EUGAIN

Best Practices from Bachelor's/Master's Studies to Ph.D.

- **Amal Mersni**
  International University of Sarajevo, Bosnia and Herzegovina

- **Caroline Oehlhorn**
  University of Bamberg, Germany

- **Erika Ábrahám**
  RWTH Aachen University, Germany

- **Karima Boudaoud**
  Université Côte d'Azur, France

- **Larissa Schmid**
  Karlsruhe Institute of Technology, Germany

- **Matilde Pato**
  Lisbon School of Engineering from Lisbon Polytechnic, Portugal

- **Miguel Goulão**
  NOVA University & NOVA LINCS, Portugal

- **Milena Vujošević Janičić**
  University of Belgrade, Serbia

- **Oleksandra Yeremenko**
  Kharkiv National University of Radio Electronics, Ukraine

- **Özge Büyükdağlı**
  International University of Sarajevo, Bosnia and Herzegovina

- **Sarah Jane Delany**
  Technological University Dublin, Ireland

- **Ute Schmid**
  University of Bamberg, Germany

Contents

Informatics attracts fewer women than men, and the percentage of women decreases with advancing academic stages. This phenomenon, often called the *"leaky pipeline"* (Clark Blickenstaff 2005), is evident from a significant drop-off in the proportion of women completing a Doctor of Philosophy (Ph.D.) in Informatics compared to those finishing a Master of Science (M.Sc.) degree, both in Europe and the United States. The declines between educational levels showcase the field's challenge with retaining and progressing female students.

According to Informatics Europe's figures (Informatics Europe 2023), in Europe, around 20% of the Informatics Ph.D. diplomas have been awarded to female students since 2010/2011, with minimal yearly variations – 19.1%, in 2021/2022. Figure 1 presents the evolution of enrolled and graduated women in the Bachelor of Science (B.Sc.), M.Sc. and Ph.D. levels from 2011 to 2022. While the percentage of women pursuing a Ph.D. in Informatics has stalled, there are small signs of progress at the master's level. Over the past decade, the proportion of female students completing a master's in Informatics has slowly but steadily grown – from 19.5% in 2010/2011 to 27.6% in 2021/2022. This steady growth contrasts with undergraduate degrees, where women earning bachelor's degrees in Informatics have edged up slower, from 17.2% to 21.1% over that same period. On average, only 20% of undergraduate Informatics degrees are awarded to women.
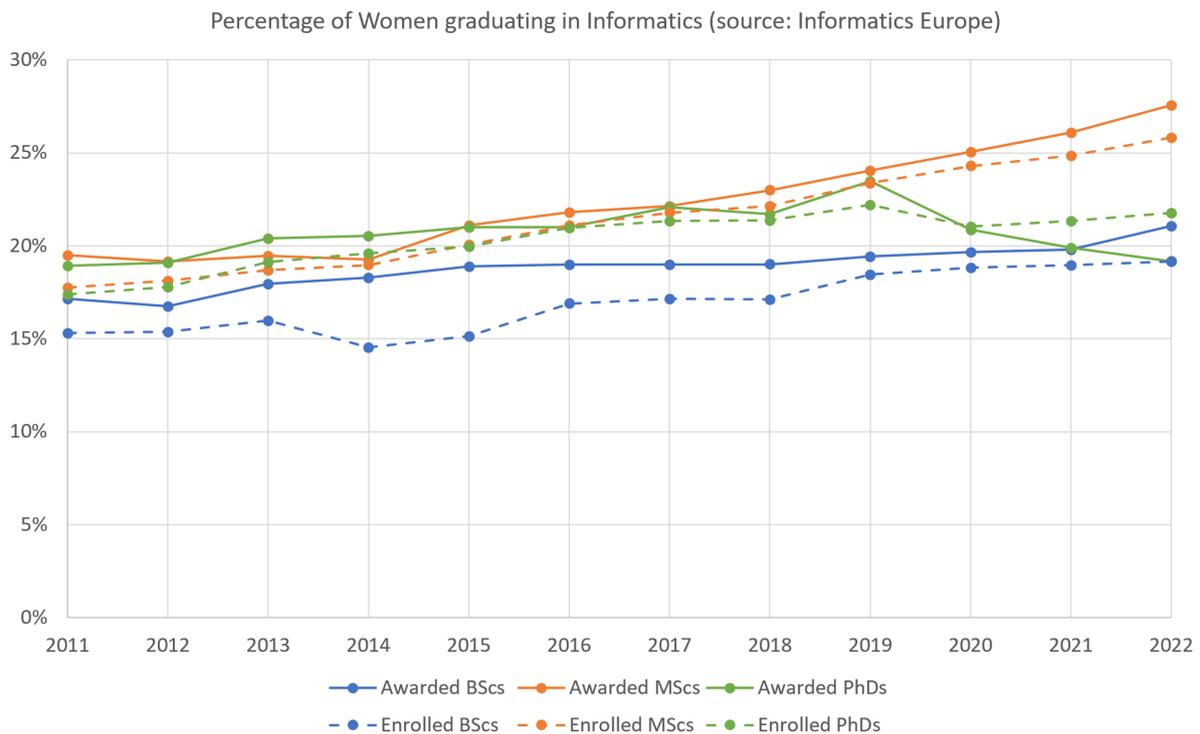

Figure 1: Percentage of Women in Informatics degrees
(source: Informatics Europe Higher Education Data Portal)

Notably, female students enrolling in Informatics programmes demonstrate strong persistence, regardless of degree. The share of enrolled female students earning a final degree is higher than the initial female enrolment percentages at both M.Sc. and Bachelor of Science (B.Sc.) levels. Though far from parity, these high completion rates for enrolled women underscore their tenacity in Informatics programmes despite substantial gender imbalance. Sustaining the upward momentum, though incremental, will be vital in narrowing these gaps. The comparatively higher percentage of female students completing their M.Sc. in Informatics could suggest a bigger pool of potential Ph.D. candidates. Yet, the evolution of female Ph.D. Informatics candidates is essentially stagnant, starkly contrasting with the encouraging evolution observed for those studying for M.Sc. degrees.

Ph.D. programmes in Informatics are pivotal in shaping a resilient, versatile, and inclusive future for technology. Prioritising diversity and empowering women pursuing doctoral studies in Informatics goes beyond addressing equality; it catalyses untapped potential, contributing to a more vibrant future for the industry and society.

This guidebook highlights the primary obstacles and prospects associated with attracting female Ph.D. candidates to embark on a journey in Informatics. We highlight initiatives targeted at helping women decide if a Ph.D. in Informatics is a good option for them. We also delve into the best practices and hurdles in retaining these students throughout their doctoral studies.

Note: We opted for a gender-sensitive bibliography style: to increase visibility we have cited women and men by including their first name in full.

References

Clark Blickenstaff, Jacob (2005). "Women and science careers: leaky pipeline or gender filter?" In: *Gender and education* 17.4, pp. 369–386. DOI: 10.1080/09540250500145072.

Informatics Europe (2023). *Higher Education Data Portal.* https://www.informatics-europe.org/data-portal/. Accessed: 2024-01-31.

Women are underrepresented in Informatics, with a declining percentage of representation as career stages advance, a phenomenon known as the "leaky pipeline", particularly observed in academia. Few women pursue Ph.D. studies after completing their master's studies in Informatics, highlighting the importance of empowering women at this career stage. To do so, we must identify why fewer women progress to Ph.D. studies than men. The motivations of female Ph.D. students are also valuable to highlight, as they can offer insights and guidelines for increasing the enrolment of female students pursuing their Ph.D. Figure 2 maps the most prominent factors supporting or blocking women's enrolment in Informatics Ph.D. studies and initiatives that can help in this decision. In this section, we further explore these factors and initiatives.
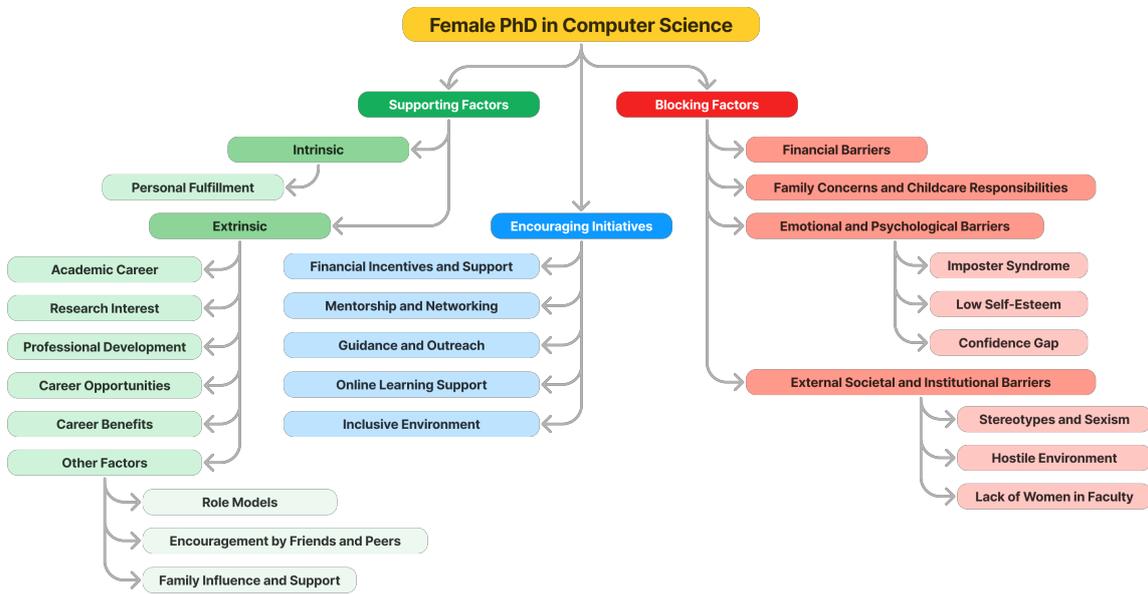
Figure 2: Factors and initiatives related to female enrolment in Informatics Ph.D. programmes.

Supporting factors

We summarise the main supporting factors encouraging enrolment in a Ph.D. programme:

Research involvement and Ph.D. life information. Engagement in research projects during undergraduate or master's studies significantly increases students' awareness of what an *academic career* looks like, their *interest in research* and the likelihood of students pursuing further studies at the Ph.D. level (Moreno and Kollanus 2013). Early engagement in research can be particularly effective in providing *role models* and early mentorship opportunities for prospective Ph.D. candidates. Additionally, attending informational sessions focused on pursuing a Ph.D. positively alleviates uncertainties and concerns related to the doctoral process. Said informational sessions can also provide valuable information about *career prospects* and *professional development opportunities* beyond the Ph.D. in industry and academia.

3

Enthusiasm and self-confidence. Individuals with interest, enthusiasm, and confidence in Informatics are more inclined to pursue a Ph.D., with women generally exhibiting comparable self-confidence to men. However, women may express slightly lower confidence in their programming skills. Women also demonstrate more enthusiasm for interdisciplinary aspects of Informatics than men. Naturally, and expected to all genders, *personal fulfilment* plays a crucial role, with a passion for understanding complex subjects, personal growth aspirations, and integrating personal interests into one's professional journey via doctoral research (Motogna et al. 2022).

Encouragement and requirements. Positive *encouragement* and *support* from professors, family, or colleagues is pivotal in influencing students' decision-making, particularly among women. This support can help mitigate the generally lower self-confidence observed in female students. Another significant factor influencing decisions is the perceived high requirements of a Ph.D. Increasing awareness of these requirements can positively impact the decision-making process (Abraham et al. 2023).

Perception of the Ph.D. process. Viewing a Ph.D. degree as *valuable*, *supportive of future careers*, and *enjoyable* provides significant motivation for pursuing a Ph.D.

Research identifies other factors, such as lack of interest in industrial positions and interest in teaching (Moreno and Kollanus 2013).

Blocking factors

The main blocking factors discouraging enrolment in a Ph.D. programme are listed below:

Uncertainty. Students need more certainty when deciding whether to pursue a Ph.D., grappling with concerns about the perceived value of research, the extended duration of Ph.D. studies, *financial constraints* (Moskal 2002), and potential limitations on job flexibility post-graduation. Women, in particular, may express concerns about the long duration of a Ph.D. programme, its funding challenges, and their impact on *family planning* and their *ability to provide for their children*. Offering opportunities for clarification during the decision-making process, implementing family-friendly policies, and support initiatives (including funding opportunities) specifically targeting women can help alleviate these uncertainties.

Emotional and psychological barriers. Lower enthusiasm, *self-confidence*, and *self-esteem* are noteworthy factors influencing the decision not to embark on a Ph.D., particularly among female students. The *"imposter syndrome"* (Rosenstein, Raghu, and Porter 2020) is more often observed in women choosing not to pursue a PhD than in men.

Industry offers. Significantly better salaries and perceived greater career flexibility in the industry are additional factors for students choosing not to pursue a Ph.D. and to proceed with a career in industry after their graduation. However, Informatics doctorates who join industry tend to receive significantly higher salaries than their peers with no Ph.D. (Zolas et al. 2015).

Lack of Role Models. The *lack of visible role models or mentors in academia* can be discouraging, particularly for women who may need help envisioning themselves succeeding in an academic career. Creating opportunities for students to find role models they can identify with (e.g. via seminars with diverse speakers with exciting careers in research) can be inspiring for students (Szlávi 2021).

Family planning considerations. The long study duration and potential impact on *family planning* can be a significant concern for women. It is important to balance academic pursuits with *family goals*, which may influence the decision-making process.

Initiatives and programmes

Numerous initiatives encouraging students to contemplate pursuing a Ph.D. aim to address these factors – either by reinforcing motivational factors or attempting to alleviate and mitigate demotivating factors. These initiatives can be categorised into five groups.

Financial incentives and support. Provide women with various forms of financial support, such as scholarships, grants, and stipends.

Mentorship and networking. Coordinate networking events to connect potential candidates with accomplished professors and peers, fostering valuable mentoring opportunities.

Organise celebratory events to highlight and recognise the achievements of female students and staff, providing inspiration and role models.

Guidance and outreach. Provide orientation activities to help female doctoral candidates navigate the academic landscape effectively.

Create specific programme application procedures tailored to underrepresented groups, including women, to streamline the application process and provide additional support.

Online learning support. Establish online doctoral programmes to increase flexibility and accessibility for women interested in doctoral study.

Conduct both online and face-to-face supervisory meetings to accommodate different learning preferences and individual circumstances.

Inclusive environment. Promote an inclusive environment by implementing gender-sensitive policies and practices within academic institutions.

Incorporate gender-responsive pedagogical practices and design curricula and teaching materials to promote an inclusive educational experience for all.

Examples of Programmes

> **Application Feedback programme for underrepresented applicants and guidance at Brown University, United States of America**
>
> *This student-led initiative comes from some of the programme participants who felt a need to aid in the application process for applicants from underrepresented groups to bolster the inclusivity and diversity of the programme (Computer Science at Brown University 2023). The initiative is optional for applicants and provides personalised feedback and guidance on the application process. Applicants can get help from a mentor, receive personalised feedback on their application, and access a collection of useful resources, including guidance sessions, testimonials, blog posts on how to make a stronger application, and links to other related initiatives from other Informatics departments from top Universities in the United States of America. Neither the feedback nor the mentorship offered are guarantees of admission, but they are perceived as useful resources in the application process.*

WoCa Lunch programme at RWTH Aachen University, Germany

The Women Career Lunch (WoCa Lunch) programme is a supporting initiative that aims to acquaint female undergraduate and master students with the possibilities for advancing their careers if they pursue Ph.D. studies. Students get encouragement from mentors and colleagues, learn from personal experiences, and get insights into the career development of female role models. Participation in this programme enables students to make well-informed decisions. The programme aims to deliver the necessary information to potential female Ph.D. students in a structured, engaging, and collaborative way.

The programme consists of eight modules. Each module takes place during lunchtime and lasts approximately one hour. The first module presents the basic ideas of the programme and what the students can expect from it, while the final module wraps up the programme as a whole and gathers feedback about the programme itself. These two modules are in person. The remaining modules address the most important topics related to Ph.D. studies. During these modules, a guest is interviewed. The interviewed guests may be members of the executing institution or external guests. The aim is to initiate discussion and reflection, dispel uncertainties, and clarify what the career path looks like for those who choose to pursue Ph.D. studies. These modules can be virtual.

A multi-language version of the WoCa Lunch programme including guidance on the structure and format, the practical procedures of the initiative, and a comprehensive catalogue of questions to be discussed during each module, is publicly available (Abraham et al. 2023). It is available in the following languages: English, French, German, Portuguese, Serbian, Spanish, Turkish, and Ukrainian.

Personal encouragement

Establishing personal connections and engaging in meaningful conversations are essential in encouraging female students to pursue a Ph.D. Direct outreach to high-achieving female students can be highly effective when institutional support for dedicated programmes or events is lacking. This could involve informal discussions during breaks or after classes, or scheduling specific meetings tailored to their interests. The following topics can serve as conversation starters:

- Inform female students about doctoral studies, providing a clear understanding of scientific research and the comprehensive nature of pursuing a doctorate. It's essential to address any misconceptions and ensure that students thoroughly grasp what doctoral studies entail.

- Provide insights into academic and industrial career paths, highlighting the impact of a doctorate in each scenario.

- Facilitate open discussions about students' interests and preferred topics, encouraging dialogue with researchers specialising in those areas. Stress the importance of choosing topics that genuinely captivate their interest.

- Illuminate common challenges associated with pursuing a doctorate, underscoring that the journey is demanding but emphasising available assistance and support.

- Introduce them to relevant role models and success stories to inspire and guide their aspirations.

- Extend an invitation for ongoing communication, encouraging them to reach out with any questions or concerns that may arise later.

Recommendations to attract female Ph.D. students

Considering the supporting and blocking factors described previously, we suggest the following best practices to attract female students to pursue Ph.D. studies:

Discovery of the research world

- To increase students' research interest, involve them as early as possible in research activities, papers, and projects (e.g., through internships and final student projects) during bachelor and master studies.

- Organise workshops and seminars.

- When involved in research activities, check if women are supervising them or if there are other women on the team, and encourage collaboration with peers.

- Encourage them to consider a career path as a teacher or researcher (in academia or industry).

- Invite them to scientific workshops and conferences organised locally.

- Celebrate and promote the achievements of female current Ph.D. students and researchers within the institution.

Understanding the Ph.D. path

- Organise a Ph.D. path seminar to explain and clarify the Ph.D. process: the objectives of a Ph.D., the underlying challenges, the recruitment process, and the requirements for a Ph.D. admission.

- Explain the different types of funding, possible research topics, and possibilities for doing a Ph.D. in collaboration with industry or an academic research lab.

- Explain the process of choosing a research topic, research group, and supervisor and the impact of this choice on their future careers.

- Share insights into the daily life of a Ph.D. student through testimonials and informational sessions.

- Host panel discussions featuring current Ph.D. students discussing their experiences.

Understanding the benefits of a Ph.D. and removing career concerns and doubts

- Explain the benefits of holding a Ph.D. in a future career either in academia or industry. For those interested in a career in

  (1) Industry: mention the potential positions that they could apply for with a Ph.D.;
  (2) Academy: explain clearly the academic path and the different options (i.e. full-time researcher, assistant/ associate professor, full professor, ...).

- Underline the skills they will develop during Ph.D. studies relevant to the career path in the industry (i.e. possibility of creating a spin-out company).

- Organise face-to-face meetings or events with industry professionals (with whom researchers collaborate) and mixed and gender-balanced panels (industry professionals and professors/researchers) to discuss the benefits of advanced degrees.

- Organise workshops with role models holding a Ph.D. that share their successful career path thanks to their Ph.D. degree.

- Explain the challenges of an academic career and how Ph.D. studies would prepare them to follow this kind of career.

- Implement mentorship programmes pairing prospective Ph.D. candidates with experienced mentors.

Understanding the requirements of female students

- Respond to their questions during the Ph.D. path seminar or through specific face-to-face meetings to understand their requirements and help them make informed decisions before enrolling in a Ph.D.

- Identify their research interest: i.e. which types of research (theoretical or practical research, possibly in a company) and research discipline (specific research domain, interdisciplinary/multi-disciplinary topic) they are looking for and can best fit their requirements.

- Identify the best duration for their Ph.D. studies. This is, of course, country-specific. There is no flexibility about the PhD duration in some countries and some universities. However, as the Ph.D. duration is relevant for potential female students, they must know the expected duration of the Ph.D. programme they are considering applying to.

- Understand their financial requirements to identify the best funding scheme adapted to their needs (scholarship, research grants, research project funding, EU funding, national funding, industry funding, etc.)

Aligning with personal fulfilment, values and goals of female students

- Show them the potential of holding a Ph.D. to enhance their personal and professional development.

- Propose a specific application programme for women, when possible.

- Introduce family-friendly policies, including flexible schedules and parental support.

- Show a welcoming, collaborative, and supportive working environment.

- Propose a research topic and funding scheme that aligns with their research focus and, more generally, with their aspiration.

References

Abraham, Erika, Miguel Goulão, Milena Vujošević Janičić, Sarah Jane Delany, Amal Mersni, Oleksandra Yeremenko, Larissa Schmid, Angela Nebot, Ozge Buyukdagli, Karima Boudaoud, and Deniz Sunar Cerci (Nov. 2023). *Women's Career Lunch — Catalog of questions for the speakers*. DOI: 10.5281/zenodo.10079419.

Computer Science at Brown University (2023). *Helping Students From Underrepresented Groups Apply To CS PhD Programs*. https://cs.brown.edu/degrees/doctoral/applications/helpful-resources-applying-computer-science-phd-programs/.

Moreno, Maria del Carmen Calatrava and Sami Kollanus (2013). "On the motivations to enroll in doctoral studies in Computer Science—A comparison of PhD program models". In: *2013 12th International Conference on Information Technology Based Higher Education and Training (ITHET)*. IEEE, pp. 1–8. DOI: 10.1109/ITHET.2013.6671028.

Moskal, Barbara (2002). "Female computer science doctorates: what does the survey of earned doctorates reveal?" In: *ACM SIGCSE Bulletin* 34.2, pp. 105–111. DOI: 10.1145/543812.543841.

Motogna, Simona, Lenuţa Alboaie, Ioana Alexandra Todericiu, and Catrinel Zaharia (2022). "Retaining women in computer science: the good, the bad and the ugly sides". In: *Proceedings of the Third Workshop on Gender Equality, Diversity, and Inclusion in Software Engineering*. GE@ICSE '22. Pittsburgh, Pennsylvania: Association for Computing Machinery, pp. 35–42. ISBN: 9781450392945. DOI: 10.1145/3524501.3527598.

Rosenstein, Adam, Aishma Raghu, and Leo Porter (2020). "Identifying the Prevalence of the Impostor Phenomenon Among Computer Science Students". In: *Proceedings of the 51st ACM Technical Symposium on Computer Science Education*. DOI: 10.1145/3328778.3366815.

Szlávi, Anna (2021). "Barriers, Role Models, and Diversity – Women in IT". In: *Central-European Journal of New Technologies in Research, Education and Practice* 3.3. DOI: 10.36427/CEJNTREP.3.3.2582.

Zolas, Nikolas J., Nathan Goldschlag, Ron S. Jarmin, Paula E. Stephan, Jason Owen-Smith, Rebecca Rosen, Barbara McFadden Allen, Bruce A. Weinberg, and Julia Lane (2015). "Wrapping it up in a person: Examining employment and earnings outcomes for Ph.D. recipients". In: *Science* 350, pp. 1367–1371. DOI: 10.1126/science.aac5949.

Retaining and supporting women during their Ph.D. studies can be challenging. To address these challenges, organisations may build on known retainment factors, such as fostering a support network for women including peers and faculty, thus promoting a sense of belonging to those students. In addition, promoting policies that support a healthy work-life balance is also relevant. The policies promoting retainment often coincide with those mitigating attrition factors. Addressing cultural and societal views on Informatics, promoting social and academic integration, and providing timely feedback and clear expectations to students can make a difference.

Retainment factors

The main retainment factors for women in Informatics Ph.D. programmes can be summarised as follows:

Social interactions. Social interactions play a crucial role in retention by providing educational and emotional support (Pantic 2020). The most common form of social support is regular interactions with peers. Although less frequent, engaging with supportive faculty also plays a crucial role in bolstering the retention of women in Informatics programmes. In addition, external support networks, including friends, family, and the wider work community, are essential, especially for Ph.D. students managing additional work commitments.

Sense of belonging. Fostering a sense of belonging starts with establishing a robust support system and facilitating connections among women at various academic levels. This can be accomplished by enhancing relationships among women in the Informatics community through mentorship programmes (Frieze and Quesenberry 2019).

Work-life balance. Maintaining a work-life balance is crucial for sustaining motivation and productivity. The capacity to establish priorities regarding research and personal time is significant. Throughout a Ph.D., there may be a more adaptable schedule. The option of remote or hybrid work presents both advantages and challenges. While it may enhance schedule flexibility, it also introduces additional difficulties in delineating a clear boundary between work and personal life. This challenge is more pronounced for women, who are often under societal pressure to take on additional responsibilities at home (André 2022).

Mental health. Preserving the mental health of Ph.D. candidates is essential. Ph.D. students experience significantly higher stress levels compared to the general population. The most prominent risk factors associated with mental health issues in Ph.D. students are isolation and identifying as female. To protect from these risks, Ph.D. students can benefit from social support, viewing the Ph.D. as a process, having a positive student-supervisor relationship and engaging in self-care (Hazell et al. 2020).

By addressing these factors, institutions can work towards creating an environment that not only attracts but also retains women in Informatics Ph.D. programmes.

Attrition factors

The main reasons for dropping out of a Ph.D. programmes in Informatics are often the opposite of the factors contributing to retention when those supportive elements are absent. In this

section, we will highlight the most important factors:

Stereotypes. Cultural and societal perceptions of Informatics act as significant attrition factors. Discrimination and micro-aggressions are impactful deterrents, contributing to women leaving their studies (André 2022).

Lack of role models. The absence of other women at similar academic levels and in authoritative positions hinders social and academic integration (Anderson-Rowland, Bernstein, and Russo 2007).

Insufficient support. A lack of support from faculty advisers can lead to uncertainties about progress during a Ph.D. The perception of achievement and success strongly predicts attainment (Fisher et al. 2019), so clear guidance and transparent communication with faculty advisers are crucial for maintaining motivation and participation. Clarification sessions regarding expected academic standards may give doctoral students a clearer view of their path.

Recommendations to retain female Ph.D. students

Considering the supporting and attrition factors described above, we suggest the following best practices to retain female Ph.D. students after engaging in a Ph.D. path:

Mentoring. Implement a mentoring programme that runs for as long as possible, ideally for the duration of a student's Ph.D. studies.

Addressing the imposter syndrome. Organise personal development (transversal skills enhancing) training and workshops to address impostor syndrome, decrease self-doubts and increase self-confidence and self-esteem. Peer support groups can also help mitigate this challenge (Rosenstein, Raghu, and Porter 2020).

Working environment. Ensure students feel welcomed in the working environment.

Promoting work-life balance. Provide resources and support for remote or hybrid work, addressing the challenges of separating work and personal life.

Avoid isolation. Organise female-focused events with peers, researchers and professors.

Support peer networking. Encourage and facilitate peer interactions through regular meetings, group activities, and networking events.

Support professional networking. Organise networking events with industry professionals to prepare for the post-Ph.D. path and inform on career opportunities for those interested in an industrial career.

Advertise positive examples. Celebrate success stories of Ph.D. students.

Promote role models. Highlight the achievements of women at various academic levels and in positions of authority.

Show a clear path. Conduct clarification sessions on academic standards to ensure students clearly understand academic requirements and pathways.

Prevent discrimination. Implement anti-discrimination policies and training to mitigate the occurrence of micro-aggressions and other discriminatory behaviours.

Testimonials

Testimonial

Bio: Studied mathematics at a German university and did her doctoral research in the research department of a company. Her research was on the safety of machine learning models.
Duration of doctoral research: 2018-2022

My journey of doctoral studies found a place in industries within a research department at a large automotive supplier. For me, this meant a strict schedule of three years and less freedom in choice of topic (or, said positively: less meandering in the beginning). But it also gave me what I was searching for back then: A direct connection to practical applications and concrete practical issues, in that case, the safety of autonomous driving perception. Interestingly, other than what one would expect in a big old company full of male engineers, I was positively surprised that gender had zero impact: We were simply a team of equals, even without much influence of hierarchies. The same held for the many different groups I collaborated with, such as the lab at university where I was supervised, my project team (including external partners), and internal expert groups. Besides many connections and friends, these research collaborations also provided me with the invaluable experience of finding, defining, and building up R&D topics and working groups around them—including the patience to nurture them over long dry spells. Despite the tough schedule (thanks to my boss for not stopping pushing me), I much enjoyed spending this time digging deep into a research topic, pushing the edge of what is known.

Testimonial

Bio: Moved from India to Germany to study computer science at a university of applied sciences and worked during her doctoral research at an institute for applied research focusing on engineering and technology. Her research was on machine learning for facial expression analysis. Duration of doctoral research: 2015-2020

My doctoral research was part of an industry-funded project. This offered several advantages, which included access to larger, well-annotated datasets and the opportunity to test the developed models in real-world settings, where they were to be deployed eventually. This closeness to practical application motivated me to explore innovative combinations of ideas from different engineering disciplines and it proved beneficial for my Ph.D. The project had fixed deadlines for deliverables, which to some extent helped speed up research, but at times also demanded coming up with practical solutions, where I was doubtful whether it was scientific enough to qualify for a Ph.D. degree. The "patent before publish" policy followed in general in the industry can sometimes delay publications, which is not desirable for doctoral research. However, a workaround would be to focus on survey papers and comparative evaluations of existing methods, which would not contribute to intellectual property but would be extremely valuable for doctoral research. The tight project schedule could reduce the time available for reading literature as well as writing own publications or even theses. The TALENTA Start scholarship from the Fraunhofer Society helped me reserve time every month for my research. It also helped me visit summer schools and conferences, and buy books relevant to my research. However, the writing of a thesis requires longer and dedicated time. In academia, researchers can dedicate 3-6 months exclusively to writing their dissertations. This is however not possible in the industry and can delay the completion of Ph.D. especially if dissertations are expected as monographs. Since I was allowed to submit a cumulative thesis at the University, I was able to finish my Ph.D. within 5 years. Finally, I must add that the pursuit of a Ph.D. caused some turbulence in my personal life, which was difficult to overcome and it made me wonder why womanhood and research were not compatible. To overcome such issues for future generations, we need to have more successful female Ph.D. holders as role models, and we need to make sure that doctoral research does not get prolonged due to overly high scientific expectations or overbearing demands of a job in the industry.

Testimonial

Bio: Did her doctoral research at a Portuguese University. Her research was on Requirements Engineering.
Duration of doctoral research: 2014-2019

During my Ph.D. I had the opportunity to explore new and exciting biometric devices that I had never worked with before, like eye trackers, electroencephalography (EEG) and electro-dermal activity (EDA) scanners. These devices brought a new dimension to my research, allowing me to do what I love the most: constantly learning and pushing my knowledge to new dimensions. Using these devices, I did experiments with more than 600 people, both students and professionals working in the software development world. All the people who participated in my experiments were volunteers, gaining nothing in return, and I'm extremely grateful for their time. Being able to gather this number of participants put my network and people skills to the test.

During my Ph.D. journey, I also had the opportunity to be a Visiting Research Student at SEGAL Research Group, University of Victoria (Canada) for 6 months. During my time there, I worked closely with software startups operating in a highly dynamic environment. This allowed me to better understand how the software industry views software requirements practices, depending on the company stage. This opportunity was also fundamental to understand the differences between theory and practice and to connect (and contrast) the theoretical concepts with the practical, real-world, reality. In the end, this experience motivated me to further contribute to a better collaboration between industry and academia.

During my Ph.D., I managed to keep a good balance between work and personal life, being able to work on my research and still have time for friends, family, travelling, and other hobbies. However, it's important to note that I had a Research Grant for Ph.D. students from FCT-MCTES (Portugal), which allowed me to completely focus on my research. Having funding gives us peace of mind that we would not have otherwise. Also, the Research Grant was time-bound, which kept me grounded and making sure I would finish my Ph.D. in time.

I had a clear routine and work schedule. However, I was fully dedicated to my Ph.D. research, not having another job and not having children. I recognise that the work and dedication that I put into my research could have been different if I had other external obligations in my personal life. Still, I believe that with the right organisational system and the right Ph.D. advisers (like I had), it's completely possible to maintain a good work-life balance and successfully finish the Ph.D.

References

Anderson-Rowland, Mary, Bianca Bernstein, and Nancy Felipe Russo (2007). "Encouragers and discouragers for domestic and international women in doctoral programs in engineering and computer science". In: *2007 Annual Conference & Exposition*, pp. 12–607. DOI: 10.18260/1-2--2786.

André, Beatriz (2022). *Gender Balance in Computer Science*. MSc thesis. NOVA School of Science and Technology. URL: https://run.unl.pt/bitstream/10362/155510/1/Andre_2022.pdf.

Fisher, Aaron J, Rodolfo Mendoza-Denton, Colette Patt, Ira Young, Andrew Eppig, Robin L Garrell, Douglas C Rees, Tenea W Nelson, and Mark A Richards (2019). "Structure and belonging: Pathways to success for underrepresented minority and women PhD students in STEM fields". In: *PloS one* 14.1, e0209279. DOI: 10.1371/journal.pone.0209279.

Frieze, Carol and Jeria L. Quesenberry (2019). "How computer science at CMU is attracting and retaining women". In: *Communications of the ACM* 62.2, pp. 23–26. DOI: 10.1145/3300226.

Hazell, Cassie M., Laura Chapman, Sophie F. Valeix, Paul Roberts, Jeremy E. Niven, and Clio Berry (2020). "Understanding the mental health of doctoral researchers: a mixed methods systematic review with meta-analysis and meta-synthesis". In: *Systematic Reviews* 9. DOI: 10.1186/s13643-020-01443-1.

Pantic, Katarina (2020). "Retention of Women in Computer Science: Why Women Persist in Their Computer Science Majors". PhD thesis. Utah State University. DOI: https://doi.org/10.26076/jhev-9r02.

Rosenstein, Adam, Aishma Raghu, and Leo Porter (2020). "Identifying the Prevalence of the Impostor Phenomenon Among Computer Science Students". In: *Proceedings of the 51st ACM Technical Symposium on Computer Science Education*. DOI: 10.1145/3328778.3366815.

COST
EUROPEAN COOPERATION
IN SCIENCE & TECHNOLOGY

Funded by
the European Union