You find it very difficult to have any progression at research level (...) without having a career in professorship associated with it. So you can have professors who don't want to be professors".</p>	<p>03</p>	<p>1</p>
<p>A PhD opens doors both in academia and in the industry</p>	<p>03 "The PhD allows me (...) to return to teaching. So I have that opening in that way. Otherwise, if I want to continue in the industry I also have one, so basically the doctorate opens both doors for me."</p> <p>05 "Even at the business level there is research and it is much more difficult to enter without a doctorate".</p> <p>10 "I had a discussion with a woman that worked in our department and she was telling me she went into the industry, did a PhD and came back to the industry for a bit and came back in academia, you have all the time in the world, if you're gonna do it, do it, and then you can do whatever you want with it" + "A lot of people juggle industry and academia and do a bit of back and forth - they aren't that separated</p>	<p>03, 05, 10, 11, 12, 13</p>	<p>6</p>

	<p>because academia is playing a lot into the industry as well”</p> <p>11 “I’ve heard the industry is looking for female candidates when they’re hiring, they’re specifically mentioning they want female candidates, but I’ve never heard anyone say they want female PhD students”</p> <p>12 “With the PhD degree I can do both. I’ve seen positions in industry that ask for PhD graduates. I like this dynamic of learning something really well, and then try to apply, you will see how it doesn’t work, then go back to academia”</p> <p>13 “When I finish my doctorate I think I’ll go [to the industry] for another go, to clear my head a bit and disconnect myself from academia.”</p>		
<p>Maternity as an essential factor for women</p>	<p>03 “You are not entitled to maternity leave (...) And I think this can be a very big impediment”</p> <p>09 “You lose your scholarship for the time if you want to take a maternity leave” + “I’ve heard that academic jobs are very limited contracts, and maybe you have to travel the world as well. Which is not the problem, but I’m at an age where I wanted to start a family as well and I wouldn’t be able to travel as flexibly” + “In corporate world, you get a lot of support. In Ireland, you can take (...) up to one year” + “Family is probably still the most important thing for a woman (...) this will dictate my choice”</p> <p>11 “Here it doesn’t really matter because you have all the benefits but in India, being a third world country, we still don’t have proper maternity leaves” + “I’ve seen people dropping out of their jobs because you’re starting a new family” + “Men and women both get some holidays, same in academia, same in industry” + “People who are living with their families and they have kids (...) it’s very important to give them the flexibility that will help them research”</p> <p>12 “It’s quite common to have kids during the Phd. At least 3 of my peers at the research group have had kids since I started. I personally don’t know how they</p>	<p>03, 09, 11, 12, 13</p>	<p>5</p>

	<p>managed to do everything” + “Government rules regarding maternity and paternity support women and men in order to have a chance to still raise a family and keep working. That’s something that is important because women don’t have to choose between having a family or having a career. Here you can have both”</p> <p>13 "The industry makes it easier. Not least because they are much more controlled by legislation".</p> <p>+</p> <p>"While we are in a PhD I think it can be easier because we can manage our own time, even if we want to be at home with the child and continue the PhD."</p> <p>+</p> <p>"Our time is a bit more accounted for, especially on a biological level, and as long as they don't worry much about that, there's not going to be a specific appeal for women to go for PhDs"</p>		
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04

<p>Research is too theoretical, need for more hands-on activities</p>	<p>04 "For those who want to continue and who have interest in the research and academic part, yes, it's an added value. But those who have interest - and it's my case - in the practical part and the business part, it wouldn't add much" + "In [our project] I felt like I was getting hands on"</p> <p>05 "People doing projects are working in a team, developing things, and it's much more similar to what goes on in a company"</p>	<p>04, 05</p>	<p>2</p>
<p>Preference for projects with more societal impact (to which the industry does not correspond)</p>	<p>04 "What captivates me about all the projects [my advisor] develops is that they have an impact, deep down, in society"</p> <p>06 "I want to do something for the world and I see technology as a means to do that" + "Very much in this sense of helping, very much in the altruistic sense (...) which, honestly, after seeing the course I think it's not really something you do a lot of" + "The girls I met (...) wanted to somehow have a job that had an impact on society, which allowed them to have the power to do things"</p>	<p>04, 06, 09</p>	<p>3</p>

	<p>for the better, to be able to help, to be able to contribute"</p> <p>09 "It's not only about the research, it's about the impact. I feel like I can impact and I can make a difference with my PhD research more than I could have done in, say, corporate world"</p>		
Discriminating comments from colleagues	<p>04 "The most I found were the comments like, eh the 10%, that we were the 10% [of women] to stand out"</p> <p>06 "I started to hear things I had never heard before in my life, such as 'You got a good grade because you batted your eyelashes at the teacher'" + "'This must be more difficult for you because boys already have their brains turned to computer science (...), for you it's an effort'" + "I often heard that in groups where it was a boy and a girl 'Ah he did the project', and 'She got a better grade on the test, but just because he was doing the project for her instead of studying'"</p> <p>08 "I remember there were comments about being the only girl to enter (...) There are always colleagues who may have less inclusive or judgmental opinions. I had some colleagues that I got to do projects with, who had ideas in relation to gender that were a little bit questionable, and towards why I got certain grades, or how I managed to and they didn't"</p> <p>10 "Whenever I would walk into a class, it was just me and everybody would look at me (...) I felt like I had a lot of things explained to me by my classmates that didn't need to be explained to me" + "It's definitely a double take a lot of the time that they need to do on me (...) There's been a lot of 'Ah you're a woman... cute that you're doing this" but there hasn't been a lot of blatant pushback"</p> <p>13 "The only difference I felt was between colleagues, you know? For example, in a subject in which I got a 20/20 they'd ask "oh, who did the work? (...) There was much more of that "ah, you're a girl, it would suit you better to go to chemistry, or bioengineering", that thing of "bioengineering is a women's course, computer science is a men's course".</p>	04, 06, 08, 10, 13	5

A PhD does not correspond to the need for visible results	04 "The research part is interesting, but then (...) it ends up blocking you at a practical level. In other words, research doesn't always work, you don't always get results". + "I get there and I see that I am doing something, I am creating something that people will use. And at the research level (...) you get results, but then the project ends and it was no use, most of the time".	04	1
Liking for research but not as a career	04 "Although I like [research], I don't see myself doing it over a long period"	04	1
Clearer separation between work and personal time in the industry	05 "In a company you enter at one hour, you leave at another, although remote working has those problems of people being able to contact you at any hour. You have things limited, you can separate your personal time from your working time". 04 "Sometimes I think there's a bit too much 'at ease' in the research and academic part. I think maybe sometimes they should limit it more. And with all the remote part that exists now with the pandemic, it's even worse." 07 "I don't bring work home (...) it doesn't drag on beyond working hours".	04, 05, 07	3

05

Lack of stability in academia / Precariousness	05 "You don't have something stable" + "You don't know what's next. That is, next year I might not have the opportunity to have this scholarship, there might be someone else, there might not be a vacancy" 09 "I was fortunate enough because I could take a career break for four years, which means my place is kind of saved. + "Maybe among women, it is more typical that if you really want to do a PhD, you try to secure yourself somehow, because you know it's not as secure as a job" 13 "Doctoral work, university teaching work, only when you're a cathedratric professor or exclusive to the university do you have	05, 09, 13	3
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	security. Because until then, it's a very precarious job".		
PhD not seen as professional experience	<p>05 "There are certain companies that do not consider a doctorate to be professional experience, and therefore do not want to pay the person the value of a doctorate" + "Four years is more or less enough to become senior in a company - and maybe [after your PhD] you will not have this equivalence when you join the company"</p> <p>07 "Nowadays, experience counts more than the degree (...) There are companies that rely a lot on the fact that you have a degree but there are others that prefer you to have more experience".</p>	05, 07	2

06

Discrimination leads to lack of confidence	<p>06 "There was a lot of things they questioned, and I honestly thought I didn't know how to program"</p> <p>10 "When you speak to men, they're very confident to be where they are. And that's phenomenal, I think we should get there (...) For us it's a lot of questioning like is this my place, is this where I should be?" + "There's a lot of microaggressions, and some people just stop because they can't see themselves doing that for the rest of their lives, or even for three to five years. I think that's also because we have so many men in academia now" + "It is still seen as a hostile environment (...) as a women you are even more so supposed to be submissive in one way or another, on top of being in the inferior position"</p>	06, 10	2
Discrimination felt from professors	<p>06 "I spoke to two friends at the time who told me exactly the same thing, that they couldn't learn to program because they felt that their doubts weren't answered, and that no teacher wasted time with them" + "It even happened that I saw a teacher staying for example one hour with a classmate, and when I went there with my friend he said 'If you don't understand the way I'm explaining it, I can't explain it any other way' and I felt that it was because we were girls".</p> <p>07 "At the level of clearing up doubts (...) I could have exactly the same question as a</p>	06, 07, 08	3

	<p>male classmate, but just because I was a girl they were not clarified in the same way"</p> <p>08 "A master's student who was giving practical lessons - my classmate and I went to solve some questions. And this teacher only spoke to my classmate. He practically didn't look at me, and asked questions(...) only from my classmate. I ended up not answering anything, because he wasn't even looking at or talking to me.</p>		
Academia does not accommodate women well	<p>06 "The environment was not conducive for learning. And it was not due to lack of ability" + "There are many details that, if the person is sensitive or starts being introspective and thinking about what is happening (...), the way you see yourself in that environment (...), the person will come to realise certain situations" + "Even the integration, (...) it seems you had to accept that you were 'the girl', it seems you couldn't have your own personality"</p>	06	1
Industry accommodates women better	<p>06 "I felt great support when I was working (...), quite motivated, I felt that I was finally applying my skills (...), I was evolving more and more, so I felt really good in the world of work in contrast to [university]"</p>	06	1
Women in positions of power still causes discomfort	<p>06 "When you are a junior, when you are learning, everything is fine (...) When you go into leadership positions it is more complicated (...) because a woman or a girl needing help is socially accepted (...), now when a woman is teaching you, that is already put in cause; for some people it is already challenging"</p>	06	1
Research allows for appealing creative activity	<p>06 "That which I had not managed to have in the course until then, which was the more creative part, the exploratory part, the human part of technology, was what I got in research" + "It brought everything together, (...) competences that are the soft skills"</p>	06	1

07

Research requires too much autonomy	<p>07 "Many of the things I didn't know I had to define myself. I was waiting to be told more or less a few guidelines (...) and then I was completely lost".</p>	07	1
Women are more	<p>07 "I was always a little more inhibited at the</p>	07	1

affected by a lack of confidence	level of (...) asking questions, afraid that I would be judged precisely because I was a girl" + "It's something that is very much in our subconscious (...) being a girl perhaps affects this type of thinking more"		
PhD as a way to "gain time"	07 "I think that a doctorate can also be a possibility of gaining some time. Imagining that I really had no idea what I wanted to go into in the business world, going for a PhD could even be a great option." 13 "Maybe it was also the fear of going into the industry already and having to look for work and all that stress" + "Maybe doctorates are more appealing to those people who are lost".	07, 13	2
Good experience with the industry	07 "Being able to have contact with the business world was very positive. Getting out of college, realising how the subjects fitted in, or didn't fit in" + "It helped me develop other skills, honestly, that I wouldn't get at college level."	07	1

08

Long research time seen as positive	08 "I am enjoying this one more because it is a longer project and has more phases, and it is more interesting" + "They have time to think well how they want to accomplish things (...) compared to a master's thesis"	08	1
Social aspect of a PhD is essential	08 "In the industry we usually have a team that we are actually working with. In PhDs you have the colleagues that are also doing it with you, but they are not all doing exactly the same project. So in that part, working in a company should be more interesting in terms of discussing ideas." 10 "I do have people to bounce ideas off of, so that's very promising for me" + "I can just speak to people and learn about things that apply to my topic but for the people that can't do that it might be even more isolating, because then it's just you and the book or you and the Youtube video" + "I don't feel particularly isolated (...) I'm also quite confident in my place" 11 "We have a very open office space. If you need peace and quiet you just do your work. But if you just look up, you can see your friends or	08, 10, 11, 12	4

	<p>colleagues, go for small coffee breaks..." + "And cooperative stuff, sometimes you get stuck. It's not always possible to go to your supervisor for a small problem, then you can just discuss with the person who's sitting next to you. And then it just gets solved"</p> <p>12 "The social element is a really crucial factor for everything. It is really important that the student or the researcher or anyone feels part of the group when she starts any kind of work or studies"</p>		
Professorship is not a main motivation for a PhD	08 "If I could go just more for research I think I would. Giving lectures make me a bit anxious. Maybe if it's an area where I'm 100% comfortable giving classes and answering questions."	08	1

09

Exposure and impact as motivators for research	09 "To see your work out there and to see people (...) it's like 'oh, your work has been read! (...) somebody is actually interested' (...) People came up to me and we had hours long conversations because they were interested in my talks (...) You're disseminating your research. This is the most enjoyable"	09	1
Bureaucracy as a negative aspect of PhDs	09 "The less positive thing is the bureaucracy (...) An ethics application takes ages, and in my university it can take months (...) You only have 4 years (...) and if it takes them half a year to approve my ethics application I'm losing so much time"	09	1
Reasons to remain in academia diverge more between genders than those to join the industry	09 "In corporate world I think it's both women and men staying. About, I suppose certain career ambitions and career progress. I don't think the corporate one is gender-separable. I think the academia might be more gender-separable"	09	1
Personal and social support is essential	09 "If you're really growing into your society, if your family is against you going into academia, which means obviously you're not earning the money anymore, you're dependent on this tiny scholarship, you can't really start a family unless you have a lot of support - all these things could prevent women" + "I had some experience, I had some savings, I get support from my family, I have a husband, who supports me completely"	09, 12, 13	3

	<p>with that, and I knew what I'm getting into in terms of finances”</p> <p>12 “I think also part of the way that how your parents supported you when you were a child is a really important thing. They treated me in the exact same way they did for my brothers so I think that environment really helped me a lot to know that I can do it and there’s no difference between being a woman or a man”</p> <p>13 "At a family level, they always told me that ‘if you want to go and learn more, go and learn’, so I knew that at the level of my parents, they would not put any obstacles in my way" + "I was lucky enough to have a family that supported me in my decision for a doctorate, so it was easier for me".</p>		
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10

Female-centric environment is very positive	<p>10 “The fact that my supervisor is also a woman and the environment that I’m in is quite female-centric, it was definitely a plus”</p> <p>11 “When I first came here we were 3 women among 8 PhDs total. Right now we are 27 PhD students and we are 10 women. So it increased a lot” + “There are small things to do outside of your PhD, like social gatherings, meetings or just small talks or seminars. And I’ve always seen women doing this”</p> <p>12 “The perception of the group of women gave me the idea that it was more balanced. It feels good to be part of a group where we are mostly women. I think it’s nice, it’s not that common yet”</p>	10, 11, 12	3
Competitive environment seen as a negative	<p>10 “Academia can have a tendency of doing that competition thing, I’ve met people that are like ‘No, in this publication I need to be the first author’” + “I feel like there’s always a competition, and I’m not particularly fond of that”</p>	10	1
Conscience of gender equality must be created/improved	<p>10 “I think it would make a hell of a lot of a difference if we had some training for gender equality and microaggressions” + “I think this is something that’s going to be hopefully fixed with time as more of us enter academia and there’s more people to mentor the people coming in”</p>	10, 11	2

	<p>11 “Equality Week happened a few months ago here and they pointed out most of the methods we use were written by men (...) We should have a balance just to get the idea that it's not an all men world out there, there are female authors” + “I think every university should have this program just to know the facts, know what's going on, to get together and discuss and show our acknowledgement. And if anything fruitful happens, even one person, that's a win”</p>		
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11

<p>Independence in research as a positive aspect</p>	<p>11 “It felt nice to be independent and dig into something and then produce something out of it” + “The thing I liked about academia is being independent and being in full control of your stuff”</p> <p>12 “It's a good opportunity, especially if you have been working in industry, where everything is urgent” + “You have enough time to think about the whole process (...) You learn to work more independently”</p>	<p>11, 12</p>	<p>2</p>
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12

N/A

13

N/A

