The Skill Gap in Software Industry: A Mapping Study

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ABSTRACT

In recent decades, the growth potential of the software industry has raised concerns about the increasing number of unfilled positions due to a shortage of human capital, known as the "Skill Gap." This article presents findings from a Mapping Study (MS) conducted from September 2020 to February 2022, reviewing 8,622 articles, with 31 studies selected for analysis. The aim of this study was to map the causes, consequences, and mitigation strategies of the skill gap in software engineering. The main causes include the misalignment between academia and industry and rapid changes in market demand, resulting mainly in costs and missed opportunities. The article concludes by outlining potential avenues for future research in this domain.

KEYWORDS

skill gap, employability, hard skill, soft skill

1 INTRODUCTION

In recent years, the software industry has been concerned with the gap between the skills and knowledge required by employers and those available in the market's professionals. According to data from the information technology (IT) sector in Brazil, the average demand for professionals in this area should be 70,000 per year between 2019 and 2024 [12]. However, in 2017, of the 46,000 trained professionals, only 26,000 were able to enter the job market [19]. In addition to the lack of sufficiently qualified professionals in sufficient numbers, new graduates are not fully prepared to meet the demands of the software industry. This indicates a gap between the skills required by employers and the training offered by undergraduate courses [4]. As a consequence of this problem, it is estimated that by 2030, in Brazil alone, there will be 1 million unfilled job positions in the IT field [15].

The data presented on the shortage of qualified human capital in the software industry is not limited to Brazil, but is a global problem. This market gap is explained by economic concepts of supply and demand, indicating that there is a mismatch between the supply and demand for qualified professionals. According to the World Economic Forum in 2020, this misalignment could lead to a significant loss of global GDP by 2028, estimated at US$11.5 trillion [20]. Studies indicate that qualification programs are not able to keep up with these changes and need to be updated [26, 32]. The result is a growing skill gap that can harm the performance of companies, as well as productivity of employees.

Thus, this present study emerged from the necessity to gain an advanced and comprehensive understanding of the Skill Gap, particularly in the field of Software Engineering (SE). The research aimed to map current knowledge on Skill Gap in the software industry, covering its primary causes, consequences, mitigation strategies, and general concepts. Following established Mapping Study (MS) guidelines, the study was conducted from September 2020 to February 2022, involving the analysis of 8,622 articles, with 31 relevant studies selected for detailed examination.

This study explored Skill Gap in SE, finding that the main causes are the misalignment between academia and industry and the rapid changes in market demands. Collaborating closely between industry and academia is a common solution, but most studies concentrate on the consequences of Skill Gap rather than its root causes. There is a shortage of empirical evidence on the effectiveness of approaches to tackle this challenge. A stronger partnership between academia and industry could help alleviate the skills gap.

2 THEORETICAL REFERENCE

2.1 Skill Gap

The concept of Skill Gap, which refers to the lack of skills and knowledge needed to meet market demands, has been discussed for many years [1]. On one hand, some authors highlight the difference between the computer science curriculum and the actual requirements of the market [6], while others emphasize the gap between companies' skill expectations and the skill level of new hires [3]. In both cases, the lack of necessary skills and knowledge is considered a strategic issue in areas such as academic research, business, and education.

Numerous global studies, including the exploratory research in Bangladesh by [26] and the software industry assessment conducted by [14], have mapped competencies and identified skill gaps. The latter study compared 360-degree feedback and self-assessments with standard competency levels, emphasizing personal aspects as the primary source of issues in software development projects. In the United Kingdom, [30] advocates for increased collaboration between universities and companies to bridge engineering skill gaps, enabling SE faculties to tailor education and training to better meet employers' needs. Similarly, the recent survey conducted by [2] involved over 600 Turkish software engineers across 13 countries, aiming to pinpoint both technical and non-technical requirements in the software industry.

This type of mapping is useful for at least three distinct audiences: (i) for **academia** to better direct their training programs towards meeting industry demands; (ii) for **professionals** to better invest their efforts in achieving higher levels of employability; and (iii) for **companies** to better understand the context in which they are competing for human capital.

According to [24], the skill gap pertains to the mismatch between skills acquired in higher education and those demanded by the software job market. In this context, the focus is specifically on the challenge of aligning human capital formation, with studies proposing strategies to address this issue. [40] examined challenges faced by recent graduates in the hiring process at software companies in the United States and Europe. Findings identified a lack of project experience and problem-solving abilities as crucial issues, emphasizing the importance of cultivating practical skills in professionals.

In summary, an important challenge in evaluating statements about problems related to the Skill Gap is to have a conceptual framework capable of understanding the problem due to its multiple determinations, thus considering the intrinsic relationship between workers and their skills, employer needs versus the job market, and other aspects.

2.2 Related works

In this chapter, we review five relevant systematic mapping articles that contributed to the literature on skill gaps. Firstly, the study by Borges and Souza [11] identified the soft skills necessary for future software engineers and the teaching methodologies that develop these skills from undergraduate education. They identified 33 soft skills and various teaching methodologies. The study proposed the FraSSD - Framework for Soft Skills Development, aiming to help balance technical and non-technical skills in the training of software engineers, contributing to filling the skill gap.

On the other hand, the study by Rikala et al. [41] explored the concept of the skill gap and some measurement approaches using a systematic-narrative hybrid strategy. It identified that skill gaps are complex and globally recognized, proposing a definition and emphasizing the need for more research to effectively map these gaps, considering different perspectives and measurement methods.

The work by Braum et al. [13] addressed the need for digital and green transitions in industries and the importance of a skilled workforce to drive these transformations. The research found that continuous worker training is essential to filling skill gaps. It proposed actions for employers, employees, education providers, and other stakeholders to collaborate in reducing these gaps.

The study by Ruoslahti et al. [42] investigated the role of cyber skills in modern society. The article identified the digital skills necessary for the effective functioning of contemporary society. The research emphasizes the importance of cyber skills and discusses their implications, strengths, weaknesses, and possible ethical concerns, offering a comprehensive view of the relevance and impact of these skills.

Finally, the study by Calonge and Shah [43] addressed the discrepancy between the skills acquired by students during their undergraduate education and those required by employers, analyzing MOOCs as a complementary solution. It found that MOOCs can help reduce the skill gap by making higher education more aligned with labor market needs.

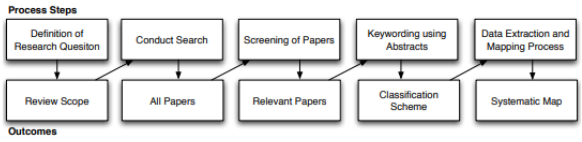
3 REVIEW PROTOCOL

In order to achieve the goal of this research, which is to develop a better understanding of the skill gap phenomenon, with a particular interest in the field of SE, a mapping study (MS) was conducted. A software engineering study map is a defined method to build a classification scheme and structure a SE field of interest [37]. States that a Mapping (or scoping) Study aim to identify all research related to a specific topic, i.e. to answer broader questions related to trends in research [16]. Typical questions are exploratory: What do we know about topic T? According to [16], over 75% of systematic literature reviews conducted in the field of SE are mapping studies.

In this section, we describe the step-by-step procedures used to conduct the study, which was based on widely known guidelines for the development of mapping studies in SE, such as [37] and [29].

For better understanding, we organized this section into subsections, according to the stages described in [37] (Figure 1).

Figure 1: Steps of a mapping study [37]



3.1 Definition of Research Questions

As presented earlier, the goal of this MS was to draw a map of the research state on the Skill Gap in the software industry. To achieve this map, we understood that the starting point would be to identify the conceptual patterns of the phenomenon in the mapped studies. Therefore, we defined as the first research question:

- RQ1. What are the definitions used in research on the Skill Gap in SE?

Next, we took a classic Input-Process-Output (IPO) model as a reference and decomposed the challenge into the following two research questions (RQ):

- RQ2. What are the known **causes** of Skill Gap in the software industry?
- RQ3. What are the known **consequences** of Skill Gap for the software industry?

Finally, we used our effort to map the strategies and techniques proposed to mitigate the skill gap problem in SE, as well as their potential contributions. Therefore, we established the following complementary research questions:

- RQ4. What strategies are being studied to mitigate this issue in the industry?
- RQ4.1 What strategies are related to mitigating the causes?
- RQ4.2 What strategies are related to mitigating the consequences?

3.2 Conduct Research

The search process consisted of three main stages. The first stage consisted of an ad hoc manual search, which was followed, in a second stage, by a systematic search in scientific article databases, and finally complemented by a third stage in which a backward snowballing process [52] was carried out. These stages are explained in detail below.

The objective of the first stage of the search was to identify a set of reference scientific articles to be used as a golden set. For this, we conducted queries using only the research keyword "skill gap." In this exercise, we selected 4 articles based on a complete reading, understanding that they were relevant and fundamental to appear in the systematic search process, ensuring a quality search.

Following the recommendation of [29], we then started from the combination of technical terms used in these studies to design a search string to be used in the automatic search process in Stage 2.

Two initial groups of terms were created. The first one referred to semantically similar terms to skill gap. We also separated the words related to skill and gap into two other blocks, in order to add more options of semantically similar terms. The second one was associated with the research's context of interest, which was focused on SE. The final string used for search was: (Skill* OR Abilit* OR "Academia-Industry" OR Competence OR Knowledge OR Talent* OR Employabilit*) AND (Gap* OR Shortage* OR Mismatch* OR Deficienc* OR Require* OR Need*) AND ("Software engineering" OR "IT Industry" OR "Software developer" OR "Software Engineers").

This sequence was then adapted to the specific syntax of each scientific database. To ensure coverage, we searched four of the most popular scientific databases in the field of SE, namely the ACM Digital Library, IEEE Xplore, Scopus, and Science Direct - Elsevier.

3.3 Screening of Papers

As mentioned earlier, the focus of this MS is on works that analyze the skill gap, or semantically related terms, specifically in the context of SE. Thus, this was the central criterion to decide whether an article would be considered potentially relevant or not, based on its title and abstract, in all stages of selection. The titles and abstracts of all articles were verified by at least two researchers. Articles identified as potentially relevant by at least one of the two analysts were considered eligible for the next stage of the process.

Then, articles with the following characteristics were excluded:

- Studies addressing the formation of computational skills prior to higher education;
- Studies addressing skills gaps in areas other than the software industry;
- Articles not written in English;
- Articles that do not contain primary data;
- Studies that are not peer-reviewed;
- Texts that are not accessible to our research team.

3.4 Data extraction and Mapping Process

After selecting the final list of articles, a quality assessment was conducted to evaluate the study's design, bias, validity, and generalizability of the results across publications. Each article was assessed through an evaluation checklist developed according to the guidelines described by [18]:

- QA1 - Is the article based on research (or is it just a "lessons learned" report based on expert opinions)?
- QA2 - Is there a clear statement of the research objectives?
- QA3 - Is the research context adequately described?
- QA4 - Is there a clear statement of the results?
- QA5 - Is the study valuable for research or practice?

3.5 Tools

For the development of the mapping study, two tools were used: Microsoft Excel and the MindMeister website. Excel was used to organize the articles found, remove duplicates, and manage all stages of the article selection process, culminating in the selection of 31 articles. MindMeister, on the other hand, was employed to construct a conceptual map of the causes, consequences, and mitigation strategies identified after reading the articles.

4 RESULTS

4.1 Results of the selection process

The searches were conducted between September 2020 and February 2022. Of the three stages, the first occurred in September 2020, the second in July 2021, and finally the third in February 2022. The first stage resulted in 4 articles, as seen earlier. Subsequently, in the second stage, the results of each search were grouped by data source. The selected data sources were reflected in various studies. The searches were limited to the terms found in the abstracts of the studies. The number of articles found per database was: 811 in the ACM Digital Library, 1,412 in IEEE Xplore, 4,102 in Scopus, and 2,297 in Science Direct – Elsevier, totaling 8,622 articles (Table 1).

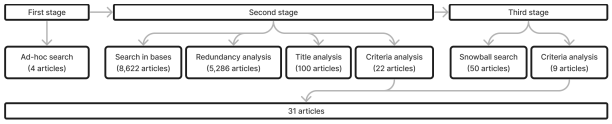
Table 1: Number of articles found per database

Database	Number of articles
ACM	811
IEEE Xplore	1,412
Scopus	4,102
Science Direct	2,297
Total	8,622

After eliminating duplicates (publications present in more than one database), the list was reduced to 5,286 unique studies. After analyzing all titles and abstracts, the list was reduced to 100 potentially relevant articles, which were read in full by four researchers. At this stage, inclusion and exclusion criteria were applied, where 10 articles were removed for not being available online and 65 for not addressing the skill gap in the SE industry, reducing the list to 22 validated articles for the MS. After that, in the third stage, the reverse snowball technique was performed, where 50 articles were listed based on the bibliographic references present in the articles resulting from the second stage. After being read by the authors, 9 articles were selected, bringing the total number of articles in the research to 31. Figure 2 illustrates the three stages of the search process. The MS protocol, including search strings, filters, list of articles, is available in our Zenodo repository (https://zenodo.org/records/10622274).

The quality analysis of the studies resulted in a total of 17 articles that met the Q1 quality criteria, meaning the articles were based on

Figure 2: Search stages



primary research. 25 articles met the Q2 quality criteria, with a clear statement of the research objectives. 28 articles met the Q3 quality criteria, with an adequate description of the context in which the research was conducted. 26 articles met the Q4 quality criteria, with clearly explained results. According to the quality analysis graph, 16 out of the 31 selected articles obtained the maximum score (5 points), demonstrating that they met all quality criteria. 6 out of the 31 selected articles obtained a score of 4, indicating that they met most of the criteria. Therefore, a total of 21 articles were well evaluated in terms of quality criteria, giving more consistency to the research.

The 31 selected articles shared their perspectives from four continents: North America (10), Asia (10), Europe (4), Africa (2), South America (2), and Oceania (1), with a focus on studies conducted in the United States (9), Pakistan (2), India (2), and China (2). These articles were published over a period of 26 years, with a growing trend from 2001 to 2020. Only two studies were published before that, in 1994 and 1997, the first with the objective of identifying essential gaps for software engineers, and subsequently performing an analysis of undergraduate computer science curricula, along with demands from the job market.

After applying the quality analysis, previously explained, the researchers carried out the data extraction procedure and the construction of the synthesis strategy. To do this, we followed the recommendations of [18], which are: 1) initial reading of the selected articles after quality analysis; 2) specific identification of the extracted segments; 3) labeling of text segments; 4) separation of the themes found; 5) creation of a thematic grouping model.

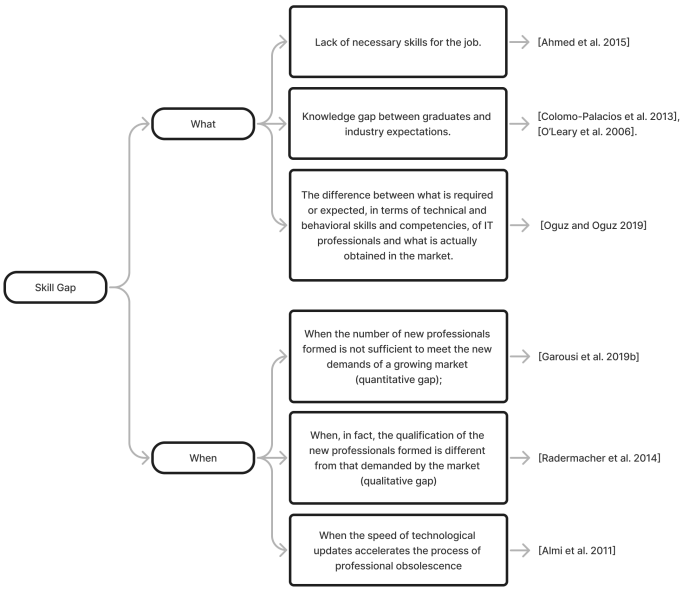
The first step in building the theme clustering strategy was to read the articles seeking answers to four research questions. We began to segment and label the texts considering the concept of skill gap, its causes, consequences, and mitigation strategies. Themes were grouped based on this division. After this stage, researchers began to create categories to group the findings of each text.

Regarding the causes of the skill gap, we grouped the findings into three categories: 1) educational deficiency (regarding basic and secondary education); 2) misalignment between academia and the software industry (for higher education); 3) Speed of changes in the IT market. Regarding consequences, we have three categories: for companies, for technology graduates, and for the software industry as a whole. Regarding strategies, the categories are: educational strategies, industry strategies, and government agency strategies.

4.2 What is Skill Gap? (RQ1)

In conceptual terms, in general, the skill gap is mentioned in the literature in different ways, such as through "lack of necessary skills for the job" [1] or as a "knowledge gap between graduates and industry expectations" [14, 35]. The Figure 3 illustrates the concepts of Skill Gap.

Figure 3: What is Skill Gap?



The study by [34] present a more careful definition for the term skill gap as "the difference between what is required or expected, in terms of technical and behavioral skills and competencies, of IT professionals and what is actually obtained in the market".

In more practical terms, skill gap is referred to through some concrete signs, such as: a) when the number of new professionals formed is not sufficient to meet the new demands of a growing market (quantitative gap); b) when, in fact, the qualification of the new professionals formed is different from that demanded by the market (qualitative gap) [40], or c) when the speed of technological updates accelerates the process of professional obsolescence [4].

4.3 What are the causes of the Skill Gap? (RQ2)

It is possible to perceive that the Skill Gap issue has been shown to be quite relevant in both dimensions, whether in the academic scope or for the software industry. In this study, some causes of the Skill Gap are pointed out. The researched authors highlight two main causes, which somehow connect and are fundamentally related to education: educational deficiency in basic and professional education [21, 32, 36], and misalignment between academia and the software industry [17, 21–23, 27, 28, 31, 34, 36, 44–46, 49].

When it comes to professional education, the causes of the gap are pointed out as: Unstructured and/or non-standardized curricula within countries [21]; There are not qualified enough teachers and those who are qualified do not have professional practical experience in the software industry, which helps to make teaching disconnected from the demands and changes of the job market [21]; Lack or low continued training of the teaching staff combined with a scarcity of more innovative equipment and training techniques [21]; inadequate accreditation of training programs [36];

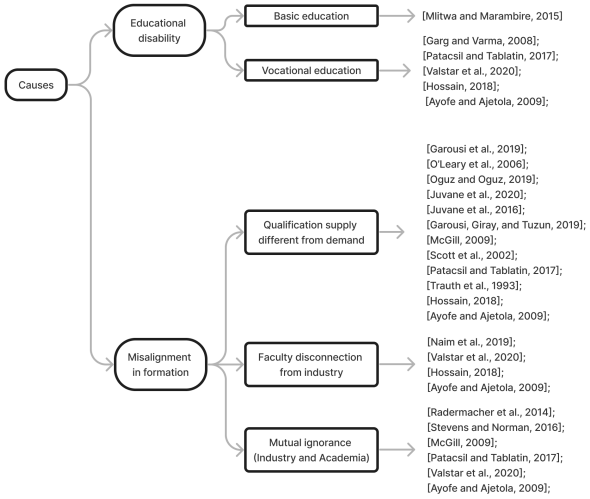
These factors are reflected in what the studied authors call the misalignment between educational institutions and the software industry [27, 35]. The rapid advancements in the software industry, along with the growing demands of new businesses, are creating a gap between educational institutes and the software industry. According to [4], the SE curriculum, for example, does not align with what the SE industry needs.

According to [33], university faculty is highly qualified, but due to limited or no exposure to current industry trends, they tend to focus on theoretical aspects of the field instead of developing in students the practical skills/competencies required by the industry. According to [34], it is not surprising to have a gap between the software industry and the academic world, considering the intangible nature of software and the rapid change in the requirements of the profession.

To understand the gap, the author proposes to divide the context into three subgroups, whether they are: 1) soft skills: although there are many studies that emphasize the importance of soft skills in SE, they are also the best-known cause of the gap since the beginning of the career. Regarding soft skills, the most common are among the lack of skill in interpersonal communication, as well as teamwork; 2) real case-based projects from the industry: both early-career software engineers and students claim that they do not experience projects whose themes and purposes reflect the real industry challenges. Forming organizations lack the applicability of problem-based learning, especially real-world problems; 3) industrial training: training focused on teaching skills and competencies required by the industry. The study by [50] cites, for example, the training of "summer schools" that happen in partnership with several companies to train graduates in the knowledge areas required for the software industry.

The study by [33] argues that students should be able to adapt to various languages and methodologies to solve problems or challenges using logical thinking as a basis, and not sticking to a specific language or system.The study by [40] shows that insufficient project experience and problem-solving skills are frequently mentioned as barriers to students' employment, emphasizing the crucial role of alignment between academic institutions and the industry in ensuring graduates employability. Figure 4 can better illustrate the causes of the skill gap.

Figure 4: Causes



4.4 What are the consequences of the Skill Gap? (RQ3)

For the authors [40], in some cases, the skills gap is so significant that it prevents recent graduates from being able to position themselves in the job market. The consequences of the skills gap extend beyond individuals, impacting recent graduates lacking required market skills, hindering their job market entry. This phenomenon affects the entire software industry's production chain, struggling to find qualified personnel for existing roles and necessitating investments in human capital training, leading to direct negative effects on industry costs and productivity. This combination directly influences the local and global economy, causing production slowdowns or interruptions.

In the case of companies, the main consequences are: a) an increase in training costs: Companies are spending a lot of money and effort to build large internal training facilities with equipped classrooms that can accommodate many employees, all of this aiming to offer training to better qualify newly hired employees [21, 25, 38, 45]. Beyond this, another challenge is to find high-quality training teams that conduct qualifications and, therefore, can deliver better-trained and more capable employees [25]; b) missed business opportunities: According to [32], companies are missing several project opportunities due to the lack of qualified professionals to fill the vacancies in the IT sector; c) impact on employee performance: Computer science and SE graduates do not always possess the necessary skills or knowledge when starting their careers in the industry. The lack of these skills can limit the productivity of recent hires/recent graduates or even hinder access to employment [32, 38, 40].

The research conducted by [40], in which managers and recruiters from the IT market were interviewed, shows that the mismatch between academia and industry has a significant impact on the lives of graduates themselves. The most frequent observations of recruiters, in the same research, indicate that recent graduates lack: knowledge of software languages and tools; experience in project development; practice in problem-solving and facing challenges; ability to understand customer needs; communication skills; and teamwork skills.

In the case of society in general, the main consequences are: a) economic slowdown, b) dependence on importing human capital (for central economy countries) and exporting human capital (for peripheral economy countries), and c) waste of human capital since people are being trained to work in professions that either have a large human capital contingent or are about to become irrelevant or no longer exist in the future [32]. Figure 5 illustrate the consequences of skill gap.

Figure 5: Consequences

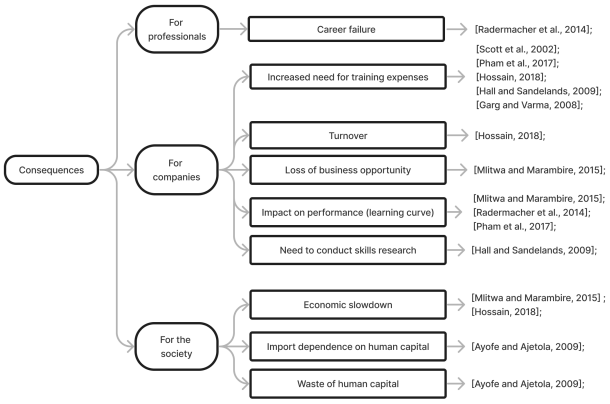
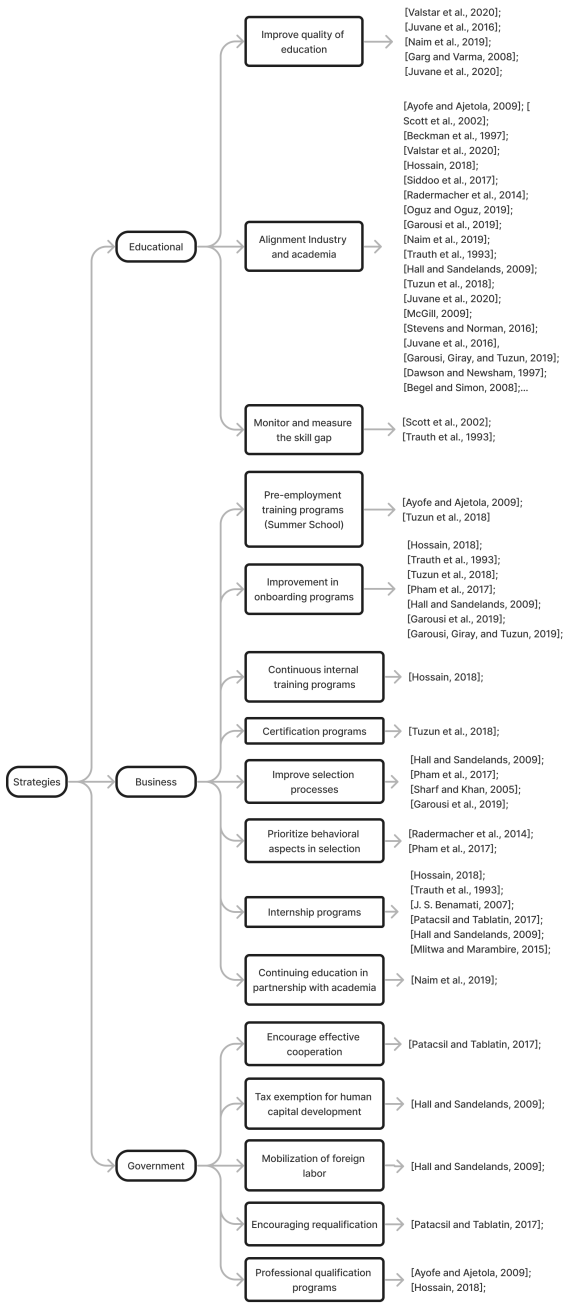


Figure 6: Strategies



4.5 What Skill Gap mitigation strategies? (RQ4)

In MS, studies were found that point to some mitigation strategies for the skill gap. Regarding the causes, we can highlight: academia/industry misalignment, which includes outdated curricula, educational deficiencies, low qualification of faculty members, human capital obsolescence, scarcity of real-world projects, and deficiency in developing behavioral skills. As for the consequences, we can point to the low performance of human capital, the continuous need for importing/exporting labor, loss of business opportunities, and increased costs with workforce training/capacitation.

The main mitigation strategies found in the literature were as follows: Regarding education, processes were found to improve the quality of education and processes to align the skills required by the industry in academia [48], such as the development of educational curriculum models [21, 27, 33], the promotion of scholarships [28], improvement in teacher training [21, 33], hiring teachers with practical experience, and the use of new teaching methods [27].

Regarding the alignment between industry and education, the main topics were providing academics with "real-world" experiences [5, 40], bringing industry into the classroom [8, 17, 33, 46], and improving curriculum management [7, 33, 50].

Some business strategies were identified in the literature, such as creating internship and summer programs [9, 10, 32, 36, 47, 49] - with the aim of accelerated training and directed towards solving real challenges faced by companies [50], improving onboarding programs [25, 38, 49], creating and encouraging certification programs [44, 50], improving selection processes [23, 25, 38], and creating continuing education processes[4, 33].

Other strategies found deal with government incentives for technical cooperation between companies and academia [36], tax exemption for human capital development, attraction and recruitment of foreign labor [25], and incentive for requalification [27, 39]. Figure 6 can better illustrate the Skill Gap mitigation strategies.

5 DISCUSSION

The software industry is recognized as a highly specialized and human-centered activity that requires a high level of education and specific skills [14]. The debate about Skill Gap focuses on the fact that a gap arises when the competency of an individual or professional (or a group of individuals or professionals) is below the level required to perform a task efficiently [14].

Skill Gap is a concept with different definitions and interpretations, studied for a few years. However, few articles clearly present

the concept of Skill Gap, focusing on highlighting causes, consequences, or mitigation strategies. In general, some works, such as [34], have managed to present us with a proposed concept that aligns with the research findings, that is, the mismatch between industry needs and the education provided by universities.

The causes of this phenomenon have also been studied for some years and point, more specifically, to education (at the basic level) and technical or higher-level training/qualification. The misalignment between academia and industry is identified by a significant number of articles as one of the main causes of the skill gap. Many articles hold academia responsible for the gap, justifying that: the curricula are obsolete and not adherent to market needs; lack of qualification and real-world experience of the faculty; there is a shortage of both laboratories and more innovative training equipment and techniques, in addition to inadequate accreditation of training programs.

The researched authors justify the skills gap by indicating these factors as determining or contributing causes. However, no articles were found that point to the market's responsibilities for the misalignment with academia. Perhaps this is justified by the fact that many researchers are from academia and do not look from the market perspective or do not perceive the determinants of the skill gap being produced by the industry: either through the distance from academia, inefficient recruitment and selection processes, lack of technical training of recruiters, or the level of demand for competencies and skills beyond what is actually required.

Among the main consequences of skill gap, we can highlight: increased costs for companies with human capital formation, loss of business opportunities, low productivity/performance of employees. If we look at the more general impacts, we can observe: economic slowdown, dependence on the import of human capital (for central economy countries) and the export of human capital (for peripheral economy countries), and the waste of human capital, since people are being trained to occupy positions and professions that are undergoing significant mutation or disappearance.

Regarding mitigation strategies, many point to solutions such as: improving the quality of education, improving the design of curricula, promoting scholarships, improving the training of teachers, hiring teachers with experience in the IT market, and offering students real-world experiences. All of these strategies are aimed at aligning academia with the job market. On the other hand, some strategies are directed towards the industry: creating internship programs, summer programs that aim to bring companies and students together to solve real-world problems, improving selection processes, improving onboarding and continuous training processes.

The articles studied indicate that mitigation strategies come from three basic sources: government, companies, and academia. Regarding the causes, articles point more towards academia. However, in terms of consequences, articles point more towards the industry. This dichotomy may indicate that the problem's source lies in academia, that is, in a given community or group of individuals or institutions, and that the consequences are felt and experienced by another community or group of individuals (that is, the industry).

6 CONCLUSIONS

This study aimed to explore how literature conceptualizes the Skill Gap and understand its causes, consequences, and mitigation strategies in the software industry through a mapping study. Initially, 8,622 articles were identified, and after applying the defined protocol, 31 were selected for preliminary studies. The selected studies highlight the longstanding concerns surrounding the Skill Gap, drawing global attention from researchers due to its profound impact on companies and their overall human capital shortages.

Analyzing the skill gap in the IT area requires consideration of the causes, consequences, and mitigation strategies involved, as well as the position of relevant individuals and institutions. The study identified that one of the main factors for this gap is the lack of alignment between the education provided by academic institutions and the needs of the job market in the software industry.

The misalignment between academic education and the needs of the IT industry results in skill gaps between graduates and professionals, which can limit the sector's expansion. Several factors contribute to this problem, including outdated curricula, lack of qualification of teachers, and the need to develop behavioral skills. The constant evolution of the IT market requires constant updating of professionals, students, and educational institutions, but it is not always possible to do so at the necessary speed to meet market demands.

However, many studies and actions are being developed with the aim of mitigating the negative effects of the Skill Gap on the IT industry, such as changes in curriculum matrices, the inclusion of new technologies in IT education, feasibility of internship programs, and development of training programs for recent graduates.

This article contributes theoretically to the Skill Gap literature by adding the systematization of the causes, consequences, and mitigation strategies of the Skill Gap pointed out by the studies that returned from the research. On the other hand, it can help both researchers and industry leaders to better understand the connections between cause, consequence, and mitigation strategy, and perhaps understand the complexities involved in solving the problem at hand.

As threats to the validity of the research, we considered possible biases in the selection of articles. Although we strictly followed the defined criteria, some relevant articles might have been excluded. Additionally, the interpretation of the data might have been influenced by the researchers' perspectives, introducing subjective bias. Despite efforts to minimize these threats, they may still affect the study's results.

Several factors can be considered as limitations to the research. One of them is related to the terms that make up the search string, i.e., terms that may have been left out of the search string in the databases, both related to the skill gap (blocks 1 and 2 of the string) and other terms related to SE (block 3 of the string). Another important factor is the temporal coverage of the research; the search for articles was conducted in July 2021, returning articles published between 2001 and 2020. Therefore, articles published after this period were excluded from the mapping study.

Thus, it is suggested for future research to replicate the study, addressing other terms related to the skill gap and the specific field, which could be more specific, such as the area of SE, or even

exploring other areas of Computer Science. Furthermore, it is recommended to replicate the study concerning temporal coverage, encompassing periods beyond 2020, considering that the skill gap issue, while not recent, undergoes constant changes, as does the field of SE. Furthermore, exploring other data sources such as grey literature is also recommended.

Additionally, in relation to suggestions for future research, this work provides a mapping of causes, consequences, and mitigation strategies for the skill gap. Therefore, it is recommended to develop research and actions focusing on causes, consequences, and mitigation strategies, either collectively or separately, especially in a practical sense, involving directly the stakeholders (Professionals, Industry, Academia, Governments, etc.). An example of this is the professional residency program developed by Porto Digital (Recife-PE) through its Management Center (NGPD), where it intervenes directly to induce an increase in the number of vacancies in higher education courses in IT and promotes closer ties between Higher Education Institutions and hiring companies [51].

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