2.3. Criteria for assessing the quality of research questions

As part of the process of formulating research questions, the evaluation of their quality was carried out using the FINER method [7], a widely recognized approach for formulating and evaluating the quality of research questions in various fields of study. This method is based on five specific criteria: Feasibility, Interest, Novelty, Ethics, and Relevance [7], which provide a comprehensive framework to ensure that the questions formulated are appropriate, feasible, original, relevant, and ethical. For the evaluation of each criterion, a score of 1 point was assigned if the question fully met the criterion, 0.5 points if it partially met the criterion, and 0 points if it did not meet the criterion, a question was considered acceptable if its average total score was between 3. Those questions that did not meet this threshold were reviewed and, if necessary, modified to ensure their relevance and pertinence to the SLR in question:

- **Feasibility (F):** Is it possible to address this question with available resources, such as access to relevant literature and analytical capacity?
- **Interesting (I):** Does the question address a topic of interest and relevance to the academic and industry community?
- **Novel (N):** Does the question explore a unique or innovative aspect that has not been widely addressed in the existing literature?
- **Ethical (E):** Will the research arising from this question be conducted in an ethical and transparent manner, respecting the principles of academic and professional integrity?
- **Relevant (R):** Is the question relevant to the field of study and does it have significant implications for software development practice and research?

To carry out the FINER method, 5 expert evaluators in the area of Software Engineering, especially in the area of process improvement and quality were involved, who helped to obtain the level of relevance and pertinence of the research questions for the SLR. This evaluation was carried out using a survey in Google Forms, through which a set of results were obtained to later analyze the results obtained, which are summarized in Table 3.

Table 3. Quality assessment criteria for research questions.

Id	Question	E	Scores per person for each of the quality criteria					Total	P
			Feasible	Interesting	New	Ethical	Relevant		
PI 1	What are the types of solutions proposed in the literature to analyze and/or manage process debt in software development?	1	1	1	0.5	0.5	1	4	3.7
		2	0.5	1	1	1	1	4.5	
		3	0.5	0.5	0	0	0.5	1.5	
		4	1	1	0.5	1	1	4.5	
		5	0.5	1	0.5	1	1	4	
PI 2	What are the types of research identified in the literature?	1	1	1	1	1	1	5	4.1
		2	1	1	0.5	0.5	1	4	
		3	0.5	1	0.5	0	0.5	2.5	
		4	1	1	1	0.5	1	4.5	
		5	1	1	0.5	1	1	4.5	
PI 3	What is the current level of maturity and/or development in the literature regarding process debt management concepts and approaches in software development?	1	1	1	1	1	1	5	4.5
		2	1	1	1	1	1	5	
		3	1	1	1	0	0.5	3.5	
		4	1	1	1	0.5	1	4.5	

		5	1	1	0.5	1	1	4.5	
PI 4	What are the benefits, challenges, causes, impact, effects and/or consequences associated with process debt research in software development?	1	1	1	1	1	1	5	3.9
		2	0.5	0.5	0.5	0.5	0.5	2.5	
		3	1	1	0.5	0	0.5	3	
		4	1	1	1	0.5	1	4.5	
		5	1	1	0.5	1	1	4.5	

Acronyms used: E: evaluator, P: Average.

Based on the answers obtained using the FINER method, the evaluators consider that the research questions meet the quality criteria established by the method, and although it can be observed that the score of the questions did not reach the maximum expected, they managed to exceed the lower limit of the threshold previously established.

2.6. Assessing the relevance and pertinence of primary studies

Evaluating the relevance and pertinence of primary articles for research allows minimizing biases and maximizing the internal and external validity of a research [5]. Following this premise and with the purpose of maintaining scientific rigor in the research, the relevance and pertinence of the selected primary articles were evaluated based on an adaptation of the instrument proposed by Kitchenham and Charters [5] Kitchenham *et al* [8]. The assessment of relevance and pertinence was based on three main factors: (i) internal validity, which refers to the ability of the study to adequately answer the research question posed; (ii) external validity, which according to Dybá *et al*. [9], allows analyzing the generalizability of the results for the population of interest and the applicability of the findings; (iii) bias, defined by Dybá *et al*. [9] as a systematic error or deviation from the truth in the results or inferences, which reflects a tendency to generate results that are systematically far from reality. Considering the above, an instrument was designed for this evaluation that includes a checklist covering four categories: clarity, rigor, credibility, and relevance of each study. Table 5 presents the questions used to measure the level of relevance and pertinence based on the four categories established. These categories are described below:

- **Clarity**: This category emphasizes the importance of presenting SLR results in a clear and concise manner so that they can be understood by other researchers and practitioners in the field of software engineering [10].
- **Rigor:** This category emphasizes the need to follow a rigorous and reliable methodology throughout the SLR process to ensure the validity of the results obtained [6].
- **Credibility:** This category allows knowing the level at which the research results are meaningful, valid and effective by evaluating the scientific methods used, discussing the limitations of the research process and analyzing the results obtained [11].
- **Relevance:** This category allows determining whether the results of the study are valid, useful, well presented and significant. In addition, it identifies the scientific methods used and the analysis of the findings found [9].

Table 5. Relevance and pertinence of primary articles.

Id	Relevance and Relevance of Primary Items	Scoring for answers			Category
		+1	0	-1	
1	Does the article clearly focus on process debt in software development?	Yes	Partially	No	Clarity
2	Does the article clearly describe the research problem and objectives?	Yes	Partially	No	
3	Does the article provide a clear and operational definition of process debt?	Yes	Partially	No	
4	Does the article follow a formal, structured research methodology?	Yes	Partially	No	Strictness
5	Are the data collection and analysis methods appropriate and well described?	Yes	Partially	No	
6	Does the article provide sufficient detail to allow replication of the study?	Yes	Partially	No	
7	Does the article have clear practical implications for the software industry?	Yes	Partially	No	Relevance
8	Does the article contribute significantly to academic knowledge about process debt?	Yes	Partially	No	
9	Does the article propose future work or additional areas of research?	Yes	Partially	No	
10	Does the article use scientific methods appropriate to the research?	Yes	Partially	No	Credibility
11	Does the article discuss the limitations and biases of the research process?	Yes	Partially	No	
12	Are the results of the article meaningful and valid?	Yes	Partially	No	

2.7. 2.7. Data extraction strategy and synthesis methods

Table 6 presents the design of the summary sheet used to facilitate the information classification process and the most important aspects considered for each primary study, which allowed for uniform data extraction and information classification. It also established the relationship of the primary studies with respect to the PIs defined (see Table 11).

Table 6. Summary of studies.

Identification		
Title:		
DOI:		Number of citations:
Publication date:	Publication type:	
Authors:		
Name	Country	University
Abstract		
Description		
Type of research (Classification of [6]): Industrial validation ☐Validation research ☐ Evaluation research ☐ Solution proposal. ☐ Research methodology ☐ Experience documents.		
Type of solution(s) offered: Conceptual definition ☐ Causes, effects, impacts, and limitations ☐ Assessment method or technique. Practical implications ☐ Case study ☐ Other.		

Proposal:
Evaluation of the proposal:

Table 8 presents a summary of the process of classification and selection of primary studies, the numerical identifiers of each data source, the name of the scientific database used, the total number of studies initially found in each source, the number of studies considered relevant for SLR after an initial evaluation, the number of studies that were identified as duplicates after semi-automatic comparison, and the number of unique studies selected as primary for SLR. The evaluation of the results obtained from the different databases shows that Google Scholar stood out for its broad coverage, since, of the 288 studies found, 233 were considered relevant and none were identified as duplicates. This fact reinforces the usefulness of Google Scholar as the main source of data, since it allowed the efficient compilation of relevant studies, covering findings from other specialized databases such as Scopus, Springer Link, Science Direct, IEEE Xplore, Web of Science and ACM, which turned out to be duplicates. The semi-automatic identification of duplicates proved to be key to ensure the accuracy of the process, reducing manual effort and avoiding overestimations of repeated studies, which allowed a greater concentration on unique and truly relevant studies. In addition, the use of the backward snowballing method [13] allowed the identification of 239 studies that met the ICs and ECs, thus totaling 20 primary studies for the investigation, as illustrated in Table 9.

Table 8. **Classification scheme.**

Id.	Data Sources	Studies Found	Relevant Studies	Duplicate Studies	Selected Primary
1	Google Scholar	288	233	0	20
2	Scopus	25	25	25	0
3	Springer Link	13	9	9	0
4	IEEE Xplore	21	18	18	0
5	Web of Science	189	114	114	0
6	Science Direct	11	9	9	0
7	ACM	18	14	14	0
Total		**565**	**422**	**183**	**20**

Table 9. Primary items.

Id	Primary Items	Year	Ref.
A1	Process Debt: a First Exploration	2020	[1]
A2	Process Debt: Definition, Risks and Management.	2024	[2]
A3	The Pandora's box of social, process, and people debts in software engineering.	2022	[3]
A4	Technical-, social-and process debt in large-scale agile: an exploratory case-study	2019	[4]
A5	A Multivocal Literature Review on Non-Technical Debt in Software Development: An Insight into Process, Social, People, Organizational, and Culture Debt	2024	[24]
A6	A study of factors that lead development teams to incur technical debt in software projects	2018	[15]
A7	A systematic mapping study on technical debt definition	2015	[25]
A8	A systems perspective on technical debt	2021	[26]
A9	A taxonomy of assets for the development of software-intensive products and services	2023	[27]
A10	Actions and impediments for technical debt prevention: results from a global family of industrial surveys	2020	[14]
A11	Technical debt: towards a crisper definition report on the 4th international workshop on managing technical debt	2013	[22]
A12	Beyond Technical Debt Unravelling Organisational Debt Concept	2024	[28]
A13	Exploring Process Debt in Large-Scale Agile Software Development For Secure Telecom Solutions	2024	[16]

A14	Identification and management of technical debt: A systematic mapping study	2016	[29]
A15	Multivocal Literature Review on Non-Technical Debt in Software Development: An Exploratory Study.	2023	[17]
A16	Society 5.0 and Soft Skills in Agile Global Software Development	2022	[18]
A17	Technical debt is not only about code and we need to be aware about it	2021	[19]
A18	Technical Debt Management: Definition of a Technical Debt Reduction Software Engineering Methodology for SMEs	2019	[20]
A19	Towards a taxonomy of code review smells	2022	[21]
A20	Towards an ontology of terms on technical debt	2014	[23]

Acronyms used: Ref: reference.

3.1 Evaluation of relevance and pertinence

The assessment of the relevance and pertinence of the primary studies, detailed in Table 10, not only reflects the theoretical foundation of the selected articles, but also provides an in-depth understanding of the areas where process debt research can still make progress. Each study was evaluated based on twelve criteria to determine the importance of its contribution to the understanding and management of process debt. The scores obtained, ranging from -12 to 12 points, reflect both the value and possible limitations of each article, making visible the diversity of approaches in this emerging area.

Figure 1 provides a clear visual grouping of the evaluated studies, and its relevance lies in highlighting how the different approaches have been rated in terms of relevance to the academic community. It is notable that only 5% of the studies [2] achieved the maximum score of 12 points, which could indicate that there are outstanding approaches that serve as key benchmarks in process debt management. This fact underlines the need to look in detail at what were the criteria and strategies that allowed this article to stand out so significantly above the rest. On the other hand, 5% of the studies [1] achieved a score of 11 points, while 15% [3], [16], [21] achieved 10 points, suggesting that there is a relatively small group of investigations that, although they do not reach the highest score, offer important contributions to process debt management. These articles stand out as significant contributions that encourage interested readers to explore further.

The distribution of studies with intermediate scores, such as those that scored between 6 and 9 points. Some 10% of the studies [24], [19] scored 9 points, while another 10% [14], [29] scored 7 points, showing approaches that, while effective, could benefit from deeper integration with real software development contexts. Nevertheless, these studies provide a valuable foundation on which to build further, and it would be advisable to examine them in more detail to identify possible improvements or areas of application in enterprise environments.

Figure 1 also highlights the presence of articles with lower scores, such as those with 5 points or less, which represent 40% of the studies evaluated. This group includes articles with negative scores, such as the study [22] (-1) and [26] (-6), which opens a space for critical reflection on the relevance of their contributions. These studies not only indicate a lack of alignment with the evaluated criteria, but also invite a deeper reading to understand whether the low score is due to methodological, contextual or focus limitations.

Given the difference in scores, both Table 10 and Figure 1 should be reviewed carefully, as both provide a visual representation that facilitates the identification of patterns of relevance across studies. These differences in scores should be viewed as an opportunity to assess

the current state of process debt research. In this sense, this is where the academic community can focus future efforts, for example: fostering interdisciplinary collaboration and developing theories that improve current management practices [2]. Similarly, case studies could be conducted in companies, training programs could be promoted and collaboration with industry could be strengthened [3]. In addition, it is essential to develop conceptual frameworks, adopt holistic approaches that integrate different forms of debt and case studies in real environments [17].

Table 10. Evaluation of the relevance and pertinence of the primary articles.

Id	Relevance and pertinence of primary articles												Total
	1	2	3	4	5	6	7	8	9	10	11	12	
A1	1	1	1	1	1	0	1	1	1	1	1	1	11
A2	1	1	1	1	1	1	1	1	1	1	1	1	12
A3	1	1	1	0	0	1	1	1	1	1	1	1	10
A4	0	1	0	1	1	0	0	0	1	1	0	1	6
A5	1	1	1	1	0	0	1	1	1	1	0	1	9
A6	-1	1	-1	1	1	0	1	0	1	1	0	1	5
A7	0	1	0	1	1	0	0	0	1	1	0	0	5
A8	-1	0	-1	0	-1	-1	1	-1	0	-1	-1	0	-6
A9	0	1	-1	1	0	0	0	0	1	1	1	0	4
A10	0	1	0	1	1	0	1	0	1	1	0	1	7
A11	-1	1	-1	0	0	-1	1	-1	1	0	0	0	-1
A12	1	1	1	0	0	-1	1	1	1	0	0	1	6
A13	1	1	1	1	1	0	1	1	1	1	0	1	10
A14	0	1	0	1	1	0	1	0	1	1	1	0	7
A15	1	1	1	1	0	0	1	1	1	0	0	1	8
A16	-1	1	-1	1	1	0	0	-1	1	1	0	0	2
A17	1	1	0	1	1	0	1	1	1	1	0	1	9
A18	0	1	0	1	0	0	1	0	1	0	1	0	5
A19	1	1	1	1	1	0	1	1	1	1	0	1	10
A20	0	1	0	1	0	-1	0	0	1	0	-1	0	1

Acronyms used: Id: item identification (see Table 9).

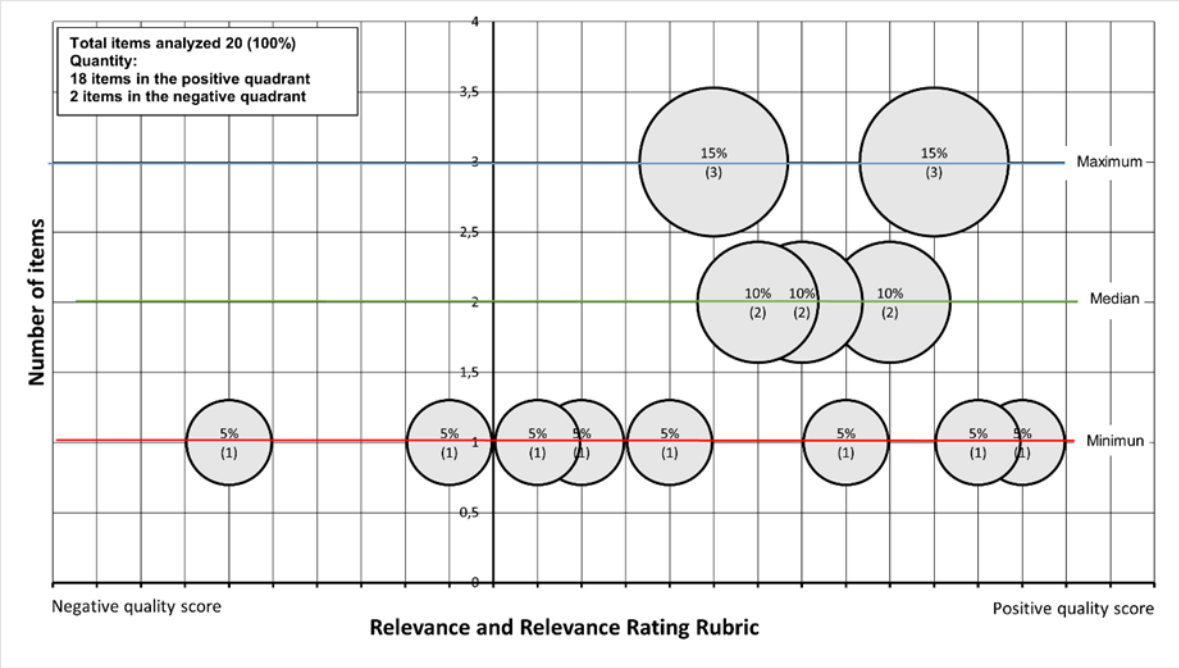
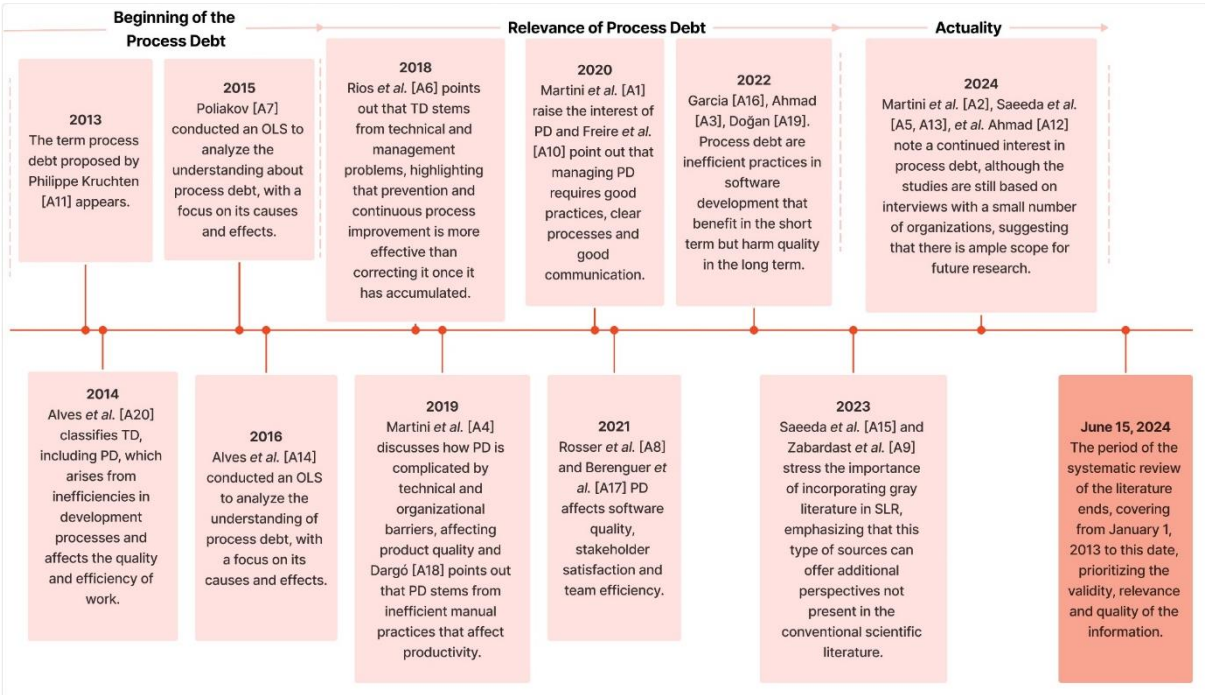


Figure 1. Visualization of the relevance and pertinence of primary articles in a bubble chart.}

3.2 Frequency and types of publications made on process debt

As shown in Figure 2, although there has been an increase in the frequency of publications on process debt, reflecting a growing interest in the topic, the number of studies remains limited compared to technical and other types of debt. This increased interest is manifested, as mentioned by Martini *et al*. [2], in empirical studies, conference papers and conceptual reviews, however, the current studies, which are often based on interviews with a small number of organizations, suggest that the results are not yet comprehensive and that there is ample scope for future research [1]. Furthermore, it is highlighted that, prior to 2019, relevant studies on process debt were scarce. Although information was available that mentioned, related and explained this concept, such information did not provide the necessary level of detail. As of the year 2019, a significant increase in research efforts in this field has been observed [4], as mentioned above, Figure 2 shows the timeline reflecting the evolution and segmentation of primary articles, highlighting the most important aspects of the literature in each relevant year (2013-2024).



Acronyms used: PD: process debt, DT: technical debt, MSL: systematic literature mapping, RSL: systematic literature review.

Figure 2. Figure 2. Timeline of the evolution and segmentation of articles according to their temporal distribution.

5.2. Limitations of the review

- **Biases in the search string.** The initial search string used in this review was quite extensive, which resulted in the exclusion of some relevant papers. To address this limitation, it was decided to use a shorter and more general search string, which allowed us to cover a larger number of studies and obtain a more complete view of the topic. Different search engines were searched, including Google Scholar, Scopus, Science Direct, IEEE Xplore, Web of Science, ACM and Springer Link. Finally, Google Scholar was selected as the primary search engine because of its ability to comprehensively cover relevant studies that were also found in other databases. However, this focus on a single main search engine may have introduced bias by relying heavily on its algorithm.
- **Biases in the selection of studies.** The selection of studies was based on predefined inclusion and exclusion criteria, which could have led to the omission of relevant research that did not meet all the established criteria. This selection process is subject to subjective biases, where the interpretation of the criteria could have influenced the decision to include or exclude certain studies. The accessibility of the documents was also a relevant factor in the selection, as documents from undergraduate, master's and doctoral theses were included, as well as types of publications ranging from conferences, scientific articles and gray literature. This diversity in the types of documents allowed for a broader view of the topic, although it could also introduce a bias by depending on the availability and accessibility of these materials.
- **Biases in data extraction.** To minimize biases in data extraction, a structured protocol was followed to select the primary articles. This protocol included a careful evaluation of the topic covered, the introduction of each article and keywords, as well as defined inclusion and exclusion criteria. Although this systematic approach helped to ensure the relevance and quality of the selected studies, subjective interpretation of these elements may have introduced bias. It is possible that greater weight was given to certain studies based on their alignment with the objectives of the review, which could have influenced the way in which the data were extracted and presented.
- **Biases in the interpretation of results.** The interpretation of the results may have been influenced by prior expectations and by the limited number of studies available that directly address process debt. This phenomenon may have led to overinterpretation of certain findings or underestimation of others, depending on how the results matched the initial hypotheses. This limits the generalizability of the results to a broader context, which is an aspect to be taken into account in future research.