

## Supporting Software Engineering Managers in Talent Retention: The Brazilian Context

Luiz Alexandre Costa · Edson Dias ·  
Danilo Ribeiro · Awdren Fontão ·  
Gustavo Pinto ·  
Rodrigo Pereira dos Santos ·  
Alexander Serebrenik

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**Abstract** In the rapidly evolving global business landscape, the demand for software has intensified competition among organizations, creating challenges in retaining qualified professionals. One of the problems faced by organizations is the retention of software engineers whose specialized skills and knowledge make them strategic professionals, often referred to as talent. This work introduces an actionable framework for the retention of software engineering (SE) talent called the TR4SEM Framework, based on a field study with 21 SE managers working in Brazilian organizations. These SE managers are professionals who lead software development teams, combining technical expertise with management skills to align technical efforts with organizational goals and foster talent retention. The TR4SEM Framework supports SE managers with strategies to address talent management challenges, emphasizing the importance of clear communication and customized career development plans

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Luiz Alexandre Costa  
Federal University of the State of Rio de Janeiro (UNIRIO), Brazil  
E-mail: luiz.costa@edu.unirio.br

Edson Dias · Gustavo Pinto  
Federal University of Pará (UFPA), Brazil  
E-mail: {ecdias, gpinto}@ufpa.br

Danilo Ribeiro  
Zup Innovation, Brazil  
E-mail: danilo.ribeiro@zup.com.br

Awdren Fontão  
Federal University of Mato Grosso do Sul (UFMS), Brazil  
E-mail: awdren.fontao@ufms.br

Rodrigo Pereira dos Santos  
Federal University of the State of Rio de Janeiro (UNIRIO), Brazil  
E-mail: rps@uniriotec.br

Alexander Serebrenik  
Eindhoven University of Technology, The Netherlands  
E-mail: a.serebrenik@tue.nl

aligned with individual goals. By promoting cohesive teams and creating motivating work environments, organizations can transform talent retention into a competitive advantage. The research findings shed light on factors that influence retention, including the need for participative leadership styles that encourage collaboration, innovation, and psychological safety in high-pressure environments driven by innovation. Furthermore, this work highlights barriers such as limited career growth opportunities and ineffective recognition mechanisms, which can hinder talent retention. Our framework provides practical guidelines that may support efforts to reduce turnover and addresses the specific demands of SE teams. We propose an approach that ensures alignment between professional growth and organizational goals. In addition, the framework reinforces the strategic value of software engineers in driving innovation.

**Keywords** Talent Retention · Field Study · Work Motivation · Work Satisfaction · Software Engineering Management

## 1 Introduction

In the contemporary global business scenario, the demand for software among companies to fulfill their objectives is increasing rapidly. This growing need for software has led to a significant increase in the number of software development companies, thus intensifying the competition for highly qualified IT professionals in Software Engineering (SE), as reported by Gartner Inc.<sup>1</sup> However, this scenario is challenging due to the scarcity of individuals with specific technical skills, which represents an obstacle for organizations aiming to build qualified software development teams (Setúbal et al., 2024).

One of the problems faced by organizations is the retention of highly qualified IT professionals, including software engineers whose specialized skills, knowledge, and contributions make them strategic professionals, often referred to as “talent” (Nittala and Jesiek, 2018; Sharma and Stol, 2020; Zhang et al., 2022). Fierce competition in the job market and a shortage of talent with specific technical skills lead to a high turnover rate in these companies (Devi and Krishna, 2016; Groenewald et al., 2024). The frequent loss of talent implies not only increased operational costs, but also the loss of accumulated knowledge and expertise, negatively affecting the operations (Luftmann and Kempaiah, 2008; Skelton et al., 2020).

Moreover, talent retention can become a significant competitive advantage for organizations, according to Resource-Based View (RBV) theory (Barney, 1991). This perspective is further corroborated by recent studies (Collings et al., 2019; Mazlan and Jambulingam, 2023). Companies that manage to attract and retain talent have the capacity to build specialized teams capable of innovating, delivering high-quality results, and adapting quickly to technological changes (Li et al., 2020; Rożman et al., 2023).

<sup>1</sup> <https://www.gartner.com/en/newsroom/press-releases/2023-04-06-gartner-forecasts-worldwide-it-spending-to-grow-5-percent-in-2023>

27 In this context, talent management has become a challenge for organi-  
28 zations (Hongal and Kinange, 2020; Montero Guerra and Danvila-Del Valle,  
29 2024). Talent retention is not only limited to initial attraction, but also in-  
30 volves the adoption of strategies and practices to keep strategic professionals  
31 engaged and satisfied in their work environment. Although intellectual curios-  
32 ity and the desire to solve complex problems are common in several professions,  
33 such as medicine, scientific research, and law, software engineers operate in a  
34 rapidly evolving environment (Piattini et al., 2021; Kirova et al., 2024).

35 The rapid advancement of technologies, the critical role of innovation in  
36 defining competitive advantage, and the reliance on these professionals to  
37 lead discussions and execute transformative projects set SE apart. The loss  
38 of strategic software engineers can hinder an organization’s ability to inno-  
39 vate and maintain technological relevance, with cascading effects on project  
40 continuity and leadership in key initiatives (Gandomani et al., 2021).

41 To highlight a current SE-specific challenge, SE faces high turnover rates  
42 due to global talent shortages and intense competition from startups and  
43 big tech, as emphasized by Deloitte<sup>2</sup>. According to a report published by Ai  
44 Group<sup>3</sup> in 2023, turnover trends also vary significantly by industry and loca-  
45 tion. In Australia, for instance, Accommodation and Food Services report the  
46 highest turnover rates, followed by Information and Media & Telecommuni-  
47 cations, which includes software engineers. Such regional variations reinforce  
48 the context-dependent nature of retention challenges in SE.

49 In addition, other factors such as gender imbalance and generational dy-  
50 namics add layers of complexity to retention. Women remain underrepre-  
51 sented in SE industry, which can affect diversity and the inclusiveness of work-  
52 place practices, potentially influencing satisfaction and long-term engagement  
53 (Trinkenreich et al., 2022). Research suggests that more inclusive environ-  
54 ments and gender-aware leadership styles can foster psychological safety and  
55 collaboration, which may enhance retention (Li et al., 2024).

56 Likewise, the entrepreneurial tendencies of Millennials and Gen Z often re-  
57 sult in greater mobility among younger professionals (Yıldırım and Korkmaz,  
58 2020), who may favor flexible, participative management styles. The conse-  
59 quences of failing to retain talent in SE extend beyond recruitment costs, af-  
60 fecting a company’s ability to maintain expertise and consistent results (Godli-  
61 auskas and Šmite, 2025).

62 To address these challenges and understand the dynamics influencing tal-  
63 ent retention in SE, we defined our main research question: **“What physical,  
64 human, and organizational aspects drive talents to stay in organi-  
65 zations?”**. This question served as the foundation for our work, guiding our  
66 exploration of the aspects that impact the decision-making process of software  
67 engineers in different organizational contexts. These aspects are supported by

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<sup>2</sup> [https://www2.deloitte.com/us/en/insights/topics/talent/overcoming-the-tech-talent-shortage-amid-transformation.html?utm\\_source=chatgpt.com](https://www2.deloitte.com/us/en/insights/topics/talent/overcoming-the-tech-talent-shortage-amid-transformation.html?utm_source=chatgpt.com)

<sup>3</sup> <https://www.aigroup.com.au/resourcecentre/research-economics/factsheets/factsheet-labour-market-dynamics-in-australia/>

68 prior research on job satisfaction and retention of software engineers (França  
69 et al., 2018).

70 In this study, physical aspects refer to tangible conditions of the work en-  
71 vironment, such as infrastructure, facilities, and tools that support day-to-day  
72 tasks. Human aspects include individual-level elements such as motivation,  
73 well-being, career goals, and perceived recognition. Finally, organizational as-  
74 pects relate to broader structures, culture, leadership practices, and policies  
75 that shape how software engineers experience and relate to their workplace.  
76 Based on our findings, we developed an actionable framework called TR4SEM  
77 (Talent Retention For Software Engineering Management), designed to sup-  
78 port SE managers in addressing retention challenges in SE.

79 According to the Software Engineering Body of Knowledge (SWEBOK)  
80 (Washizaki, 2024), SE managers are professionals who combine technical and  
81 leadership skills to manage SE teams, are responsible for coordinating projects,  
82 supporting the career development of team members, promoting collaborative  
83 practices, and aligning technical efforts with organizational goals. These pro-  
84 fessionals act as intermediaries between strategic management and technical  
85 teams, ensuring the delivery of high-quality software solutions while creating  
86 an environment that favors the talent retention (Wasserman, 2023).

87 This work presents an extension and significant refinement of a preliminary  
88 framework introduced earlier (Costa et al., 2024). Our updated framework  
89 seeks to understand and guide SE managers to improve and support the talent  
90 management process. The TR4SEM Framework is grounded in data collected  
91 through interviews. We conducted interviews with 21 SE managers across dif-  
92 ferent software industries, from small to large multinational corporations, to  
93 understand the challenges that their organizations face in retaining talent and  
94 emerging factors that are perceived as important to them. Although our pre-  
95 vious study provided an initial overview of the structure of the framework,  
96 this work details the qualitative analysis and explicitly describes the core ele-  
97 ments and interrelations of the framework. We also instantiate the framework  
98 through a real scenario, illustrating how it can be applied in practice.

99 We selected SE managers as participants because they are responsible for  
100 implementing retention strategies and conducting exit interviews. They also  
101 monitor team dynamics, which gives them a privileged perspective on both  
102 individual and organizational factors that influence talent retention. Our in-  
103 terviews revealed the strategies SE managers use to overcome barriers, as well  
104 as the coping mechanisms they turn to when general strategies do not work.

105 The outcome of our work is a practical framework that accomplishes the  
106 following: i) presents a set of **factors** that may affect talent retention; ii)  
107 explores the **contextual characteristics** that may moderate the impact of  
108 the factors on talent retention; iii) identifies the **barriers** that compromise  
109 and prevent SE managers from improving their talent retention experience;  
110 and iv) documents the **strategies** and **coping mechanisms** employed by SE  
111 managers to overcome these barriers and enhance one or more dimensions of  
112 their talent retention experience. Our framework emphasizes the idea that it

is not only theoretical or conceptual, but can also be applied in practice to guide concrete actions and decision-making.

Studying SE managers is important for SE because the relationship between them and software engineers often involves a closer level of career mentoring (Duan et al., 2024). SE managers ensure project deliverables and support professional growth, working to create career development plans. Their dual role as technical leaders and career mentors uniquely positions SE managers to address the specific challenges of retaining skilled software engineers, particularly in environments where innovation and adaptability are critical. Through our results in this work, we contributed to the advancement of SE by offering guidelines for talent management processes that can help organizations face the challenges of retaining talent in a highly competitive environment.

This work is organized as follows: Section 2 presents the background and related work; Section 3 traces our research method; Section 4 introduces our findings that lead to the TR4SEM Framework; Section 5 describes the structure of the framework; Section 6 presents the supporting elements of the framework; Section 8 describes how the TR4SEM Framework can be instantiated by practitioners and researchers; Section 9 details the limitations; and finally, Section 10 concludes with final remarks and future work.

## 2 Background and Related Work

This section provides the conceptual and contextual foundations of our study. We begin by clarifying the definitions of talent and talent retention adopted in this work, and then review the factors that influence talent retention in SE.

### 2.1 Definitions

The definition we use for **talent** in our work is: *“talents are strategic people in the organization who have a unique combination of characteristics: i) they have the ability to exercise their profession with technical excellence, mastering the necessary skills and knowledge; ii) they are aligned with the company’s culture and business, sharing the organizational values and objectives; and iii) they are able to influence inside and outside their team, bringing positive impact and contributing to the success of the organization”*.

Our definition is inspired by Michaels et al. (2001) and Boudreau and Ramstad (2005), and further supported by the typology proposed by Vardi and Collings (2023), which frames **talent** as the convergence of competence, commitment, and organizational contribution. In the first study, the authors introduce the concept of “talentship” and discuss the importance of talent segmentation in organizations. They emphasize the need for organizations to identify and nurture individuals with unique combinations of skills and characteristics to achieve sustainable success. In the latter, the authors discuss the fierce competition for highly skilled individuals in various industries, including IT. The authors highlight the characteristics that define talented people.

We also use the concept of **talent retention**. The definition of this concept used in our work is “*an organizational process that aims to keep the best employees in the organization, called ‘talent’*”. Therefore, talent retention focuses on the retention of strategic individuals within an organization. It is important to note that other similar concepts, such as employer retention and turnover intention, differ from what we refer to as talent retention.

Employer retention refers to the ability of an organization to encourage employees to remain in the organization for a long period (Schyns et al., 2007), without necessarily focusing on talent-specific factors. It encompasses strategies and practices aimed at reducing overall employee turnover within the organization. On the other hand, turnover intention relates to an individual employee’s intention or inclination to change the job or organization voluntarily (Das and Baruah, 2013).

## 2.2 Talent Retention

The studies in the talent retention field often relate talent retention to other human factors such as motivation, job satisfaction, and leadership. For instance, Ghani et al. (2022) conducted a literature review on challenges and strategies for talent retention in the healthcare sector. The authors organized their findings based on equity theory (Adams and Freedman, 1976), job characteristics theory (Hackman et al., 2015), expectancy theory (Vroom et al., 2015), and Maslow’s theory (Vroom et al., 2015). The authors link factors from these theories, such as career growth, leadership, communication, trust in the organization, and work relationships, to employee satisfaction, which ultimately impacts talent retention. The study also presents strategies for talent retention in the healthcare sector, such as implementing work-hour policies, offering recognition, bonuses, and other retention strategies.

Effective talent management is critical for organizations, seeking to gain a competitive advantage in a highly competitive market (Michaels et al., 2001; Hadijah, 2023). This view underscores the strategic importance of identifying, recruiting, and retaining top IT professionals amid the competitive talent scenario. It offers valuable insights into how organizations can gain a competitive edge through efficient talent management. The authors address the unique challenges organizations encounter in talent retention and provide best practices for fostering an environment that promotes the growth and involvement of talented professionals.

This approach is aligned with RBV theory of Barney (1991). The RBV is a widely recognized theory in the field of business strategy and management (Barney, 2001; Ray et al., 2004). It focuses on analyzing an organization’s internal resources as a source of competitive advantage. According to the RBV, an organization’s unique resources and capabilities, such as tangible (e.g., infrastructure, technology) and intangible assets (e.g., knowledge, organizational culture) can be sources of sustainable competitive advantage. The theory em-

phasizes that the combination and effective use of these resources can generate value for the organization and differentiate it from competitors.

When considering the talent retention scenario (Vaiman and Holden, 2011; Hongal and Kinange, 2020; Allen and Vardaman, 2021), we should take into account specific factors, such as economic uncertainties, social inequalities, limited supply of technical specialists, and cultural aspects. Understanding local dynamics and challenges helps organizations adopt more effective strategies to retain talent and gain a sustainable competitive advantage.

### 2.3 Talent Retention in Software Engineering

Talent retention management is a widely studied topic in literature, and talent retention applies to various industries and employee categories (Cappelli, 2008; Pandita and Ray, 2018; Chopra et al., 2024). However, software engineers have unique characteristics and challenges that can differentiate them from other employees (Turley and Bieman, 1995; Uden and Dix, 2004; França et al., 2018). To cite a few, innovation and knowledge continuity, in which software engineers thrive on innovation and continuous learning, and the changing technology scenario that requires software engineers to stay updated with the latest tools.

Taking into account these unique characteristics, recent studies have explored how the high turnover intentions among IT professionals, including software engineers, are shaped by the dynamic and competitive nature of the field. Zaza et al. (2023) found that retention in SE is particularly influenced by perceptions of career stagnation, insufficient opportunities for innovation, and misalignment with personal or organizational values. The authors highlighted the importance of fostering environments where professionals can continuously grow, engage in challenging and impactful work, and feel supported through tailored retention strategies. Such initiatives may sustain organizational competitiveness in a rapidly evolving technological landscape.

Software engineers in management roles are responsible for overseeing development projects, mentoring teams, and ensuring alignment between technical and organizational objectives (Wasserman, 2023). SE managers may navigate a complex landscape where technical innovation and people management intersect. Acting as mentors, SE managers should align individual aspirations with organizational goals, creating structured career development paths that help reduce turnover. These managers also address challenges such as skill obsolescence and shifting project priorities by maintaining open communication and adapting strategies to meet team needs, thus preventing stagnation and dissatisfaction. By combining technical expertise with human-centric leadership, SE managers create environments that promote growth and innovation to contribute to the success of talent retention (Grundy et al., 2020).

Finally, the COVID-19 pandemic has presented significant challenges for organizations regarding the talent retention of software engineers (Aguinis and Burgi-Tian, 2021; Nolan et al., 2021). With the rapid transition to remote work and the economic uncertainty resulting from the crisis, several IT professionals

239 have found themselves reassessing their career priorities, which has led to an  
240 increase in turnover (Shen et al., 2020). The balance between personal and  
241 professional lives has become more complex (Russo et al., 2021). Organizations  
242 face the challenge of adopting flexible retention strategies to meet the needs  
243 and expectations of employees and to keep their talent engaged and motivated  
244 during this period (Bailey and Breslin, 2021).

245 According to Santos et al. (2024), in the post-pandemic period, the work-  
246 place has undergone structural changes, notably the widespread adoption of  
247 remote and hybrid work models. These changes opened a wide range of op-  
248 portunities for software engineers to participate in geographically distributed  
249 teams and access global job markets from their homes. While this flexibility in-  
250 creased work-life balance for some professionals, it also intensified competition  
251 among companies for technical talent, since engineers are no longer limited  
252 by regional constraints. As a result, retention strategies should now consider a  
253 more dynamic and borderless talent market, requiring organizations to rethink  
254 engagement, compensation, and long-term value propositions.

## 255 2.4 Related Work

256 Understanding talent retention in SE requires a dialogue with contemporary  
257 studies that examine this phenomenon from different organizational, cultural,  
258 and methodological perspectives. The literature reveals that talent manage-  
259 ment is increasingly seen as a strategic priority in both traditional and agile  
260 environments, particularly due to the intensification of global competition and  
261 the rise of remote work models. This section highlights both foundational and  
262 recent contributions that help shape the state-of-the-art in talent management  
263 and talent retention, especially within software development contexts.

264 Our study revealed that toxic management, lack of recognition, and limited  
265 opportunities for challenge and growth are primary drivers of turnover per-  
266 ceived by SE managers, reinforcing the need for contextualized strategies that  
267 go beyond compensation. We present an actionable framework (TR4SEM) de-  
268 signed to help SE managers diagnose challenges, plan strategies, and improve  
269 talent retention in their everyday leadership activities.

270 By emphasizing both organizational conditions and individual motivations,  
271 and by anchoring our findings in the lived experience of SE managers across  
272 diverse companies, we position our work as a distinct contribution to the  
273 state-of-the-art in SE talent retention. We also share insights into applying  
274 the TR4SEM Framework in practice, along with a small-scale evaluation that  
275 explores its applicability in an organizational setting.

276 To better situate our contribution within the existing body of knowledge,  
277 Table 1 provides a comparative summary of TR4SEM and prior studies on  
278 talent retention. This table highlights key contributions and limitations of  
279 each work, offering a high-level overview that clarifies how our framework  
280 complements, extends, or diverges from previous approaches. In the following,

281 we examine these studies in greater depth to contextualize the development  
282 and originality of TR4SEM.

**Table 1** Comparative summary of TR4SEM and prior studies on talent retention.

Reference	Key Contribution	Limitations Addressed
Cappelli (2008)	Conceptual review in HR proposing a supply-chain approach to make talent management more dynamic.	Not focused on SE teams; lacks actionable guidance for technical leadership.
Pandita and Ray (2018)	Meta-analysis in HR context linking talent practices and employee engagement to retention outcomes.	Does not consider the particularities of SE environments or team-level strategies.
Chopra et al. (2024)	Quantitative study in IT showing how employer branding indirectly influences talent retention via engagement.	Emphasizes symbolic perception; lacks insights from daily team-level SE practices.
Zaza et al. (2023)	Qualitative study in IT identifying barriers like stagnation and lack of innovation as causes of turnover.	No structured or actionable framework to support SE managers.
Akdur et al. (2024)	Survey with remote Salesforce developers highlighting how effective onboarding reduces turnover.	Context-specific to onboarding; lacks broader applicability to SE retention strategies.
Alias et al. (2022)	Conceptual review in manufacturing emphasizing the need for tailored HR strategies for engineering professionals.	Not empirical; not focused on SE dynamics or leadership.
Gandomani et al. (2021)	Systematic literature review on agile SE teams calling for human-centered, empirical models for talent management.	Does not provide field-validated strategies or practical guidance for SE managers.
Costa et al. (2024)	Initial conceptual overview of talent retention framework based on interviews with SE managers.	Preliminary version; lacks methodological depth and practical refinement.
<b>Our Work</b>	Qualitative study with 21 SE managers, resulting in an actionable framework to guide talent retention in SE teams.	Addresses the lack of empirical, manager-centered strategies tailored to the dynamics of SE work.

283 Cappelli (2008) argued that traditional talent management models are out-  
284 dated and proposed a "talent-on-demand" approach inspired by supply chain  
285 management. While insightful, this proposal focuses primarily on strategic or-  
286 ganizational design, whereas the TR4SEM Framework offers a practice-driven  
287 model tailored to SE teams, emphasizing actionable guidance for SE managers.

288 Pandita and Ray (2018) conducted a meta-analysis linking talent man-  
289 agement practices to employee engagement and retention. Their conceptual

290 model emphasizes synchronization between management initiatives and em-  
291 ployee experience, aligning in spirit with our findings. On the other hand, our  
292 study offers empirically grounded qualitative insights from SE managers from  
293 diverse organizational settings, providing practical guidance tailored to the  
294 realities of SE environments.

295 Chopra et al. (2024) explored how employer branding influences talent  
296 retention, mediated by employee engagement. While their focus lies in orga-  
297 nizational perception and symbolic capital, our study complements this per-  
298 spective by examining the concrete actions and decision-making processes of  
299 SE managers, grounded in the day-to-day realities of SE teams.

300 Zaza et al. (2023) highlighted key barriers to retention in IT, such as ca-  
301 reer stagnation and lack of innovation, which are factors also prominent in  
302 our interviews. Unlike their study, which emphasizes the uniqueness of IT pro-  
303 fessionals, our TR4SEM Framework translates those insights into structured  
304 strategies and support mechanisms that SE managers can apply in practice.

305 Akdur et al. (2024) proposed the Virtual Integration and Retention Frame-  
306 work (VIRF) to investigate how virtual onboarding practices influenced the  
307 turnover intentions of Salesforce Commerce Cloud developers during the pan-  
308 demic. The study, published in the *Journal of Systems and Software*, adopted  
309 a two-stage, higher-order quantitative approach and identified that successful  
310 virtual onboarding positively affects job satisfaction and workplace relation-  
311 ship quality, which in turn reduces turnover intention. Virtual onboarding  
312 success was linked to role clarity, social integration, knowledge of culture, and  
313 delivery of technical resources. The authors emphasized that organizations  
314 must prioritize virtual onboarding practices as a strategic retention mecha-  
315 nism in a remote context.

316 Alias et al. (2022) conducted a conceptual review on the retention of en-  
317 gineers in the manufacturing sector, with a particular focus on talent man-  
318 agement practices. The study, grounded in RBV and Social Exchange Theory  
319 (SET), argues that engineers require exclusive retention strategies due to their  
320 unique KSA (Knowledge, Skills, and Abilities). The article emphasizes that  
321 common human-resources (HR) practices may fail when applied generically  
322 across roles and industries, reinforcing the importance of contextualized tal-  
323 ent management models. Notably, the authors identified employer branding,  
324 career development, and performance management as key talent management  
325 practices that influence engineers' intention to stay. This review supports the  
326 need for sector-specific models that respond to the nuanced expectations and  
327 behaviors of engineering talent.

328 Gandomani et al. (2021) conducted a systematic review that examined the  
329 role of talent management in agile software development. The study highlights  
330 how human-centered values in agile methodologies, such as autonomy, collabo-  
331 ration, and informal communication, demand specific approaches to managing  
332 and retaining talent. The authors observed that talent management remains  
333 underexplored in agile contexts. They identified key gaps, including the ab-  
334 sence of applicable talent management models for agile teams, limited research  
335 on identifying "agile heroes", and the lack of effective strategies for selecting

336 and developing roles (e.g., scrum masters and product owners). The study calls  
337 for more empirical investigation and the design of dynamic talent management  
338 models that can respond to the complexity and fluidity of agile environments.

339 In a previous short paper published in the companion proceedings of the  
340 International Conference on Software Engineering (Costa et al., 2024), we  
341 presented an initial version of our talent retention framework, grounded in  
342 interviews with 21 IT managers. That early publication focused on outlining  
343 the structure of what we called the TR (Talent Retention) Framework, sum-  
344 marizing key categories such as influencing factors, contextual characteristics,  
345 barriers, strategies, and coping mechanisms. However, due to the nature of  
346 a poster track (2 pages), the paper offered only a high-level overview of the  
347 findings, with limited detail on methodology, analysis, and implications.

348 The current work significantly extends that initial work by offering a com-  
349 prehensive presentation of the research design, a deeper analysis of interview  
350 data using Grounded Theory techniques, and richer insights into the strate-  
351 gic role of SE managers in talent retention. We also introduce the TR4SEM  
352 Framework as a refined and actionable evolution of the earlier model, sup-  
353 ported by a field study and positioned within a broader discussion of related  
354 literature. By advancing from a conceptual sketch to a fully contextualized  
355 and validated framework, this work makes a novel and original contribution  
356 to the understanding of how organizations can retain SE talent in dynamic  
357 and competitive environments.

358 Despite the insights provided by prior related work on talent management  
359 in remote onboarding, engineering sectors, and agile contexts, there remains a  
360 gap in research that explicitly addresses the strategic role of SE managers in  
361 the retention of technical talent. Most of the related work either emphasizes  
362 structural HR practices or focuses on individual turnover predictors. However,  
363 these studies fail to capture the perspective of those responsible for aligning  
364 technical execution with talent development in software teams. These gaps  
365 underscore the motivation for developing the TR4SEM Framework.

### 366 **3 Research Method**

367 We grounded our work on Empirical Software Engineering (ESE) guidelines (Stol  
368 and Fitzgerald, 2020), adopting a knowledge-seeking approach, which is ap-  
369 propriate to understand phenomena in real-world SE scenario.

370 We conducted a field study as a research method to identify specific char-  
371 acteristics of the talent retention process in organizations, such as culture,  
372 hierarchical structure, workload, human resource (HR) policies, and benefits.  
373 We chose this method according to Lethbridge et al. (2005), who defines it  
374 as any empirical investigation conducted in a real-world context, including in-  
375 terviews carried out in organizational settings to understand how phenomena  
376 occur in practice.

377 This research method is also commonly adopted in recent empirical studies  
378 in SE (e.g., Greiler et al. 2022, Steglich et al. 2023, and Malcher et al. 2024).

379 Furthermore, it provides an opportunity for participants to share their experi-  
380 ences and perspectives based on semi-structured interviews, as proposed by  
381 Seaman (1999).

382 To do so, we conducted a set of interviews based on the recommendations  
383 for field studies (Singer et al., 2008). Although the subject of talent retention  
384 has been widely studied in the management literature (Cappelli, 2008; Pandita  
385 and Ray, 2018; Chopra et al., 2024), we sought to understand how retention  
386 occurs in SE and what particular aspects shape this phenomenon.

387 The participants were composed of a diverse set of SE managers in terms  
388 of role, industry, and experience (Myers and Avison, 2002). Next, we used  
389 qualitative analysis of semi-structured interviews to develop a framework to  
390 understand the talent retention process and identify relationships emerged  
391 from the collect data. We applied coding procedures to analyze qualitative  
392 data, inspired by the initial procedures for the Grounded Theory (GT) of  
393 Strauss and Corbin (1990).

394 The Socio-Technical Grounded Theory (STGT) of Hoda (2021) provides a  
395 specialized approach for exploring socio-technical interactions in SE studies.  
396 As we did not explore technical factors, such as technologies, development  
397 processes, or agile practices, we choose to use the GT approach (Strauss and  
398 Corbin, 1990) in our work due to the focus primarily on social factors, such as  
399 organizational culture, professional growth, and employee satisfaction. In this  
400 section, we present an overview of our interview participant selection process,  
401 the questions used, and our approach for analyzing the results.

### 402 3.1 Research Questions

403 Our research questions aimed to allow the researcher to obtain detailed and  
404 rich information about participants' experiences, opinions, and perspectives on  
405 the topic at hand. The research questions evolved as we collected and examined  
406 our data, and they were further revised.

407 Our initial research question (RQ0) was: **“What physical, human, and**  
408 **organizational aspects drive talents to stay in organizations?”**. Dur-  
409 ing our interviews, we found not only factors that influence talent retention,  
410 but also contextual characteristics (e.g., team size, remote work policy, and  
411 organizational culture) that appeared to shape retention practices. These in-  
412 sights led to RQ1, which focuses on these contextual elements. In parallel, the  
413 participants described the challenges and obstacles they faced when trying to  
414 retain talent, which led to RQ2, centered on barriers.

415 In addition, the participants shared strategies they implemented success-  
416 fully, which we formulate as RQ3. Some interviewees highlighted the gap be-  
417 tween desirable initiatives and organizational constraints, prompting RQ4 to  
418 investigate the practical challenges of implementing innovative actions. Finally,  
419 we noted a set of adaptive behaviors and informal solutions used to mitigate  
420 difficulties in talent retention, leading to the emergence of RQ5 on coping  
421 mechanisms. As mentioned, our work begins with a preliminary research ques-

tion (RQ0), which evolved into more specific research questions (RQ1–RQ5) as the study progressed (Charmaz, 2006; Greiler et al., 2022). These refined questions are detailed in Table 2.

**Table 2** RQ overview and goals.

ID	Question	Rationale
RQ1	Which <b>factors</b> influence talent retention in organizations?	Our goal is to understand the factors that influence a talent’s decision to stay (or leave), as well as obtain insights into software engineers’ concerns and motivations.
RQ2	Which <b>contextual characteristics</b> moderate how important a factor is to talent retention’s experience in the organizations?	Our goal is to identify external factors that may moderate organizations’ ability to retain talent, including software engineers.
RQ3	Which <b>barriers</b> prevent SE managers from improving factors that affect the talent retention of software engineers?	By identifying the barriers, our goal is to improve the factors that affect the permanence of a talent, such as financial resources, bureaucracy, and skills.
RQ4	Which <b>strategies</b> do SE managers employ to improve the talent retention of software engineers in their organizations?	Our goal is to identify the strategies that SE managers are using to retain talent aiming to reduce software engineer turnover.
RQ5	Which <b>coping mechanisms</b> do SE managers resort to when factors that negatively impact the talent retention of software engineers are not improved?	Our goal is to identify gaps in talent retention policies beyond existing efforts.

### 3.2 Semi-Structured Interviews

We conducted semi-structured interviews with 21 SE managers. The interviews were carried out by two researchers with professional experience in SE and qualitative research. To ensure consistency between sessions, all followed a standardized interview protocol, including the same guide with open questions and predefined prompts to explore emerging topics in more depth. The interview guide was developed collaboratively by the research team through consensus, grounded in the study objectives and the prior literature on talent retention and SE management.

The interviews aimed to gather opinions on: i) the factors that affect the permanence of talent in the organization (*RQ1*); ii) the organizational environment characteristics that can modify the importance of a factor in the talent retention experience (*RQ2*); iii) the barriers and challenges that managers face in retaining talent (*RQ3*); iv) the strategies that managers use to retain talent

439 (*RQ4*); and v) the turnaround mechanisms that managers use to ensure talent  
440 retention actions (*RQ5*).

441 The number of interviews was not predetermined. Instead, according to  
442 Creswell and Poth (2016), we continued conducting interviews until we reached  
443 data saturation, i.e., the point at which no new information or themes were  
444 observed in the data. This approach ensured that we captured a comprehensive  
445 and nuanced understanding of the issues. As a result, saturation was achieved  
446 after 21 interviews, which provided a robust dataset for our analysis.

447 The interviews were conducted in Portuguese between September 2022 and  
448 February 2023, during the COVID-19 pandemic and post-pandemic periods.  
449 Although the World Health Organization formally declared the end of the  
450 public health emergency in May 2023, the interviews reflect a transitional  
451 period in which several organizations had already adopted post-pandemic work  
452 models and remote arrangements as the new normal.

453 This period may have influenced participants' perceptions regarding talent  
454 retention. During the pandemic, discussions often revolved around maintain-  
455 ing team cohesion, managing remote work models, and ensuring job security  
456 amid uncertainty. In contrast, interviews conducted after the acute phase of  
457 the pandemic increasingly emphasized employee expectations for flexible work  
458 arrangements (hybrid models), meaningful career development, and greater  
459 alignment between personal and organizational values. This temporal varia-  
460 tion likely enriched the data by capturing evolving managerial challenges and  
461 responses in relation to talent retention across shifting workplace contexts.

462 The transcription and refinement of the interviews were carried out from  
463 February to August 2023, followed by iterative data analysis, coding, and  
464 review from September 2023 to August 2024, and finally, the elaboration and  
465 review of the report until December 2024. The interviews lasted an average of  
466 38 minutes. Each session was conducted via Zoom<sup>4</sup> and audio-recorded with  
467 participant consent. Transcriptions were generated using the Transkriptor<sup>5</sup>  
468 service and subsequently verified and corrected manually by a researcher to  
469 ensure accuracy and preserve data integrity.

470 We followed the interview questions from the interview guide which can  
471 be found at <https://doi.org/10.5281/zenodo.15718138>. As a part of the  
472 field study method, the semi-structured interviews helped bring theory closer  
473 to practice and provided a deeper understanding of the real-world challenges  
474 that SE managers face (Seaman, 1999).

475 In the first part of the interviews, we provided each participant with a high-  
476 level definition of talent, as described in Section 2.1. In the second part, we  
477 asked about each participant's professional history, age, and academic back-  
478 ground. The intention was to bring the participant closer to the interviewer,  
479 making him more comfortable during the interview.

480 Finally, in the third part of the interviews, we focused on understanding  
481 how participants could improve talent retention in their teams, the impor-

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<sup>4</sup> <https://www.zoom.com/>

<sup>5</sup> <https://transkriptor.com/>

482 tance of investing in talent retention, the organizations' strategies and policies  
483 for retaining their most talented and valuable employees, and the difficulties  
484 or barriers that managers may run across when attempting to improve the  
485 elements that influence a talent's durability.

### 486 3.3 Demographics of Participants

487 To select participants, we used convenience sampling by reaching out to SE  
488 managers in our network. We used email and other online communication  
489 channels (WhatsApp<sup>6</sup> and LinkedIn<sup>7</sup>) to reach them. Our selection criteria to  
490 recruit credible practitioners were based on guidelines of Rainer and Wohlin  
491 (2022): i) relevant experience: SE managers have knowledge and practical ex-  
492 perience, including leadership skills, recruiting, and retaining talent; ii) strate-  
493 gic position: SE managers are directly involved in making decisions related to  
494 personnel management and play an important role in retaining talent within  
495 their teams; iii) variety of organizations: by selecting SE managers from dif-  
496 ferent types of organizations makes it possible to get a broader picture of the  
497 situation; and iv) diversity of perspectives: by selecting SE managers from dif-  
498 ferent backgrounds, genders, experience levels, and professional backgrounds,  
499 we can get different points of view on the topic of talent retention.

500 Before each meeting, we asked the participants for their consent to be inter-  
501 viewed and their permission to record the session. We inform participants that  
502 they could withdraw from the interview at any time and that their responses  
503 would be deleted. All participants have management skills and experience in  
504 matters related to talent retention, which helps to ensure that the selected  
505 sample is representative and relevant to the research objectives. Six of the 21  
506 participants had less than ten years of SE management experience, and nine of  
507 those had 15+ years of experience. Four of the participants had between five  
508 and seven years of experience. Participants worked in a variety of industries  
509 (including the insurance, auditing, government banking, fintech, and general  
510 software consulting). The size of the teams our participants manage ranged  
511 from 6 to 250 people, and their company sizes varied between 80 and 49K+  
512 people.

513 Regarding geographic and organizational scope, all participants based in  
514 Brazil. Although the interviewees are Brazilian professionals, their companies  
515 vary in scope: while some organizations operate exclusively within Brazil, oth-  
516 ers are subsidiaries of global enterprises or maintain international operations.  
517 This diversity is reflected in our demographic Table 3, which includes the scope  
518 of each company (e.g., local, global, or Brazilian subsidiary of a global com-  
519 pany). The growing prevalence of remote work, especially after the COVID-19  
520 pandemic, has blurred national boundaries, enabling Brazilian software en-  
521 gineers and SE managers to collaborate with international teams and adopt

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<sup>6</sup> <https://www.whatsapp.com/>

<sup>7</sup> <https://www.linkedin.com/>

522 global practices. These dynamics may influence talent retention, adding im-  
523 portant contextual layers to the interpretation of our findings.

524 Our sample includes organizations from both the private and public sec-  
525 tors, including a large government bank. This diversity allowed us to capture  
526 contextual nuances in talent retention practices. For instance, while public-  
527 sector organizations may offer greater job security, they often provide limited  
528 opportunities for rapid career growth or exposure to cutting-edge technologies.  
529 This scenario may result in a potential misalignment with software engineers’  
530 motivation for innovation and continuous learning. On the other hand, private  
531 companies typically offer more dynamic environments, characterized by faster  
532 promotion paths and greater technological exposure, although often associated  
533 with lower job stability.

534 Table 3 also shows a summary of the demographics of the SE managers  
535 we interviewed. An interesting fact worth mentioning is that the participants  
536 began their careers in technical roles in the field of SE. Over time, these profes-  
537 sionals transitioned to management positions, where they now oversee teams  
538 of software engineers and participate in leadership and decision-making pro-  
539 cesses. Some participants have even advanced to executive roles, highlighting  
540 their progression from technical to strategic responsibilities in organizations.

541 This progression is relevant because it combines technical and manage-  
542 rial skills, enabling a clearer understanding of both the challenges faced by  
543 software engineers and the strategic decisions related to talent retention. We  
544 interviewed SE managers because their position at the intersection of leader-  
545 ship and team dynamics provides unique insights into organizational strategies  
546 and engineers’ retention behaviors. Their daily experience offers visibility into  
547 turnover patterns and the circumstances that shape them, making these man-  
548 agers essential voices for understanding retention from a systemic perspective.

549 Our Informed Consent Term and interview instructions can be found in our  
550 supplementary material at <https://doi.org/10.5281/zenodo.15718138>. Al-  
551 though this study was not submitted to a formal Research Ethics Committee,  
552 all ethical precautions were rigorously followed in line with established guide-  
553 lines for qualitative research in SE (Strandberg, 2019). Participants received  
554 detailed information about the study’s objectives, provided informed consent,  
555 and were assured of their right to withdraw at any time. All interviews were  
556 anonymized and securely stored to preserve confidentiality. Importantly, all  
557 transcriptions were performed exclusively by members of the research team,  
558 ensuring full control over sensitive data and avoiding potential third-party ex-  
559 posure. These procedures are consistent with recommendations on consent,  
560 confidentiality, data minimization, and responsible data handling outlined in  
561 the recent literature on ethical interview practices.

### 562 3.4 Interview Procedures

563 Before refining our interview guide and conducting the final set of 21 inter-  
564 views, we performed a pilot with three participants (SE managers). We did

**Table 3** Details of participants from 11 different companies, where scope refers to: L-Local Company, G-Global Company, and S-Subsidiary of Global Company.

ID	Company Size	Industry	Scope	Team Size	Current Role	Gender	Experience
P1	100	Software Consulting	L	15	IT Manager	M	6 yrs
P2	4,000	Software Consulting	S	105	Head of IT Operations	M	29 yrs
P3	7,000	Insurance	G	35	IT Manager	M	26 yrs
P4	10,000	Auditing	S	32	IT Manager	F	5 yrs
P5	49,000	Government Banking	L	12	IT Manager	F	10 yrs
P6	7,000	Insurance	G	6	Tech Lead	M	15 yrs
P7	400	Business Intelligence	L	9	Data Engineer Lead	M	6 yrs
P8	3,000	Software Consulting	L	70	IT Manager	M	5 yrs
P9	3,000	Software Consulting	L	92	IT Director	F	12 yrs
P10	3,000	Software Consulting	L	60	IT Manager	M	8 yrs
P11	200	Software Consulting	L	80	Chief Information Officer	M	34 yrs
P12	4,000	Software Consulting	S	250	Vice President	M	30 yrs
P13	7,000	Insurance	G	15	IT Manager	M	20 yrs
P14	1,200	Software Consulting	G	38	IT Manager	M	7 yrs
P15	15,000	Software Consulting	S	30	IT Manager	M	30 yrs
P16	7,000	Insurance	G	8	IT Manager	F	32 yrs
P17	4,000	Software Consulting	S	150	Director of IT Operations	M	15 yrs
P18	7,000	Insurance	G	19	IT Manager	M	23 yrs
P19	3,000	Software Consulting	L	35	IT Manager	M	10 yrs
P20	3,000	Software Consulting	L	15	IT Manager	M	10 yrs
P21	80	Fintech	L	80	Founder	M	13 yrs

565 not use data from the pilot research in our analysis. The pilot encouraged us to  
566 add a definition of talent retention at the beginning of the interview. Without  
567 a clear definition of talent, there may be different interpretations of who is con-

568 sidered a talent in the organization, which could lead to divergent responses.  
569 The pilot also helped us ensure that everyone understood the questions and  
570 gave us confidence in improving the interview process. Minor refinements were  
571 made to two questions in the interview script to enhance clarity and ensure  
572 alignment with the research objectives.

573 The concept of “saturation” was adopted to establish the number of re-  
574 quired interviews. According to Creswell and Poth (2016), a saturation is  
575 reached when performing a new set of interviews does not come up with any  
576 new emerging data. It is a challenge to define how several interviews are re-  
577 quired to conclude a field study. We exceeded the reference recommendation  
578 of Guest et al. (2006), who explain that a saturation usually could be obtained  
579 with 12 interviews.

580 Due to a lack of new data as we go through the interviews, we observe  
581 whether participants are repeating information and topics already discussed  
582 earlier. Thus, we realized that our codes and insights were fully saturated  
583 (Glaser and Strauss, 1999). Interview recordings and transcriptions were con-  
584 tinually revisited in an iterative process. For each new interview, we went back  
585 to previous interviews to see if previous interviewees also mentioned the new  
586 insights. Once no new codes or insights emerged in three consecutive inter-  
587 views, we concluded that our findings were saturated and stopped recruiting  
588 new participants.

### 589 3.5 Coding Process

590 To analyze the interviews, we performed an open and axial coding approach  
591 which we coded the interviews inspired by the initial procedures for the GT of  
592 Strauss and Corbin (1990). The method uses an inductive approach (bottom-  
593 up), which means that theories emerge from collected data rather than being  
594 imposed by the researcher (Charmaz, 2006).

595 All initial codes and categories were derived directly from the data during  
596 the open and axial coding phases, without relying on pre-established theoret-  
597 ical constructs. After completing these procedures, we used the work of Greiler  
598 et al. (2022) as a reference to guide the organization and naming of the final  
599 five core categories. This alignment was interpretive and did not constrain or  
600 direct the initial coding process.

601 Two researchers independently conducted and coded the interviews over  
602 an average of three iterative cycles. The codes were generated inductively, i.e.,  
603 emerged directly from the data without prejudice or prior assumptions by the  
604 researchers. To ensure a collaborative, comprehensive, and reliable approach,  
605 all interviews were reviewed three times by each researcher to allow for the  
606 exchange of perspectives and consensus on code generation. During the cod-  
607 ing process, the points of disagreement between researchers were discussed  
608 transparently and resolved through consensus in a new review meeting. Three  
609 researchers with more than 18 years in ESE revisited the emerging categories,

610 discussed the coding interpretations with the main authors, and ensured the  
611 consistency and credibility of the final dataset.

612 The first and second authors divided the **transcripts** of the participants  
613 into coherent units (sentences or paragraphs) and added **preliminary codes**  
614 that represented the key points that each participant talked about. Based on  
615 the preliminary codes, we set the **focused codes** that captured the most  
616 frequent and relevant factors affecting talent retention, as shown in Table 4.  
617 Next, we formed axial coding as described by Charmaz (2006) to group the  
618 codes into categories using ATLAS.ti tool<sup>8</sup>. We also performed three iterative  
619 cycles of discussions among the researchers to refine the codes and categories  
620 and build relationships between them, forming a logical and coherent structure,  
621 as shown in Table 4. For the sake of research transparency, we have preserved  
622 the code mapping in our raw data, which is available at [https://doi.org/  
623 10.5281/zenodo.15718138](https://doi.org/10.5281/zenodo.15718138).

624 In our analysis, the TR4SEM Framework was built, consisting of five core  
625 categories (that may aggregate other categories in our code hierarchy), inspired  
626 by the work of Greiler et al. (2022): 1) **factors** that affect the retention of  
627 talent in organizations; 2) **contextual characteristics** that encompass the  
628 particularities of the environment and moderate the importance of factors; 3)  
629 **barriers** that identify the obstacles that prevent SE managers from improving  
630 talent retention; 4) **strategies** that address the actions and initiatives of SE  
631 managers to improve talent retention; and 5) **coping mechanisms** that SE  
632 managers resort when they face difficulties in improving the talent retention  
633 experience in the organizations.

634 These five core categories are components in the TR4SEM Framework that  
635 emerged from our analysis, as shown in Fig. 1. The TR4SEM Framework is our  
636 main research outcome and it also helped us refine our preliminary research  
637 questions as presented in Section 3.1. The core categories and codes will be  
638 described in Sections 5 and 6. Table 4 shows examples of the coding process  
639 for some transcripts, the resulting codes, and core categories. The codebook  
640 can be found in our supplementary materials at [https://doi.org/10.5281/  
641 zenodo.15718138](https://doi.org/10.5281/zenodo.15718138).

642 These core categories collectively constitute the TR4SEM Framework and  
643 serve as actionable lenses through which SE managers can analyze and re-  
644 spond to talent retention challenges. While each category can be explored in-  
645 dividually, the value of the framework lies in its integrative use. For instance, a  
646 manager might identify a key talent considering departure due to lack of recog-  
647 nition (factor), further complicated by rigid internal policies in a public-sector  
648 organization (context). In this case, the SE managers may face limited auton-  
649 omy for promotion (barrier), yet implement alternative recognition strategies  
650 (strategy) such as team visibility and involvement in high-impact projects. If  
651 those strategies prove insufficient, the manager may resort to coping mecha-  
652 nisms, such as reassigning the professional to a different project or visibility

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<sup>8</sup> Tool that supports locating, coding/tagging, and annotating features within bodies of unstructured data. <https://atlasti.com/>.

653 in leadership forums. This example illustrates how the TR4SEM Framework  
654 supports a holistic and context-sensitive approach to retention.

**Table 4** Illustration of the coding process.

<p><b>Transcript Unit:</b> Money is a decisive factor in your decision to look for a new opportunity, but it is not the main one. It depends on the context in which you work. For example, I started as a programmer, progressed in all steps of my career in the technical area, and then moved on to the management area. I remember that what most motivated me was constant learning and technological innovation. I also see this happening nowadays with talented people. One of the things that most motivates talented people is constant learning. While they are learning and gaining knowledge about a new technology that will increase their employability in the future, the tendency is for them to stay with the company. <b>(P12)</b></p>		
<p><b>Preliminary Code:</b> Talented people are motivated when they work in a constantly learning and innovative environment.</p>		
<p><b>Focused Code:</b> Continuous Learning and Innovation</p>	<p><b>Category:</b> Organizational Culture</p>	<p><b>Core Category:</b> Factors</p>
<p><b>Transcript Unit:</b> We have a slow process of effecting salary increases, so it sometimes causes us to lose talent. I have to wait for internal and international bureaucracies. <b>(P17)</b></p>		
<p><b>Preliminary Code:</b> Bureaucracy is a barrier to improving talent retention.</p>		
<p><b>Focused Code:</b> Bureaucracy</p>	<p><b>Category:</b> -</p>	<p><b>Core Category:</b> Barriers</p>

#### 655 4 TR4SEM Framework

656 The primary result derived from our work is the **TR4SEM Framework**, as  
657 shown in Figure 1. The core concept within our framework is **Talent Retention**  
658 **For Software Engineering Management**, characterized by satisfaction and moti-  
659 vation as mind dimensions. The other two parts of the framework are called  
660 *understanding* (left side) and *supporting* (right side). There are some reasons  
661 why we built an actionable framework (Agostinelli, 2021; Greiler et al., 2022):

- 662 – **Guidance for practice:** the main motivation is to provide clear and practical  
663 guidance for practitioners, decision-makers, or stakeholders involved  
664 in organizations.
- 665 – **Applicability and usefulness:** the actionable framework aims to ensure  
666 that search results are useful and applicable in organizations.
- 667 – **Bridge between theory and practice:** the actionable framework seeks  
668 to establish a connection between theory and practice, translating theoret-  
669 ical concepts into concrete actions.
- 670 – **Effective implementation:** by providing a clear set of actions and strate-  
671 gies, the actionable framework facilitates the effective implementation of  
672 research findings.

The central concept of the proposed framework is to offer a structured representation of how SE managers understand and address talent retention. The five core categories, such as factors, contextual characteristics, barriers, strategies, and coping mechanisms, were derived from qualitative data and serve as the foundational components of the TR4SEM Framework. These categories are visually organized into two dimensions.

On the left side of the framework, we represent the “understanding” dimension, composed of factors reported by SE managers that affected their experience and contextual characteristics that moderated the importance of these factors to SE managers. On the right side, the dimension “supporting” outlines practical elements to improve retention, including barriers that hinder effective action, strategies employed to address challenges and coping mechanisms adopted when standard strategies do not work. The arrows connecting these components are not merely directional. They represent interpretive and operational flows, highlighting how understanding informs action and how barriers can influence or disrupt intended strategies. The central node of the diagram works as a visual anchor, emphasizing the dynamic interaction between diagnosis and intervention in the retention of SE talent.

In the following sections, we first present the empirical findings resulting from the qualitative analysis (categories and codes), followed by the explanation of how these findings were organized into components of the TR4SEM Framework.

## 5 Understanding Talent Retention

In this section, we describe the factors that influence talent retention in SE teams, along with the contextual characteristics that shape their relevance across organizational settings. These categories constitute the “understanding” dimension of the TR4SEM Framework.

### 5.1 Factors Affecting Talent Retention

We aim to identify key elements that SE managers perceive as the most important factors affecting talent retention in organizations. As described in Section 3, we iteratively coded their responses to RQ1 and grouped them into categories. These categories represent themes that helped us to understand a set of factors as a group. Identifying and understanding these factors will help us create practical retention strategies. In the following section, we discuss the emerging factors, our focused codes for this core category, and the categories we grouped them through axial coding. Table 5 presents all the identified factors that affect talent retention. In the following, we detail each of them.

Based on the analysis of the interviews, sixteen key factors were identified that influence talent retention in SE teams. The factor most frequently mentioned was **Healthy Work Environment** (FA15), cited by 14 out of 21

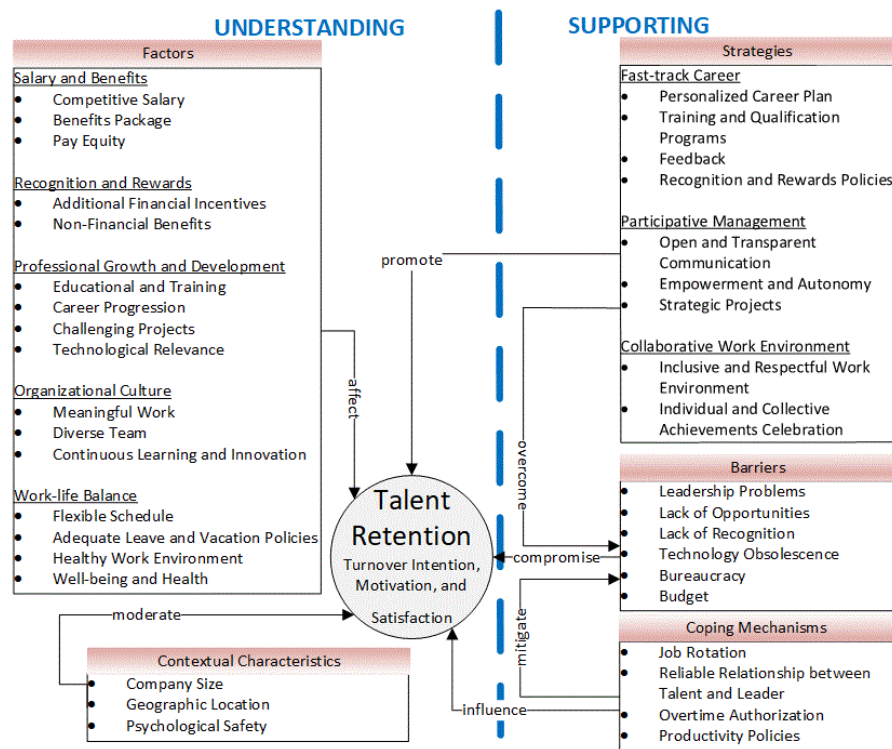


Fig. 1 TR4SEM Framework.

713 participants (67%), followed by **Career Progression** (FA07), mentioned by  
 714 13 participants (62%), and **Well-being and Health** (FA16), cited by 12 par-  
 715 ticipants (57%). These findings highlight that aspects related to organizational  
 716 climate, quality of life at work, and opportunities for professional growth are  
 717 crucial for the retention of talent. Other relevant factors include **Challenging**  
 718 **Projects** (FA08) and **Continuous Learning and Innovation** (FA12), each  
 719 mentioned by 9 participants (43%), and **Competitive Salary** (FA01), cited  
 720 by 7 participants (33%). Although less frequently mentioned, factors such as  
 721 **Pay Equity** (FA03), **Additional Financial Incentives** (FA04) (9%) each  
 722 one, and **Adequate Leave and Vacation Policies** (FA14) (5%), suggest  
 723 that specific benefits and flexibility can also influence employees' decisions to  
 724 stay or leave the organization.

### 725 5.1.1 Salary and Benefits

726 The focused codes in this category were mentioned by the largest number of  
 727 participants during the interviews, indicating their recurrence among different  
 728 experiences related to talent retention in organizations. **Competitive salary**  
 729 is essential to attracting and retaining qualified talent. IT professionals usu-

**Table 5** Factors that affect the talent retention.

ID	Factors	Mentioned in interviews by
FA01	Competitive salary	P4, P7, P9, P10, P13, P14, P19
FA02	Benefits Package	P12, P17, P18
FA03	Pay Equity	P3, P18
FA04	Additional Financial Incentives	P15, P21
FA05	Non-Financial Benefits	P5, P6, P7, P8, P9, P10, P17, P20
FA06	Educational and Training	P7, P12, P13, P17
FA07	Career Progression	P1, P2, P3, P6, P7, P8, P9, P11, P14, P15, P18, P19, P20
FA08	Challenging Projects	P2, P5, P8, P9, P13, P16, P18, P19
FA09	Technological Relevance	P2, P3, P5, P11, P21
FA10	Meaningful Work	P1, P3, P4, P10, P13, P14, P18, P19
FA11	Diverse Team	P1, P3, P4
FA12	Continuous Learning and Innovation	P2, P3, P6, P7, P9, P12, P16, P17, P18
FA13	Flexible Schedule	P4, P7, P12, P13
FA14	Adequate Leave and Vacation Policies	P21
FA15	Healthy Work Environment	P1, P3, P4, P5, P6, P7, P11, P12, P13, P14, P15, P18, P20, P21
FA16	Well-being and Health	P1, P3, P4, P5, P7, P8, P9, P10, P15, P17, P19, P20

ally have specialized skills and are in high demand in the market. Therefore, offering salaries that are competitive with the industry average is important to ensure that employees are not tempted to seek better opportunities elsewhere. In addition to the base salary, the **benefits package** is also significant. It may include benefits such as healthcare assistance, life insurance, a pension plan, or food vouchers. Offering attractive benefits can increase employee satisfaction and demonstrate the organization's commitment to their well-being and quality of life. As P4 shared: *"The main factor is remuneration, money really, even more so when you talk about IT, where we see very aggressive startup companies with very competitive salary and benefits"*.

**Pay equity** is another important factor in talent retention. IT employees expect their compensation to be fair in relation to their responsibilities, experience, and performance, as well as compared to their peers. It is essential to ensure a fair and transparent remuneration policy, avoiding unjustified wage disparities that could lead to dissatisfaction and the loss of talent. As P3 commented: *"I would not want to leave here, saying: look, if you give flowers every morning, people will not leave. Just imagine that when IT professionals realize they are being paid fairly and equally with colleagues in the same role, it creates harmony in the work environment"*.

### 5.1.2 Recognition and Rewards

The focused codes included in this category refer to the appreciation of employees' work. It is critical to the motivation and engagement of IT professionals. **Additional financial incentives** can also be an effective form of retention. It may include performance bonuses, profit sharing, stock option programs,

754 or other results-based incentives. These incentives can motivate employees to  
755 reach goals and reward good performance. P21 stated: *“Several practitioners*  
756 *come to me precisely to complain about the lack of recognition, not from the*  
757 *immediate management but from the company as a whole. In most of these*  
758 *cases, we managed to get some kind of reward to retain, but it was reactive”*.

759 In addition to financial compensation, there are **non-financial benefits**  
760 that can be equally valuable for retaining IT talent. This can include learn-  
761 ing and development opportunities, mentoring programs, flexible schedules, a  
762 pleasant work environment, an inclusive organizational culture, recognition,  
763 and non-monetary rewards such as additional days off, wellness programs, re-  
764 mote work options, prizes, accolades, and opportunities for growth. As P9  
765 shared: *“I try to provide outstanding experiences, such as children’s birthdays.*  
766 *You create an emotional bond, right? If one day these talents leave the com-*  
767 *pany, they will be missed”*.

### 768 5.1.3 Professional Growth and Development

769 It refers to the possibilities offered to IT professionals to advance their careers,  
770 acquire new skills, and expand their knowledge. **Education and training** op-  
771 portunities are essential to the professional development of IT employees. It  
772 may include participation in specific courses, workshops, seminars, webinars,  
773 and training programs to update technical skills. These initiatives allow IT  
774 professionals to stay current with the latest technologies and work practices,  
775 improving their effectiveness and value in the marketplace. P13 stated: *“Invest-*  
776 *ment is associated with talent retention. Not only in terms of salary increases*  
777 *but also in terms of investment in training to place talented people in positions*  
778 *where they can make the difference they have”*.

779 **Career progression** may involve defining a career plan with clear steps  
780 and the possibility of promotions based on performance and professional growth.  
781 Promoting continued employee development is achieved by offering challeng-  
782 ing goals and the opportunity to take on additional responsibilities. P7 stated:  
783 *“Career progression is kind of the fuel that feeds IT professionals’ desire for*  
784 *growth. When they see clear opportunities for development in the company’s*  
785 *hierarchy, they are more engaged to stay in the same place”*.

786 Enabling IT professionals to take on **challenging projects** is a way to pro-  
787 mote their growth and development. By involving them in innovative projects,  
788 the practitioners have the opportunity to expand their skills, face new chal-  
789 lenges, and learn from practical experiences. As P13 shared: *“Money is impor-*  
790 *tant, but having a challenging work proposal is essential to retaining talent”*.

791 Having **technological relevance** is critical to IT professional develop-  
792 ment. It may include access to technical libraries, software development tools,  
793 test labs, online learning platforms, and other sources of knowledge and sup-  
794 port. Technological relevance indicates that a product or technology is cur-  
795 rent, useful, and in line with current standards and demands. IT professionals  
796 generally seek to work with innovative technologies. A company that stays up-  
797 to-date technologically increases the satisfaction of these professionals. As P5

798 shared: *“The other day, an employee told me that when he works on a software*  
799 *project with new technology, it becomes motivating to stay at the company”*.

#### 800 5.1.4 Organizational Culture

801 A positive organizational culture can create a sense of identification and con-  
802 nection between IT professionals and the organization, becoming a way to  
803 retain talent. The factors included in this category refer to values, beliefs,  
804 norms, practices, and behaviors shared within an organization. IT profes-  
805 sionals value the opportunity to do **meaningful work** where they can apply their  
806 skills and knowledge. As P18 stated: *“The reason for a talent’s decision not*  
807 *to stay in the company was the work proposal and the daily routine that were*  
808 *not compatible with what he wanted. He no longer had a sparkle in his eyes”*.

809 A **diverse team** in an organizational culture that values diversity and in-  
810 clusion can be attractive to IT professionals as it fosters innovation, creativity,  
811 and mutual learning. P4 shared: *“Our company is proud to be a diverse and in-*  
812 *clusive workplace, with people from several ethnicities and genders”*. A culture  
813 that values **continuous learning and innovation** is attractive to IT profes-  
814 sionals. Talent seeks organizations that encourage professional growth, offer  
815 development opportunities, foster creativity, and value experimentation and  
816 continuous improvement. A culture that encourages learning and innovation  
817 encourages the engagement and retention of talent. P12 stated: *“One of the*  
818 *things that motivates the most talented people is constant learning. While they*  
819 *are learning and gaining knowledge about a new technology that will increase*  
820 *their employability in the future, the tendency is to stay in the company”*.

#### 821 5.1.5 Work-life Balance

822 *Work-life balance* refers to IT professionals’ ability to balance their work re-  
823 sponsibilities and demands with their personal needs and commitments out-  
824 side of the work environment. The factors addressed in this category play a  
825 crucial role in talent retention as they directly influence employee well-being,  
826 satisfaction, and quality of life. **Flexible schedules** are an effective way to  
827 promote work-life balance. This could include flexible work schedules, com-  
828 pressed schedules, part-time work schedules, or the option to work remotely.  
829 This flexibility allows IT professionals to accommodate their personal respon-  
830 sibilities, such as taking care of the family, carrying out leisure activities, or  
831 dealing with important personal commitments. As P7 shared: *“We place great*  
832 *importance on fulfilling our activities with quality and within the established*  
833 *deadlines. Other than that, we are flexible with regard to hours”*.

834 A **healthy work environment** is essential to ensuring a balance between  
835 personal and professional lives. It may involve implementing stress-reducing  
836 practices such as encouraging regular breaks, promoting a balanced work cul-  
837 ture, and stimulating mutual support among team members. Additionally,  
838 encouraging off-hours digital disconnection and avoiding excessive workload  
839 are important steps to ensure employees have the time to take care of their

840 personal needs. P11 stated: “*We lost a talent in our team due to a hostile*  
841 *environment with a lot of pressure for fast and quality deliveries*”.

842 Encouraging employee **well-being and health** is another factor in pro-  
843 moting work-life balance. It can include wellness programs such as i) physical  
844 activity, meditation, or yoga sessions; ii) counseling services or psychological  
845 support; and iii) incentives to healthy habits. IT professionals who invest in  
846 their health and well-being contribute to their quality of life and overall hap-  
847 piness, making them more likely to stay with the organization. As P20 shared:  
848 “*We offered him a good salary increase, but even so, he wanted to leave the*  
849 *company. He wanted to work fewer hours to have a better quality of life*”.

## 850 5.2 Contextual Characteristics Moderating Talent Retention

851 When considering the core category *contextual characteristics*, it is important  
852 to adapt retention strategies to meet the specific needs of the organization  
853 and the environment in which it operates. Every organization has its own  
854 unique context, and understanding these elements is critical to implementing  
855 effective approaches to overcoming barriers during the talent retention process.  
856 These contextual characteristics are outlined below, where we show them as  
857 moderating the talent retention experience by SE managers. Table 6 presents  
858 all the contextual characteristics identified that moderate talent retention. In  
859 the following, we detail each of them.

**Table 6** Contextual characteristics that moderate the talent retention.

ID	Contextual Characteristics	Mentioned in interviews by
CT01	Company Size	P2, P3, P6, P10
CT02	Geographic Location	P4, P5, P7, P12, P14, P21
CT03	Psychological Safety	P1, P2, P3, P4, P5, P6, P9, P10, P11, P13, P14, P15, P16, P17, P18, P19, P20, P21

860 The analysis of the interviews revealed three contextual characteristics that  
861 moderate talent retention. The most prominent was **Psychological Safety**  
862 (CT03), cited by 18 out of 21 participants (86%), highlighting the importance  
863 of a work environment where employees feel safe to express themselves and take  
864 risks without fear of negative consequences. **Geographic Location** (CT02)  
865 was mentioned by 6 out of 21 participants (29%) and is increasingly relevant  
866 in the context of remote work, which has enabled professionals to relocate with  
867 minimal impact on their daily routines, expanding their employment options  
868 without geographic constraints. Lastly, **Company Size** (CT01) was cited by  
869 4 out of 21 participants (19%), suggesting that organizational scale can affect  
870 retention particularly when it shapes opportunities for visibility, mobility, or  
871 employee recognition.

872 **Company size** can play an important role in retaining talent. Companies  
873 of different sizes can offer different advantages and challenges for IT profes-

874 sionals. For example, in smaller companies, IT professionals may have the op-  
875 portunity to assume a variety of responsibilities and enjoy a closer and more  
876 collaborative atmosphere. On the other hand, larger companies can offer more  
877 robust resources and opportunities for growth. Understanding company size  
878 and its implications can help tailor retention strategies to specific needs. As P6  
879 described: *“I lost a great talent to a startup, a small, versatile, and innovative*  
880 *company that promised to become a unicorn*<sup>9</sup>. *This employee chose to leave*  
881 *based on this scenario and still gained the advantage of having his position*  
882 *evolve much higher”.*

883 The **geographic location** of the organization also plays a significant role  
884 in retaining talent. In some regions, there may be a greater concentration of IT  
885 job opportunities, while in others, there may be talent shortages. In addition,  
886 factors such as quality of life, access to services, cost of living, and technological  
887 infrastructure can influence the attractiveness of a region for IT professionals.  
888 As P14 explained: *“In a country such as [omitted], some talents have the will*  
889 *to work in a more promising IT market or in interior regions. Others want*  
890 *an international career for salary appreciation in another currency. I had a*  
891 *talent who was assigned to an international project so that he could reside in*  
892 *the country he desired. Currently, in the post-pandemic scenario and with the*  
893 *possibility of home office, it has not happened”.*

894 Lastly, participants mentioned **psychological safety**, which refers to an  
895 environment in which people feel safe to express their opinions, ideas, and  
896 concerns without fear of reprisal or negative judgment. According to Edmond-  
897 son Edmondson (1999), there is a strong relationship between psychological  
898 safety and team performance, noting that a climate of safety promotes the  
899 open exchange of information, knowledge sharing, and problem solving more  
900 effectively. P20 reinforced: *“I started to work with the team to understand each*  
901 *other’s career goals. I think this approach made people more motivated and en-*  
902 *gaged. This closer and more frequent career follow-up provided a more trusting*  
903 *work environment”.*

## 904 6 Supporting Talent Retention

905 In this section, we detail the barriers that SE managers face in retaining talent,  
906 the strategies they employ to foster engagement, and the coping mechanisms  
907 they adopt when retention initiatives are at risk. While strategies are planned  
908 practices aimed at long-term retention, coping mechanisms are reactive re-  
909 sponses to practical constraints. These categories constitute the “supporting”  
910 dimension of the TR4SEM Framework.

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<sup>9</sup> Privately held startup company with a valuation of US\$1 billion or more.

## 911 6.1 Barriers Compromising Talent Retention

912 Barriers are obstacles or challenges that prevent the retention of talent in  
 913 organizations. Once SE managers identify the barriers, the management team  
 914 will be aware, actively work to overcome them, and develop mechanisms to  
 915 improve retention. Table 7 presents the set of barriers identified in our work.  
 916 In the following, we detail each of them.

**Table 7** Barriers that prevent the talent retention.

ID	Barriers	Mentioned in interviews by
BA01	Leadership Problems	P9, P12, P15, P21
BA02	Lack of Opportunities	P4, P5, P8, P9, P11, P13, P18, P19, P20
BA03	Lack of Recognition	P1, P2, P6, P7, P10, P15
BA04	Technology Obsolescence	P1, P2, P3, P5, P12, P21
BA05	Bureaucracy	P3, P4, P5, P10, P11, P13, P14, P15, P16, P17, P18, P19, P20
BA06	Budget	P2, P3, P4, P5, P7, P8, P9, P10, P11, P12, P13, P14, P17, P19, P20

917 Based on the analysis of 21 interviews, six main barriers that prevent talent  
 918 retention were identified. The most frequently barrier mentioned was **Budget**  
 919 (BA06), reported by approximately 71% of the participants (15 out of 21),  
 920 referring to limitations in salary adjustments, promotions, and investments in  
 921 people. **Bureaucracy** (BA05) appeared in around 62% of the interviews (13  
 922 out of 21), highlighting rigid processes and excessive formalities that hinder  
 923 agility and retention actions. **Lack of Opportunities** (BA02) was cited by  
 924 43% of the participants (9 out of 21), often related to limited career paths or  
 925 role transitions. **Lack of Recognition** (BA03) was mentioned by 29% of the  
 926 interviewees (6 out of 21), especially regarding the absence of appreciation or  
 927 merit acknowledgment. **Technology Obsolescence** (BA04) was also identi-  
 928 fied by 29% of the participants (6 out of 21), referring to outdated tools and  
 929 technological environments. Finally, **Leadership Problems** (BA01) were re-  
 930 ported by 19% of the respondents (4 out of 21), including challenges such as  
 931 misaligned leadership styles and insufficient support from managers.

932 Leadership plays a key role in retaining talent. SE managers who demon-  
 933 strate a lack of leadership skills, a lack of support for employees, or toxic  
 934 behaviors can undermine talent satisfaction and engagement. The presence of  
 935 **leadership problems** can discourage talent from staying with the organiza-  
 936 tion and create an unfavorable work environment. As P15 shared: “*Empathy*  
 937 *with the immediate manager is fundamental for the continuity of the work.*  
 938 *Before taking an administrative decision, I try to talk to the person to find out*  
 939 *what is going on, mainly related to the drop in performance”.*

940 The **lack of opportunities** for professional advancement makes IT pro-  
 941 fessionals look to the market for opportunities for growth and development  
 942 in their careers. If the organization does not offer clear opportunities for  
 943 professional advancement, such as training, qualification courses, challenging

944 projects, or promotions, talents may feel stagnant and decide to look for other  
945 opportunities in organizations that offer these growth perspectives. P4 shared  
946 a personal experience: *“In an internal interview, the department manager was*  
947 *very clear and told me: look, here in this corporate area, you can only get to*  
948 *this point. So I declined the invitation to change and started to look for an*  
949 *opportunity in the market”*.

950 Recognition is an important motivational factor for employees. If SE man-  
951 agers do not recognize talent’s contributions and accomplishments, it can lead  
952 to a feeling of worthlessness. The **lack of recognition** can lead talent to seek  
953 recognition and rewards in other organizations. P1 stated: *“Due to the fact*  
954 *that the IT area is very dynamic, personal issues are not noted as much. The*  
955 *IT area is much more focused on technical bias. The lack of recognition is a*  
956 *factor that encourages talent not to stay in the organization”*.

957 The rapid evolution of technology is a reality for organizations. If the or-  
958 ganization fails to keep up with or provide talented people with access to  
959 modern and relevant technologies, it can lead to **technology obsolescence**.  
960 Lack of up-to-date resources and outdated technologies can make work less  
961 challenging and interesting for IT professionals, reducing their motivation and  
962 satisfaction. In addition, talent can look for organizations that offer opportu-  
963 nities to work with more advanced and innovative technologies. As P5 shared:  
964 *“Legacy system does not motivate anyone. You take care of only the prob-*  
965 *lems. When we work on legacy systems with obsolete technologies, it does not*  
966 *encourage anyone to stay”*.

967 The **bureaucracy** can create obstacles and delays in decision-making pro-  
968 cesses, implementing changes, and accessing necessary resources. This can be  
969 especially problematic in organizations, where agility and quick responsive-  
970 ness are highly valued. Excessive bureaucracy can discourage talent, who of-  
971 ten seeks an agile and flexible environment, from remaining in the organiza-  
972 tion. Furthermore, bureaucracy can create barriers to innovation and profes-  
973 sional advancement, limiting growth opportunities for talented people. As P17  
974 stated: *“We have a slow process of effecting salary increases, so it sometimes*  
975 *causes us to lose talent”*. This situation may also reflect a slow-paced career  
976 advancement process, reinforcing how bureaucratic delays can impact both  
977 compensation and professional growth opportunities.

978 When **budget** is constrained, it can be difficult for the organization to com-  
979 pete with other companies that offer more attractive compensation packages.  
980 Furthermore, a lack of financial resources may limit the organization’s ability  
981 to provide adequate incentives and rewards. As P7 shared: *“We have a budget*  
982 *to carry out salary adjustments. However, it is possible to have an exception*  
983 *that exceeds this limit. In this case, we must escalate to the IT board.”*

## 984 6.2 Strategies Promoting Talent Retention

985 In the coding paradigm, the term “strategies” refers to actions directed toward  
986 a phenomenon, regardless of whether the research is focused on individuals,

groups, or collectives. Strategies can be used to overcome, deal with or react to the phenomenon under investigation (Corbin and Strauss, 2014).

This core category involves formulating concrete strategies to promote talent retention. Based on our findings we identify specific strategies to attract, engage, and retain talent in organizations. Table 8 presents a summary of these strategies. In the following, we detail each of them.

**Table 8** Strategies that promote talent retention.

ID	Strategies	Mentioned in interviews by
ST01	Personalized Career Plan	P1, P3, P4, P6, P7, P10, P11, P14, P15, P16, P17, P18, P19, P20
ST02	Training and Qualification Programs	P2, P4, P11, P13, P14
ST03	Feedback	P1, P7, P8, P9, P10, P11, P17, P18, P19
ST04	Recognition and Rewards Policies	P2, P4, P6, P7, P8, P9, P10, P12, P14, P15, P17, P20, P21
ST05	Open and Transparent Communication	P1, P2, P3, P5, P10, P11, P12, P13, P18, P19
ST06	Empowerment and Autonomy	P8, P9, P12, P13, P14, P16, P17, P19
ST07	Strategic Projects	P12, P13, P19, P21
ST08	Inclusive and Respectful Work Environment	P2, P3, P5, P6, P7, P8, P18
ST09	Individual and Collective Achievements Celebration	P3, P16, P21

The analysis of 21 interviews revealed nine **Strategies** that promote talent retention. The most frequently strategy mentioned was **Personalized Career Plan** (ST01), cited by 14 participants, which corresponds to approximately 67% of the sample. **Recognition and Rewards Policies** (ST04) were also prominent, identified by 13 participants (62%), followed by **Feedback** (ST03), mentioned by 9 participants (43%). **Open and Transparent Communication** (ST05) appeared in 10 interviews (48%), while **Empowerment and Autonomy** (ST06) was discussed by 8 participants (38%). **Training and Qualification Programs** (ST02) was mentioned by 5 participants (24%), and **Inclusive and Respectful Work Environment** (ST08) by 7 participants (33%). Less frequently, we have **Strategic Projects** (ST07), reported by 4 participants (19%), and **Individual and Collective Achievements Celebration** (ST09), cited by 3 participants (14%).

### 6.2.1 Fast-track Career

Items covered in this category indicate a desire to progress quickly in an IT career, achieve promotions, or move faster in terms of job responsibilities and opportunities. Creating a **personalized career plan** that provides opportunities for growth, such as challenging projects, job rotation, participation in strategic teams, project leadership, and international career opportunities.

P17 stated: *“To be able to retain talent, it is necessary to understand what each person has as a professional desire. The HR recruiter interviews all developers every 3 months. Then we generate reports and graphs to identify what they worked with and what they would like to work with. We establish a set of priorities together. So, it is possible to propose an individualized career plan”*.

Investment in the development of talents through **training and qualification programs**, such as internal or external courses, workshops, mentoring, and continuous learning opportunities, can help to improve the skills and knowledge of talents, promoting their professional growth and increasing their job satisfaction. As P4 shared: *“We have a partnership on an online course platform for employees”*. Provide constructive **feedback** on a regular basis, identify areas for improvement, and offer guidance so talented people can grow and progress in their careers. As P1 explained: *“Give constant feedback to align objectives and avoid understanding noise”*.

**Recognition and rewards policies** aim to recognize and reward exceptional performance. It may include formal or informal recognition programs such as public accolades, awards, or performance-based bonuses. In addition, offering opportunities for career growth and promotions can also be a way to reward talent and encourage them to stay with the organization. As P17 shared: *“A form of recognition that does not require financial investment but makes people feel valued is to highlight or praise in corporate groups”*.

### 6.2.2 Participative Management

Strategies in this category describe a leadership style in which employees are encouraged to actively participate in organizational decisions, promoting collaboration and empowerment. Establishing an **open and transparent communication** channel to promote the exchange of ideas, opinions, and feedback between IT professionals and the management team creates an environment in which everyone feels heard and has the opportunity to contribute to the company’s decisions. P13 stated: *“We should listen to the talent and make him feel free to be heard, to talk, and to give ideas”*.

**Empowerment and autonomy** are aimed at delegating responsibilities to talented people so that they can make decisions within their areas of expertise. This attitude demonstrates confidence in their abilities, allowing them to feel more engaged and valued. As P14 shared: *“In my team, talents have the autonomy to make decisions. They are self-managing employees who are able to work independently and prioritize their tasks effectively”*. This concept aligns with the work of Demerouti et al. (2015), which emphasizes the proactive behaviors employees take to optimize their work environment and tasks to better fit their abilities and preferences.

Participating in the organization’s **strategic projects** allows talented people to contribute to the company’s success, develop new skills, and have a sense of purpose in their work. As P21 explained: *“I encourage talented people to have challenges suited to their size and potential”*.

### 6.2.3 Collaborative Work Environment

Talented people feel valued and engaged, have the opportunity to share and expand their knowledge and acquire a sense of belonging to a close-knit, collaborative team. This strengthens your bond with the organization and increases your motivation to stay and contribute to the company's success. Create an **inclusive and respectful work environment** where all team members feel valued and comfortable voicing their opinions. This corporate synergy contributes to retaining talented people. P18 stated: *“As a manager if I do not have a good working environment with respect, partnership, and team spirit, I cannot even start with other strategies. It is not easy, but this is the first step”*.

Use the various internal communication channels (i.e., e-mail, instant messaging, collaboration platforms, and virtual meetings) to **celebrate individual and collective achievements** and promote a positive and motivating climate in the work environment. As P16 shared: *“My position gives me almost no freedom to financially recognize a talent. However, I have the autonomy to publish a corporate message of congratulations so that these people feel valued”*.

### 6.3 Coping Mechanisms Influencing Talent Retention

When factors that negatively affect talent retention are not improved, SE managers can resort to different coping mechanisms to deal with the situation. This category refers to the means or tools that can be used to deal with frustration in the talent retention process to establish turnaround actions. Table 9 presents the set of coping mechanisms identified in our work. In the following, we detail each of them.

**Table 9** Coping mechanisms to deal with talent retention.

ID	Coping Mechanisms	Mentioned in interviews by
CM01	Job Rotation	P1, P6, P8, P9, P11, P17, P21
CM02	Reliable Relationship between Talent and Leader	P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12, P13, P14, P15, P16, P17, P18, P19, P20, P21
CM03	Overtime Authorization	P5, P14
CM04	Productivity Policies	P1, P2, P3, P5, P6, P8, P9, P10, P11, P12, P13, P14, P15, P16, P18, P20

The coping mechanism **Reliable Relationship between Talent and Leader** (CM02) was mentioned by all participants (21 out of 21, 100%). This overwhelming presence underscores the centrality of trust-based, supportive leadership in efforts to retain SE talent. **Productivity Policies** (CM04) were also prominent, referenced by 16 participants (76%), often tied to career development plans, structured feedback loops, and mechanisms to recognize high performance. **Job Rotation** (CM01) appeared in 7 interviews (33%), generally as a means to re-engage demotivated professionals by exposing them to

1086 new challenges or environments. Lastly, **Overtime Authorization** (CM03)  
1087 was mentioned by only 2 participants (10%), suggesting that compensatory  
1088 flexibility in work hours is a less commonly employed or institutionally sup-  
1089 ported strategy in these contexts.

1090 **Job rotation** involves moving talented IT professionals to different posi-  
1091 tions or projects within the organization to allow them to acquire new skills,  
1092 expand their knowledge, and have the opportunity to work in different busi-  
1093 ness areas. Job rotation can help combat monotony and disinterest, keeping  
1094 talent motivated and engaged. In addition, it offers opportunities for profes-  
1095 sional growth and career development, which can increase the organization's  
1096 attractiveness as a place to work in the long term. As P11 explained: "*As SE*  
1097 *manager, you must be concerned about finding the best activities for talent. If*  
1098 *he stopped performing well, you should plan actions to remove him from the*  
1099 *project or area and drive him to another one*".

1100 **Strengthening the relationship between talent and leadership** cre-  
1101 ates a more positive, collaborative work environment where IT professionals  
1102 feel valued, heard, and supported. When professionals have a healthy, trust-  
1103 ing relationship with their leaders, they feel more motivated and committed  
1104 to the organization. In addition, a good relationship between the IT team  
1105 and leadership allows professionals to express their concerns, challenges, and  
1106 needs, opening space for dialogue and the search for solutions together. As P7  
1107 shared: "*I think that remuneration is obviously important, but what SE man-*  
1108 *agers should pay attention to is knowing how to listen to their talents, knowing*  
1109 *what their expectations are for their career, and how we can align their goals*  
1110 *in the organization*".

1111 When factors that negatively influence talent retention, such as poor com-  
1112 pensation, cannot be easily addressed due to budget constraints or other bar-  
1113 riers, **overtime authorization** can be a way to provide a temporary solution  
1114 for IT professionals. This mechanism allows them to increase their income,  
1115 even temporarily, helping alleviate any financial pressure and providing an  
1116 additional incentive to stay with the organization. However, it is important to  
1117 emphasize that overtime authorization as a coping mechanism must be used  
1118 with care. It should not be seen as a solution to talent retention problems, as  
1119 constantly working overtime can lead to exhaustion and burnout for profes-  
1120 sionals, negatively affecting their quality of life and well-being. P5 stated: "*I*  
1121 *authorize overtime to be added on a regular basis to the salary. It is a way to*  
1122 *motivate, but you have to be careful with legal rights and human fatigue*".

1123 **Productivity policies** (i.e., additional days off for birthdays or family  
1124 events) aim to recognize and reward exceptional performance by talented peo-  
1125 ple, encouraging them to continue to excel and contribute meaningfully to the  
1126 organization. Hence, this mechanism contributes to the balance between work  
1127 and personal life, the well-being of employees, and the retention of talent in  
1128 the organization. As P3 shared: "*I usually authorize talented people to take a*  
1129 *day off to extend the holiday and enjoy a longer break, as long as the activities*  
1130 *have been performed on time and with the required quality*".

## 1131 7 Using the TR4SEM Framework

1132 To support the practical adoption of the TR4SEM Framework, we propose a  
 1133 guideline based on the Plan-Do-Check-Act (PDCA) cycle (Deming, 1986) as  
 1134 illustrated in Fig. 2. This guideline is directed at **SE managers and HR**  
 1135 **analysts**, the main stakeholders involved in talent retention practices, and is  
 1136 grounded in the empirical findings of our work. PDCA cycle is a widely used  
 1137 management model for continuous improvement in several areas and can be  
 1138 adapted to suit the implementation of the TR4SEM Framework.

1139 In the following section, we outline the main steps for applying the TR4SEM  
 1140 Framework using this guideline.

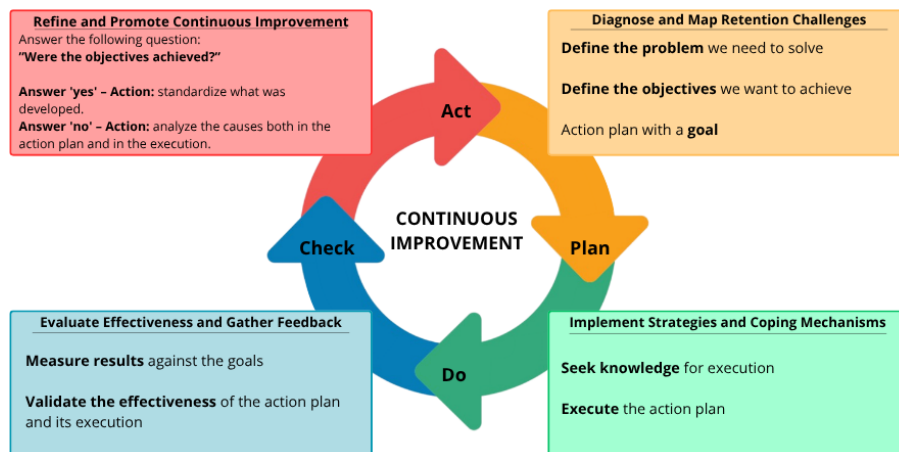


Fig. 2 TR4SEM Framework through the PDCA cycle.

### 1141 7.1 Steps for Using TR4SEM with PDCA

1142 To operationalize the TR4SEM Framework in organizational contexts, we de-  
 1143 scribe a four-step process based on the Plan-Do-Check-Act (PDCA) model.  
 1144 Each step is aligned with the framework's empirical foundations and is de-  
 1145 signed to guide **SE managers and HR analysts** in identifying and address-  
 1146 ing talent retention challenges in a structured and iterative manner.

1147 1. **Plan – Diagnose and Map Retention Challenges.** In this step, SE  
 1148 managers and HR analysts collaborate to assess the current state of talent  
 1149 retention. This includes identifying critical factors, barriers, and contextual  
 1150 characteristics as described in the TR4SEM Framework. Techniques such  
 1151 as interviews, surveys, or workshops can be used to map organizational  
 1152 conditions against the framework's dimensions.

- 1153 *Key outputs:* Retention diagnostics report, map of TR4SEM factors, barriers, and contextual characteristics of the organization.
- 1154
- 1155 2. **Do – Implement Strategies and Coping Mechanisms.** In this step,
- 1156 actions are designed and executed based on the strategies and coping mechanisms from the TR4SEM Framework. When barriers persist, SE managers
- 1157 may apply coping mechanisms.
- 1158 *Key outputs:* Strategy deployment plan and records of coping mechanisms used.
- 1159
- 1160
- 1161 3. **Check – Evaluate Effectiveness and Gather Feedback.** This step involves evaluating the outcomes of the implemented actions. SE managers
- 1162 and HR analysts collect relevant data, such as turnover metrics, engagement indicators, and feedback from software engineers. The objective is
- 1163 to assess the impact of the strategies and coping mechanisms on talent retention.
- 1164
- 1165 *Key outputs:* Evaluation report, dashboard of retention indicators, and analysis of outcomes. Table 10 presents examples of retention-related metrics and indicators that SE managers and HR analysts can use to assess
- 1166 the effectiveness of implemented strategies and coping mechanisms.
- 1167
- 1168
- 1169

**Table 10** Examples of Retention Metrics and Indicators.

Retention Metric	Indicator
Turnover Reduction	% decrease in voluntary exits
Recognition Effectiveness	% of team members reporting recognition
Career Development Impact	% with updated individual development plan
Psychological Safety	Qualitative scores from post-action survey

- 1171 4. **Act – Refine and Promote Continuous Improvement.** In this step,
- 1172 SE managers and HR analysts review results, refine the strategies, and incorporate successful practices into daily activities. It may also involve
- 1173 identifying previously unconsidered barriers or adjusting the use of coping mechanisms. Lessons learned contribute to the evolution of the framework’s
- 1174 applicability in the organizational context.
- 1175 *Key outputs:* Updated action plan, refined implementation strategies, organizational learning summary.
- 1176
- 1177
- 1178

1179 By following this cycle, SE managers and HR analysts can adopt a repeatable and adaptive process for addressing SE talent retention, grounded in

1180 real-world conditions and guided by empirical evidence. In the next section, we illustrate how this process was applied in practice through a *small-scale*

1181 *evaluation* conducted within a real organizational setting.

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## 1184 7.2 Small-scale Evaluation

1185 We conducted a *small-scale evaluation* to explore the applicability and practical value of the TR4SEM Framework in an organizational setting. This type

1186

of evaluation is particularly suited to SE research where the goal is to demonstrate the feasibility, relevance, or utility of a proposed artifact (Wohlin and Rainer, 2022). As described by Robson (2017), a small-scale evaluation refers to a study conducted by a single researcher or a small team, over a limited time period, with constrained resources, typically in a single setting.

In line with this definition, our evaluation was performed in an organization, over a limited time span, and involved a small number of practitioners without formal triangulation procedures. Rather than aiming for theory-building or generalization, the purpose was to observe how SE managers and HR analysts could apply the TR4SEM Framework to identify and address SE talent retention challenges.

This type of evaluation, as clarified by Wohlin and Rainer (2022), plays a vital role in SE research by providing early insights into the practical utility of research contributions. It enables researchers to gather initial feedback, understand contextual factors, and reflect on potential refinements before conducting more comprehensive or rigorous assessments. In the following subsections, we describe the organizational context and detail the implementation of the TR4SEM Framework using the PDCA cycle, followed by a discussion of lessons learned.

### 7.2.1 Case Description

Due to privacy reasons, the organization’s name is omitted. From now on, we refer to it as organization “X”. Founded more than 80 years ago, the organization “X” is one of the largest insurance groups in Latin America, operating internationally in multiple segments, including auto, property, health, capitalization, and open supplementary pension. The organization maintains more than 200 branches (service centers, offices, and customer service units) throughout the country and partners with more than 40,000 insurance brokers.

In a highly competitive business environment, IT plays a critical role in sustaining the organization’s performance by providing information flows that add value without compromising operational efficiency (Rugeviciute et al., 2023). As part of a broader digital transformation (DT) initiative, organization “X” has shifted its strategic focus toward client-centered services and business value generation. DT involves leveraging digital technologies to solve traditional organizational problems, such as drops in productivity, performance, and agility, and requires structural changes within companies (Vial, 2021).

A major challenge facing organization “X” is that the business rules of the predigital era are no longer sufficient. To remain competitive, the company must modernize its legacy systems, restructure its software development processes, and mainly, attract and retain highly qualified software engineers capable of driving innovation and ensuring technological sustainability.

However, retaining software engineers has proven to be a growing concern within the company. Internal HR reports have shown a significant increase in voluntary turnover among software development teams over the last two years. Interviews with technical managers revealed recurring difficulties in aligning

1231 individual career expectations with organizational career paths and dissatis-  
1232 faction with recognition mechanisms. In addition, team members expressed a  
1233 strong desire to work with up-to-date and relevant technologies, as outdated  
1234 tools were perceived as limiting professional growth and market competitive-  
1235 ness. Concerns related to psychological safety also emerged, with some engi-  
1236 neers reporting reluctance to voice dissenting opinions or share uncertainties  
1237 due to fear of negative repercussions or lack of managerial openness.

1238 These issues are particularly critical in the context of DT, where organiza-  
1239 tional agility and knowledge continuity are essential. The loss of experienced  
1240 engineers not only delays ongoing digital initiatives but also increases onboard-  
1241 ing costs and disrupts team cohesion. The SE leaders also reported that newly  
1242 implemented agile practices often conflict with legacy management styles, cre-  
1243 ating uncertainty among teams regarding autonomy and accountability.

1244 Given this scenario, organization “X” identified the need to structure a sys-  
1245 tematic and context-sensitive approach to understand and address the talent  
1246 retention among its software engineers. To this end, the TR4SEM Framework  
1247 was selected to guide a structured diagnosis and define actionable retention  
1248 strategies. In the following, we detail how the framework was instantiated  
1249 through the PDCA cycle to support this initiative.

1250 *7.2.1.1 Plan.* In the Plan phase, HR analysts and SE managers conducted  
1251 a structured diagnosis using the TR4SEM Framework as a reference. Semi-  
1252 structured interviews were carried out with SE managers and HR analysts  
1253 involved in DT projects. The goal was to identify which retention factors,  
1254 barriers, and contextual conditions, previously mapped by the framework, were  
1255 present in the organization’s reality.

1256 The assessment, guided by dimensions of the TR4SEM, revealed several  
1257 factors influencing retention, such as lack of recognition, unclear career pro-  
1258 gression paths, and limited psychological safety. Barriers included bureaucratic  
1259 promotion processes, the persistence of legacy management styles, and limited  
1260 internal mobility. The hierarchical culture, team size, and the coexistence of  
1261 legacy and agile practices were recognized as contextual characteristics. As  
1262 a result, a contextual profile of the SE environment was developed to guide  
1263 action planning in the next phase.

1264 *7.2.1.2 Do.* In the Do phase, SE managers and HR analysts collaboratively  
1265 designed and implemented actions based on the strategies and coping mech-  
1266 anisms defined in the TR4SEM Framework. Two SE teams were selected to  
1267 pilot the initiatives.

1268 Career development plans were co-created with individual engineers to  
1269 align expectations with growth opportunities. Informal recognition rituals were  
1270 introduced during retrospectives, and managers scheduled regular one-on-one  
1271 feedback meetings. As coping mechanisms, managers adopted adaptive dele-  
1272 gation to increase team autonomy and encouraged open communication to  
1273 foster psychological safety. These actions were tailored to address the diag-  
1274 nosed barriers while considering the organization’s structural constraints.

1275 *7.2.1.3 Check.* In the Check phase, the effectiveness of the implemented ac-  
1276 tions was assessed using feedback surveys and HR metrics. SE managers and  
1277 HR analysts reviewed turnover rates, feedback participation, and perceived  
1278 improvements in recognition and psychological safety.

1279 Initial results indicated a moderate reduction in voluntary turnover and  
1280 increased engagement with career planning. Software engineers reported feel-  
1281 ing more valued and comfortable expressing doubts or proposing changes. The  
1282 informal recognition and open communication practices were highlighted as  
1283 particularly impactful in team retrospectives.

1284 *7.2.1.4 Act.* In the Act phase, the outcomes and lessons learned from the pilot  
1285 were consolidated. Successful actions, such as informal recognition practices  
1286 and personalized development plans, were documented and proposed for wider  
1287 adoption. SE managers shared experiences in cross-team meetings, and HR  
1288 analysts began drafting internal guidelines for scaling the practices.

1289 The use of TR4SEM as a structuring tool was considered effective in align-  
1290 ing talent management efforts with the real needs of software teams. Organi-  
1291 zation “X” plans to expand this cycle to other engineering areas, reinforcing  
1292 continuous improvement in talent retention strategies.

### 1293 7.3 Lessons Learned

1294 The small-scale evaluation of the TR4SEM Framework offered important in-  
1295 sights into both its strengths and the practical challenges of its implementa-  
1296 tion. One of the most positive outcomes was the level of engagement observed  
1297 among SE managers and HR analysts. When given a structured approach that  
1298 helped them visualize the factors and barriers affecting retention, participants  
1299 felt more confident in diagnosing underlying issues that had previously been  
1300 discussed only informally. The framework’s categories, such as the contextual  
1301 characteristics, strategies, and coping mechanisms, enabled focused conversa-  
1302 tions and helped translate abstract concerns into actionable topics.

1303 Another key strength was the flexibility of the PDCA cycle as an opera-  
1304 tional structure. It offered a familiar logic to practitioners, allowing them to  
1305 navigate between analysis, action, and reflection without requiring extensive  
1306 methodological training. The iterative nature of the cycle also encouraged con-  
1307 tinuous learning, which aligned well with the dynamic context of SE teams,  
1308 where organizational needs and team compositions often evolve rapidly.

1309 However, some limitations emerged during the evaluation. One challenge  
1310 was the difficulty in separating structural from cultural factors during the  
1311 diagnosis phase. For instance, issues related to psychological safety were in-  
1312 tertwined with organizational hierarchy or legacy leadership styles, making it  
1313 hard for participants to isolate causes or propose changes. While the TR4SEM  
1314 Framework accounts for contextual characteristics, the evaluation showed that  
1315 additional guidance might be needed to help teams map these interactions.

1316 Finally, although the PDCA structure supported a cycle of continuous im-  
1317 provement, the evaluation also showed that measuring the impact of retention  
1318 strategies remains a complex task. Some indicators, such as turnover rates or  
1319 feedback scores, are influenced by several external factors and may not change  
1320 in the short term. It suggests the importance of combining quantitative in-  
1321 dicators with qualitative feedback from software engineers and team leads,  
1322 particularly in early iterations of the framework's application.

1323 Overall, the evaluation reinforced the practical relevance of the TR4SEM  
1324 Framework and its alignment with the realities faced by SE teams. At the same  
1325 time, it surfaced concrete areas for refinement and pointed to opportunities for  
1326 developing assets that can enhance its adoption and effectiveness over time.

## 1327 8 Discussion

1328 In this section, we discuss the implications of our work and propose how the  
1329 TR4SEM Framework can be used by both researchers and practitioners.

1330 Our work takes a holistic view of talent retention from the perspective of  
1331 SE managers' experiences. We ground our framework in two key dimensions  
1332 that play a key role in retaining talent in organizations: satisfaction and mo-  
1333 tivation: **i) satisfaction:** factors identified in our framework, such as salary  
1334 and benefits, professional growth and development, organizational culture, and  
1335 balance between work and personal life are directly related to the satisfaction  
1336 of IT professionals. When employees are satisfied with these aspects, they are  
1337 more likely to stay with the organization and be committed to their work; and  
1338 **ii) motivation:** elements of our framework, such as recognition and rewards,  
1339 challenging projects, and collaborative work environment are factors that can  
1340 motivate IT professionals and play a crucial role in retaining talent. When  
1341 organizations provide opportunities for growth, interesting challenges, and a  
1342 stimulating work environment, they contribute to employee motivation and  
1343 their willingness to stay with the company.

1344 Our work complemented the studies of Gurcan and Sevik (2019) and Maria  
1345 (2021) when we addressed talent retention specifically in the context of SE, as  
1346 we provide valuable nuances, such as:

- 1347 1. Specific skills and expertise: software developers possess specialized techni-  
1348 cal skills and knowledge that are in high demand across various industries,  
1349 which aligns with the TR4SEM Framework's focus on *Educational and*  
1350 *Training and Challenging Projects*;
- 1351 2. Market competition: due to the global demand for software and the rapid  
1352 growth of technology companies, software developers often have more em-  
1353 ployment opportunities and job mobility than other professionals, reflected  
1354 in the TR4SEM Framework in *Salary and Benefits*;
- 1355 3. Innovation and knowledge continuity: losing experienced software develop-  
1356 ers can result in loss of organizational knowledge and disrupt the conti-  
1357 nuity of ongoing projects, addressed by the *Organizational Culture* in the  
1358 TR4SEM Framework; and

1359 4. Changing technology landscape: organizations need to retain developers  
1360 who are adaptive and willing to embrace technological advancements, cap-  
1361 tured in the TR4SEM Framework under *Technological Relevance and Chal-*  
1362 *lenging Projects*. Software developers are indeed driven by challenges and  
1363 have a strong desire for continuous learning and these roles might differ  
1364 from those in other industries (Hall et al., 2008).

1365 Our interviews revealed that in SE, leaders often take on the role of ca-  
1366 reer facilitators more than in other professions (Kalliamvakou et al., 2017). SE  
1367 leaders are not only responsible for ensuring project deliverables but also for  
1368 planning and supporting the career growth of their team members. It involves  
1369 working closely with individuals to develop career plans, providing opportu-  
1370 nities for learning and development, and offering appropriate challenges to  
1371 help them grow. It is aligned with the TR4SEM Framework's focus on *Career*  
1372 *Progression*. Leaders in SE act as mentors and coaches, fostering a supportive  
1373 environment that encourages continuous improvement and professional devel-  
1374 opment (Squires et al., 2022), as emphasized by **Continuous Learning and**  
1375 **Innovation** and *Meaningful Work* in the TR4SEM Framework.

1376 Furthermore, gender dynamics in SE present unique challenges (Carver and  
1377 Serebrenik, 2019). Among our 21 interviewees, 17 were men and 4 were women,  
1378 reflecting a gender imbalance that is common in the field. Studies indicate  
1379 that the tech industry, and SE in particular, tends to have a predominance of  
1380 men, which can influence the workplace environment and retention strategies  
1381 (Hill et al., 2010). It is reflected in the TR4SEM Framework under *Diverse*  
1382 *Team*. Addressing gender diversity and creating inclusive policies are essential  
1383 for improving talent retention. Trinkenreich et al. (2022) highlight gender-  
1384 specific challenges, such as biases and lack of representation, that need to  
1385 be acknowledged and addressed to create a more equitable and supportive  
1386 environment for all software engineers.

1387 Additionally, the age of software engineers can also impact talent reten-  
1388 tion. Millennials, known for their entrepreneurial spirit and desire for rapid  
1389 career growth, often seek new opportunities more frequently than previous  
1390 generations (Deal et al., 2010). This generational characteristic is particularly  
1391 pronounced in SE, where the demand for technical skills and the lure of startup  
1392 culture offer numerous opportunities for career mobility (Myers and Sadaghi-  
1393 ani, 2010). Our TR4SEM Framework addressed these particularities under  
1394 *Career Progression* and *Challenging Projects*.

1395 Although our study focused specifically on SE professionals, some of the  
1396 findings and categories in the TR4SEM Framework may extend to broader  
1397 computing roles. General factors such as recognition, opportunities for growth,  
1398 and flexible work arrangements are relevant across most technical professions.  
1399 However, several elements emerged as context-specific to SE, such as the pres-  
1400 sure for constant skill updates, the interdependence in collaborative devel-  
1401 opment environments, and the dual-role nature of SE managers balancing  
1402 technical leadership with team management.

Such particularities are more pronounced in SE than in other computing fields such as infrastructure, technical support, help desk, or operations roles, where technical autonomy is lower, interdependence is more procedural, and the pace of technological change is often slower. This contrast suggests that, while the framework may be adaptable to other computing contexts, its greatest applicability lies within the SE domain.

The TR4SEM Framework can serve as a theoretical basis for future research on talent retention in organizations. We provide information to investigate causal relationships between different factors, contextual characteristics, barriers, strategies, and coping mechanisms. The framework can also be used as a basis for designing quantitative and qualitative studies. Researchers may develop questionnaires and survey scales based on the categories and elements identified in the TR4SEM Framework, allowing the collection of quantitative data on talent retention.

While several of the factors identified in our study are broadly recognized in the HR literature, our findings contextualize them within the specific realities of SE. The TR4SEM Framework does not merely replicate general concepts, but rather tailors them to the unique demands of SE environments. This includes considerations such as rapid technological change, the hybrid role of SE managers, and the emphasis on technical growth and autonomy. As such, our contribution also lies in bridging established HR knowledge with the practical challenges of retaining talent in software teams.

Importantly, we have to take into account that this work took place in a COVID-19 pandemic scenario. The pandemic brought about significant changes in the work environment and HR management practices, which may have impacted the ways in which software engineers perceived their careers and their relationships with organizations (Shen et al., 2020).

Furthermore, although our participants are all based in Brazil, their companies vary in geographic scope, ranging from local organizations to subsidiaries of global enterprises. The rise of remote work blurred national boundaries and enabled several Brazilian professionals to collaborate with or be employed by international teams. This context shift influences talent expectations regarding compensation, career growth, and organizational culture, as several software engineers now benchmark their experiences not only locally but also globally. These scenarios are particularly relevant in the Global South, where disparities in currency value and work conditions further complicate retention. Therefore, while our findings are rooted in Brazilian organizational contexts, they reflect broader tensions in a globalized labor market for software engineers.

## 8.1 Key Findings

While a competitive salary is certainly an important factor in retaining talent in an organization, it is not necessarily the main factor. Talent retention is influenced by a combination of several factors, which vary according to the individual preferences and needs of IT professionals Sutton (2007). Our results

are aligned with RBV theory of Barney (1991) and revealed that, despite a competitive salary, other factors for retaining talent can be considered a source of competitive advantage as they help attract and retain talent. In our findings, beyond salary, factors such as motivation, organizational culture, and leadership practices contribute to this advantage. These factors support the retention of valuable, rare, and hard-to-imitate human capital, which is central to the RBV theory.

Retention challenges in SE share some commonalities with other fields, but several nuances make these issues more pronounced in SE (Zaza et al., 2023). By exploring the interaction between these issues and the findings of our study, we identified the following key insights:

1. **High turnover rates.** It is a challenge in several professions, such as healthcare and sales, where demand for skilled professionals is consistently high. However, in SE, this issue is intensified by the global talent shortage, the rapid evolution of technology, and the mobility of professionals who frequently switch jobs for better opportunities or technical challenges. Our study revealed that creating a **positive work environment** that fosters collaboration, respect, and psychological safety can mitigate turnover by building stronger connections between professionals and their organizations, as stated by Edmondson (1999) and Sutton (2007);
2. **Professional obsolescence.** Professions in cutting-edge fields, such as artificial intelligence engineering, also face the risk of obsolescence due to rapid advancements in their respective technologies. However, in SE, this risk is increased by the accelerated pace at which new programming languages, frameworks, and tools emerge, requiring constant upskilling. Our findings emphasize the role of **professional growth opportunities**, such as training programs, mentoring, and challenging projects, in helping software engineers remain relevant and motivated. These initiatives address obsolescence while providing clear pathways for career advancement, aligning with prior research of Cascio and Boudreau (2010);
3. **Workplace pressure.** Professions such as medicine and law also face high-pressure environments, but in SE, this pressure is often tied to tight deadlines, dependency on evolving technologies, and the need for continuous innovation. Our study emphasized the importance of **work-life balance**, with flexible schedules and remote work policies emerging as effective strategies to alleviate this pressure, particularly in a post-pandemic landscape as mentioned by Russo et al. (2021);
4. **Impact of HR strategies.** In SE, practices such as career planning, skills development, and job rotation are particularly critical (França et al., 2014). Our results underscore the necessity of tailoring these practices to SE professionals' expectations, with a focus on **professional growth opportunities** that address both technical and personal development needs;
5. **Financial motivation.** Competitive salaries are universally important and the transparency in compensation (e.g., Glassdoor platform<sup>10</sup>) ampli-

<sup>10</sup> <https://www.glassdoor.com>

1490        fies their impact (Cullen, 2024). However, in SE, our findings reveal that  
1491        **recognition and non-financial rewards**, such as leadership roles, pub-  
1492        lic acknowledgment, and exciting project opportunities are equally vital in  
1493        retaining talent, offering a counterbalance to financial incentives;

1494 6. **Stress and burnout.** Stress is prevalent in several professions, such as  
1495        policemen and firemen. In SE, pressure for innovation under conditions  
1496        of high competition with reduced deadlines and short development cycles  
1497        contribute to burnout. Our findings highlight that promoting a **positive**  
1498        **work environment**, free from toxic behaviors and enriched by team col-  
1499        laboration, can reduce burnout and maintain engagement, as corroborated  
1500        by Sutton (2007);

1501 7. **Importance of workplace relationships.** Strong interpersonal rela-  
1502        tionships are valued across several professions (e.g., finance analysts work  
1503        closely with stakeholders to understand needs and craft tailored investment  
1504        strategies). In SE, the interdependence of teams and the collaborative de-  
1505        mands of projects make these relationships even more critical. Our work  
1506        found that promoting **psychological safety** (Edmondson, 1999) and en-  
1507        suring open communication are key to building trust and fostering team  
1508        cohesion, which are essential for software engineers retention; and

1509 8. **Leadership styles.** The leadership styles not only mitigate turnover risks  
1510        but also create a collaborative and motivating work environment, enabling  
1511        teams to thrive in high-pressure, innovation-driven settings (Maaitah, 2018).  
1512        It underscores the necessity for SE managers to adapt the **participative**  
1513        **management** strategy to meet the unique demands of their SE teams  
1514        while promoting long-term retention and engagement. Our findings cor-  
1515        roborate with the study of Westlund and Hannon (2008), which highlights  
1516        that satisfaction with supervision significantly impacts turnover intentions  
1517        among software engineers.

1518        We acknowledge that some aspects of the TR4SEM Framework may fall  
1519        under distinct managerial roles. Although line managers or HR may handle fac-  
1520        tors such as salary and benefits, project managers influence motivation, daily  
1521        work, and technical growth. Thus, we recommend adapting the application of  
1522        the framework to the organization’s structure, engaging all stakeholders.

## 1523 8.2 Implications

1524        Our TR4SEM Framework can be useful in the daily lives of industry profes-  
1525        sionals and researchers:

- 1526        – **SE managers** could use the framework as a guide to identify the key fac-  
1527        tors that affect talent retention in the IT teams, assess the current situa-  
1528        tion and identify areas for improvement based on the framework categories,  
1529        develop specific strategies to address the identified factors, context charac-  
1530        teristics, and barriers in order to improve talent retention, and implement  
1531        practices and policies based on the strategies proposed in the framework,

1532 such as recognition and rewards programs, personalized career plans, and  
1533 a collaborative work environment;

- 1534 – **HR analysts** could use the framework as a diagnostic tool to assess the  
1535 effectiveness of existing talent retention practices, identify gaps and areas  
1536 for improvement based on the framework categories and propose corrective  
1537 actions, and collaborate with SE managers and other organizational leaders  
1538 in implementing talent retention strategies aligned with the dimensions and  
1539 strategies proposed in the framework; and
- 1540 – **SE researchers** could explore how regional and industry-specific dynam-  
1541 ics influence talent retention in SE. Furthermore, investigating the impact  
1542 of leadership styles on talent retention and examining how SE managers  
1543 balance their dual roles as technical leaders and career mentors in fostering  
1544 team cohesion and job satisfaction provide fertile ground for research.  
1545 Generational and technological changes also open up space for research  
1546 on the evolution of career expectations for software engineers. Studying  
1547 how Millennials react to retention strategies, especially in dynamic and  
1548 innovative environments, can provide information on how to adjust talent  
1549 management practices in a constantly changing sector.

## 1550 9 Threats to Validity and Credibility

1551 The reliability of the results is directly linked to the validity of the study. Every  
1552 study has threats that should be addressed and considered together with the  
1553 results, considering the classification proposed in Runeson et al. (2012). Unlike  
1554 quantitative studies, qualitative studies face a higher risk of threats to credi-  
1555 bility than validity. The credibility and trustworthiness of qualitative research  
1556 primarily depend on the diligence, thoroughness, and integrity demonstrated  
1557 by the researchers throughout the process of data collection and analysis (Rob-  
1558 son, 1993). In the following, we discuss potential threats to our work.

1559 As *external credibility*, we ensured a sufficient sample size by including 21  
1560 participants, which exceeds the recommended threshold for achieving satu-  
1561 ration, as suggested by Guest et al. (2006). Our participant group consisted  
1562 of active SE managers who shared a relatively homogeneous background. It  
1563 should be noted that no new categories or concepts emerged during the last  
1564 three interviews, indicating that saturation was reached. These factors provide  
1565 us with confidence in the external credibility of our work.

1566 Nonetheless, we recognize that all interviews were conducted in Portuguese  
1567 with SE managers based in Brazil, which may introduce regional and cultural  
1568 influences. Our sample includes local and global companies, some of which  
1569 operate internationally. However, remote work opportunities with foreign em-  
1570 ployers may influence retention perceptions in ways specific to Brazil and other  
1571 countries of the Global South. This contextual specificity may limit the gener-  
1572 alizability of some findings, and we encourage future replications in different  
1573 cultural and economic settings.

1574 Regarding *internal credibility*, our concern is the bias of the researcher.  
1575 The researcher's involvement during interviews can influence the participants'  
1576 responses. Interactions between the researcher and SE managers may create a  
1577 dynamic where participants feel pressured to provide answers that match the  
1578 researcher's expectations. It is important to recognize this potential influence  
1579 to ensure the objectivity of the results.

1580 To minimize this risk during data collection, we employed neutral phras-  
1581 ing, avoided leading questions, and followed a standardized interview guide  
1582 reviewed by senior researchers. To mitigate threats to analytical validity, while  
1583 the main coding was performed by the first two authors, other three researchers  
1584 double-checked and participated extensively in the axial coding process.

1585 It should be mentioned that these three researchers with more than 18  
1586 years of SE research and ESE supported the study design and data analysis.  
1587 In addition, we also kept an extensive audit trail in the form of complete  
1588 transcripts of all participants. All coding steps were documented and available  
1589 to all researchers.

1590 We also acknowledge the possibility that some SE managers may be reluc-  
1591 tant to recognize or disclose their own management shortcomings as potential  
1592 causes of talent attrition. This self-reporting bias may have influenced the re-  
1593 sponses, potentially limiting the emergence of more critical or introspective  
1594 viewpoints related to leadership challenges. To mitigate this risk, we included  
1595 participants with diverse levels of experience and seniority, which helped bring  
1596 a range of perspectives.

1597 As *construct validity*, our interview guide was designed to align with the  
1598 research objectives and framework categories, such as factors, context char-  
1599 acteristics, barriers, strategies, and coping mechanisms. The interview ques-  
1600 tions were iteratively reviewed and refined by two researchers with more than  
1601 15 years of experience in SE research to ensure clarity and relevance. Fur-  
1602 thermore, we conducted pilot interviews with SE managers to validate the  
1603 comprehensiveness of the questions. This iterative refinement helped us min-  
1604 imize misunderstandings and ensure alignment between the constructs under  
1605 investigation and the data collected.

1606 We also acknowledge that several participants work in consultancy firms,  
1607 which may limit the generalizability of our findings. These environments often  
1608 differ from in-house product teams or public-sector organizations in terms of  
1609 structure and retention dynamics. However, the diversity in company size,  
1610 industry, and global scope in our sample helps to mitigate this threat.

1611 Additionally, since our data was collected exclusively from SE managers,  
1612 the views and experiences of software engineers themselves were not directly  
1613 captured. It may present a bias, as certain factors or interpretations related  
1614 to talent retention could be perceived differently by engineers. To partially  
1615 mitigate this threat, we note that several of the interviewed managers began  
1616 their careers as software engineers and currently work in close collaboration  
1617 with technical teams, which gives them grounded and empathetic insight into  
1618 the engineers' perspectives. Interviewing software engineers also warrants a  
1619 dedicated study and is suggested as future work.

1620 As *conclusion validity*, we list sample size and representativeness. Although  
1621 we conducted interviews with 21 SE managers, we consider that this sample  
1622 may not be fully representative of all organizations. The sample size may limit  
1623 the generalization of the results to a broader context. To mitigate this threat,  
1624 we ensured that the sample included SE managers from different types of  
1625 organizations, company sizes, genders, and geographic locations.

1626 As a *limitation* of our study, we acknowledge the potential presence of self-  
1627 selection bias resulting from the use of convenience sampling, as other studies  
1628 (e.g., Greiler et al. (2022)). Managers who are more engaged or interested in  
1629 the topic of talent retention may have been more likely to participate, which  
1630 could have led the sample to reflect more positive views on the topic. Although  
1631 we ensured diversity in terms of industries, roles, and company sizes, future  
1632 work could adopt randomized sampling techniques to mitigate this bias and  
1633 capture a broader range of viewpoints.

1634 Another *limitation* relates to the scope of our interview guide. Although  
1635 participants occasionally mentioned aspects such as work practices and the  
1636 role of management, these topics were not the focus of our data collection  
1637 and were not explored in depth during the interviews. Additionally, personal-  
1638 ity traits and individual preferences, which are known to influence workplace  
1639 satisfaction, were not explicitly investigated. These omissions may limit the  
1640 comprehensiveness of our findings.

## 1641 10 Conclusion and Future Work

1642 In this work, we presented the TR4SEM Framework, an actionable framework  
1643 that addresses talent retention in organizations. Our work reveals that talent  
1644 retention is influenced by a number of key factors, the importance of which  
1645 varies according to the characteristics of the context in which IT professionals  
1646 are inserted. In addition, we identified the main barriers that can negatively  
1647 affect talent retention as well as effective strategies to overcome them. Finally,  
1648 we discussed coping mechanisms that can be employed to deal with situations  
1649 where talent retention strategies prove ineffective.

1650 In answering our main research question, this study highlights a combina-  
1651 tion of organizational (e.g., career development opportunities, fair recognition  
1652 mechanisms), human (e.g., supportive leadership, team collaboration, psycho-  
1653 logical safety), and physical or environmental aspects (e.g., remote work flexi-  
1654 bility, adequate tooling) that collectively influence SE talent retention. These  
1655 factors were identified through the lived experiences of SE managers and are  
1656 integrated into the TR4SEM Framework, which offers a practical and context-  
1657 sensitive guide to improving retention strategies in software teams.

1658 The framework may assist organizations in identifying and addressing fac-  
1659 tors that influence talent retention. Increasing employee productivity and sat-  
1660 isfaction has a positive impact on the overall performance of the organization.  
1661 We recognized the importance of an environment that promotes talent re-  
1662 tention by providing a balance between identified factors such as competitive

1663 salary and benefits, adequate recognition and rewards, professional growth and  
1664 development, a healthy organizational culture, and a work-life balance. Orga-  
1665 nizations should seek to enable professionals to give their best by providing  
1666 a stimulating and rewarding work environment. By adopting strategies and  
1667 policies that address factors and overcome barriers, organizations can create  
1668 a talent retention culture that contributes to the long-term success of both IT  
1669 professionals and the organizations themselves.

1670 Based on our findings, we conclude that retaining talent is especially rele-  
1671 vant for SE professionals, whose motivation is driven by technical challenges,  
1672 continuous pursuit of learning, an environment that promotes innovation and  
1673 collaboration, and valuing the well-being of personal life with flexible schedule  
1674 policies and remote work options.

1675 As future work, we intend to perform multiple case studies in different  
1676 organizations to understand how the framework will be applied in practice and  
1677 how results related to talent retention management vary across organizations.  
1678 In addition, we plan to conduct a follow-up field study involving software  
1679 engineers to capture their individual perspectives on retention, allowing us to  
1680 compare and enrich the findings originally obtained from SE managers.

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