Requirements Elicitation for Collaborative Systems: A Systematic review

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***Abstract*—Requirements elicitation is one of the most essential activities in requirements engineering. A growing trend in collaborative applications has imposed a challenge for requirements engineers to properly elicit requirements. The aim of this work is to identify and present the elicitation techniques that have been applied in the collaborative systems development. We conducted a systematic literature review by surveying 2576 initial and 21 primary studies. The findings of this review revealed that interviews, observation and audio/screen recording were the most frequently used elicitation techniques. The elicitation techniques were also grouped considering two classification perspectives. The results obtained from this research may assist requirements engineers to identify the suitable techniques that can be adopted in future collaborative applications.**

Keywords—requirements elicitation, requirements engineering, collaborative applications, collaborative systems, CSCW.

I. INTRODUCTION

Requirements elicitation is concerned with discovering the sources of requirements (stakeholders, existing systems), identifying their needs, negotiating potential conflicts, and establishing clear scope and boundaries of the system. Information gathered during requirements elicitation often has to be interpreted, analyzed, specified, and validated before the requirements engineer can feel confident that a complete enough set of requirements of the system have been collected [1].

Several techniques to elicit requirements have been proposed over the years [2]. Some of them are widely used in practice, others are relatively unknown by practitioners or rather theoretical. Cost may be an important consideration when choosing a technique for the groups involved, especially in terms of time invested with each technique. A number of other factors may influence the choice of a specific technique or combination of techniques [3].

Concerning Collaborative Systems, requirements elicitation represents a major challenge due to the users' interaction needs with the system in order to process, interpret, and share information collaboratively. Compared to other systems, collaborative systems are distinguished by the fact that the users are engaged in a shared goal and have a critical need to interact closely with each other. To achieve this distinction in developing collaborative systems, mechanisms for communication, coordination, collaboration, and awareness should be considered. Hence, the success of such system depends on the quality of the definition of requirements. The quality of the requirements is greatly influenced by the techniques employed during requirements elicitation [4].

Like other types of systems, requirements elicitation for collaborative systems is a critical and error-prone stage. Researchers recognize that the type of the system to be developed, project purpose, and communication forms between elicitors and stakeholders significantly affect the way in which requirements elicitation is conducted [2; 5].

In order to contribute to the state-of-the-art in the software engineering and CSCW fields, a systematic literature review was developed about the elicitation techniques used for developing collaborative systems. Additionally, based on the results we developed a framework considering two perspectives: one according to *the typical characteristics that a elicitation technique has* and other one according to *the manner in which the communication with the stakeholder is performed*.

This document is organized as follows: Section II discusses related work about elicitation techniques in collaborative systems. Section III describes the research methodology and research question of the review process. Section IV presents the results and the analysis of primary studies. Finally section V concludes this work.

II. RELATED WORK

Regarding systematic literature reviews about elicitation techniques we can find some comprehensive works. For instance, Zowghi and Coulin [2] developed a comprehensive survey of techniques, approaches, and tools in order to examine the trends and challenges faced by researchers and practitioners in computer-based systems. Furthermore in order to offer meaningful insights into the communication practices of the system design process at the requirements level, Coughlan and Macredie [5] performed a comparative analysis of four socio-technical methodologies for requirements elicitation.

Systematic literature reviews of requirements elicitation have been successfully applied in several application domains

(e.g. mobile applications [6], IoT [7]). However, previous systematic reviews of elicitation techniques have not dealt with the context of collaborative systems. In the collaborative systems field, most of the studies are related to requirements engineering (RE) methodologies or notations for RE applied to collaborative system development. In other words, a systematic understanding of which elicitation techniques are used for collaborative systems is still lacking.

III. RESEARCH METHOD

This section discusses the methodology of systematic review which was followed to obtain material for this research. The discussion will cover the search strategy, search engines used, selection criteria, and data extraction strategy. The methodology is based on the software engineering systematic review guidelines by Kitchenham [8].

A. Research Questions

The research questions for this study are as follows: *"Which elicitation techniques are used in the development of collaborative systems and how are they applied?"*.

An answer to this research question will allow us to summarize the current knowledge about the use of requirements elicitation techniques in the development of collaborative systems and to identify gaps in current research in order to suggest areas for further investigation.

B. Data Sources and Search Strategy

In this study we reviewed research material obtained from the following scientific digital libraries:

- IEEE Electronic Library (https://ieeexplore.ieee.org)
- Springer (http://www.springerlink.com)
- ACM Digital Library (http://dl.acm.org)
- Science Direct (http://www.sciencedirect.com)
- Scopus (http://www.scopus.com)
- Web of Science (http://apps.webofknowledge.com)

The search string was the following:

("elicitation" OR "requirements gathering" OR "requirements collection" OR "requirements discovery" OR "requirements acquisition" OR "requirements engineering")

AND

("CSCW" OR "groupware" OR "collaboration system" OR "collaboration application" OR "collaborative system" OR "collaborative application")

In some cases the search terms were adapted or divided due to characteristics or limitations of the search database engines.

C. Inclusion and Exclusion Criteria

The selection criteria are intended to identify those primary studies that provide direct evidence about the research question. For that, we considered the following phases:

- Criteria for the first phase (filter 1):
  1. The selected data is only in English language.
  2. Book chapters and papers published in journals and conferences were considered.
  3. The title and abstract of the selected work is read by the researchers for its relevance. In case of duplication it is necessary to remove the duplication.
- Criteria for the second phase (filter 2):
  1. Publications related to our domain are selected
  2. Papers whose abstract is included but full text is unavailable are excluded
  3. The full work is read for its validity.
  4. Only publications related to elicitation to systems supporting collaborative processes are included (publications related to elicitation of business processes were excluded).

D. Data Extraction Strategy

The extracted data was analyzed according to the research question stated above and the following three criteria were established in order to answer such question:

- The first criterion is about the *techniques employed* to capture the requirements.
- The second criterion is the explicit *elicitation of awareness requirements.*
- The third criterion is *automated support*, which refers to counting on a software tool for assisting the requirement elicitation process.
- The fourth criterion is *empirical validation*, which refers to perform one or more controlled experiments to validate the elicitation process.

IV. RESULTS AND DISCUSSION

The results of the selection process are presented in Table I. As previously mentioned, six scientific digital libraries were searched using the search string established in the previous section.

TABLE I. SEARCH RESULTS (NUMBER OF PAPERS)

Search Engine	Query Results	Other search settings	Filter 1 (title and abstract)	Backward and fordward search	Filter 2
IEEE	138		2	1	0
Springer	1,126	Computer Science, engineering	18	6	5
ACM	62		6	2	3
Science Direct	1004		16	2	9
Scopus	217	Computer Science and Engineering	28	3	3
Web of Science	29		9	6	2
Total	1276		79	20	21

TABLE II. SUMMARY OF ELICITATION TECHNIQUES USE ACCORDING TO EACH PRIMARY STUDY.

Aspect / Elicitation technique / [Study] - year	Source of study	Elicitation techniques																						Awareness requirements	Automated support	Empirical study
		Interview	Questionnaire	Screen/audio recording	Checklist	Document study	Meeting	Brainstorming	Prototyping	Focus group	Workshop	Thematic seminar	Storytelling	Delphi study	Simulation	JAD	Observation	Ethnography	Task analysis	Viewpoints	Use cases	Scenarios	Mining based			
[9] - 2009	Ch	X	X			X		X								X	X				X			X	X	X
[10] - 2019	J	X																			X	X				
[11] - 2013	C		X	X		X									X		X							X		X
[12] - 2007	C																	X								
[13] - 2010	C			X														X	X						X	X
[14] - 2005	C														X											X
[15] - 2011	C	X		X													X								X	X
[16] - 2018	J	X		X						X								X								X
[17] - 2009	J	X		X		X	X														X				X	X
[18] - 2006	J	X	X	X													X							X	X	X
[19] - 2015	J	X																		X						
[20] - 2016	J																						X			X
[21] - 1992	J	X						X			X			X												
[22] - 2005	J	X				X			X								X							X	X	X
[23] - 2008	J	X	X						X			X					X					X			X	X
[24] - 2013	J	X	X			X											X									X
[25] - 2008	C			X		X											X	X							X	X
[26] - 2005	C												X											X	X	X
[27] - 1996	J	X									X															X
[28] - 2017	J													X												X
[29] - 2015	J				X				X				X													X
Total		12	5	7	1	6	1	2	3	1	2	1	2	2	2	1	8	4	1	1	3	2	1	5	9	17
%		57%	24%	33%	5%	29%	5%	10%	14%	5%	10%	5%	10%	10%	10%	5%	38%	19%	5%	5%	14%	10%	5%	24%	43%	81%

A total of 2,576 papers were found. In the second step, 79 of the 2,576 studies were selected based on the analysis on the title and abstract. Besides the 79 studies, 20 were added due to backward and forward searches resulting in a total of 99 studies. In the final step, the detailed inclusion and exclusion criteria were applied which resulted in 21 papers.

Twenty two elicitation techniques were identified in the review of the studies. A summary of the elicitation techniques use according to each work is presented in Table II. The twenty one primary studies listed in such table were dated between 1992 and 2019. Thirteen (62%) were *journal studies* (labeled with J in the first blue column from Table II), seven (33%) were *conference studies* (labeled with C), and one (5%) was a *book chapter* (labeled with Ch).

Like other mentioned application domains (e.g. mobile applications [6] and IoT [7]), the most frequently elicitation technique was the *interview* (57%). This result highlights the fact that researchers give special attention to this elicitation technique. Interview was followed by the *observation* (38%), and then by the *screen/audio recording* (33%).

It is remarkable that several elicitation techniques commonly used in software engineering were barely considered in these primary studies. This is the case of the *focus group*, the *meeting*, *JAD*, and *task analysis* (5% each of them).

Furthermore, sixteen studies (76%) used more than one technique to perform requirements elicitation (24% of the studies considered only one technique). This fact indicates us that using a combination of elicitation techniques seems to be more effective for capturing requirements.

A. *An elicitation techniques framework for the collaborative systems development*

In an attempt to understand the use of different types of elicitation techniques in the primary studies, we developed a framework named *Elicitation Techniques for Collaborative Systems*. For that framework, we considered two perspectives to classify such techniques:

I. a perspective according to *the typical characteristics that an elicitation technique has*, and

II. a perspective according to *the manner in which the communication with the stakeholder is performed*.

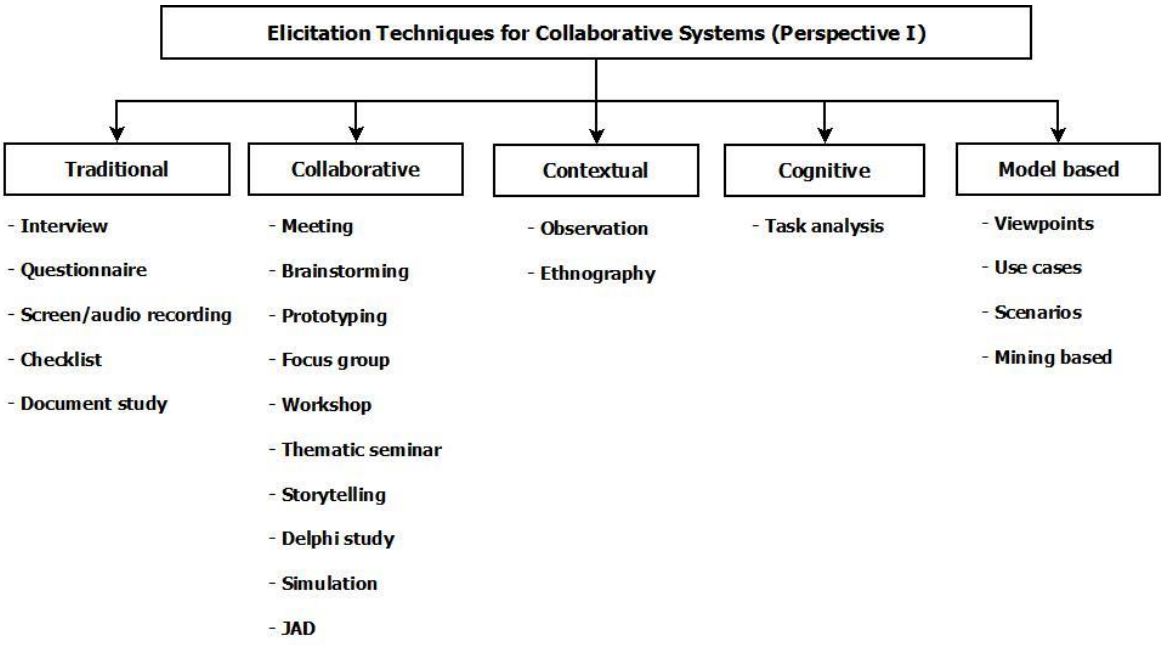

Fig. 1. Elicitation techniques according to *the typical characteristics that a elicitation technique has*

The first perspective was based on the proposals by Coughlan and Macredie [5] and Butt and Li [30]. Such perspective is shown in figure 1. The categories of this perspective are explained in table III.

TABLE III. DESCRIPTION OF THE ELICITATION TECHNIQUES CLASSIFICATION ACCORDING TO PERSPECTIVE I

Category	Description
Traditional	Traditional techniques include a broad class of generic data gathering techniques.
Collaborative	These techniques aim to foster stakeholder agreement and buy-in, while exploiting team dynamics to elicit a richer understanding of needs.
Cognitive	Cognitive techniques include these originally developed for knowledge acquisition for knowledge-based systems.
Contextual	Contextual techniques emerged as an alternative to both traditional and cognitive techniques. Contextual approaches are based on the premise that local context is vital for understanding social and organizational behavior, and the observer must be immersed in this local context in order to experience how participants create their own social structures.
Model based	These techniques provide a specific model of the type of information to be gathered and use this model to drive the elicitation process.

Under this perspective, whereas in some categories the number of techniques is high, in others the number was quite low. Several studies used *collaborative techniques*. This preference seems reasonable because the development of such systems requires effective and efficient collaboration among various experts. Eliciting group insights of different stakeholders that will be involved with the system is a valuable factor to derive suitable requirements. Therefore, these techniques, applied in an adequate manner, are effective tools in requirements engineering.

We also observed that such *collaborative techniques* were mainly used in combination with *traditional* ones. For instance *brainstorming* was used with *interview*; *questionnaire* was used with *document study*; *focus group* was used with *interview* and *screen/audio recording*; and *workshop* was used with *interview*, among other combinations. The previous insight also indicates us that *traditional techniques* were recurrently used in the development of collaborative systems (at least one in 16 out of 21 studies). The effectiveness of these techniques in the development of typical software systems seems to convince authors of their use in the collaborative domain.

Some authors based their studies in popular *model-based techniques*, as *use cases* and *scenarios*, which are also used in typical software systems development. In addition *viewpoints* and *mining based* techniques, although less trending than the first two, represent interesting options to be explored in collaborative systems development.

Regarding *contextual techniques*, although less diverse, they were recurrently used (11 out of 21 studies used *observation* or *ethnography*, or both, which represents 52% of the total studies). This result was expected, since these techniques are effective to understand how and why the activities are done in a certain manner. Experts coincide in the convenience of using them to study phenomena inside the social, cultural and organizational context.

It should be noted that only one primary study used a *cognitive technique*. In that study, the authors propose an approach based on *task analysis*, *ethnography* and *screen/audio recording* in order to study people and find their reasoning mechanisms according to their experience. With this proposal, the authors aim to discover basic requirements for the construction of artifacts that can support the process of team members' decision-making.

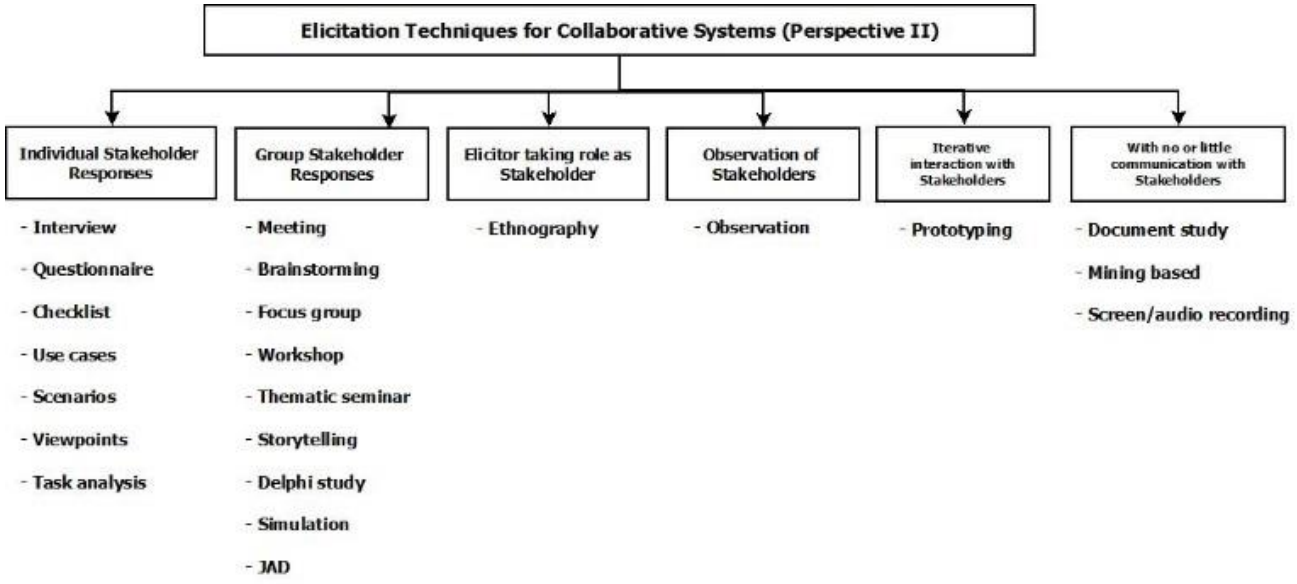

Fig. 2. Elicitation techniques according to the manner in which the communication with the stakeholder is performed.

On the other hand, the second perspective (perspective II) considers *the manner in which the communication with the stakeholder is performed*. This perspective is shown in figure 2 and their categories are explained in table IV.

TABLE IV. DESCRIPTION OF THE ELICITATION TECHNIQUES CLASSIFICATION ACCORDING TO PERSPECTIVE II

Category	Description
Individual Stakeholder responses	In these techniques, individual communication is carried out between elicitators and stakeholders.
Group Stakeholder responses	In these techniques, group communication is carried out between elicitators and stakeholders.
Elicitor taking role as Stakeholder	In this type of techniques, the elicitor performs the role of one or many stakeholders.
Observation of Stakeholders	In these techniques, the elicitor must be immersed in this local context of stakeholders.
Iterative interaction with Stakeholders	In these techniques, several iterations are needed in order to obtain a complete set of requirements.
With no or little communication with Stakeholders	In this kind of techniques, the elicitation can be carried out without (or minimal) participation of stakeholders.

This perspective was based on a communication viewpoint. Communication can be seen to be a key factor in the design of successful systems. However, what is also noticeable is that communication (or lack of) is an important issue in a shared understanding in requirements elicitation [5]. We consider that this perspective may assist engineers when choosing elicitation techniques. Of course, they should evaluate the available resources as well as stakeholders' expertise and communication skills, among other factors, in order to choose a suitable elicitation technique or a combination of techniques.

Considering this perspective in an analysis performed on the primary studies we found some interesting issues to be taken into account:

- The majority of techniques from the *"Individual Stakeholder responses"* category were complemented with techniques from the *"Group Stakeholder responses"* category or the technique from the *"Observation of Stakeholders"* category (or with both). Given the collaborative systems nature, such a combination of techniques results appropriate.

- Four papers used the only technique in the category *"Elicitor taking role as Stakeholder"* (i.e. *ethnography*). It was performed in the following manner:
    - Alone [12];
    - together with two techniques from the "*With no or little communication with Stakeholders*" category (*document study* and *screen/audio recording*) and one technique from the *"Observation of Stakeholders"* category *(observation)* [25];
    - together with one technique from the "*Individual Stakeholder responses*" category (*task analysis*) and one technique from the "*With no or little communication with Stakeholders"* category *(audio/screen recording)* [13]*;*
    - together with one technique in the "*Individual Stakeholder responses*" category (*interview*), one technique in the "*With no or little communication with Stakeholders"* category *(audio/screen recording)* and one technique in the "*Group Stakeholder responses"* category (*focus group)* [16].

These results indicate us that the technique in the *"Elicitor taking role as Stakeholder"* category *(i.e. ethnography)* is able to be used effectively in combination with techniques from the remaining categories, with the exception of the "*Iterative interaction with Stakeholders*" category. This exception can be explained because *prototyping* was mainly used together the *observation* technique (i.e. observation was considered enough to achieve the inquiry goals).

- From the three times that the technique in the "*Iterative interaction with Stakeholders*" category (i.e. *prototyping*) was used, it was performed in the following manner:
    - together with one technique in the "*Individual Stakeholder responses*" category (*interview*), one technique in the "*With no or little communication with Stakeholders"* category *(document study)* and one technique in the "*Observation of Stakeholders"* category (*observation)* [22]*;*
    - together with three techniques in the "*Individual Stakeholder responses*" category (*interview, questionnaire, and scenarios*), one technique in the *Group Stakeholder responses"* category (*thematic seminar)* and one technique in the "*Observation of Stakeholders"* category (*observation)* [23]*;*
    - together with one technique in the "*Individual Stakeholder responses*" category (*checklist*) and one technique in the "*Group Stakeholder responses"* category (*storytelling)* [29].

As evidenced in their use, these different categories from the perspective II are not mutually exclusive. Factors such as expertise and communication skills of stakeholders, available resources, budget, and time among others, should be analyzed in order to design a suitable combination of elicitation techniques.

B. Advantages and disadvantages of elicitation techniques

It is known that each elicitation technique has some advantages and disadvantages. Our interest is not to give a comprehensive set of these aspects but only to describe the main benefits and drawbacks to have into account when an elicitation technique is considered. Such aspects are briefly described in Table V.

TABLE V. ADVANTAGES AND DISADVANTAGES OF ELICITATION TECHNIQUES

Technique	Advantages and disadvantages of using such technique
Interview	*Advantages*: simple to carry out; low cost. *Disadvantages*: tacit knowledge externalization problem.
Questionnaire	*Advantages*: applicable to many stakeholders; low cost. *Disadvantages*: inflexibility to the stakeholder's language, interests, views.
Screen/audio recording	Advantages: count on permanent information that can be recurrently analyzed; provides the opportunity to several researchers to perform their own interpretations and a collaborative multidisciplinary analysis can be created an unbiased view of the events at any moment. *Disadvantages*: the amount of data this technique makes available for analysis (a very significant amount of work is required to analyze and structure the content).
Checklist	*Advantages*: simple to use. *Disadvantages*: limited in the depth of knowledge it is able to elicit.
Document study	*Advantages*: especially useful when the goal is to update an existing system or when the understanding of an existing system will enhance a new system. *Disadvantages*: document analysis alone is rarely enough to thoroughly extract all of the requirements for any given project.
Meeting	*Advantages:* especially useful in case of a conflict among different stakeholders. *Disadvantages:* managing meetings effectively requires both expertise and experience to ensure that individual personalities do not dominate the discussions; less effective in highly political situations.
Brainstorming	*Advantages*: it usually improves the working atmosphere; promotes freethinking and expression, and allows the discovery of new and innovative solutions to existing problems. *Disadvantages*: although brainstorming may produce a wide variety of ideas, many of them may not be quality ideas.
Focus group	*Advantages*: data is gathered quickly. *Disadvantages*: for sensitive topics, it can be hard to get honest insights.
Workshop	*Advantages*: useful to elicit requirements for complex and large systems. *Disadvantages*: require a greater time commitment from each participant; considerable cost.
Thematic seminar	*Advantages*: it involves all actors, which facilitates the acquisition of all possible needs. *Disadvantages*: time-consuming; the engagement of domain experts is mandatory.
Storytelling	*Advantages*: understandable and attractive for users; useful for complementing existing approaches and tools. *Disadvantages*: divergent stakeholders' stories can be difficult to analyze.
Delphi study	*Advantages*: allows true opinion to emerge as it is anonymous; suitable for high conflict situations. *Disadvantages*: considerable planning and preparation time.
JAD	*Advantages*: gives a better understanding of the objectives and goals relative to their skills and knowledge; saves time. *Disadvantages*: the selection of people to participate in the workshops may alter or bias the results.
Observation	*Advantages*: helps in identifying needs of the user who even the users may not be aware. *Disadvantages*: expensive to perform in terms of the time required; require significant elicitor skills.
Ethnography	*Advantages*: it provides insight to a user' own motivation to use the system and it helps in identifying needs of the user who even the users may not be aware. *Disadvantages*: it is difficult to analyze the social requirements of the people and hence the psychologists are required to provide their services.
Task analysis	*Advantages*: detailed information is obtained. *Disadvantages*: considerable effort is required to perform it.
Viewpoints	*Advantages*: provides different perspectives which is effective for projects where the system entities have detailed and complicated relationships with each other. *Disadvantages*: do not enable non-functional requirements to be represented easily; expensive to use in terms of the effort required.
Mining-based	*Advantages*: useful when the size of information to process is large. *Disadvantages*: it is difficult to identify relevant needs for a specific system by a non-expert.
Prototyping	*Advantages*: widely useful when there is a great deal of uncertainty about the requirements, or where early feedback from stakeholders is needed. *Disadvantages*: in many cases prototypes are expensive to produce in terms of time and cost.
Use cases	*Advantages*: simple; understandable for users. *Disadvantages*: write effective use cases requires much practice and experience.
Scenarios	*Advantages*: simple; understandable for users; useful for understanding and validating requirements, as well as test

	case development. *Disadvantages*: write effective scenarios requires much practice and experience.
Simulation	*Advantages*: allows capturing perceptions of major actor involved in the development of the collaborative system; allows to find unexpected behaviors. *Disadvantages*: other elicitation techniques are usually required to get an effective simulation; it is not adequate if the number of users is high.

C. Discussion of results

The aim of this systematic review is answering the general research question "*Which elicitation techniques are used in the development of collaborative systems and how are they applied?* According to the reviewed primary studies we found several issues to be discussed.

Regarding the *explicit elicitation of awareness requirements*, only 25% of the studies (5 out of 21) considered explicitly the elements to be captured. This result is a flashpoint to take into account in the development of collaborative systems. Furthermore, it was notable that the *observation* technique was involved in four of the five papers that elicited awareness elements, which is understandable since its contextual nature. The other one was *storytelling*, which is an interesting option to be explored in this aspect. Such as described in [30], awareness is considered a fundamental component of collaborative systems that helps users achieving their shared goals. Of course, a lack of explicit awareness requirements elicitation may represent a serious problem for the collaborative system to be developed.

With respect to *automated support*, 43% of the papers mentioned a tool to give assistance to the elicitation process. Having a supporting tool is widely useful to practitioners since it may provide an efficiency advantage when compared to a purely manual analysis; however, when this artifact is complex and it requires a specialized training (e.g. the case of a mobile tool in [14]) can lead to a loss of information or erroneous results as described in [31].

Moreover, 81% of the papers validated their approach with *empirical studies* (controlled experiments). Empirical studies are needed to develop or improve processes, methods, and tools for software development and maintenance [32]. As evident, most of the analyzed works have a strong support in this aspect. Such studies are valuable since they provide engineers the confidence to redo such experiments in order to obtain similar results in their own projects.

Various limitations have been identified in the reviewed works. Among them we can mention the following ones:

- Lack of a tool that help elicitors to integrate their work [19; 25]
- Focused on just a specific application domain [10; 11; 14; 15; 16; 20; 21; 22; 23; 24; 25; 27; 28; 29]
- Limited to one time perspective (e.g. synchronous collaboration) [11; 23]
- Focused on eliciting specific aspects of collaborative systems (e.g. social presence) [29]
- Expensive with regard to cost, time, and effort to carry out the requirements elicitation [18; 24]
- Lack of validation in application domains that the researchers expect that the study works [20]
- Researchers consider that their study results may vary when conditions are changed (e.g. the number of users, the size of the system to be developed) [11; 12].

The majority of the authors of the primary studies recognize that more research should be done to validate their proposals. Clearly, the collaborative domain requires emphasis on different aspects with regard to traditional systems (e.g. communication, coordination, collaboration, and awareness). Such aspects should be then considered and analyzed when elicitation techniques are selected.

Similar to other application domains, in the development of collaborative applications the choice of elicitation technique depends on, besides of the characteristics of the specific system, the time and resources available to the requirements engineer. Furthermore, the two developed perspectives and the list of benefits and drawbacks from requirements elicitation techniques may assist practitioners when they are choosing techniques in the development of collaborative applications.

V. CONCLUSION

This work has presented a systematic review aimed at identifying which requirements elicitation techniques for development of collaborative systems have been employed. We decided to conduct this type of study because it is an objective and repeatable method for evaluation. Several research gaps were identified in the analysis of the results. Our results have also shown that there is a need for validating the performed studies in several applications domains. Building empirical evidence is determining to decide which techniques are better in certain situations. The studied works provide a clear motivation for further research in requirements elicitation for the development of collaborative applications. The results obtained from this research may assist requirements engineers to identify the suitable elicitation techniques that can be adopted in future collaborative systems. Such results are not limited to the techniques analyzed in the primary studies.

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