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Paloma Guenes Costa

Impostor Phenomenon in Software Engineers

Dissertação de Mestrado

Dissertation presented to the Programa de Pós-graduação em Informática of PUC-Rio in partial fulfillment of the requirements for the degree of Mestre em Informática.

Advisor : Prof. Marcos Kalinowski
Co-advisor: Profª. Maria Teresa Baldassarre

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Prof. Marcos Kalinowski
Advisor
Departamento de Informática – PUC-Rio

Profª. Maria Teresa Baldassarre
Co-advisor
Uniba

Profª. Simone Diniz Junqueira Barbosa
PUC-Rio

Profª. Margaret-Anne Storey
UVic

Rio de Janeiro, November 29th, 2023

Paloma Guenes Costa

Bachelor in Computer Science, Federal University of Rio de Janeiro.

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Abstract

Costa, Paloma Guenes; Kalinowski, Marcos (Advisor); Baldassarre, Maria Teresa (Co-Advisor). **Impostor Phenomenon in Software Engineers**. Rio de Janeiro, 2023. 57p. Dissertação de Mestrado – Departamento de Informática, Pontifícia Universidade Católica do Rio de Janeiro.

The Impostor Phenomenon (IP) is widely discussed in Science, Technology, Engineering, and Mathematics (STEM) and has been evaluated in Computer Science students. However, formal research on IP in software engineers has yet to be conducted, although its impacts may lead to mental disorders such as depression and burnout. This study describes a survey that investigates the extent of impostor feelings in software engineers, considering aspects such as gender, race/ethnicity, and roles. Furthermore, we investigate the influence of IP on their perceived productivity. The survey instrument was designed using a theory-driven approach and included demographic questions, an internationally validated IP scale, and questions for measuring perceived productivity based on the SPACE framework constructs. The survey was sent to companies operating in various business sectors. Data analysis used bootstrapping with resampling to calculate confidence intervals and Mann-Whitney statistical significance testing for assessing the hypotheses. We received responses from 624 software engineers from 26 countries. The bootstrapping results reveal that a proportion of 52.7% of software engineers experience frequent to intense levels of IP and that women suffer at a significantly higher proportion (60.6%) than men (48.8%). Regarding race/ethnicity, we observed more frequent impostor feelings in Asian (67.9%) and Black (65.1%) than in White (50.0%) software engineers. We also observed that the presence of IP is less common among individuals who are married and have children. Moreover, the prevalence of IP showed a statistically significant negative effect on the perceived productivity for all SPACE framework constructs. The evidence relating IP to software engineers provides a starting point to help organizations find ways to raise awareness of the problem and improve the emotional skills of software professionals.

Keywords

Impostor Phenomenon; Impostor Syndrome; Human Aspects; Perceived Productivity; Software Engineering.

Resumo

Costa, Paloma Guenes; Kalinowski, Marcos; Baldassarre, Maria Teresa. **O Fenômeno do Impostor em Engenheiros de Software**. Rio de Janeiro, 2023. 57p. Dissertação de Mestrado – Departamento de Informática, Pontifícia Universidade Católica do Rio de Janeiro.

O Fenômeno do Impostor (FI) é amplamente discutido em Ciências, Tecnologia, Engenharia e Matemática (STEM) e tem sido avaliado em estudantes de Ciência da Computação. No entanto, ainda não foi realizada nenhuma investigação formal sobre FI em engenheiros/as de software, embora os seus impactos possam levar a transtornos mentais, como depressão e burnout. Este estudo descreve uma pesquisa que investiga a extensão dos sentimentos de impostor em engenheiros/as de software, considerando aspectos como gênero, raça/etnia e papeis profissionais. Além disso, investigamos a influência do FI na produtividade percebida. O instrumento de pesquisa foi elaborado usando uma abordagem baseada em teoria e incluiu questões demográficas, uma escala de FI validada internacionalmente e questões para medir a produtividade percebida com base nos construtos teóricos do framework SPACE. A pesquisa foi enviada para empresas que atuam em diversos setores de negócios. A análise dos dados utilizou bootstrapping com reamostragem para cálculo dos intervalos de confiança e teste de significância estatística de Mann-Whitney para avaliação das hipóteses. Recebemos respostas de 624 engenheiros e engenheiras de software de 26 países. Os resultados do bootstrapping revelam que uma proporção de 52,7% dos engenheiros de software sofrem de níveis frequentes a intensos do FI e que as mulheres sofrem em uma proporção significativamente maior (60,6%) do que os homens (48,8%). Em relação à raça/etnia, observamos sentimentos de impostor mais frequentes em engenheiros/as de software asiáticos (67,9%) e negros (65,1%) do que em engenheiros/as de software brancos (50,0%). Observamos também que a presença de FI é menos comum entre indivíduos casados e com filhos. Além disso, a prevalência de FI mostrou um efeito negativo estatisticamente significativo na produtividade percebida para todos os construtos do framework SPACE. A evidência que relaciona a FI aos engenheiros de software fornece um ponto de partida para ajudar as organizações a encontrar formas de aumentar a consciência sobre o problema e melhorar as competências emocionais dos profissionais de software.

Palavras-chave

Fenômeno do Impostor; Síndrome do Impostor; Aspectos Humanos; Produtividade Percebida; Engenharia de Software.

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IP – Impostor Phenomenon

CIPS – Clance Impostor Phenomenon Scale

SE – Software Engineering

You can't fight what you can't name. [...] And, when you don't know where you come from, it's easier to go where the mask says you belong.

Djamila Ribeiro

1 Introduction

1.1 Context

Have you ever found yourself having doubts about your abilities or expertise when others around you indicate otherwise? Have you ever denied praise for something you think was too easy or where you believe that anyone else could have done a better job? Recent studies reveal that many software engineers often experience negative feelings such as frustration and unhappiness when they think about their own perception of their abilities or skills (FORD; PARNIN, 2015; GRAZIOTIN et al., 2018; GIRARDI et al., 2020).

In 1978, Pauline Clance and Suzanne Imes (CLANCE; IMES, 1978) identified the Impostor Phenomenon (IP)[1] in high-achieving female individuals. IP corresponds to the feeling of not recognizing oneself accurately and frequently facing a great fear of being discovered as a fraud. Later, Dr. Clance created a scale (the Clance IP Scale - CIPS) (CLANCE, 1985) to determine to which extent individuals suffer from IP.

Gathering user requirements and transforming them into software is the responsibility of software engineers. Their activities may relate to any phase of a software development process (HUMPHREY, 1988), which, being challenging, could lead to feelings of being an impostor. They typically know they must be ready to constantly overcome challenges intrinsic to the profession while coding new features or fixing bugs. Whereas succeeding in a task is a moment of joy experienced by developers, getting stuck and the dread of failure and frustration are prejudicial to productivity (GRAZIOTIN et al., 2018). The consequences of IP (CLANCE; IMES, 1978; CAWCUTT; CLANCE; JAIN, 2021) perceived by software engineers include anxiety, burnout, and depression (GRAZIOTIN et al., 2017).

[1]The term *Impostor Syndrome* is also used to refer to Dr. Clance's work. However, the terminology "syndrome" is related to an official medical diagnosis, while IP is not. In this dissertation, we acknowledge the official name Impostor Phenomenon while also considering research that uses the term *Impostor Syndrome*.

1.2 Motivation

Valerie Young, widely recognized as an expert on Impostor Syndrome, in her book *The secret thoughts of successful women: Why capable people suffer from the Impostor Syndrome and how to thrive in spite of it* (YOUNG, 2011), describes five types of impostors:

- The Expert
- The Super Woman/Man
- The Perfectionist
- The Soloist
- The Natural Genius

Each type suffers somehow because they try to achieve extraordinary results in little time or alone, and even if their goal is reached, they usually feel that they should be capable of doing even more.

Regarding professionals involved in software engineering, while we still lack scientific evidence, we hypothesize that specific behaviors related to the impostor types might be common.

In 2018, a blog called teamblind[2] that has more than five million followers talking about culture, workplace issues, and career advice, asked tech professionals a yes or no question: *"Do you suffer from impostor syndrome?"*. More than 10000 professionals from IT companies like Amazon, Facebook, Salesforce, Oracle, and Apple answered. The result was that 58% of tech workers feel like impostors. A senior member at Salesforce, with 14 years of experience working in solutions used globally stated his/her frustration saying *"I feel like I'm nowhere near where I should be skill-wise"* (TEAMBLIND, 2018). While this study can serve as a preliminary indication of a potential prevalence of IP in tech professionals and motivate further research, self-reporting being an impostor is not enough to make a diagnosis.

Furthermore, the results of a study on confidence in programming skills based on the *Stack Overflow Developer Survey* show that respondents from underrepresented groups tend to believe they are not as good as their peers (SILVEIRA et al., 2019), which also indicates symptoms of IP within these groups.

Based on the current literature, we know that impostor feelings are shared among Computer and Data Science students (ROSENSTEIN; RAGHU;

[2]https://www.teamblind.com/

PORTER, 2020; BERNUY et al., 2022; DUNCAN et al., 2023). The commonality among these studies is that over half of the students suffer from IP. Despite the evidence presented by these three studies, there is no scientific confirmation that impostor feelings persist in the professional life of people with a degree in Computer Science (CS). Moreover, Dr. Clance in 1978 had already observed that impostor feelings predominantly afflict students among the general population. Besides, there is limited research regarding professionals (e.g., (MAJI, 2021; MCLEAN; AVELLA, 2016)), however these studies focus on specific regions and subgroups of developers. Therefore, there is no clear evidence that IP also manifests in software engineers. Such evidence relating IP to software engineers could provide a starting point to help organizations find ways to improve the emotional skills of software professionals.

1.3 Objectives

This dissertation aims to investigate the presence of IP in software engineers regarding their roles and profiles (*e.g.*, age, gender, race/ethnicity) and its impact on their perceived productivity through a survey.

To address this goal, we designed a survey instrument using a theory-driven approach. We identified two main research questions: *RQ1 - How does IP manifest in software engineers?* and *RQ2 - Does IP affect the perceived productivity of software engineers?* We detail these research questions and our derived hypotheses to be assessed.

Our survey instrument was built to support the testing of these hypotheses. For measuring the IP, we obtained authorization from Dr. Clance to use the internationally validated CIPS scale (CLANCE, 1985). For the perceived productivity, similar to other researchers (BIRD et al., 2023), we derived statements to measure the constructs of the SPACE developer productivity framework (Satisfaction and well-being, Performance, Activity, Communication and collaboration, and Efficiency and flow) (FORSGREN et al., 2021a; FORSGREN et al., 2021b) using a five-point Likert-scale.

1.4 Summary of the Findings

We were granted authorization to use the CIPS scale within our survey using a closed invitation format, i.e., directly addressing the target population. We reached out to over 100 companies worldwide of different sizes and different business domains, asking them to distribute the survey internally to their software engineers. We received responses from 624 software engineers from

26 countries, a sample size that allows us to achieve conclusion validity. Furthermore, to strengthen our confidence in the representativeness of our sample, we compared it against the sample of the Stack Overflow Annual Developer survey of 2023 (OVERFLOW, 2023) and observed comparable distributions for the main variables we considered.

Our main findings indicate that 52.72% of software engineers suffer from frequent to intense levels of IP. Analyzing underrepresented groups sheds light on alarming differences. For instance, women suffer from IP at a significantly higher rate (60,64%) than men (48,82%). Furthermore, Asian (67.85%) and Black (65.11%) suffer more than White (50.00%) software engineers. We also observed that the presence of IP is less common in individuals who are married and have children. Concerning perceived productivity, the prevalence of IP showed a statistically significant negative effect on all five SPACE developer productivity framework constructs (as presented later).

1.5 Dissertation Outline

The rest of this dissertation is organized as follows. Chapter 2 provides the background on the Impostor Phenomenon, related work, and introduces the SPACE developer productivity framework. Chapter 3 details our goal and research questions. It also explains our methods for designing the survey, data collection, and data analysis. Chapter 4 presents our results and a discussion about them. Chapter 5 concludes the dissertation after discussing the threats to the validity, limitations, and future work of our study.

2
Background and Related work

2.1
Introduction

In this chapter, we provide the theoretical background for our research and review related work. First, we describe the IP and psychometric instruments for its measurement. Thereafter, as the literature still does not characterize IP in software engineers in general, we report on studies investigating IP in computer science and data science students (the closest research to our topic of investigation). Finally, we briefly introduce the SPACE of Developer Productivity framework, which we use to investigate the potential impacts of IP on perceived productivity and well-being.

2.2
Impostor Phenomenon

As originally defined, the Impostor Phenomenon is the experience of intellectual phoniness perceived by high-achieving professionals (CLANCE; IMES, 1978). These individuals have a great fear that others will discover that they are not as competent as they appear, attributing their successes to luck, meeting the right people, being in the right place at the right time, or even their personal charm (CLANCE; IMES, 1978).

In 1985, Dr. Clance, one of the psychologists who first identified this phenomenon in high-achieving women, created a scale to determine if a person is suffering from IP and to what extent (CLANCE, 1985). While there are four scales to determine IP (Clance Impostor Phenomenon Scale, Harvey Impostor Scale, Perceived Fraudulence Scale, and Leary Impostorism Scale), Clance Impostor Phenomenon Scale (CIPS) is the most used scale by researchers and practitioners (MAK; KLEITMAN; ABBOTT, 2019).

The CIPS scale consists of a 20-item questionnaire. Each item concerns a statement that is rated on a Likert scale from 1 to 5. A rating of 1 corresponds to “Not at all true” or total disagreement with the aforementioned statement, and a rating of 5 corresponds to “Very true” or complete agreement.

Upon completing the questionnaire, it is necessary to sum the values of each response in order to obtain the scale value results. The higher the result, the more often and seriously IP interferes with a person’s life. According to the CIPS scale, scoring more than 60 points represents that the respondent has frequent and intense IP feelings, which means meeting the diagnostic criteria used in previous research with students (discussed in Section 2.3).

2.3 Impostor Phenomenon in Computer and Data Science Students

There are two recent studies that investigate IP in Computer Science students, both using the CIPS scale and these were conducted in research-intensive environments.

In 2020, Rosenstein *et al.* (ROSENSTEIN; RAGHU; PORTER, 2020) conducted a study in a North American institution and found that among over 200 students, 57% suffered from frequent and intense IP. Besides, the study concludes that IP in Computer Science students happens more often than in other groups from comparable studies. They also observed that IP was particularly prevalent in women (of which 71% suffered from frequent and intense levels of IP).

Two years later, Zavaleta *et al.* (BERNUY et al., 2022) in a newer study on Computer Science students corroborated the previous one (mentioned above). They found a larger number of students suffering from IP (68%) and, again, women reported higher CIPS scores than men (78%). The diagnostic criterion in this study was scoring above 60.

Recently, a study conducted with 86 master students of data science (DUNCAN et al., 2023) from three different universities found out that 53% of students have intense or frequent feelings of IP. However, they have not found significant differences in IP related to gender or race.

Even though there might be a natural connection between computer science, data science students, and software engineers, the professional context is different and there is currently no study investigating the prevalence and manifestation of IP in software engineers.

In this study, we also consider the diagnostic criterion as scoring above 60, which means having frequent to intense levels of impostor feelings.

2.4 Other Related Work

A qualitative investigation with experienced female Software Engineers in the Indian Information and Technology sector uncovers that parenting patterns marked by a scarcity of praises, sibling comparisons, a lack of trust in children's potential, and strict adherence to gender values are noteworthy precursors to Impostor Phenomenon (MAJI, 2021).

Results from a study conducted in 2016 (MCLEAN; AVELLA, 2016), with 374 experienced IT professionals (at least 7 years of experience in the IT field), suggested that individuals below the age of 60 encounter Impostor Phenomenon more frequently than those aged 60 and above. The mentioned research explored potential variations in the Impostor Phenomenon (IP) among IT professionals based on specific demographic categories (gender, age, and level of education). Age was the only independent variable that yielded statistically significant results.

In (SILVEIRA et al., 2019), the authors analyzed that the underrepresented group participants of their study tend to believe they are *not as good as their peers*. Male participants predominantly are the ones who strongly disagree with that statement and are also those who less strongly agree with it. They proposed a discussion about unconscious bias, stereotypes, linking the latter to the frustration arising from failing to meet self-imposed standards.

2.5 SPACE of Developer Productivity

Forsgren *et al.* recently created the SPACE of Developer Productivity framework (FORSGREN et al., 2021a; FORSGREN et al., 2021b). This framework considers five dimensions of productivity, including the individual's perspective and how the developer deals with the work environment: the amount and quality of tasks developed and teamwork, among others. This framework is widely used in industry for measuring productivity and well-being, for example, see the research on the impact of AI on developer productivity (BIRD et al., 2023). A short description of the SPACE dimensions follows, based on (FORSGREN et al., 2021b).

- Satisfaction and well-being: Satisfaction is how fulfilled developers feel with their work, team, tools, or culture; well-being is how healthy and happy they are and how their work impacts it.
- Performance: Refers to the outcome of a system or process. It is related to quality, reliability, absence of bugs, ongoing service health and impact, customer satisfaction, customer adoption and retention, feature usage, and cost reduction.
- Activity: Refers to the count of actions or outputs (e.g., issues, code reviews) completed in the course of performing work.
- Communication and collaboration: Captures how people and teams communicate and work together.

– Efficiency and flow: Capture the ability of an engineer to complete their work or make progress on it with minimal interruptions or delays, whether individually or through a system.

Productivity and performance are the areas most affected by the dissatisfaction of developers (GRAZIOTIN et al., 2018). In this dissertation, we posit that individuals who view themselves as impostors also tend to perceive their productivity as lower than their peers. We propose to use the SPACE framework to understand the perceived productivity of software engineers and its relation with IP.

2.6 Concluding Remarks

This chapter encompassed a presentation of the theoretical foundation for our study and a review of pertinent literature. Initially, we detailed the concept of the Impostor Phenomenon (IP) and the tools used to measure it psychometrically. Following this, due to the absence of literature specifically addressing IP among software engineers, we explored research focusing on IP in computer science and data science students, which aligns closely with our area of interest. Lastly, we outlined the SPACE of Developer Productivity framework, a tool we employed to examine how IP might influence perceived productivity and well-being. In the following chapter, we will delve into our research objectives and the development of our instrument.

3
Research Goal and Instrument Design

3.1
Introduction

In this chapter, we describe the research objectives and elaborate on the construction of the instrument. Initially, we expound on the research goal and two primary questions, focusing on the extent of IP in software engineers and their perceived productivity. Subsequently, we introduce our hypotheses and the rationale behind them. The Instrument Design section furnishes comprehensive details about the survey questions we incorporated and devised. Following this, we elucidate the procedures for data collection and analysis. Finally, we delve into the validity assessment criteria we took into account when formulating the survey.

3.2
Research Goal and Questions

Our research goal can be stated according to the Goal-Question-Metric paradigm goal definition template (BASILI; ROMBACH, 1988) as follows; *Analyze* the prevalence of Impostor Phenomenon in software engineers *with the purpose of* characterizing *with respect to* the prevalence of the phenomenon in different roles and profiles (e.g., gender, race/ethnicity) and its relation with perceived productivity *from the point of view of* the researcher *in the context of* software engineering professionals.

From this goal, we derived and detailed two Research Questions (RQs) addressed through a survey instrument:

- RQ1: How does IP manifest in software engineers?
  - RQ1.1: What proportion of Software Engineers suffer from IP?
  - RQ1.2: How does IP manifest in different genders, races/ethnicities, and roles?
- RQ2: Does IP affect the perceived productivity of software engineers?
  - RQ2.1: Does IP affect Satisfaction and Well-being?
  - RQ2.2: Does IP affect Performance?
  - RQ2.3: Does IP affect Activity?
  - RQ2.4: Does IP affect Communication and Collaboration?
  - RQ2.5: Does IP affect Efficiency and Flow?

In order to answer RQ1.1, we used the CIPS scale. For RQ 1.2, we applied the blocking principle to the results on the IP prevalence based on the demographic questions. To answer RQ2, we created a group of questions to understand the developer's perceived productivity, considering the five dimensions of the SPACE framework. Further details on the survey design follow.

3.3 Survey Design

We used a theory-driven survey design approach (WAGNER et al., 2020), in which we first hypothesize on the theory to be assessed and then elaborate the survey instrument by selecting validated scales for the different theoretical constructs. Our first hypothesis, related to RQ1, concerns the overall prevalence of IP in software engineers. Hypotheses 2 to 6 were formulated to investigate RQ2.

Hypothesis H1: More than 50% of software engineers suffer from the Impostor Phenomenon. More than half of computer and data science students were tested and identified as suffering from frequent to intense levels of IP meeting the diagnostic criteria (ROSENSTEIN; RAGHU; PORTER, 2020; BERNUY et al., 2022). It seems reasonable to assume that the fear of being discovered as a fraud will not disappear once they graduate and start a professional life. Also, we want to understand the prevalence of IP within specific groups of software engineering professionals, in particular, per gender, race/ethnicity, and role.

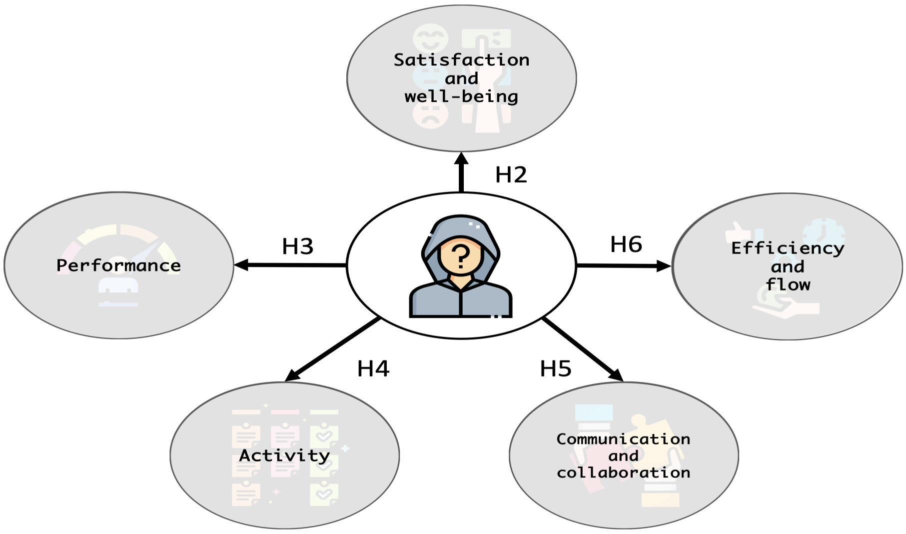
Assuming hypothesis H1 is supported, we want to understand the impact of IP on perceived productivity. We used the SPACE framework dimensions as constructs to assess the impact on productivity.

Figure 3.1 shows the constructs and the related hypotheses. The SPACE framework evaluates productivity by five means: satisfaction and well-being, performance, activity, communication and collaboration, and efficiency and flow. Therefore, each of them is a construct linked with Impostor Phenomenon.

Furthermore, we want to assess if there is a difference for software engineers suffering from IP on their perceived productivity using the SPACE developer productivity framework dimensions as constructs. We assume that people who consider themselves a fraud also perceive themselves as less productive than others. We elaborate on Hypotheses 2 to 6 based on this informal deductive intuition and Dr. Clance's book (CLANCE, 1985).

Hypothesis H2: Software engineers that meet the diagnostic criterion of IP have lower perceived satisfaction and well-being. The second hypothesis

Figure 3.1: Constructs and hypotheses



is related to the satisfaction and well-being productivity construct. Forsgren *et al.* (FORSGREN et al., 2021a) declare that low productivity is related to low personal satisfaction. We hypothesize that there is a relationship between suffering from IP and low perceived personal satisfaction and well-being.

Hypothesis H3: Software engineers that meet the diagnostic criterion of IP have lower perceived performance. We derived H3 based on the Impostor Cycle defined by Dr. Clance (CLANCE, 1985), which states that the feeling of gratefully succeeding in a task is quickly transposed by the feeling that if they could do it, anyone else could perform the same way or even better. Therefore, people suffering from IP may not perceive that they deliver high-quality and impactful work even if they receive acknowledgment.

Hypothesis H4: Software engineers that meet the diagnostic criterion of IP have lower perceived activity. We theorize that IP feelings prevent people from solving a number of work items, pull requests, code reviews, etc., because they tend to remember the difficult times more vividly than their accomplishments in tasks completed with ease. They often focus on unfamiliar details rather than promptly applying their existing knowledge (CLANCE, 1985).

Hypothesis H5: Software engineers that meet the diagnostic criterion of IP have lower perceived communication and collaboration. We believe that communication might be impaired because of fear of judgment, being exposed as fraud, and constantly worrying about not matching others' expectations. That is, since they tend to believe more in others than in themselves, they tend not to give their opinion even about subjects where they are specialists (CLANCE, 1985).

Hypothesis H6: Software engineers that meet the diagnostic criterion of

IP have lower efficiency and flow. We hypothesize that efficiency and flow are rarely perceived by individuals with IP. In general, feelings of being stuck or held back are common in individuals with IP because they tend to doubt themselves constantly (CLANCE, 1985).

3.4
Instrument Design

To design the survey instrument, first, we included demographic and filter questions of our interest to improve criterion validity and to allow us to investigate how the IP manifests in different groups, including underrepresented ones. These questions concern objectively gathering information on the gender, race/ethnicity, role, age, level of education, and experience.

Additionally, a study focused on Open Source Software shows that women in this context have half as many kids as men (ROBLES et al., 2016), and very few are married or cohabiting with partners (MANI; MUKHERJEE, 2016). To understand if IP is related to these situations, we added two more questions asking about marital status and the number of children.

For the substantive questions, we considered the CIPS scale as the psychometric instrument for assessing IP (CLANCE, 1985). The main reason for this decision was that it is a widely accepted and validated scale and the most used one by researchers and practitioners (MAK; KLEITMAN; ABBOTT, 2019). Furthermore, this scale allows the comparison of our results with the previous studies conducted with computer and data science students (*cf.* Section 2.3).

The CIPS score is divided into four scoring categories: 40 or less, representing few impostor characteristics; 41 to 60, representing moderate IP experiences; 61 to 80, representing frequently having impostor feelings; and 80 or more, representing intense IP experiences. Scoring more than 60 means meeting the diagnostic criterion.

For the productivity constructs involved in H2 to H6, we used the definition of these constructs provided by the SPACE framework (FORSGREN et al., 2021a) and phrased Likert-scale self-assessment statements, ranging from 1 (strongly disagree) to 5 (strongly agree). Table 3.1 details the 10 created questions. We reviewed the questions with experts on the SPACE framework. At the very end of the survey, we added an open-ended question allowing the participants to share any additional comment or experience.

Regarding ethics, we followed recommended procedures to obtain consent for empirical studies in software engineering (BADAMPUDI, 2017). We embedded an informed consent form in our survey, communicating the purpose of

Table 3.1: SPACE based questions

Research Question	SPACE Dimension	Survey Question
RQ2.1	Satisfaction and Well-Being	1. I feel fulfilled at my work. 2. I am healthy and happy when I work.
RQ2.2	Performance	3. I deliver high quality work. 4. I deliver impactful work.
RQ2.3	Activity	5. I complete as many tasks as expected from me in my position.
RQ2.4	Communication and Collaboration	6. I feel comfortable communicating with my team. 7. My team supports and values my communication. 8. I play an important role in my team.
RQ2.5	Efficiency and Flow	9. I am able to focus on and make progress on my work without internal interruptions (eg., mind wandering, lack of confidence). 10. I am able to focus on and make progress on my work without external interruptions (eg., notification from mobile device, a colleague asking a question).

the research, importance of the research and rigor, procedures, voluntariness, right to terminate, benefits/risks, and assuring anonymity and confidentiality. The research plan, the informed consent form, and the survey were submitted to the university ethics board for approval and adjusted until they entirely met the required criteria.

We implemented the survey in a tool called Tally, which enables us to compute and provide the CIPS score as feedback once the user completes the survey. The chosen tool is secure for data transmission and is GDPR compliant[1]. The authorization to use the CIPS scale, the consent form we designed, the complete survey instrument we used, our anonymized raw data,

[1] https://tally.so/help/gdpr

and our analysis scripts can be found in our online open science repository[2].

Additionally, we included questions on perceived productivity and well-being from the world health organization health and work performance questionnaire (HPQ) (KESSLER et al., 2003), mainly for cross-validation purposes.

3.5 Data Collection

As mentioned, we formally obtained the required authorization from Dr. Clance to use the CIPS scale. However, the use of the scale requires surveys to have a closed invitation format, directly addressing the target population. Hence, we could not spread the survey on the open internet or social media platforms. Therefore, our method was to approach partner companies by sending e-mails to software project managers and developers with a link to access the survey and asking them to distribute it within their companies. All respondents were asked to agree with the consent form before getting access to the survey. We conducted a pilot in April 2023 with seven software engineers who have more than 3 years of work experience, representing distinct genders, ages, education levels, and ethnic backgrounds. After minor adjustments, data collection happened from May 2023 to July 2023.

3.6 Data Analysis Procedures

To discuss the representativeness of our sample, we compare the characteristics of our sample (e.g., age range, company size, and working experience) with data from Stack Overflow's software developer survey (OVERFLOW, 2023). Annually, they conduct a survey among their users to gain insights into the software engineering community. This year, their survey received more than 90,000 answers(OVERFLOW, 2023).

To assess the manifestation of the IP in software engineers, we calculate confidence intervals using a technique called Bootstrapping that has been reported to be more reliable and precise than statistical inferences drawn directly from samples (LEI; SMITH, 2003; WAGNER et al., 2020). Bootstrapping calculates confidence intervals by re-sampling our data set, creating many simulated samples to promote a more robust and accurate analysis. Considering our sample size N, to perform bootstrapping, we create new samples S times of the same size N. Re-samples may include a given response zero or more times. We set S to 1000, a value known to yield meaningful statistical results (LEI; SMITH, 2003). We also calculate simple frequencies for the prevalence of IP in

[2]https://doi.org/10.5281/zenodo.8415205

different races/ethnicities, roles, educational levels, years of experience, marital status, and number of children. We created scripts in Python to support the analysis of our sample. The CIPS scale provides a score representing the intensity of IP for each respondent. We created a Boolean column to explicitly indicate whether the person had met the IP criterion aiming to streamline the subsequent analysis.

Finally, with respect to the relation of IP with perceived productivity, we applied the nonparametric Mann-Whitney U-test to check for statistically significant differences (alpha value 0.05) in the answers to the statements of Table 3.1. This test can be safely applied when one variable is nominal (e.g., having met the IP criterion or not) and one is ordinal (e.g., our Likert-scale questions). The anonymized raw data and our Python analysis scripts can be found in our online open science repository[3].

3.7 Validity Assessment

Hereafter we discuss validity types that are typically considered for survey research (WAGNER et al., 2020) and actions taken to improve the chances of safely concluding that the proposed survey measures what it is supposed to measure:

- **Face Validity**
  Threat: Unsuitability of the survey for the target audience. Mitigation action: Improve survey after running pilot.
- **Content Validity**
  Threat: Unsuitability format of the survey for the target audience. Mitigation action: Improve survey after revision by specialists.
- **Criterion Validity**
  Threat: Open access survey: we could receive answers from other professionals and not only from software engineers. Mitigation action: Besides the role list of our interest, there will be an option to write a profession that is not included. Furhtermore, demographic data will allow us to do segregated analysis.
- **Construct Validity**
  Threat: Using improper instruments. Mitigation action: Use of validate scales such as Clance IP Scale, SPACE and WHO[3] Questions.
- **Reliability**
  Threat: Lack of statistical conclusion validity because of the sample

[3]World Health Organization

size and lack of representativiness of the sample. Mitigation action: Use of bootstraping technique to provide confidence intervals, aiding in the amplification of sample data to encourage a more robust and accurate analysis. Comparison of our sample with reference data on software developers from StackOverflow[4]. Besides, questions from the WHO HPQ instrument will be used to cross-validate findings related to productivity.

3.8 Concluding Remarks

In that chapter, the research goal was described, and we elaborated on the construction of the instrument. We expounded on the research goal and the research questions. Subsequently, we presented hypotheses along with their underlying rationale. The Instrument Design section offered thorough information about the survey questions that were included and created. Procedures for data collection and analysis were elucidated and, finally, we delved into the validity assessment criteria we considered before formulating the survey. Next chapter will show our results.

[4]Public platform best known as a Q&A platform that over 100 million people visit every month to ask questions, learn, and share technical knowledge.

4
Survey Results

4.1
Introduction

This chapter is dedicated to presenting the results of our study. Initially, we provide a comprehensive overview of our study population, aiming to assess the representativeness of our sample. We have dedicated sections for each research question, delving into our primary findings. Following this, we discuss these results in the subsequent discussion section. The chapter concludes with an exploration of potential threats to validity, aligning with the validity assessment discussed in the previous chapter.

4.2
Study Population

Similar to Wagner *et al.* (WAGNER et al., 2020) and according to Yamane's equation to calculate a suitable sample size (YAMANE, 1973), considering the worldwide developer population to be 26.3M developers[1], a sample size of N=400 software engineers would be sufficient to allow generalizability for most purposes, a criterion that we achieved successfully with 624 answers. By distributing the survey to key contacts from over 100 different companies, we were able to reach 26 countries from five continents, as shown in Figure 4.1. The 16 *Others* represent two participants from Cuba, Finland, and Romania and one participant from Argentina, Austria, China, Cyprus, Czech Republic, Pakistan, Peru, Russian Federation, Senegal, and Slovakia. All survey questions were mandatory except the open-ended question for which 67 respondents left a comment. One-third of our respondents work in companies exceeding ten thousand employees.

The results of the demographic questions are shown in Table 4.1. Men represent 67.63% of our sample, while women constitute 30.13%. The most common ethnicity of software engineers in our sample is *White* (78.21%), followed by *Black or African American* (6.89%) and *Asian* (4,49%). *Other* represents *American Indian or Alaska Native*, *Other Race*, and *Prefer not to answer*. With respect to the level of education, the majority (58.33%) hold a Bachelor's degree or equivalent. The sample also shows a balance between

[1] Updated numbers from Evans Data Corporation. Site: www.evansdata.com

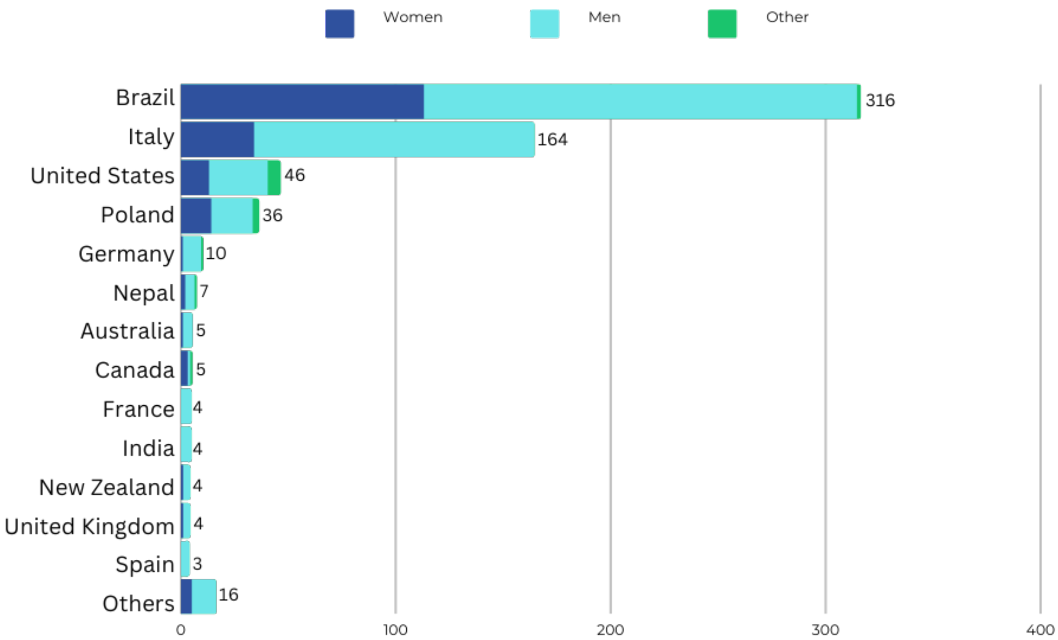


Figure 4.1: Participants' countries.

married (49.68%) and single (44.23%) respondents. Finally, the majority (68.75%) of our sample reported not having children.

Figure 4.2 shows a word cloud representation of the most common business sectors. *Banking/Financial* and *Sales/E-commerce* business sectors together represent 30% of our sample. We received a significant number (202) of responses in the *Other* text field, primarily encompassing *Consulting* and the *Public Sector*.

Figure 4.2: Business sectors.

Regarding the roles of the respondents, software developers (323) make up the largest portion of our sample, as shown in Figure 4.3. The respondents had the option to select multiple roles in the survey question asking for it.

Table 4.1: Demographic questions.

Survey Question	Options	Percentage
What is your gender?	Male	67.63%
	Female	30.13%
	Other	1.44%
	Prefer not to answer	0.8%
What is your predominant race/ethnicity?	White	78.21%
	Black or African American	6.89%
	Asian	4.49%
	Other	10.42%
What is your level of education?	Bachelor's or equivalent level	58.33%
	Master's or equivalent level	27.40%
	Secondary education	7.69%
	Doctoral or equivalent level	6.41%
	Primary education	0.16%
What is your marital status?	Married or Cohabiting	49.68%
	Single	44.23%
	Prefer not to answer	3.85%
	Divorced	2.08%
	Widow/Widower	0.16%
How many children do you have?	0	68.75%
	1	14.74%
	2	12.02%
	3 or more	2.72%
	Prefer not to answer	1.76%

Our list of roles encompassed professionals engaged in software projects, not exclusively limited to those involved in coding. For this research, it is crucial to also take into account leadership positions, as they represent senior and more experienced professionals (a concrete achievement) engaged in software engineering. Respondents could report to be working in more than one role. The *Other* role was described in a text field by 39 respondents. Consultant, Cyber Security Engineer, and Analyst were the most common within these answers.

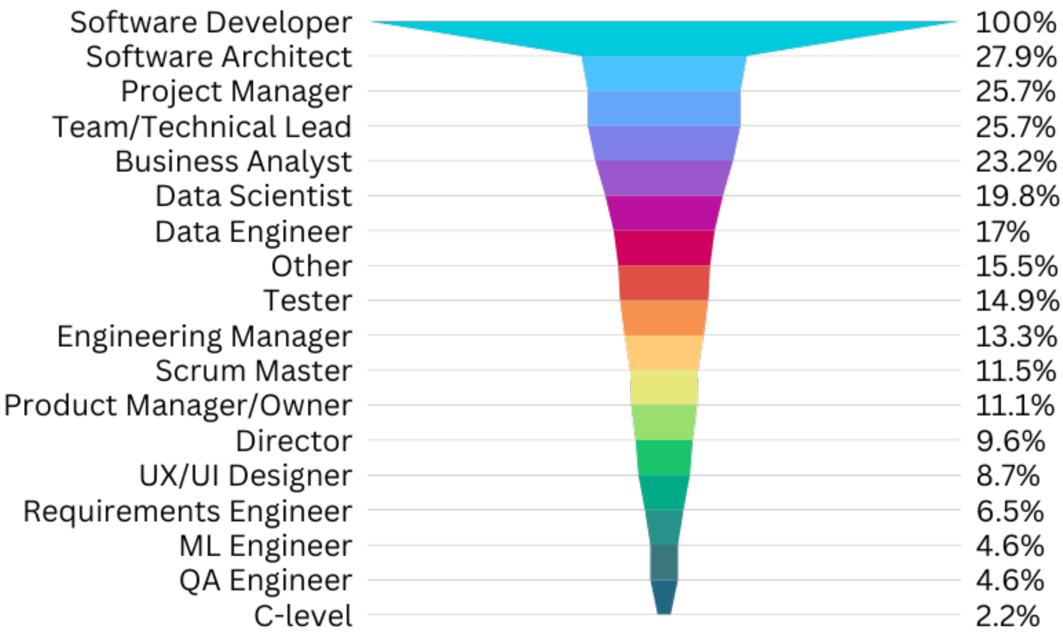


Figure 4.3: Participants' roles.

We also had a question asking about the major program of previous study in order to compare our findings with previous studies with CS students. From 480 answers, 340 respondents have a major in Information Technology (IT). The most common is Computer Science (165), followed by Analysis and Systems Development (29) and Computer Engineering (22). Non-IT courses include: Engineering, Mathematics and Science. Our sample also contains people whose major was in Humanities.

For the purpose of assessing the representativeness of our sample, we conducted a comparative analysis with data from the Stack Overflow Annual Developer Survey 2023 (OVERFLOW, 2023). Figures 4.4, 4.5, and 4.6 portray the distribution of age range, years of working experience, and company size from both studies. Comparisons shown in Figure 4.4 were facilitated by using similar age categories. To calculate the distributions shown in Figures 4.5 and 4.6, we used the raw data available from Stack Overflow (OVERFLOW, 2023).

It is possible to observe that the distributions of the studies were similar considering age range (see Figure 4.4), working experience, and company size addressed in both studies. There are few differences. For instance, in Fig. 4.5, we observe that our sample had a greater representation of participants in the early stages of their careers. Also, Figure 4.6 allows us to observe that our sample has a higher representation of individuals from companies with over 10k employees and a lower representation from companies with less than 9 employees. It is noteworthy that the Stack Overflow survey in its question *Approximately how many people are employed by the company* *or organization you currently work for?* had a specific option for freelancers, while our restricted data collection, required for using the CIPS scale, made it difficult to reach out to professionals that were not working for a specific company. For the same reason, our geographic distribution was naturally different, as we had to personally reach out to companies we had contact with. Overall, the similarities of the samples exceed our expectations and increase the confidence in the sample's representativeness, particularly considering that the Stack Overflow survey sample comprises over 90k responses.

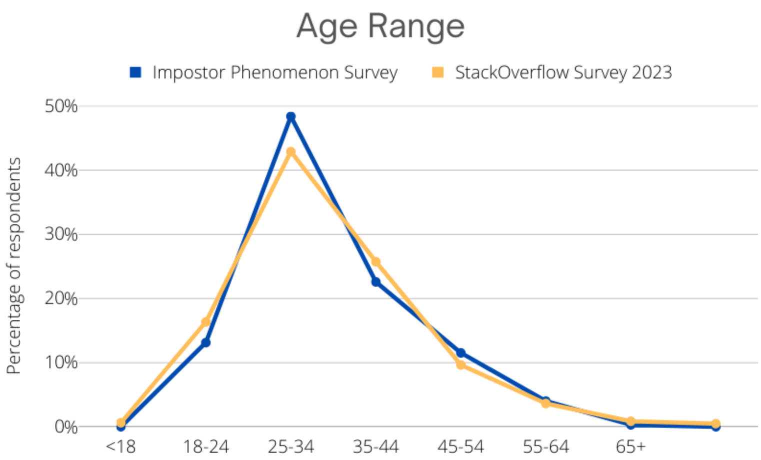


Figure 4.4: Age range distribution from this study and the 2023 Stack Overflow survey.

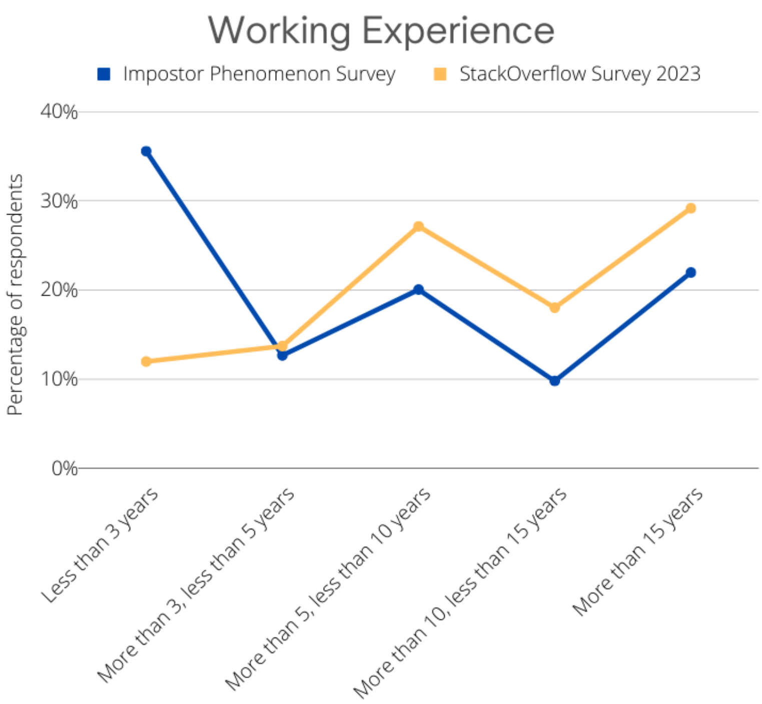


Figure 4.5: Working experience distribution from this study and the 2023 Stack Overflow survey.

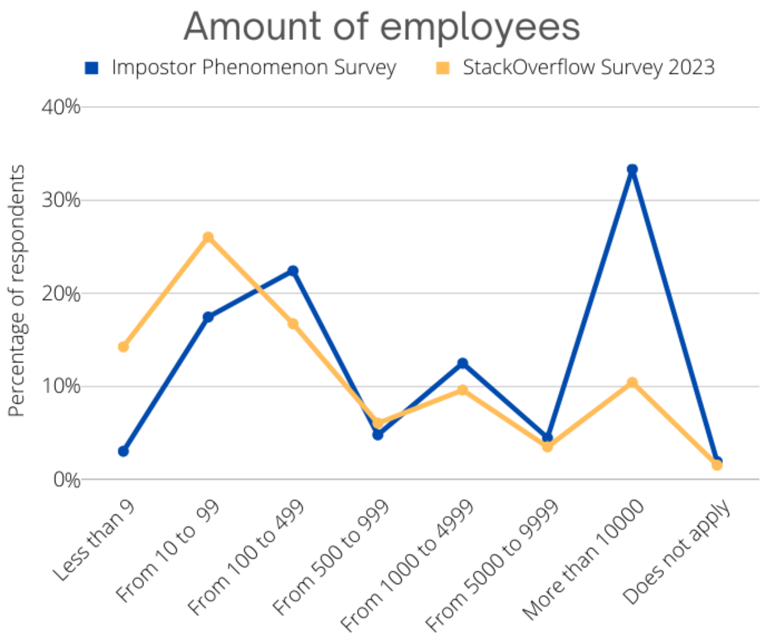


Figure 4.6: Company size distribution from this study and the 2023 Stack Overflow survey.

Another difference is that 30.13% of our answers were provided by women, significantly more than in the 2023 Stack Overflow survey (5.17%). Greater female participation in our sample can possibly be attributed to the fact that we do not consider only developers (who are the main users of Stack Overflow). We consider software engineering professionals involved in different roles in the software process.

4.3 RQ1 - How does IP Manifest in Software Engineers?

Answering RQ1.1, the proportion of software engineers who suffer from IP is shown in Figure 4.7, together with an error bar that represents the 95% confidence interval. Both the Proportion (P) and the Confidence Intervals (CI) were calculated using bootstrapping (WAGNER et al., 2020). The results show that P = 52.72% (CI [48.72, 56.57]) match the diagnostic criteria of IP, suffering from frequent to intense levels of impostor feelings. Therefore, while we observe a high proportion of software engineers suffering from IP, considering the confidence interval, we cannot confirm hypothesis H1, which states that more than 50% of software engineers suffer from IP. However, software engineers' mean IP score is 62.12, which is high and comparable to the mean score of 64.18 observed among Computer Science students (ROSENSTEIN; RAGHU; PORTER, 2020).

RQ1.2 concerns the manifestation of IP within different genders, races/ethnicities, and roles. With respect to genders, Figure 4.7 shows that

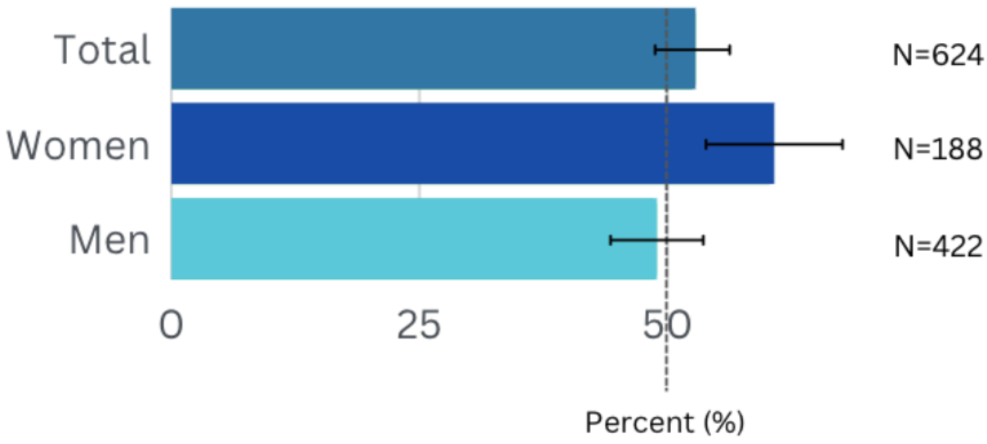


Figure 4.7: Bootstrapping proportions of IP with confidence intervals.

significantly higher proportions of women (P = 60.64% [53.72, 67.55]) suffer from IP than men (P = 48.82% [44.06, 53.55]). This allows us to confirm H1 for women, but not for software engineers in general nor for men. Unfortunately, our sample includes a very limited representation of genders other than male or female, not allowing for statistical bootstrapping. Therefore, we only report the simple frequency. From 14 answers (including *Prefer not to answer*), nine met the diagnostic criterion, meaning a (high) frequency of 64.28% within these gender groups.

Regarding mean and median IP scores, Table 4.2 presents the difference of mean and median scores from men, women and all respondents. In the first line, we can see the results from the ones who have IP in the current study. Subsequent lines facilitate a comparison: results from this study and the mean scores originate from the first study with CS students joined with the median scores from the second study (both of them are listed in chapter 2). As anticipated, given the higher scores in CIPS among students, it was expected that software engineering professionals surveyed in this study would exhibit lower mean and median scores, as evident from the results. It is noteworthy that women have higher mean and median scores in all instances.

IP is prevalent among over half of women across almost all age groups, meanwhile after the age of 34, the number of men affected by IP decreases. Men have more than 50% of IP in only one age group, as Figure 4.8 depicts.

Concerning years of experience, Figure 4.9 illustrates that, similarly to the behaviour of women in age range groups, over than half of women have IP in all years of experience categories. It is noteworthy that the number of IP instances among women decreases with an increase in years of experience. However, after reaching 10 years of experience, the number of instances rises

Table 4.2: IP Score: Mean and Median

Sample	Gender	Mean*	Median
People with IP**	Male	74.5	73
	Female	79	79
	All	76	75
All respondents	Male	60	60
	Female	67	70
	All	62	62.50
CS students studies***	Male	63	70
	Female	68	77
	All	64	70

*Mean scores are rounded to the nearest.
** Mean people who met diagnostic criteria of suffering IP (score >= 61)
***The mean and median scores are derived from each study involving computer science students as described in the related work.

once more. It's important to note that the results may have been influenced by the limited number of women (N=13) in this specific category.

Regarding the prevalence of IP among software engineers of different races/ethnicities, given the number of categories, we also conservatively did not apply statistical bootstrapping and limited our analysis to frequency counting without inferential statistics. The frequencies are shown in Table 4.3. It is noteworthy that respondents who identify predominantly as *Asian* (67.85%) and *Black or African American* (65.11%) software engineers suffer more than respondents who identify as *White* (50.00%). Hence, for races/ethnicities, we also observed differences that deserve attention from the community.

To address how IP manifests in different roles, Figure 4.10 depicts the frequency of respondents matching the IP diagnostic criterion within each role. While it is not possible to draw any conclusions, it seems that technical roles, in particular, roles related to data science (*e.g.*, data scientist and data engineer), have slightly higher IP manifestation frequencies.

Finally, we analyzed the IP frequencies per marital status (Table 4.4) and number of children (Table 4.5). Again, we refrain from using inferential statistics for smaller groups within the categories. Still, the frequencies lead to interesting conjectures. For instance, we observed a less common presence of IP in respondents who are married and who have one or two children. According

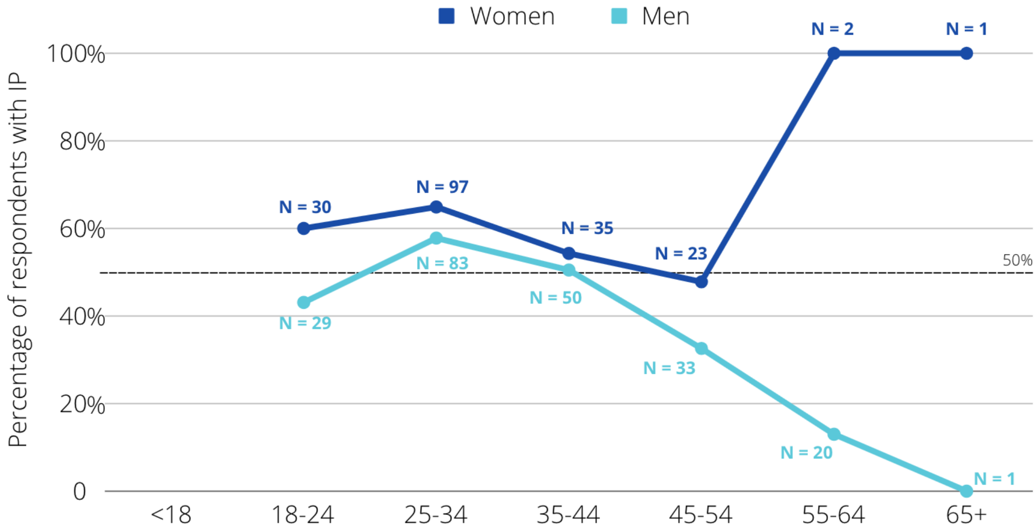


Figure 4.8: IP x age range

Table 4.3: Races/ethnicities and IP frequencies.

Predominant Race/Ethnicity	N	IP Frequency	Mean Score*
White	488	50.00%	76
Prefer not to answer	60	58.33%	76
Black or African American	43	65.11%	78
Asian	28	67.85%	78
Other Race	3	100.00%	68
American Indian or Alaska Native	2	0.00%	0

*Mean scores are rounded to the nearest.

to our data[3], this holds for men and women.

Concerning the 54 respondents who scored more than 80 in CIPS, revealing intense feelings of IP, 27 of them are women. The majority of them, 32 people, are married and 36 does not have children. They represent diverse business sectors and hold various roles. The age range provides limited insight, ranging from 22 to 59 years old. Among them, 30 hold a bachelor's degree, while 20 possess a master's degree. Only 16 have more than 3 and less than 5 years of experience.

4.4 RQ2 - Does IP Affect the Perceived Productivity of Software Engineers?

To answer RQ2, we analyze if satisfying the IP diagnostic criterion has an effect on the Likert-scale self-assessment statements (*cf.* Table 3.1). We applied the Mann-Whitney U-test to check for statistically significant differences (alpha value 0.05) between software engineers suffering from IP and those not suffering from it in their productivity self-assessments.

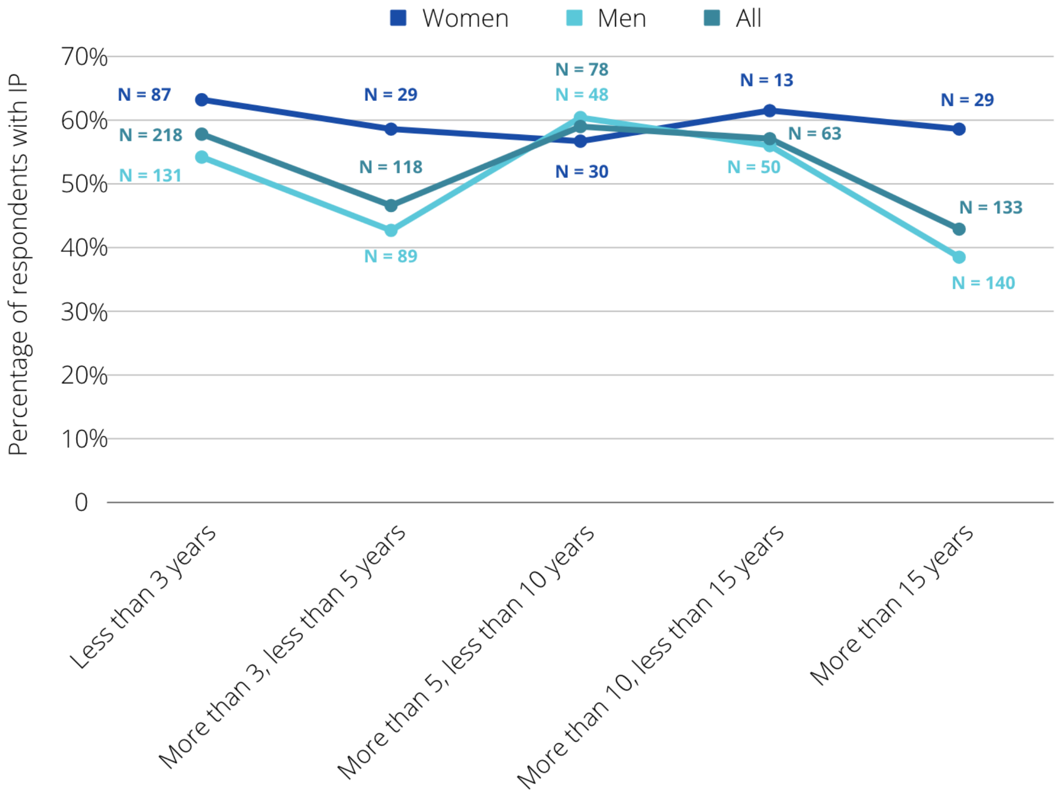


Figure 4.9: IP x years of experience

Figures 4.11 to 4.15 provide diverging stacked bar charts that enable visualizing the differences in the Likert-scale results for each statement. It is easy to observe differences with higher agreement frequencies in all statements for software engineers who do not suffer from IP. In fact, all the differences were statistically significant with extremely low p-values, and hypotheses H2 to H6 were confirmed. Software engineers suffering from frequent to intense levels of IP have lower perceived productivity.

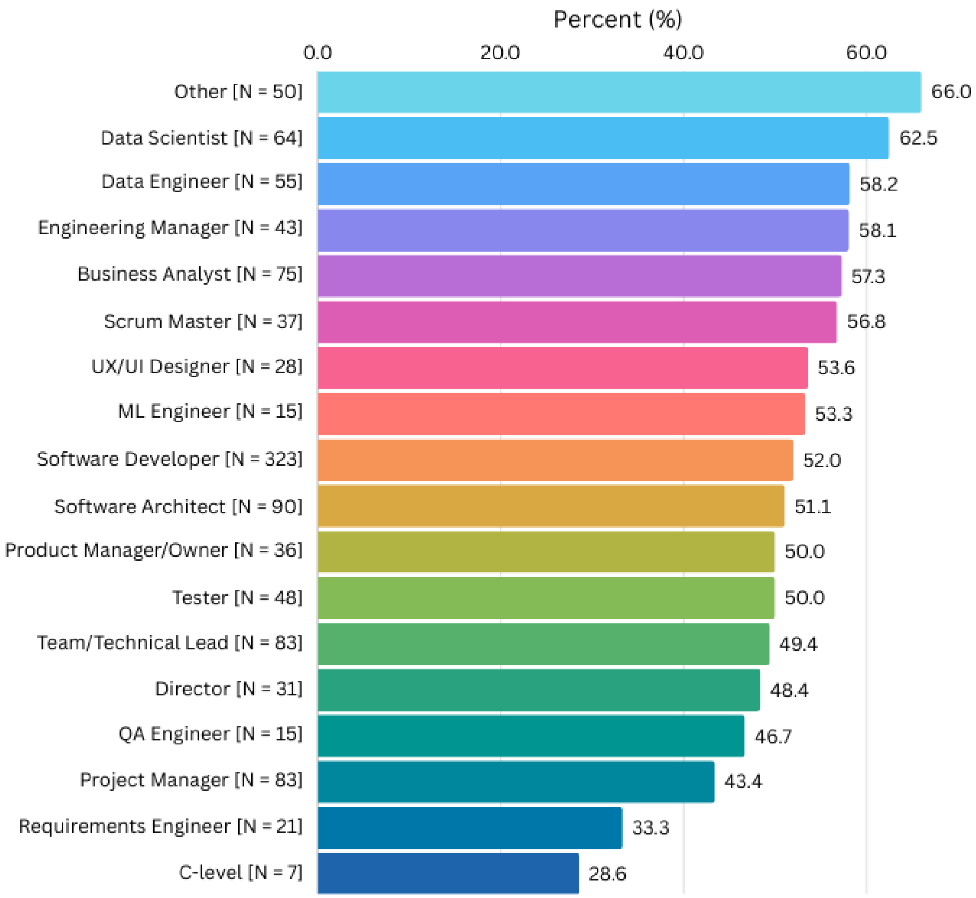


Figure 4.10: Manifestation frequency of IP in different roles.

Table 4.4: Marital statuses and IP frequencies.

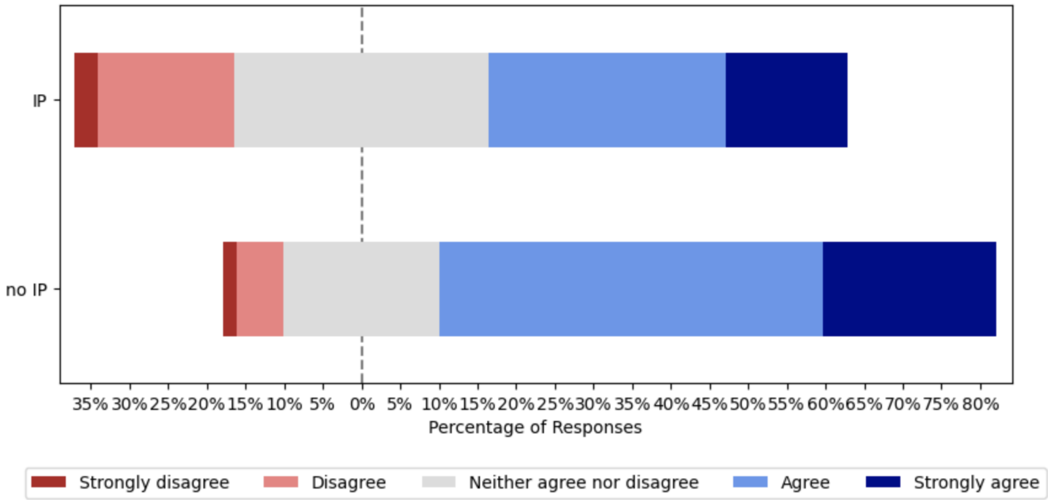
Marital Status	N	Percentage with IP	Mean Score*
Single	276	59.78%	76.5
Married or Cohabiting	310	47.09%	76
Prefer not to answer	24	41.66%	73.5
Divorced	13	53.84%	77.5
Widow/Widower	1	100.00%	80

*Mean scores are rounded to the nearest.

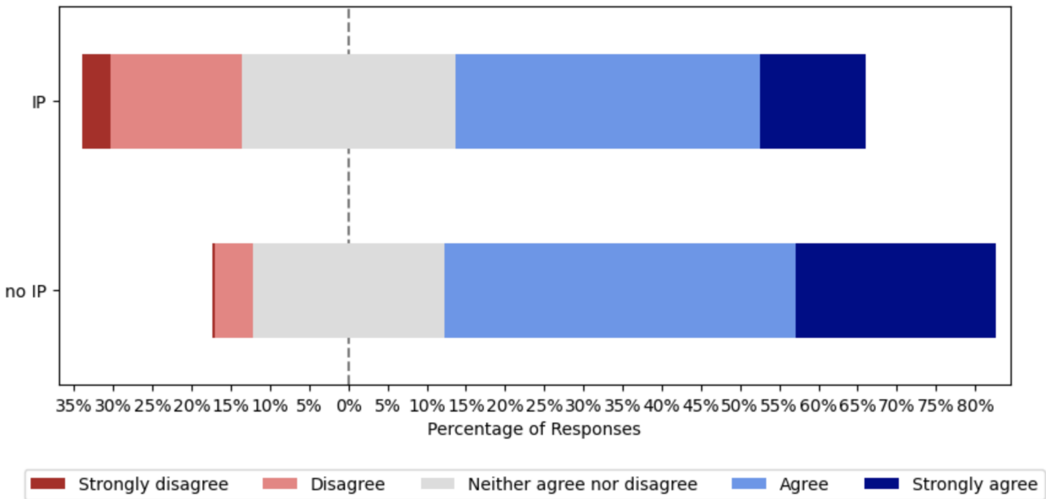
Table 4.5: Number of children and IP frequencies.

Number of Children	N	Percentage with IP	Mean Score*
0	429	57.10%	76
1	92	45.65%	73
2	75	33.33%	78.5
3 or more	17	64.70%	75
Prefer not to answer	11	54.54%	77

*Mean scores are rounded to the nearest.

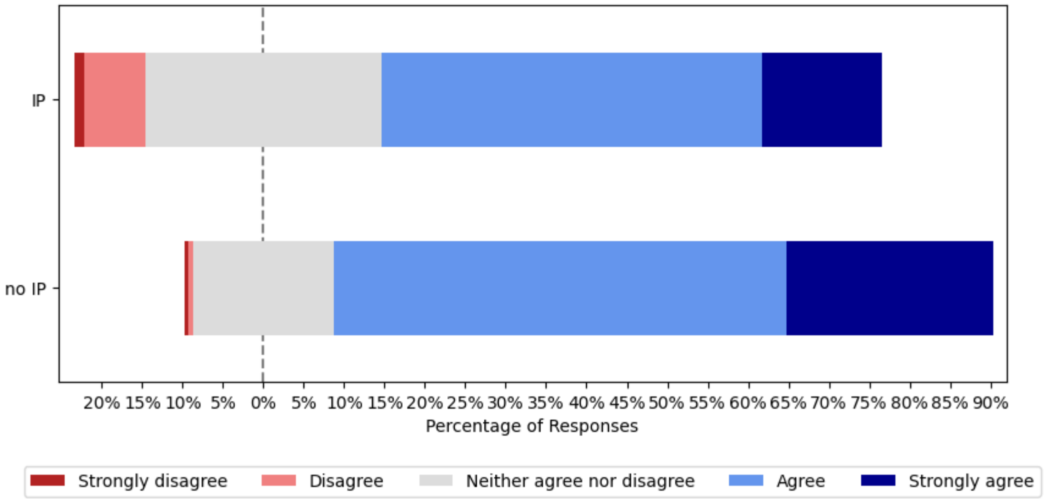


1. I feel fulfilled at my work (p-value = 3.56e-09).

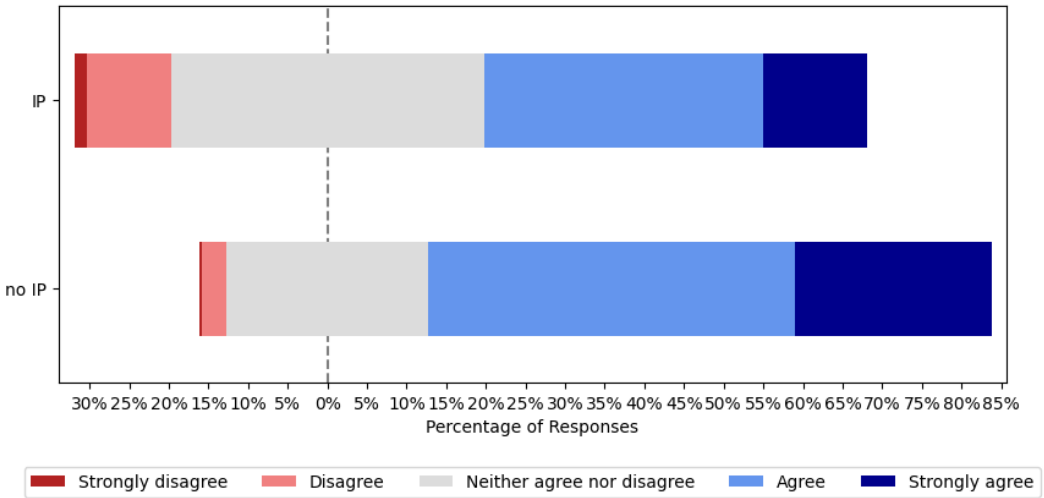


2. I am healthy and happy when I work (p-value = 3.34e-12).

Figure 4.11: Perceived satisfaction and well-being.

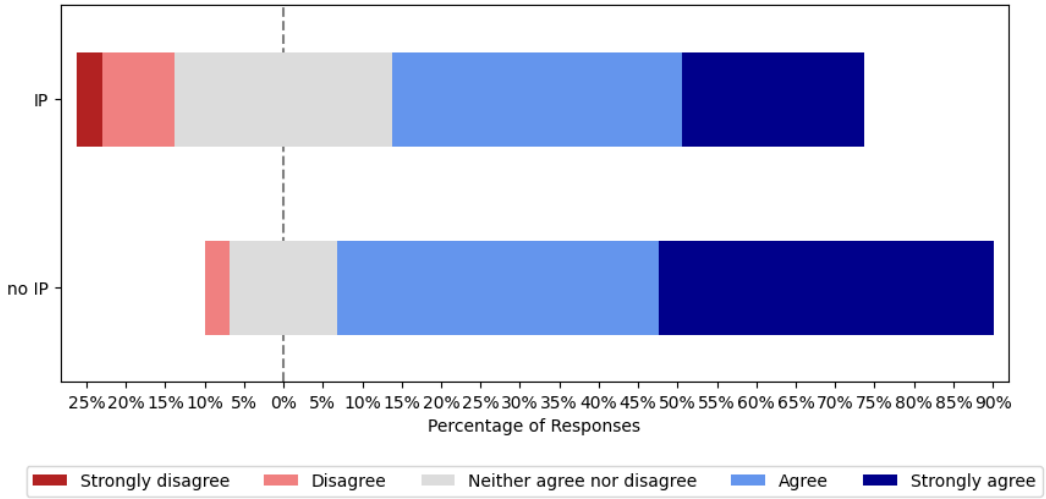


3. I deliver high-quality work (p-value = 8.78e-09).



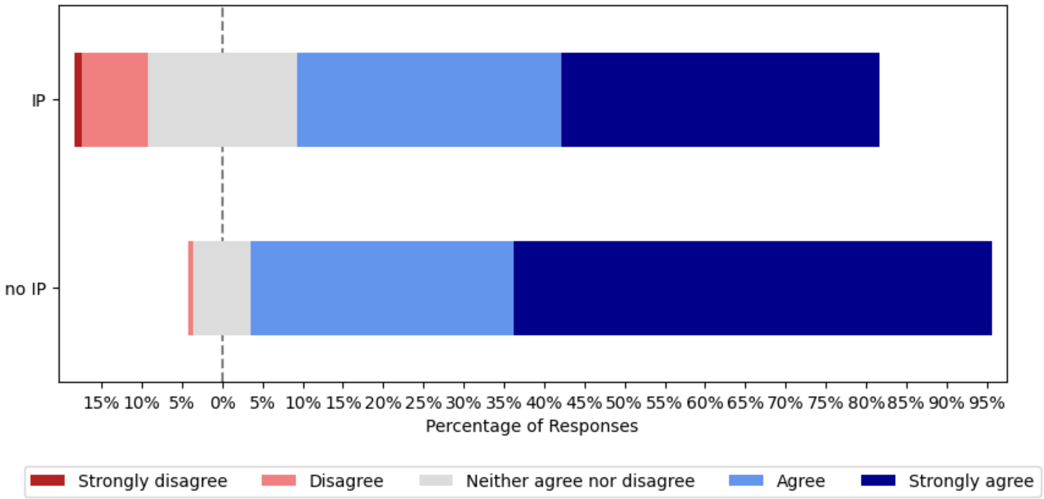
4. I deliver impactful work (p-value = 4.95e-10).

Figure 4.12: Perceived performance.

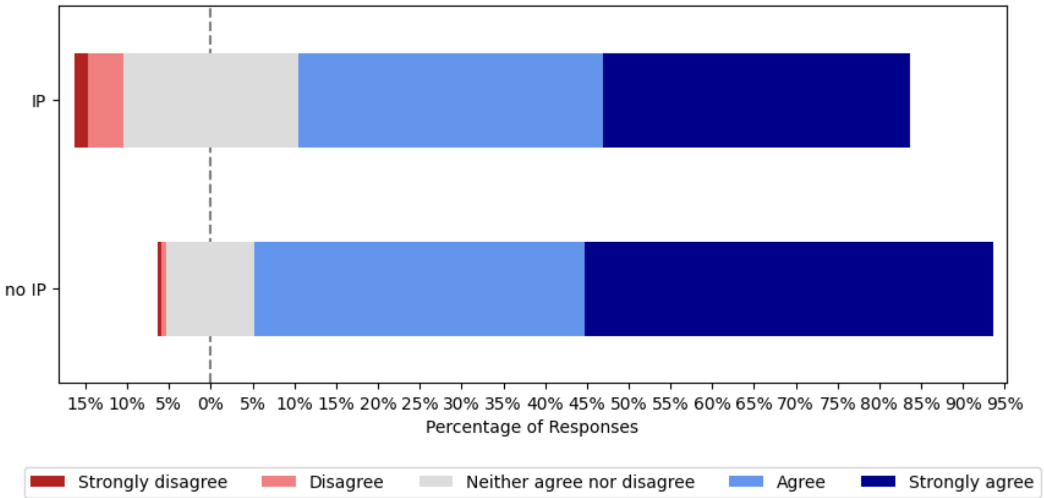


5. I complete as many tasks as it is expected from me in my position (p-value = 4.95e-10.

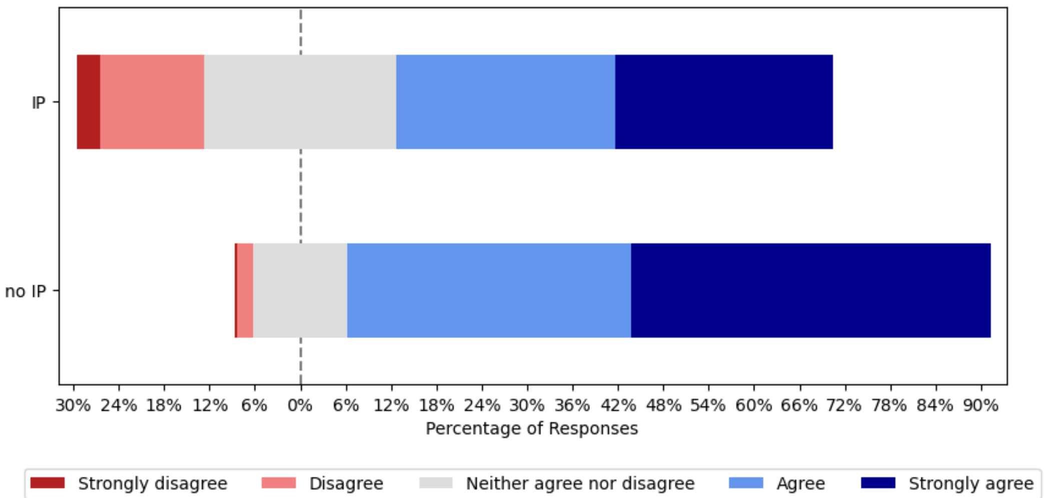
Figure 4.13: Perceived activity.



6. I feel comfortable communicating with my team (p-value = 2.38e-10).

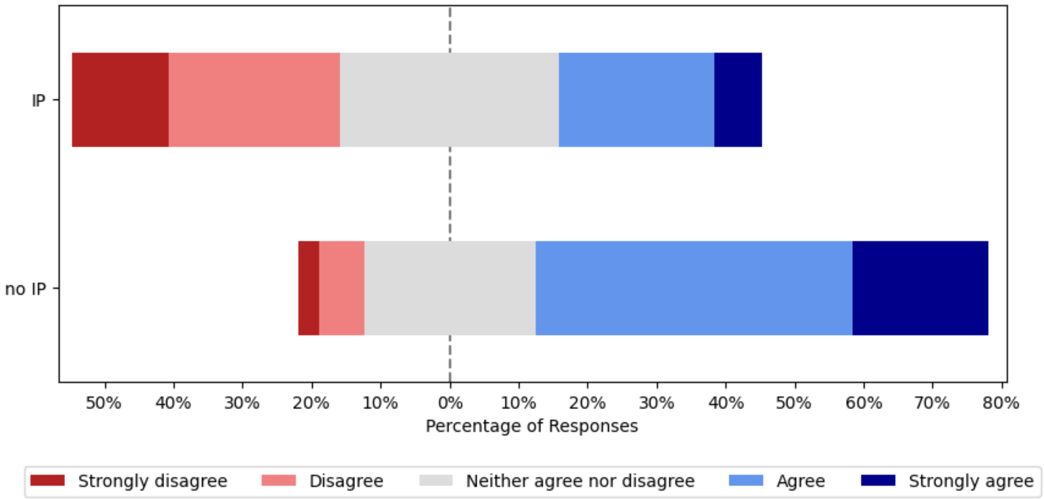


7. My team supports and values my communication (p-value = 1.14e-05).

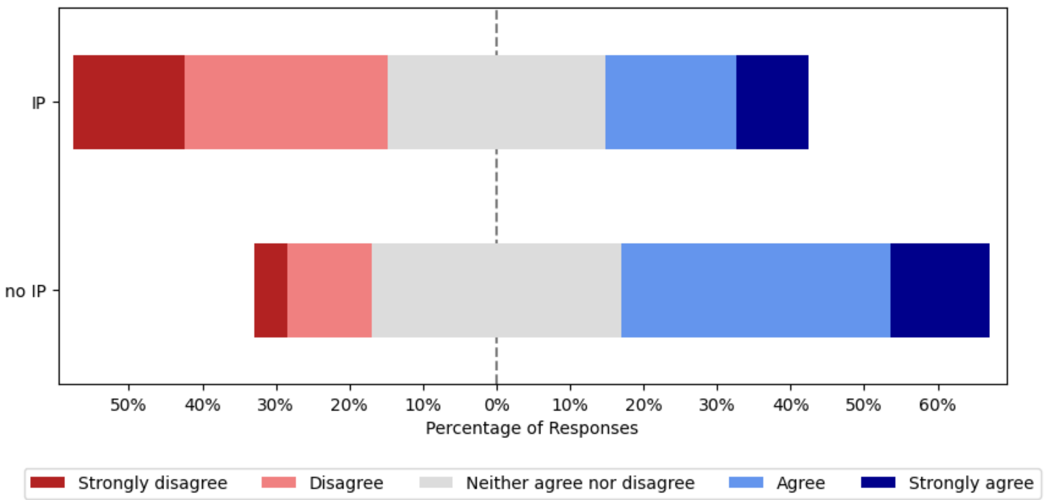


8. I play an important role in my team (p-value=5.87e-13).

Figure 4.14: Perceived communication and collaboration.



9. I am able to focus on and make progress on my work without internal interruptions (p-value=5.75e-23).



10. I am able to focus on and make progress on my work without external interruptions (p-value=1.54e-12).

Figure 4.15: Efficiency and flow.

4.5 Discussion

The results obtained from our study offer valuable insights into the prevalence of IP among software engineers, shedding light on various aspects of this phenomenon. Hereafter, we discuss the main findings related to our research questions.

RQ1 - How does IP manifest in software engineers? This question explored how the IP manifests across different software engineering demographic and professional dimensions. The investigation into the overall prevalence of impostor feelings among software engineers (RQ1.1) revealed that a proportion of about 52.72% (CI [48.72, 56.57]) experience frequent to intense levels of impostor feelings. Given that IP may lead to mental disorders such as depression and burnout, this scenario highlights the need for further investigation into this phenomenon.

With regard to gender (RQ1.2), the results indicated significant differences in the manifestation of impostor feelings. A notably higher proportion of women software engineers suffer from impostor feelings (60.64%) compared to men (48.82%). The results for races/ethnicities (RQ1.2) indicated higher frequencies of IP in respondents predominantly identifying as Asian (67.85%) and Black or African American (65.11%) software engineers when compared to those identifying as White (50.00%). In the case of underrepresented groups, it is essential to take into account that the work environment may play a role in either triggering or exacerbating these symptoms. For instance, organizations that value psychological safety tend to nurture an environment where people feel encouraged to share ideas without fear of personal judgment.

With respect to IP across various professional roles (RQ1.2), it appears that technical roles, particularly those related to data science, exhibited slightly higher frequencies of impostor feelings. In fact, the data scientist profile, where domain expertise and data-driven insights are pivotal, is typically expected to excel in math/statistics, computing, and business-related skills (KIM et al., 2017), which seem hard to combine in a single person.

While the majority of our sample comprises individuals aged between 25 and 34 years old (Figure 4.4a), and this age group also includes a higher number of individuals with IP (Figures 4.8), it should not be inferred that the predominant portion of the sample consists solely of inexperienced software engineers (Figure 4.9). Besides, among the ones who suffer from intense levels of IP, the majority of them have more than 5 years of experience.

Additionally, we noted that individuals who are married and have children tend to experience IP less frequently than those who are single. These observations suggest potential relationships between personal life circumstances and the prevalence of impostor feelings, which require further investigation.

RQ2 - Does IP affect the perceived productivity of software engineers? A consistent pattern emerged for this research question, indicating lower perceived productivity across all five assessed productivity dimensions (RQ2.1 to RQ2.5) of the SPACE developer productivity framework for software engineers suffering from IP. Notably, these differences were statistically significant. These findings provide evidence confirming the hypothesized notion that IP can be a significant barrier to professional productivity.

The fulfillment of hypotheses 2 to 6 implies that individuals meeting the diagnostic criteria experience lower levels of personal satisfaction and well-being, as well as diminished performance, activity, communication, collaboration, efficiency, and flow. Therefore, people suffering from IP may fail to recognize praise even if they receive acknowledgment. The apprehension of criticism, the fear of being exposed as a fraud, and persistent concerns about not meeting others' expectations hinders collaboration in workplace.

Lower perceived efficiency and flow is the productive dimension in which people with IP disagreed and strongly disagreed the most among all SPACE questions. This observation may reveal the impostor cycle [2] vividly working in their minds fearing evaluation, recalling moments of failure and contemplating how they could handle those moments again, also wondering how to achieve perfection and the need to be the very best. These thoughts can be disturbing, constantly interrupting their concentration.

Recognizing the prevalence and impact of IP as a potential hindrance to productivity, software engineering organizations may consider implementing strategies and support mechanisms to help professionals cope with and overcome these feelings. Such initiatives could include mentorship programs, peer support networks, training in emotional resilience, and fostering a culture of openness and psychological safety.

4.6
Open-ended Question

As aforementioned, in the last question of the survey, respondents were encouraged to freely share any comments or experiences they had regarding the Impostor Phenomenon.

We received feedback from two individuals who introduced the topic of ADHD (Attention Deficit Hyperactivity Disorder) into the discussion. Two of them scored more than 80 points in CIPS and have more than 5 years of professional experience. *"I was diagnosed with ADHD last month."* was mentioned by a white technical lead man who scored 85. A software architect and tech lead with over a decade of experience with a score of 84, suggests that he aligns with the Impostor Phenomenon (IP) cycle. This cycle involves individuals thinking that if they can achieve something, anyone else could do it as well, or even better. Consequently, the person expects continuous

[2]The second phase of the impostor cycle (overpreparation or procrastination) is defined in dr Clance's book. It describes the loop in which IP victms start and end fearing new project or tasks. They engage in procrastination or excessive preparation in order to achieve a goal. Up to completion of this goal, the feeling of relief is quickly transposed by thoughts that say "I was just lucky" or "If I could accomplish it, anyone else could as well".

improvement, striving for perfection. Not reaching these high standards leads them to consistently feel as though they are lagging behind. *"I constantly don't live up to my own expectations. I'm never as successful as others, never as good as others at my job, never delivering as quickly, and constantly doing less work. This has led to a low worry which comes and goes of maybe getting fired, or put on a pip. I seek feedback regularly, but my perfectionism and ADHD tendencies mean that it's tough for me to action on that feedback, which sees the same worries and problems repeat."*. He finishes his comment with hope *"Some days are better, some weeks are better. I'll figure it out slowly, with time, and patience, and work."*.

A respondent, holding the second-highest score (93) from those who left a comment, serves as a tech lead in a company with over 10,000 employees. Despite this, the individual lacks a sense of belonging due to the absence of a university degree: *"Even though I'm a tech lead, I'm the only college dropout (due to financial and medical reasons) on a team full of PhDs and people with masters degrees. I know I can do the job, but it feels like I'll get discovered to be a dropout and thus be blocked from future opportunities at any moment."*.

Women seem to have more knowledge in the subject. One of them, who scored 79, did not appear surprised as can be inferred by her straightforward comment: *"I would like to know techniques to help me to be better."*. A similar inference can be drawn for another women who possess a bachelor's degree and suffers from intense levels of IP (score = 82). She just said: *"Well. I'm a woman."*. Being women should not be a reason for having IP.

A black data analyst women with more than 15 years of experience, also suffering from frequent levels of IP, described what is to feel like an impostor for her: *"Sometimes I feel not comfortable or confident to do my work but I always receive a good feedback from the client for the amount of work done in a little period of time."*. This comment delineates a productive individual, particularly in terms of performance and activity. However, she seems unable to recognize it, likely engaged in a struggle with the need to be perfect.

Bring awareness to the problem is the first step to overcome it. A 63 year old employee from an Oil and Gas company who scored 73 wrote: *"I do not have any information about it. This is the first time I hear about it indeed some times I felt as an impostor in the past."*.

Overall, the comments depicts at least a need to talk about the subject which should promote seeking for ways to overcome it. *"I believe that I have put a lot of pressure on myself since I was little, I don't know if it was because I was always asked for the best, always for excellence in everything I did, so perhaps today I feel like an impostor for being able to live without the constant* *pressure for excellence. . Thank you for the questions, it was very reflective, success in your research!"*, said a black man who scored 89.

4.7
Hints to Overcome the Impostor Phenomenon

Dr Valerie Young and Dr Pauline Clance, in their books, gave some advice and recommend some behaviours to overcome the Impostor Phenomenon. Some of them are listed here:

– *Be aware of the problem.* Recognize that those who does not feel like impostors are not necessarily smarter, more capable, or better than who feels like one. They simply have different thoughts and, for them, it is normal to not excel in everything, which means we need to learn not to think like impostors.
– *"Fix" your thoughts.* People should develop a conscious awareness of the cycle that initiates when they start on a new project or task. It is needed to observe their thoughts in situations that trigger their impostor feelings.
– *Fake it till you make it.* When someone is about to present something and starts trembling, they should think: I am confident! I am very excited for this. As a result, their body will grasp that experiencing it isn't necessary to embody it. With consistent practice, the person will develop the belief needed to stop feeling like an impostor.
– *Own your achievements.* There is a strategy for that: individuals ought to write down their achievements and understand that all the reasons they created to discredit themselves are just the impostor feelings speaking.

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4.8
Threats to Validity

Hereafter, we discuss validity types that are typically considered for survey research (LINAKER et al., 2015) and the reliability of our research, as well as mitigation actions taken to address threats and improve the chances of safely concluding that the proposed survey accurately measures what it is supposed to measure.

Face Validity. A threat to face validity concerns the unsuitability of the survey instrument for the target audience. To mitigate this threat, we conducted a pilot study to evaluate the instrument, after which we made some minor improvements to the instrument to improve clarity (*e.g.*, adjust numbering and some answer options).

Content Validity. To improve content validity, a group of subject matter experts, researchers from universities of three different countries, active with research related to human aspects in software engineering, reviewed and evaluated the questionnaire. One of these experts also had extensive knowledge of the SPACE framework.

Criterion Validity. A threat related to criterion validity would be receiving answers from other professionals and not only from software engineers. The survey was sent to representatives of our target population in closed invitation format (WAGNER et al., 2020). Also, we explicitly capture the role of the respondents in the survey, allowing segregated analyses.

Construct Validity. The main threat regarding construct validity is using improper instruments. Besides demographics, the survey had two sections, one on IP and one on perceived productivity. For measuring the IP, we made authorized use of the CIPS scale (CLANCE, 1985), which is the most used scale and has been reported as a reliable instrument(MAK; KLEITMAN; ABBOTT, 2019) and has been used in our related work (*e.g.*, (ROSENSTEIN; RAGHU; PORTER, 2020; BERNUY et al., 2022)). For perceived productivity, there was no scale for measuring the SPACE productivity framework constructs. Therefore, we designed statements and validated them with subject matter experts.

Reliability. With respect to reliability, the main threats would be a potential lack of statistical conclusion validity because of the sample size and the lack of representativeness of the sample. According to (WAGNER et al., 2020), for most intents and purposes related to software developers, with a sample size of more than 400, it is possible to claim strong generalizability as long as the representativeness of the sample has also been checked. Our sample of 624 exceeds this suggested sample size. Furthermore, we checked the representativeness by comparing it against the sample from the Stack Overflow Annual Developer survey, for which we observed that the distributions closely resemble, reinforcing our confidence in the quality of the sample. One might argue that the distribution of the countries of the respondents is not representative. This was mainly due to the obligation to use a closed invitation format in order to be allowed to use the CIPS scale. Still, regardless of the country, the developer profile resembles the one from the Stack Overflow survey. Nevertheless, our results and call for actions to prevent IP in software engineers are rather conservative, considering that if we remove the two countries with the most responses (Brazil and Italy), the IP frequency goes up even higher to 65.27% (94 out of 144). Due to space constraints, a complete country-based analysis is out of the scope of this dissertation and points to future work.

As suggested by (LEI; SMITH, 2003; WAGNER et al., 2020), and similar to other survey-based studies (WAGNER et al., 2019), we used bootstrapping to provide confidence intervals, allowing a more robust and accurate analysis. Our sample and all our analysis procedures are available in our online open science repository[3] and are auditable.

4.9 Concluding Remarks

This chapter was dedicated to presenting our results. Initially, we provided a comprehensive overview of our study population. In the two sections for each research question, we delved into our primary findings. Subsequently, these results were discussed. Finally, we explored potential threats to validity, aligning with the validity assessment discussed in the previous chapter. The next chapter will serve as the conclusion to this dissertation.

5
Conclusion and future work

5.1
Contributions

This research represents the first investigation of the prevalence and manifestation of IP in software engineers as a whole, rather than focusing solely on a subgroup within the field. The main outcomes of this dissertation were accepted for publication at the Software Engineering in Society track of the International Conference on Software Engineering (GUENES et al., 2024). We carefully planned and conducted a survey using a validated scale for measuring IP, gathering responses from 624 software engineering professionals. The observed prevalence of IP among software engineers, with 52.72% (CI [48.72, 56.57]) of respondents experiencing frequent to intense levels of IP, highlights the need for increased awareness and support within the software engineering community, especially given that IP may lead to other severe mental disorders (CLANCE, 1985).

Furthermore, we observed disparities across gender, race/ethnicity, and professional roles. For instance, underrepresented groups, including women and black people, more frequently suffer from IP than men and white people. We should pay attention to, in the case of underrepresented groups, the work environment may play a role in either inducing or even worsening these symptoms.

Moreover, we provide statistically significant evidence that software engineers who suffer from IP perceive themselves as less productive than others in terms of their satisfaction and well-being, performance, activity, communication and collaboration, and efficiency and flow. Based on our results, we put forward that software engineering organizations should consider implementing strategies and support mechanisms to promote psychological safety, especially considering underrepresented groups, and help professionals cope with IP feelings and overcome them, ultimately fostering a more inclusive and productive workforce.

5.2
Limitations

As previously mentioned, our sample already comprises a substantial number of responses, suggesting the potential for further increasing the number of respondents. One strategy to achieve this could involve establishing a dedicated team tasked with disseminating the survey in additional regions.

Half of the sample for this study is from Brazil. While this approach allowed for an in-depth examination of software engineers in Brazil, it may not capture the full spectrum of IP across different demographic groups. Therefore, caution should be exercised when generalizing the results. Nevertheless, we assessed the representativeness of our sample comparing it to the annual Stack Overflow survey. We also observed that when blocking out the data from Brazil no the behaviors seemed comparable to our overall findings. However, we are aware that future research endeavors should consider expanding the sample to include a more diverse country representation.

5.3 Future Work

Our dataset enables more targeted investigations, therefore offering the opportunity for additional data analyses focused on the underrepresented groups experiencing impostor feelings most acutely. One approach could involve delving into the specific distinctions between genders, emphasizing the primary differences between males and females. Within the female category, it would be valuable to explore variations among different ethnic backgrounds. We could also conduct additional analyses using the data, such as examining the relationship between gender and perceived productivity.

Furthermore, additional empirical strategies, such as case studies could provide valuable insights into comprehending the interactions among colleagues within high and intensive levels of IP software development teams. We could correlate it with other characteristics (such as the use of agile methods, etc.) to understand which scenarios facilitate (or hinder) the manifestation of the phenomenon. It would likely be meaningful to:

- evaluate the impact of the environment by examining contextual demographics, including team size, gender distribution, absences due to illness and non-participation in meetings
- explore the effects of remote work
- assess task complexity and investigating whether the company provides dedicated learning time for employees or requires them to learn while actively coding could provide valuable insights
- observe whether the employee aligns with a description of an impostor type as outlined by Dr. Valerie. It may be valuable in assisting with the respective behaviour and symptoms

– analyze productivity from an individual's perspective and through another person's evaluation (360-degree assessment) for cross-validation purposes.

A case study or other experimental strategies could call attention from companies and might unveil causal relationships between IP and performance. The outcome of these additional investigations could yield tailored solutions for addressing impostor feelings effectively.

Overall, this study rises numerous questions, some of which cannot be answered with our collected data. For example: is there a negative correlation between IP and ADHD? Would it be valuable to investigate the impact of using AI (e.g. co-pilot) on IP? A longitudinal study would reveal that employees move more from companies than others? To which extent the environment exacerbates (or not) IP feelings in underrepresented groups? Additionally, it would be beneficial to investigate why IP increases in high achieving women when they have from 5 to 10 years of experience.

6
Bibliography

BADAMPUDI, D. Reporting ethics considerations in software engineering publications. In: IEEE. **2017 ACM/IEEE International Symposium on Empirical Software Engineering and Measurement (ESEM)**. [S.l.], 2017. p. 205–210. Cited in page 25.

BASILI, V. R.; ROMBACH, H. D. The tame project: Towards improvement-oriented software environments. **IEEE Transactions on software engineering**, IEEE, v. 14, n. 6, p. 758–773, 1988. Cited in page 22.

BERNUY, A. Z. et al. Additional evidence for the prevalence of the impostor phenomenon in computing. p. 654–660, 2022. Cited 4 times in pages 16, 19, 23, and 50.

BIRD, C. et al. Taking flight with copilot. **Commun. ACM**, Association for Computing Machinery, New York, NY, USA, v. 66, n. 6, p. 56–62, may 2023. ISSN 0001-0782. Cited 2 times in pages 16 and 20.

CAWCUTT, K. A.; CLANCE, P.; JAIN, S. Bias, burnout, and imposter phenomenon: the negative impact of under-recognized intersectionality. **Women's Health Reports**, Mary Ann Liebert, Inc., v. 2, n. 1, p. 643–647, 2021. Cited in page 14.

CLANCE, P. R. **The impostor phenomenon: Overcoming the fear that haunts your success**. [S.l.]: Peachtree Pub Limited, 1985. Cited 8 times in pages 14, 16, 18, 23, 24, 25, 50, and 52.

CLANCE, P. R.; IMES, S. A. The imposter phenomenon in high achieving women: Dynamics and therapeutic intervention. **Psychotherapy: Theory, research & practice**, Division of Psychotherapy (29), American Psychological Association, v. 15, n. 3, p. 241, 1978. Cited 2 times in pages 14 and 18.

DUNCAN, L. et al. An evaluation of impostor phenomenon in data science students. **International journal of environmental research and public health**, MDPI, v. 20, n. 5, p. 4115, 2023. Cited 2 times in pages 16 and 19.

FORD, D.; PARNIN, C. Exploring causes of frustration for software developers. In: IEEE. **2015 IEEE/ACM 8th International Workshop on Cooperative and Human Aspects of Software Engineering**. [S.l.], 2015. p. 115–116. Cited in page 14.

FORSGREN, N. et al. The space of developer productivity. **Communications of the ACM**, ACM New York, NY, USA, v. 64, n. 6, p. 46–53, 2021. Cited 4 times in pages 16, 20, 24, and 25.

FORSGREN, N. et al. The space of developer productivity: There's more to it than you think. **ACM Queue**, ACM New York, NY, USA, v. 19, n. 1, p. 20–48, 2021. Cited 2 times in pages 16 and 20.

GIRARDI, D. et al. Recognizing developers' emotions while programming. In: **Proceedings of the ACM/IEEE 42nd International Conference on Software Engineering**. [S.l.: s.n.], 2020. p. 666–677. Cited in page 14.

GRAZIOTIN, D. et al. Consequences of unhappiness while developing software. p. 42–47, 2017. Cited in page 14.

GRAZIOTIN, D. et al. What happens when software developers are (un) happy. **Journal of Systems and Software**, Elsevier, v. 140, p. 32–47, 2018. Cited 2 times in pages 14 and 21.

GUENES, P. et al. Impostor phenomenon in software engineers. In: **2024 IEEE/ACM 46th International Conference on Software Engineering: Software Engineering in Society (ICSE-SEIS)**. [S.l.: s.n.], 2024. Cited in page 52.

HUMPHREY, W. S. The software engineering process: definition and scope. In: **Proceedings of the 4th International Software Process Workshop on Representing and Enacting the Software Process**. [S.l.: s.n.], 1988. p. 82–83. Cited in page 14.

KESSLER, R. C. et al. The world health organization health and work performance questionnaire (hpq). **Journal of occupational and environmental medicine**, JSTOR, p. 156–174, 2003. Cited in page 27.

KIM, M. et al. Data scientists in software teams: State of the art and challenges. **IEEE Transactions on Software Engineering**, IEEE, v. 44, n. 11, p. 1024–1038, 2017. Cited in page 46.

LEI, S.; SMITH, M. R. Evaluation of several nonparametric bootstrap methods to estimate confidence intervals for software metrics. **IEEE Transactions on Software Engineering**, IEEE, v. 29, n. 11, p. 996–1004, 2003. Cited 2 times in pages 27 and 51.

LINAKER, J. et al. Guidelines for conducting surveys in software engineering. **Lund University**, v. 50, 2015. Cited in page 49.

MAJI, S. "they overestimate me all the time:" exploring imposter phenomenon among indian female software engineers. **Metamorphosis**, SAGE Publications Sage India: New Delhi, India, v. 20, n. 2, p. 55–64, 2021. Cited 2 times in pages 16 and 19.

MAK, K. K.; KLEITMAN, S.; ABBOTT, M. J. Impostor phenomenon measurement scales: a systematic review. **Frontiers in psychology**, Frontiers Media SA, v. 10, p. 671, 2019. Cited 3 times in pages 18, 25, and 50.

MANI, A.; MUKHERJEE, R. A study of foss 2013 survey data using clustering techniques. In: **2016 IEEE International WIE Conference on Electrical and Computer Engineering (WIECON-ECE)**. [S.l.: s.n.], 2016. p. 118–121. Cited in page 25.

MCLEAN, M.; AVELLA, J. Impostor phenomenon in information technology. **Journal of Information Technology Management**, v. 27, n. 4, 2016. Cited 2 times in pages 16 and 20.

OVERFLOW, S. **Stack Overflow Annual Developer Survey**. 2023. Disponível em: <https://insights.stackoverflow.com/survey>. Cited 3 times in pages 17, 27, and 33.

ROBLES, G. et al. Women in free/libre/open source software: The situation in the 2010s. In: SPRINGER. **Open Source Systems: Integrating Communities: 12th IFIP WG 2.13 International Conference, OSS 2016, Gothenburg, Sweden, May 30-June 2, 2016, Proceedings 12**. [S.l.], 2016. p. 163–173. Cited in page 25.

ROSENSTEIN, A.; RAGHU, A.; PORTER, L. Identifying the prevalence of the impostor phenomenon among computer science students. p. 30–36, 2020. Cited 5 times in pages 16, 19, 23, 35, and 50.

SILVEIRA, K. K. et al. Confidence in programming skills: Gender insights from stackoverflow developers survey. In: IEEE. **2019 IEEE/ACM 41st International Conference on Software Engineering: Companion Proceedings (ICSE-Companion)**. [S.l.], 2019. p. 234–235. Cited 2 times in pages 15 and 20.

TEAMBLIND. 2018. <https://www.teamblind.com/blog/index.php/2018/09/05/58-percent-of-tech-workers-feel-like-impostors/>. Accessed: 2023-03-01. Cited in page 15.

WAGNER, S. et al. Status quo in requirements engineering: A theory and a global family of surveys. **ACM Transactions on Software Engineering and Methodology (TOSEM)**, ACM New York, NY, USA, v. 28, n. 2, p. 1–48, 2019. Cited in page 51.

WAGNER, S. et al. Challenges in survey research. **Contemporary Empirical Methods in Software Engineering**, Springer, p. 93–125, 2020. Cited 7 times in pages 23, 27, 28, 30, 35, 50, and 51.

YAMANE, T. **Statistics. An introductory analysis. Third edition**. [S.l.]: Harper & Row, 1973. (Harper International edition). Cited in page 30.

YOUNG, V. **The secret thoughts of successful women: Why capable people suffer from the impostor syndrome and how to thrive in spite of it**. [S.l.]: Currency, 2011. Cited in page 15.