To Group or Not to Group?
Group vs. Individual Techniques in Requirements Elicitation

Luisa Mich[1], Victoria Sakhnini[2], and Daniel Berry[2]

[1] Department of Industrial Engineering, University of Trento, Italy
luisa.mich@unitn.it
[2] Cheriton School of Computer Science, University of Waterloo, Canada
{vsakhnini,dberry}@uwaterloo.ca

Abstract. **[Context]** Requirement elicitation can be done by individuals or by groups.
[Objectives] From the software engineering and the project management viewpoints, a relevant overall research question is, "Is it possible to give advice about the number of requirements analysts (RAs) to involve in requirements elicitation and idea generation sessions?"
[Method] To address this research question, we conducted two studies. The first was a review of software engineering (SE) and requirements engineering (RE) textbooks to see if and how they address this question for requirements elicitation. The second was a study on the factors affecting group size for requirements elicitation in computer-based system (CBS) development projects, based on an online questionnaire submitted to professional business or RAs.
[Results] The review of the textbooks showed that very few give advice on the number of RAs to involve in requirements elicitation sessions. When they do, the advice is quite general and is usually not supported by quantitative data that can help project managers decide the number of RAs needed. According to the data gathered from the questionnaire, the ideal number of RAs for a requirements elicitation session appears to be 2. However, there are settings of the size, timing, complexity, and domain of a CBS development project that seem to require different numbers of RAs.
[Conclusion] Both the textbook review and the data from the questionnaire say that it is better to aim for small groups than to have individual RAs working separately, but large groups are necessary in some cases. Factors to be considered in deciding the sizes of groups for requirements elicitation are related to characteristics of people involved in the requirements elicitation, relations among the people, characteristics of the requirements that are the output of requirements elicitation, and characteristics of the development project in which the requirements elicitation is done.
Keywords: Creativity techniques, Group work, Individual work, Projects, Requirements elicitation

1 Introduction

Whether a process should be carried out by a group or by an individual, and if by a group, how big is the group, is called the *GvsI*[1] *issue* in this paper. The GvsI issue is relevant in many disciplines, e.g., Systems Theory, Psychology,

[1] Glossary of Non-Standard Acronyms:

BPR	business process redesign
BoRA	business or requirements analyst
CBS	computer-based system
CPRE	Certified Professional for Requirements Engineering
GvsI	group vs individual
IREB	International Requirements Engineering Board
JAD	Joint Application Design
RAD	Rapid Application Development
ReqElic	requirements elicitation or idea generation
RESG	Requirements Engineering Specialist Group
RIG	requirements are identified in groups
RWS	requirements workshop
SME	subject matter expert
SWAT	software action team
SWEBOK	SoftWare Engineering Body of Knowledge
SWS	software system

Psychiatrics, etc. [52,59,63]. Managerial disciplines have investigated the GvsI issue in many contexts, e.g., in project management, operations research, decision making, etc. [21,51,57].

In computer science, the problem of supporting many people working on the same document or project is a major concern to the design of computer-supported cooperative work systems, including group decision support systems, office automation solutions, and more recently, knowledge management systems, online communication tools, and many others [3,9].

In software engineering (SE), some computer-based system (CBS) development life-cycle models suggest having people working together for specific tasks, particularly for tasks related to the specification, design, and implementation of any large-scale CBS [55]. Examples include Joint Application Design (JAD) [11] and Scrum meetings [53]. Also recommendations about analysis and design methods suggest that some processes could take advantage of collaboration and group work.

Once it is decided for a particular process to have a group carry it out, the next question is "How many people should be in the group?". As is shown in later sections, there is not a lot of guidance to answer this question. However, many authors, e.g., all listed in Table 1, discuss the communication problems of groups. Some explain the problems by introducing a formula that shows how communication between group members grows quadratically with group size; for group size n, the number of lines of communication between the group members is $\frac{n\times(n-1)}{2}$.

In requirements engineering (RE), two key processes in which groups are often used, groups of stakeholders, groups of requirements analysts (RAs), or both, are requirements elicitation and requirements idea generation. *Requirements elicitation* is the general process of eliciting a CBS's requirements from the organization of the CBS's client. By "organization" is meant not only the client's people, but also its environment, its culture, its current work processes, its current CBSs, and any other information that might be relevant to determining the CBS's requirements [19,44]. *Requirements idea generation* is the specific process of having people produce ideas for requirements of a CBS. The people can be RAs, representative of the CBS's client, end users, and other stakeholders, or any combination thereof. Requirements idea generation often benefits from creativity to yield fresh, innovative ideas for requirements. It can therefore make use of brainstorming [42] or other creativity enhancement techniques [17,29,47].

Very often, requirements idea generation for a CBS is part of requirements elicitation for the CBS, which in turn, is part of RE for the CBS. Since client-side people may participate in requirements idea generation, some consider requirements elicitation and requirements idea generation to be the same general process. Therefore, in an effort to cover as many viewpoints as possible, this paper collects all RE processes that are considered requirements elicitation, requirements idea generation, or both under the term "ReqElic". On the other hand, when this paper talks about what a specific other document says, this paper uses document's own words, so as not to put words into other authors' mouths.

Thus, the research question that is the focus of this paper is, in its most general form:

> Is it possible to give advice about the number of RAs to involve in ReqElic sessions?

For ReqElic, as is shown in Section 2.2, there are recommendations to use groups, and there are recommendations to use individuals. However, more often than not, no data are given to support any claim for how to decide whether a process should be done by a group or by an individual, and if by a group, how big the group should be. Very little information is given about the criteria for making the decision.

Some documents use "team" instead of or as a synonym for "group". This paper uses only the term "group" unless it is talking about what a specific other document says, in which case, this paper uses the document's own term.

The first part of the paper reviews how some of the most successful and well known SE and RE textbooks address the GvsI issue for ReqElic. The second part of the paper reports the results of an online survey [31] focusing on the GvsI issue in ReqElic. The survey attempted to gather data on the factors that affect decisions about group sizes and ideal group size, if any, for ReqElic sessions. The results of the questionnaire offer some useful insights on how to form ReqElic groups[2].

Results of the analysis of the answers to the open questions suggest that the three classical measures about a project, namely (1) time required for its completion, (2) the size of the CBS it is developing, and (3) the complexity of

[2] We published some preliminary results in three previously written reports [33,49,50], each using the replies that the survey had received by its publication. Specifically, we reported the results derived from 35 [49], 53 [50], and 92 [33], replies, respectively. These results considered only the answers to the multiple choice questions and did not consider the answers to the open-ended questions. This paper adds a review of textbooks, an analysis of the 92 answers to the open-ended questions, and some cross tabulations between the 92 answers.

the CBS it is developing, are relevant to making decisions about the sizes of ReqElic groups in the project. To classify the factors named by the respondents, we introduced four categories namely: relations, project, people, and output.

In the rest of this paper, Section 2 consists of, in one subsection, a review of well known SE textbooks, and in the next subsection, a review of well known RE textbooks. The review of any textbook describes how well it addresses the GvsI issue and answers the research question. Each subsection comes to its own conclusions, but an the overall conclusions are deferred to Section 4. Section 3 introduces the design and submission of the on-line questionnaire; the results of a descriptive statistical analysis; the results of the analysis of the open questions; and cross tabulations. Section 4 discusses the results. Section 5 considers the limitations of the study and the threats to the validity of the conclusions, and Section 6 concludes the paper with guidelines based on the conclusion for both parts of the study.

2 The Group vs. Individual Problem in the Textbooks

The scenario that drives decisions concerning the conduct of the first study to review SE and RE textbooks is that an RA needs advice on staffing a project, in particular on the sizes of groups to perform the various RE processes. The scenario actually begins during the education of the RA prior to his or her becoming a professional RA, responsible for staffing projects. The teachers of the RE courses that the RA took had to adopt one or more textbooks, and these textbooks end up being the primary sources for guidance about what to do on the job for the RA who have taken these courses. Therefore, when an RA needs advice on staffing an RE process and to deal with the GvsI issue for this process, he or she will consult his or her old textbook. Another reason to check textbooks is that the successful ones are continuously updated with best practices from the industrial and academic worlds.

The first goal of the review of any textbook was to see if the textbook does take into consideration the fact that ReqElic activities can be accomplished as group or individual activities. If the answer to that question is “Yes”, then the goal was to see what recommendation the book made in the GvsI issue.

2.1 Software Engineering Textbooks

2.1.1 Introduction: Choosing the SE Textbooks

The first part of the textbook review focused on SE textbooks. Data about textbooks and related information were retrieved using the Google (`google.com`), Amazon (`amazon.com`), and Worldcat (`worldcat.org`)[3] search engines.

For selecting the most popular SE textbooks, we considered only those SE textbooks that

– have reached at least three editions, and
– have been translated into at least one language other than its original language, which is usually English.

We found five qualifying textbooks, and they are listed in Table 1 ordered by decreasing numbers of editions.

Each textbook is available also as an e-textbook, usually as a Kindle edition.

The number in Column 1 of the table for each textbook is the textbook’s rank in this order. The information in Column 2 for each textbook is a citation[4] to the most recent edition of the textbook that we know of. When there is more than one citation for a textbook in Column 2, it is because the textbook has undergone a title or an author-list change, and each other citation is that of the most recent edition with its title and author list. Among the information in Column 3 for each textbook are the dates of its first and last editions.

The first two textbooks, by Sommerville and by Pressman, stand out for their high numbers of editions, 10 and 9, respectively. Interesting is the fact that each’s first edition was published in 1982, about when SE began to emerge as a profession. Thus, perhaps these books helped SE to become recognized as a new profession. Also, around this year, the first courses in SE were introduced in many university computer science programs [37].

[3] Worldcat is a Website to search for books in libraries. That is, it allows finding libraries, mostly university libraries, in which a given book is available.

[4] Since each table entry is citationally complete, there is no entry for it in the bibliography, unless the textbook is cited also in a section other than one in which it is reviewed as an SE or RE textbook. In the paragraphs about any textbook, any unattributed quotation is from that textbook.

Table 1. Software Engineering Textbooks

	Textbook	**Editions**
1	Sommerville, Ian: *Software Engineering*, 10th ed., Pearson, 2018	1st ed. 1982 10th ed. 2015 International Edition, 10th ed., 2018 Translated to Chinese, Czech, Dutch, French, German, Greek, Hungarian, Korean, Italian, Japanese, Polish, Portuguese, Spanish, Thai
2	Pressman, Roger S. and Maxim, Bruce R.: *Software Engineering: A Practitioner's Approach*, 9th ed., McGraw Hill Education, 2019 Pressman Roger S., Software Engineering: A Practitioner's Approach, 7th ed., McGraw Hill Education, 2010	1st ed. 1982 9th ed. 2019 International Student Edition, 9th ed., 2020 Translated to Chinese, German, Korean, Italian, Japanese, Polish, Portuguese, Spanish
3	Schach, Stephen R.: *Object-Oriented and Classical Software Engineering*, 8th ed., McGraw-Hill, 2011 Schach, Stephen R.: *Classical and Object-Oriented Software Engineering with UML and Java* or *Classical and Object-Oriented Software Engineering with UML and C++*, 4th ed., McGraw-Hill, 1998 Schach, Stephen R.: *Classical and Object-Oriented Software Engineering*, 3th ed., Richard D. Irwin, 1996 Schach, Stephen R.: *Software Engineering*, 2nd ed., Richard D. Irwin (formerly Richard D. Irwin/Aksen Associates), 1993	1st ed. 1990 8th ed. 2011 Translated to Korean, Spanish, and Chinese
4	Pfleeger, Shari Lawrence and Atlee, Joanne M.: *Software Engineering: Theory and Practice*, 4th ed., Pearson (formerly Ellis Norwood), 2009 Pfleeger, Shari Lawrence: *Software Engineering: Theory and Practice*, 2nd ed., Prentice Hall, 2001	1st ed. 1998 4th ed. 2009 International Edition, 4th ed., 2009 Translated to Spanish, Russian
5	van Vliet, Hans: *Software Engineering: Principles and Practice*, 3rd ed., Wiley, 2010 van Vliet, Hans and Kroese, Stenfert: *Programvaruteknik* (Software Engineering) (in Dutch), [Publisher unknown], 1988	Dutch ed. 1988 1st ed., 1993 3rd ed., 2010 Student Edition, 3rd ed., 2010 Translated to Chinese, English, German, Italian

While all editions of the Sommerville textbook have only him as the author, the last two editions of the Pressman textbook have Maxim added as a co-author. The same happened to the Pfleeger textbook; the last two editions of this textbook have Atlee added as a coauthor. The opposite happened to the van Vliet textbook; van Vliet's own Website (`https://www.cs.vu.nl/~hans/`) says that he considers all editions of his English textbook to be later editions of his first, Dutch textbook, which he and Stenfert Kroese wrote in 1984 and published in 1988.

Each textbook but the one by van Vliet was published in English first and then translated to other languages. The information in Column 3 of Table 1 for each textbook includes a list of the languages to which the editions of the textbook have been translated from its original language. Each textbook but the one by van Vliet has an international, a student, or an international student edition. The Sommerville and Pressman textbooks have been translated to Chinese, German, Italian, Japanese, Korean, Polish, Portuguese, and Spanish, as well as to some other languages. These textbooks are available in 15 and 9 different languages, including English, respectively [5]. Each of the Schach textbook's 8 editions has been translated to at least Chinese.

It is impossible to estimate the number of people who have read any of the textbooks[6]. However, the large numbers of editions and of languages in which textbooks have been published support the assumption that many RAs and software engineers have used these textbooks as sources of information for real projects.

2.1.2 Groups and Requirements Elicitation in SE Textbooks

Each of the five SE textbooks listed in Table 1 addresses in one way or another the possibility of having multiple people working as a group in a single CBS development project and how to help these groups to be effective. Some of them, in fact, use the term "team" instead of "group". It is important to remember that the scope of an SE textbook is larger than that of an RE textbook, for the simple reason that RE is only one part of the SE lifecycle. Therefore, an SE textbook deals with groups for more processes than does an RE textbook. Possibly for the same reason, the role of RA or requirements engineer is often not explicitly introduced in an SE textbook.

In the first textbook of the table, Sommerville addresses the problem of teamwork in a chapter dedicated to project management. He starts the chapter declaring that the objective is to "understand key issues that influence team working, such as team composition, organization, and communication". The goal is that each team consists of people (1) who have the skills necessary to cover all the steps of its CBS development project and (2) who can effectively interact (a) with other members of the team; (b) with the CBS's users and clients, not only for requirements elicitation; and (c) with other teams interacting with the project. Terms such as "skills", "experience", "personality", and "team spirit" are used to give insights to project managers, but no advice is given about the number of people with which to form any team.

In the second textbook of the table, Pressman and Maxim are more explicit about the size of a CBS development team, and offers, as a general rule, that no SE project team should have more than 10 members, in order to reduce communication overhead and keep it manageable. They even state that if a project is developing a small CBS, it is better to have a single individual than a team conducting it. On the other hand, developing a large, complex CBS needs more people, to cope with its complexity. The problems of having multiple people working together are described as staffing risks, one type of risk in a CBS development project. They argue that it is not always possible to have (1) enough people available, (2) the right combination of skills, and (3) people committed to remain in the project for its entire duration. For the requirements analysis steps, they underline that many problems are due to (1) poor communication, (2) inadequate techniques and tools, (3) a tendency of developers to take shortcuts, and (4) a failure to consider alternatives.

In the third textbook of the table, Schach emphasizes the need to have a requirements team[7], but he gives no hint about the number of members in such a team. However, as a best-practice recommendation for student CBS

[5] No one edition of these textbooks has been translated to all the listed languages.

[6] The Wikipedia page about Pressman (`https://en.wikipedia.org/wiki/Roger_S._Pressman`) says that his *Software Engineering: A Practitioner's Approach* textbook has been used at over 500 Universities worldwide and is also widely used in industry and is required reading for many industry and government short courses.

[7] Schach actually calls them "requirements teams" and uses the term "team" more than 600 times, in almost every page, and he describes nearly every activity in terms of a team performing it.

development projects, Schach states that the ideal size of a development team is 3, “the smallest number of team members that cannot confer over a standard telephone”[8].

In the fourth textbook of the table, Pfleeger and Atlee mention team size and team interactions as important considerations for a CBS development project. In particular, they highlight that teams working separately can check each other’s views in a checks-and-balances approach to CBS development. About the size of a team, they recommend that 3 is better than 4. However, this recommendation is for inspection teams, and no other recommendations are given about team size, apart from (1) including a project’s manager in the project’s team and (2) building a hierarchy of the roles needed to conduct the steps of the project.

In the fifth and last textbook of the table, van Vliet dedicates an entire chapter to the topic of teams in SE, as one of the problems to be addressed in project management. He recommends forming small teams to increase productivity and to reduce communication overhead. In addition, van Vliet advises selecting people with different roles and specializations. For roles, he names manager, tester, designer, programmers, but not analyst. For specializations, he names in particular, competency in advanced tools that support CBS development. His suggested size for CBS development teams is from 4 to 5 members. He discusses the need (1) for different expertises for multidisciplinary projects and (2) for sufficient domain knowledge among team members in a CBS development project. He discusses the failure to fulfill these needs in inspection teams as risks that need to be addressed. Concerning requirements, van Vliet observes that “market-driven software development (...) is more like requirements invention or problem-formulation”, and as a consequence, creativity plays an important role in requirements elicitation.

2.1.3 Other Sources

Among the textbooks not satisfying all the criteria used to select the SE textbooks listed in Table 1, it is worth mentioning:

Tsui, Frank; Karam, Orlando; and Bernal, Barbara: *Essentials of Software Engineering*, 4th ed., Jones & Bartlett Learning, 2018 Tsui, Frank and Karam, Orlando: *Essentials of Software Engineering*, 2nd ed., Jones & Bartlett Learning, 2010	1st ed. 2007 4th ed. 2019

with 4 editions that are available only in English. Its first edition was published in 2007. So, it is more recent than any of the five books listed in Table 1.

Tsui *et al.* discuss communication problems and the need to have people with the right skills in the context of assigning people to the roles of designing and coding of different features of a CBS. They highlight the need to address the tradeoffs between communication problems and expertise and between the size of teams and the number of teams. For example, to optimize intra-team communication, small teams are better, but each small team runs the risk of lacking skills necessary for its mission. For a CBS development project with specific minimum number of people, the size of teams and the number of teams can be traded off, with the effect of exchanging intra-team and inter-team communication overhead.

Tsui *et al.* describe a number of CBS development methods, including the Scrum Agile method and two versions of their own Cristal method. For each method, they describe its optimal number of roles or team members, e.g.: 3 – 10 members for Scrum, 4 roles for Cristal Version 1, and 14 roles for Cristal Version 2. However, these numbers are for the size of the whole CBS development team, and not for the size of any requirements analysis or elicitation team. They suggest that one of the essential roles in a CBS development project team is that of requirements gatherer. Tsui *et al.* devote an entire chapter to requirements analysis and another to project management, but team size is not considered in either of these chapters.

It is worth mentioning also the technical writing textbook by Laplante [26], which observes that group-oriented elicitation techniques embody some form of brainstorming. Brainstorming as a requirements gathering technique is also suggested by Stephens [56]. He notes on one hand, that it is advisable to convene for a brainstorming session, as diverse a group of stakeholders as possible, to allow as many viewpoints as possible. He notes on the other, hand that brainstorming becomes less effective if the size of its group becomes larger than 10 or 12.

[8] Schach offered this advice no later than 2011, long before the popularization of online meeting applications.

2.1.4 Conclusions for the SE Textbook Review

Recall that the scenario driving decisions concerning the conduct of the study to review SE and RE textbooks is that an RA needs advice on staffing ReqElic activities in a CBS development project and on the GvsI issue for these ReqElic activities. The RA consults the SE and RE textbooks that he or she used during his or her education as an RA. The main result of the SE textbook part of the study is that the RA will not find any real advice. Each of the most successful SE textbooks deals, albeit in its own way, with the GvsI issue for SE processes in general. Only a few give detailed numerical group size recommendations for some SE processes, and none gives a detailed recommendation for RE-process group size.

First, each textbook mentioned in Table 1 points to the critical role of communication among the members of any group. Each textbook explains that the effectiveness and efficiency of any group's communication depend on the amount of communication overhead in the group. Some of them quantify the communication overhead of a group using the classical quadratic formula for the number of communication links in the group as a function of the number n of members in the group, $\frac{n\times(n-1)}{2}$. The amount of time needed from group members to service each line of communication varies from group to group, and even within a group. No matter what the minimum time per line is for any group, there is always some number m of members such that the amount of time required to service the $m-1$ new lines of communication created by adding the m^{th} group member adds up to more time than the m^{th} member adds to the total work time of the group. Thus, we can say that there is an upper bound on a *useful* group size. This growth in *group communication overhead* was in play when Brooks observed in his seminal *The Mythical Man-Month* [7], that "Adding more people to a late project makes it even later." — because of this group communication overhead plus the simple fact that the new member initially soaks up some of the work hours of those assigned to mentor him or her.

Some of the textbooks mention behavioral factors affecting communication effectiveness and efficiency. For example, status differences among group members can effect communication, if status-conscious group members allow managers and the more experienced members to dominate the group's communication.

To no surprise, all the textbooks consider the size and complexity of the CBS being developed as a key factor impacting the GvsI issue. After all, the field of SE emerged in 1968 out of alarm at the increasing size and complexity of CBSs [38].

All the textbooks say that projects to develop big CBSs need more people than those to develop small CBSs. For example, Pressman states that if the CBS to be developed is small, then it is better to have a single individual than a multi-person group developing it. However if the CBS to be developed is big, its development project will need more people to cope with its complexity.

Limits on the duration of a CBS development project, e.g., to beat competitors to the market or to meet the CBS client's deadline, force additional constraints on project staffing. For example, Schach declares that "Today's projects are too large to be completed by a single individual within the given time constraints. Instead, a team of software professionals collaborate on the project".

Out of recognition that a CBS development project involves a variety of different processes, many of the textbooks recommend that the skills and expertises that are needed in the development be considered in staffing the project's group. In particular, a group's size can be no smaller than the number of people needed to provide the needed skills and expertises.

Consideration of the GvsI issue for RE groups shows up in a round-about manner. All five text books suggest using creativity enhancement techniques [20, 48], in particular, brainstorming to mitigate the risks arising from communication overhead or lack of domain or professional expertise in groups for RE processes. Thus, indirectly, group size recommendations for brainstorming become implicit group size recommendations for the RE processes. The fact is that the description of many creativity techniques advise on the number of people to be involved. For example, the original descriptions of brainstorming [41, 42] suggests having 12 people, both experts and novices, with the novices being expected to provide more unexpected ideas. However, recent studies of brainstorming have shown that, depending on the kind of problem to be solved by a brainstorming sessions, small groups and even individuals may be more effective at brainstorming than large groups [2, 32, 50]. The idea is that often, is not possible to have a large number of people, and a small number of open-minded experts and novices, guided by a creativity enhancement technique, can effectively cover the space of creative ideas. The guidelines for the JAD technique suggests a group size corresponding to the number of possible stakeholders inside and outside the system [11, 62]. However, the textbooks that suggest using brainstorming and JAD do not mention that there are guidelines for the size of groups for these methods. The

Schach textbook discusses Agile development methods and its concept of pair programming [1]. However it does not explicitly address the GvsI issue in this context.

It is important to remark that none of the numbers given by the SE textbooks appears to have a formal empirical basis; that is none is described as arising from an empirical study of group sizes for its process. Each seems to arise from the personal, possibly industrial experience of its textbook's authors or from what these authors understand that industrial practitioners believe.

Finally, in the SE textbooks, all suggestions concerning group sizes are about the overall CBS development process, and are not focused on RE activities. Even creativity techniques, which are used a lot in RE, can be applied in many other steps of the CBS development process, e.g., to identify possible implementations of specified requirements and to identify defects in an inspected document.

2.2 Requirements Engineering Textbooks

2.2.1 Introduction: Choosing the RE Textbooks

The second part of the textbook review focused on RE textbooks. Books and the related information were retrieved using the Google (`google.com`), Amazon (`amazon.com`), and Worldcat (`worldcat.org`) search engines, as for the SE books. The scenario, introduced at the beginning of Section 2, that describes how textbooks are used by an RA to answer his or her GvsI questions, now includes the possibility that the textbook the RA consults is an RE textbook.

For selecting RE textbooks, we applied criteria weaker than those for SE books[9]. The differences arose from the necessity to take into account that RE is a specialized sub-area of SE and therefore the target audience and market for an RE textbook are smaller. Not only will there be fewer readers, but also the textbook will be translated into fewer languages. In addition, RE as a research and professional area started later than SE, i.e., in the early 1990s. Also, the first RE textbooks were first published more than 15 years after the first SE textbooks were. Finally, the simple fact is that the focus of this paper is on RE; therefore, we needed a way to include more RE textbooks. The main weakening is that we counted a reprinting of an unchanged edition as well as a new edition as evidence of popularity. We ended up considering only those RE textbooks that

- have reached at least three editions *or reprintings or*[10] (not "and")
- have been translated into at least one language other than the original language.

To simplify the ensuing discussion, we use the term "version" to mean "edition or reprinting".

There are many other books for RE, and many of these are specialized to a specific approach, e.g., Agile; issue, e.g., analysis of non-functional requirements; or techniques, e.g., elicitation techniques. However, we focused our study on those books that have possibly been adopted as textbooks, so that they have to be more comprehensive in their coverage of RE processes.

In the end, we found ten qualifying textbooks, and they are listed in Table 2, ordered by decreasing numbers of versions.

Each textbook is available also as an e-textbook, usually as a Kindle edition.

The structure of 2 is the same as that of Table 1, except that the information in Column 2 for each textbook is a citation to the most recent *version* of the textbook that we know of.

A first analysis of Table 2 confirms that RE became established as a taught discipline in the second half of the 1990s. The table also shows that each of the main publishers has at least one successful RE textbook.

An interesting observation is that eight of the ten textbooks listed in the table have at least 350 pages in their last versions, with Pohl's textbook reaching 813 pages. Also, when a textbook has more than one version, the last version has more pages than the first. These high page numbers reflect the more complete, in-depth coverage of topics of the textbooks involved. The two exceptions, the textbooks by Hull *et al.* and by Kotonya and Sommervile, each with fewer than 300 pages in its last version, cover topics to only the depth necessary to explain to the practitioner what to *do*, probably accounting for their success and being listed in the table. On the other hand, a longer textbook does possibly address many specific topics, such as those related to our research question, "Is it possible to give advice about the number of RAs to involve in ReqElic sessions?"

[9] Otherwise, the list of RE textbooks to examine would be empty!
[10] The weakeners of the criteria are italicized.

Table 2. Requirements Engineering Textbooks

	Textbook	Editions
1	Dick, Jeremy; Hull, Elizabeth; and Jackson, Ken: *Requirements Engineering*, 4th ed., Springer, 2017 Hull, Elizabeth; Jackson, Ken; and Dick, Jeremy: *Requirements Engineering*, 3rd ed., Springer, 2011	1st ed. 2002 (213 pages) 4th ed. 2017 (239 pages) Translated to German, Korean
2	Robertson, Suzanne and Robertson, James: *Mastering the Requirements Process: Getting Requirements Right*, 3rd ed., ACM Press/Addison-Wesley, 2012 Robertson, Suzanne and Robertson, James: *Mastering the Requirements Process*, Addison-Wesley, 1999	1st ed. 1999 (404 pages) 3rd ed. 2012 (reprinted 2014) (547 pages) Translated to Chinese, Japanese
3	Wiegers, Karl E. and Beatty, Joy: *Software Requirements*, 3rd ed., Microsoft Press, 2013 Wiegers, Karl E.: *Software Requirements*, Microsoft Press, 1999	1st ed. 1999 (350 pages) 3rd ed. 2013 (reprinted 2015) (637 pages) Translated to Chinese, German, Czech, Portuguese
4	Maciaszek, Leszek: *Requirements Analysis and Systems Design*, 3rd ed., Pearson, 2007 Maciaszek, Leszek: *Requirements Analysis and Systems Design: Developing Information Systems with UML*, Addison-Wesley, 2001	1st ed. 2001 (378 pages) 3rd ed. 2007 (656 pages) Translated to Chinese
5	Laplante, Phillip A.: *Requirements Engineering for Software and Systems*, 3rd ed., CRC Press, Taylor & Francis, 2017	1st ed. 2009 (241 pages) 3rd ed. 2017 (400 pages) No translations
6	Leffingwell, Dean and Widrig, Don: *Managing Software Requirements: A Use Case Approach*, 2nd ed., Addison-Wesley Professional, 2003 Leffingwell, Dean and Widrig, Don: *Managing Software Requirements: A Unified Approach*, Addison-Wesley Professional, 1999	1st ed. 1999 (528 pages) 2nd ed. 2003 (reprinted 2012) (544 pages) No translations
7	van Lamsweerde, Axel: *Requirements Engineering: From System Goals to UML Models to Software Specifications*, 2nd ed., Wiley, 2011	1st ed. 2009 (682 pages) 2nd ed. 2011 (reprinted 2013) (682 pages) Translated to German
8	Kotonya, Gerald and Sommerville, Ian: *Requirements Engineering: Processes and Techniques*, 7th reprinting, Wiley, 2005	Only ed. 1998 (294 pages) 7th reprinting 2005 (294 pages) No translations
9	Sommerville, Ian and Sawyer, Pete: *Requirements Engineering: A Good Practice Guide*, 6th reprinting, Wiley, 2006	Only ed. 1997 (404 pages) 6th reprinting 2006 (404 pages) Translated to Italian
10	Pohl, Klaus: *Requirements Engineering: Fundamentals, Principles and Techniques*, Springer 2010 Pohl, Klaus: *Requirements Engineering — Grundlagen, Prinzipien, Techniken* (in German), Dpunkt 2008	German ed. 2008 (741 pages) English ed. 2010 (813 pages)

2.2.2 Groups and Requirements Elicitation in RE Textbooks

The first editions of the RE textbooks by Sommerville & Sawyer and by Kotonya & Sommerville were published in 1997 and 1998 respectively, about a half decade after RE became a named field. The first editions of the RE textbooks by industrial RE practitioners Robertson & Robertson and Wiegers were published in 1999.

In the first textbook of the table, Dick *et al.* describe requirements elicitation as having multiple activities of which stakeholder identification is the most important. They suggest using teams for many of the activities. For example, they suggest team workshops with stakeholders as a way to gather the stakeholders' requirements. They recommend splitting a large team of stakeholders into small teams, but with no recommendation about the size of these small teams. Only when Dick *et al.* describe an actual project, they report actual team sizes, but these sizes are reported as historical facts, and not as recommendations:

> In the Network Rail project, there are some 500 satisfaction arguments that serve to decompose the high-level requirements through to subsystem requirements. A team of between two and five requirements engineers was dedicated to the maintenance of this information over about 3 years.

They appear to use "brainstorming" to describe meetings that go beyond just the basic creative idea generation. This generalization of the meaning of "brainstorming" appears to be common in industrial practice. However, with this generalization, it is not possible to apply what is known from empirical studies about brainstorming in its traditional form to all processes they call "brainstorming".

In the second textbook of the table, Robertson and Robertson name "requirements analyst", "business analyst", and "project manager" as roles to be included in the project team that develops a CBS together with more traditional roles such as "developer"[11]. They suggest that the best requirements analysts have many skills, including listening, understanding, translating, modeling, inventing, negotiating and mediating, iterating, and organizing. They discuss the problems of team productivity and composition. Concerning a team's productivity, Robertson and Robertson cite Brooks's recommendation not to add people to a late project in order to avoid making it even more late. However, they offer no other hint about team sizes.

To find a response to any business event, Robertson and Robertson suggest having an event workshop, an intensive session involving stakeholders and analysts. They suggest creativity techniques, such as innovation workshops and brainstorming, as ways to trawl for, i.e., to elicit, requirements from stakeholders. That said, they nevertheless emphasize that often requirements need to be invented not elicited.

In the third textbook of the table, Wiegers and Beatty describe RE in terms of team activities. One such team activity is the requirements workshop (RWS); it should be kept small, but it should include the right stakeholders. The roles of an RWS include a facilitating business analyst (BA), a project manager, a product manager, a product owner, a subject matter expert (SME), a developer, and sometimes even a user. If each role is played by a different person, this recommendation implies a team of seven members. On the other hand, Wiegers and Beatty say that a small team works much faster than a larger team, because "workshops with more than five or six active participants can become mired in side trips, concurrent conversations, and bickering". That is, communication problems are considered harmful to team productivity. Also, they advise running multiple workshops in parallel in order to explore the requirements of different user classes.

Wiegers and Beatty say that the skills of a BA must include

> communication, facilitation, and interpersonal skills with technical and business domain knowledge and the right personality for the job. Patience and a genuine desire to work with people are key success factors .... Knowledge, experience, and the authority to make decisions are qualifications for participating in elicitation workshops.

In addition, a BA needs to know how to apply a variety of different elicitation techniques, according to what the current situation demands.

[11] The literature *and* this paper tends to use all variations of the verb "to develop" *but one* as applying to the whole of a project to build, construct, etc. — i.e., to develop — a CBS. The one exception is the specific word "developer" that tends to be used strictly to name someone who converts specifications or ideas into code. Thus, someone playing the role of RA is not considered by most to be playing the role of developer.

They provide rules of thumb for the number of people to put into development, not RE, groups. For example, for software to be developed from scratch, for each 1 BA, 6 developers are needed to write the software; that is, each BA can produce requirements that will keep 6 developers busy writing code. However, for software to be developed out of commercial-off-the-shelf (COTS) components, for each 3 BAs, only 1 developer is needed to write the glue software pasting the the COTS software together.

For inspecting a requirements document, Wiegers and Beatty recommend having several small groups inspecting the same document in parallel and then combining their defect lists, while removing any duplicates. They say that "Research has shown that multiple inspection teams find more requirements defects than does a single large group."[12]

Among requirements elicitation techniques, in addition to JAD, a group technique, Wiegers and Beatty suggest brainstorming with the support of a mind-mapping tool. However, they frequently use the term "brainstorming" as a synonym of meeting and not as the name of a full-fledged technique, based on a few clear principles and guidelines.

In the fourth textbook of the table, Maciaszek describes what he calls requirements determination as a two-step process in which BA and system analyst are the main roles. A BA has to discover a CBS's requirements by consulting with the CBS's customers and experts in the CBS's domain, unless he or she already has sufficient experience with this domain. Maciaszek considers working in groups as relevant in almost all development phases, including testing, which is to be assigned to a CBS quality assurance group[13]. In the initial phases of a CBS development project, when a business process redesign (BPR) and the identification of the related requirements are necessary, Maciaszek suggests that a team should be responsible for one or more end-to-end business processes. He highlights (1) the synergies among team members as critical and (2) the need "to align personal goals with organizational strategies and objectives emphasize teamwork".

The only indication of recommended team sizes that Maciaszek offers are for the teams that are developing a CBS's GUI (graphical user interface), whose design in general requires an interdisciplinary approach, and in turn, a number of experts:

> Good GUI design requires the combined skills of a graphic artist, requirements analyst, system designer, programmer, technology expert, social and behavioral scientist and perhaps a few other professions, depending on the nature of the system. [28, p. 387]

He says that for the design of a GUI for a small CBS, for which a formal approach is not necessary, a team of 10 developers is preferred.

Maciaszek describes the role of teams in other methods and organizational structures, such as Agile methods, Rapid Application Development (RAD), and SoftWare Action Teams (SWAT). However, for requirements identification techniques, Maciaszek says that every modern group technique for requirements elicitation involves group dynamics. He describes one of them, brainstorming, as a requirements elicitation method that "can help [an analyst] to be a bit more creative". For a brainstorming session, Maciaszek suggests having from 12 to 20, more than recommended in the original description of the technique [41,42]. He describes JAD as a brainstorming-like technique, while suggesting that the number of people to participate in a JAD group should not be more than 25 to 30. However, these recommendations are for groups working in the whole development process and are not for requirements elicitation groups.

In the fifth textbook of the table, Laplante introduces RE and describes the different roles that a competent requirements engineer has to play: software or systems engineer, subject matter expert, architect, business process expert. He then describes the skills each role needs. He explains that the RE for any particular CBS may need to involve different analysts, each playing one or more of the roles. Laplante's list of roles is actually a different approach, to illustrate the skills needed to be a competent RA, and in turn, to illustrate the need to involve different RAs in any RE activity.

Laplante devotes a whole section to group work in his chapter on requirements elicitation, in which he describes many specific requirements elicitation techniques. In this section, he explains that many of these techniques, e.g., brainstorming and JAD, benefit or require group work. He gives a number of recommendations, e.g, "Stay on the agenda throughout the meeting (no meeting scope creep)" and "Allow all to have their voices heard" that help a group to be productive while avoiding the risk of conflict and divisiveness. Other than the fact that the risk of conflict and divisiveness that can reduce a group's productivity arises at least partially from having too large a group, there is no discussion about the number of members a group should have.

[12] We did not copy this quotation incorrectly. It *does* use "team" and "group" to mean the same thing.

[13] Almost all the textbooks describe testing as a team activity.

In the sixth textbook of the table, Leffingwell and Widrig describe CBS development as a team activity; thus, so is requirements elicitation. They also state that larger teams need heavier methods. Their approach to RE is based on what they call six "team skills":

1. analyzing the problem,
2. understanding user needs,
3. defining the system,
4. managing the system's scope,
5. refining the system's definition,
6. building the right system.

The first skill, analyzing the problem, includes identifying stakeholders and users so that they may be involved in modeling the business. The second skill, understanding user needs, includes eliciting requirements which are a reflection of user needs. A system analyst leads and coordinates requirements elicitation.

Besides traditional requirements elicitation techniques, such as interviewing, questionnaires, and prototyping, most of Leffingwell and Widrig's suggested techniques are team techniques: requirements workshops, brainstorming, and role playing. They express a strong preference for workshops, which is, in their minds, the most powerful technique for eliciting requirements. They say that it is "the one to choose if you have only one to pick up". Leffingwell and Widrig describe a brainstorming session as the most important part of requirements workshops:

> Whether you are in the workshop setting of or whenever you find yourself needing new ideas or creative solutions to problems, brainstorming is a very useful technique. It's simple, easy to do, and fun. [27, p. 102]

A requirements workshop team must include all significant stakeholders plus one facilitator.

Leffingwell and Widrig give very general suggestions concerning the make up and conduct of a CBS development team, i.e., for the entire development process. In particular, for the skill of building the right system, they recommend to keep the team's size from small to moderate, from 10 to 30 members, to cover all the necessary roles and activities. However, in the real-life case used to illustrated their approach, neither a requirements engineer nor an RA is included. They give another recommendation to deal with a need to add a new team member, who must be able to participate in a coordinated team effort and to communicate effectively with the other members. Leffingwell and Widrig, in considering the role of creativity in requirements elicitation, emphasize that in a brainstorming session "having ideas that can be easily pruned is an indicator of a quality process. The absence of a fair number of wild and crazy ideas indicates that the participants were not thinking far enough 'out of the box'".

The seventh textbook of the table, van Lamsweerde's RE textbook, at 682 pages, is the second largest listed in the table. Van Lamsweerde covers requirements elicitation in the second out of 18 chapters. Very early in the chapter, he emphasizes stakeholder identification as enabling effective interaction with stakeholders for requirements elicitation. He divides requirements elicitation techniques into two kinds, (1) artifact driven, based on artifacts used to gather useful information, such as questionnaires, scenarios, and prototypes, and (2) stakeholder driven, based on different forms of interaction with system stakeholders and users, such as interviews and observations. The stakeholder-driven techniques include also group sessions. A group session is organized in the form of a group workshop in which participants have defined roles: leader, moderator, manager, user, and developer. Apparently, the number of people in a group depends on the number of representatives of roles. Van Lamsweerde suggests JAD as a variant of a group session. He proposes brainstorming as an unstructured group session, in which participants have less defined roles. Brainstorming is run in two stages, idea generation and idea evaluation, based on rules derived from those of the traditional brainstorming technique [41, 42], but with no suggestion of the number of people to be involved.

The discussion of the pros and cons of groups emphasizes

- on the pro side, (1) the synergies that support conflict resolutions and (2) the idea that finding new ways to address a problem fosters the desired creativity, and
- on the con side, the group dynamics that (1) can be time consuming and (2) can lead to lack of focus, rambling discussion, and superficial coverage of technical issues, working against the efficiency and effectiveness of the group.

Van Lamsweerde cites group size in RE as a parameter to be evaluated if an Agile approach is deemed suitable for the project at hand. In particular, he says that "the project has to be sufficiently small to be assignable to a single, small-size, single-location development team". However, he does not give more specific numbers.

Sommerville, the author of the most popular SE textbook, co-wrote two RE textbooks, one with Kotonya and another with Sawyer.

In the eighth textbook of the table, one of the shortest of the RE textbooks, Kotonya and Sommerville focus on the RE process, its activities, and its techniques. Their starting point is that "as there is no one catch-all technique applicable to all types of systems, requirements engineers need to know about a range of different techniques." They describe the roles that are needed for the activities in the RE process and state that each role may have a person or a group playing it.

Kotonya and Sommerville illustrate a variety of elicitation techniques: interviewing, software system analysis, scenario analysis, ethnography, prototyping and requirements reuse. They also introduce a viewpoint-oriented requirements analysis technique and say that it has to consider the needs and goals of a variety of different stakeholders, such as users and related interacting systems. They observe that RE is a human endeavor. Therefore, each method needs to be able to support multiple people to communicate effectively. In their descriptions of activities and techniques, they only rarely mention teams and how activities and techniques are affected by or affect teams. Among the exceptions, teamwork and team distribution are described as factors that have to be manifest in the requirements database and a problem to solve for effective requirements analysis. The size of teams is cited as one of the factors influencing traceability, but in all the other mentions, no advice is given on the size of any group.

Kotonya and Sommerville do discuss team membership for the requirements review activity. They observe that a program inspection team normally has 4 or 5 members. However, a requirement review "may involve a varying number of people ranging from 3 to perhaps 10 people. There is no ideal size — it depends on the size of the system and the number of stakeholders who are likely to be affected by the system."

In the ninth textbook of the table, Sommerville and Sawyer, by their practical-sounding textbook title, imply that the goal of their textbook is to illustrate "guidelines which reflect the best practice in requirements engineering". Throughout the textbook, they use the phrase "discovering ... requirements", a creative process, to describe the first step of the RE process, the step that is normally called "requirements elicitation".

Sommerville and Sawyer mention the roles of RA and requirements engineer and of stakeholder representative. Based on their experience in research and in CBS development, Sommerville and Sawyer propose 66 guidelines, or key good practices, to improve RE processes. Some of the guidelines are specific for discovering requirements. Concerning teamwork, Sommerville and Sawyer give almost the same general recommendations as the other textbooks. Specifically, they say that teams are necessary to improve the RE process, to review and validate requirements, and in general, to apply the practices suggested by the Capability Maturity Model [43].

Sommerville and Sawyer introduce the issue of team size and composition in a guideline about introducing traceability. They suggest that a team that is large or is not located in one place needs more formal and detailed traceability policies than do other teams.

Elsewhere, they suggest that to institute the practice of formal specification in an organization, it should choose as a pilot project the development of a CBS small enough that a small team suffices.

In another guideline, Sommerville and Sawyer emphasize that when there are many teams or there are teams working in different locations, requirements management has to be supported by a requirements database. However, they do not discuss the use of teams in the context of discovering requirements, and in the first part of the textbook, they say nothing about the need for teamwork in RE activities.

Sommerville and Sawyer suggest brainstorming, as a creative technique, in order to identify and analyze hazards in a CBS. However, at the same time, they say that creativity may not be necessary.

The tenth textbook of the table, Pohl's RE textbook, at 813 pages, is the largest listed in the table, and it is the most recent. Pohl gives a comprehensive description of a variety of requirements elicitation techniques, whose common goal is to develop also "new and innovative requirements". He emphasizes that RE is a process performed by teams. Teams' doing processes allows team members to influence each other for the benefit of the whole team. Therefore, he suggests group work for many of the RE activities, including to evaluate the relevance of stakeholders and to find new and innovative requirements.

He gives detailed descriptions and illustrations of many techniques, including group techniques: group interviews; JAD; group workshops, focus groups. For a workshop, Pohl suggests inviting between 5 and 15 participants, to be able to include representatives of all relevant stakeholders and experts to cover all the types of requirements. On the other hand, he says that it is necessary to avoid too-large groups, which suffer the negative effects of group-communication overhead. To address the tradeoff between too-small and too-large groups, he suggests splitting a large group into sub-groups for specific processes. Pohl does give advice on what to do when the problems, such as conflicts and contradictions, associated with group communication surface, e.g., regard them as opportunities for negotiating and coming up with innovative ideas and solutions A workshop should be moderated, if possible, by an external moderator. Pohl discusses negative effects arising in group work, including the so-called group-thinking effect, in which less dominant participants tend not to express their ideas.

Pohl describes brainstorming as an assistance technique, i.e., a technique that can be applied, for example, in a workshop in which participants are selected from the stakeholders. For brainstorming, Pohl suggests using from 8 to 10 of the participants of the workshop. If more than 10 brainstormers are needed, then the brainstormers should be split into sub-groups. Another assistance technique is the KJ technique [40], so named after its inventor, Jiro Kawakita. The original version of the KJ technique includes individual brainstorming as its first step. KJ is a group technique, and Pohl suggests to limit its group size to five or six participants.

2.2.3 Conclusions for the RE Textbook Review

Recall that the scenario driving decisions concerning the conduct of the study to review SE and RE textbooks is that an RA needs advice on staffing ReqElic activities in a CBS development project and on the GvsI issue for these ReqElic activities. The RA consults the SE and RE textbooks that he or she used during his or her education as an RA. The main result of the RE textbook part of the study is that the RA will find only generic advice.

Almost every reviewed RE textbook recommends group work as important for conducting good RE. However, there are differences in how work group is introduced. Some textbooks, i.e., those by Wiegers and Beatty, by Widrig, and by Pohl, suggest work group more strongly than others and describe RE specifically in terms of group activities. On the other hand, some textbooks, i.e., by Kotonya and Sommerville and by Sommerville and Sawyer, rarely mention group work. Each of the textbooks in Table 2 that talks about group work, talks about it for the entire RE process. Very few textbooks describe group work specifically for carrying out ReqElic activities. For example, the textbook by Laplante devotes a whole section to group work in the chapter on requirements elicitation. Thus, only a few RE textbooks actually address the research question and the GvsI issue for ReqElic activities.

In some of the textbooks, i.e., those by Robertson and Robertson and by Maciaszek, the relevance of RE in the SE process is reflected in the new specialized role of RA, BA, or both. Nevertheless, many of the RE textbooks, i.e., those by Robertson and Robertson, by Wiegers and Beatty, by Laplante, by Leffingwell and Widrig, by Dick *et al.*, and by Sommerville and Sawyer, describe skills for this role. Basically, an RA or BA has to have both soft skills — the ability to effectively interact inside and outside groups, and to act as a stakeholder representative — and hard skills — the ability to apply SE, RE, and business knowledge. The descriptions of these skills are used to give suggestions for the composition of groups, starting from the basic consideration that any productive group has to include RAs and BAs that cover all the named skills.

For group activities in RE, almost every textbook suggests workshops. Some textbooks recommend workshops specifically for requirements elicitation. For example, Wiegers and Beatty suggest requirements workshops; Robertson and Robertson suggest event workshops, and Van Lamsweerde suggests group session in which each participant has defined roles; and Leffingwell and Widrig consider requirements workshops to be the most powerful requirements elicitation technique.

Similar to the SE textbooks, many an RE textbook suggests creativity techniques, usually brainstorming, to help elicit requirements. Sommerville and Sawyer suggest brainstorming for the specific purpose of identifying hazards in a CBS; they add that creativity may not be necessary for this specific kind of brainstorming. Many an RE textbook suggests group techniques other than brainstorming for requirements elicitation, usuall JAD.

For the application of group techniques, some textbooks provide recommendations on group sizes. Those that suggest workshops, recommend — in different ways and for different reasons — to keep groups small, but to include the right participants. The common goal for these recommendations is to minimize group dynamics and to maximize skill and stakeholder coverage. For example, Dick *et al.* recommend splitting a large workshop team into small teams, but say nothing about the sizes of these small teams. Pohl suggests 5 to 15 participants to represent all relevant stakeholders and to cover all the types of requirements. He advises avoiding too-large groups that suffer the negative effects of group-communication overhead by splitting a large group into sub-groups, each for a specific process. Robertson and Robertson recommend not to add people to a late project, to avoid making it even later; however, they offer no other hint about group sizes. Wiegers and Beatty say that a small team, with 5 to 6 participants, works much faster than a larger team. For a brainstorming session, Maciaszek suggests having 12 to 20 participants, even though the original description of brainstorming recommends that each brainstorming group should have 12 participants [42], For a JAD group, he suggests having even more, namely 25 to 30 participants. Leffingwell and Widrig recommend that a group should have 10 to 30 participants, to cover all the necessary roles and activities. However, these recommendations are for groups working in the whole RE process, to cover all roles and activities, and are not specifically for ReqElic groups.

Van Lamsweerde says that it is possible to adopt an Agile approach for a CBS project and assign it to a small group, if the CBS to be developed is small enough. However, he does not give specific numbers to quantify either the size of the project or the size of the group.

Finally, Kotonya and Sommerville discuss the size of a team that is conducting a requirements review. They say that such a team normally has 4 or 5 members. They emphasize that there is no ideal size, as it depends on the size of the CBS being developed and on the number of stakeholders.

In conclusion, many RE textbooks give recommendations for sizes of groups for RE as a whole and for specific RE activities. However, few give recommendations for sizes of groups specifically for ReqElic activities. The recommendations that are given are explained in qualitative terms, e.g., not to be too big and to cover needed expertise. Most importantly, none gives data-supported advice for the GvsI issue relative to ReqElic activities.

3 The Online Survey

3.1 Design of the Survey

To investigate the research question defined for our study, we designed a survey based on an online questionnaire. In designing the questionnaire, we took into account general guidelines and good practices for questionnaires [36, 54]. We designed a pilot questionnaire with only 12 questions, mostly multiple-choice questions. A few questions were open, asking the respondent to complete a partial sentence, such as "Three factors that cause me to recommend using *xxx* for *yyy* are ...". We gave the pilot to three practicing RAs that we knew personally. We were able to validate that the questions were understood as we intended them to be. In addition, we received some suggestions to improve some of the questions. These suggestions included simplifications of the wording of some questions, making sure that the same word is used for any concept throughout the questions, making the wording of some related questions more uniform, and providing more and better choices for answers to some questions. In particular, we decided to abbreviate "requirements elicitation" everywhere in the questionnaire by "ReqElic", to distinguish it from "RE", which is the more general "requirements engineering". We abbreviated also "business or requirements analyst" as "BoRA" Finally, we decided to provide an incentive to answering the questionnaire by offering each respondent an opportunity to win a copy of some RE books.

Based on this feedback, we designed the final questionnaire with 12 questions, Q1–Q12, each of which has from one to four subquestions, for a total of 19 subquestions to answer. A so-called question is a place holder for its answerable subquestions. Overall, the questions ask each respondent about how ReqElic is done in CBS development projects at his or her company. Among Q1–Q12, each of the 15 subquestions of Q1–Q8 is multiple choice, Q9 is open, asking the respondent to explain his or her answer to the multiple-choice subquestion of Q8, and each of Q10–Q12 is open, asking the respondent to complete a partial sentence.

Each of the 13 multiple-choice subquestions of Q1–Q6 asks the respondent how frequently something X happens in CBS development projects at his or her company. The subquestion simply *asserts* X. Then the respondent indicates how often X happens by choosing one of four possible answers[14]. The possible answers to an assertion are variations of "in all our projects", "in most of our projects", "in some of our projects", and "in none of our projects". Thus, each possible answer is a *frequency* of X's happening, in terms of a coarse-grained estimate of the fraction, among all CBS development projects in the respondent's company, of the projects in which X happens. Occasionally, each "project" in the four possible answers for a subquestion of this form is qualified by the same adjective, e.g., "complex", limiting the kind of project to be considered in answering the subquestion.

In more detail:

- The four subquestions of Q1 ask the frequency with which the respondent plays, in his or her company, each of four different CBS development roles that include three RE roles that, in turn, include two ReqElic roles.

[14] A possible answer is called a "modality" in the statistical literature.

- The three subquestions of Q2 ask the frequency with which requirements identification is done in the respondent's company in each of three different configurations of working individually or in a group in the respondent's company.
- The three subquestions of Q3–Q5 ask the frequency with which requirements identification is done in the respondent's company in groups for each of three different kinds of projects. For each of these subquestions, each "project" in the possible answers is qualified by the kind, i.e., "large", "tight-deadline", or "complex", of project the subquestion is about.
- The three subquestions of Q6 ask the frequency with which each of three specific ReqElic techniques is used in ReqElic group activity sessions in the respondent's company.
- The one subquestion of Q7 asks to choose the usual group size in the respondent's company, in terms of one of five specific numbers of BoRAs.
- The one subquestion of Q8 asks to choose the ideal group size in the respondent's company, in terms of one of three specific configurations of 4 individuals and 0, 1, or 2 groups.
- The one subquestion of Q9 asks for an explanation of the respondent's answer to Q8.
- The one subquestion of Q10 asks to list three factors that cause the respondent to recommend using groups of BoRAs for ReqElic.
- The one subquestion of Q11 asks to list three factors that cause the respondent to recommend not using groups of BoRAs for ReqElic.
- The one subquestion of Q12 asks to list three keywords that characterize the domain or sector of the respondent's company's software system development projects.

In the rest of this paper, when Qn has only one subquestion, something like "the subquestion of Qn asks" is written as simply "Qn asks".

3.2 Realization of the Survey

In the end, in late August 2012, we deployed at GoogleDocs, now GoogleForms), an online questionnaire titled "Requirements elicitation (ReqElic) in my company" [31]. To implement the planned incentive to answer the questionnaire, we added a last question, Q13, inviting the respondent to be entered into a drawing to win a copy of the proceedings of the next REFSQ (Requirements Engineering: Foundation for Software quality) Conference. We began to solicit respondents through a variety of venues. We sent an advertisement describing the questionnaire to RAs or software development managers that we knew and asked that they send the advertisement on to other people in similar roles. We posted the advertisement and the propagation request on the Facebook, Google+, LinkedIn, ResearchGate, Slideshare, and Twitter accounts of one of the authors. We posted the advertisement and the propagation request also on several e-mail lists, e.g., IIBA, INCOSE, Requirements Engineering Network's forum, RE-online, and Yahoo's Requirements-Engineering Group. We posted also at several LinkedIn groups, including AICA, Community of Practice Systems Engineering (CoP SE), America's Requirements Engineering Association, Business Analysts — Bangalore, ICT Africa, ICT Australia, IEEE Computer Society Italy Chapter, INCOSE, IREB Certified Professional for Requirements Engineering (CPRE), ModernAnalyst.com — Business Analyst Community, Requirements Engineering Specialist Group (RESG), Systems Engineers, and Requirements Engineering. Sometimes we were assisted by the help of a friend who was in a targeted organization and could post advertisements. Thus, we have a convenience-enhanced-by-snowballing sampling.

From the first advertising round, we got 53 answered questionnaires and reported preliminary findings [50]. During a second advertising round, we sent reminders to the groups and communities of the first round, and we sent the announcement to some new target groups and conference attendee lists. After this round, we reached a total of 92 responses [33]. We cannot know the response rate because we have no idea how many people saw the advertised invitation to fill out the questionnaire. However, our analysis of the answers to Q12, which asks a respondent for three keywords to characterize the domain or sector of his or her company's software system development projects, allows us to be confident that the respondents were working in many different domains. To the extent that different companies work in different domains and that each company specializes in few domains, we can be somewhat confident that the respondents are working in many different companies or in at least different divisions of the few large multi-domain companies.

3.3 The Data

Strictly speaking, the conclusion about any subquestion should be in the form "The 92 respondents say that X". However, often the statement of the X involves more than one variables and one clause about each variable. Each clause should be in the form of "The 92 respondents say that ...". Therefore, to simplify the text of the conclusion, we assume that what the respondents say is true, "The 92 respondents say that" is omitted, and X is asserted as a fact. Occasionally, the text reminds the reader that what is written is only what the respondents say.

3.3.1 Q1

The four subquestions of Q1 determine the frequency with which the respondents play, in their companies, each of four different CBS development roles that include three RE roles that, in turn, include two ReqElic roles:

- I'm directly involved as a business or requirements analyst (BoRA),
- I'm directly involved as a software engineer,
- I'm supervising ReqElic as a project manager or similar role, and
- I'm involved in ReqElic as a representative of the client or customer,

and the multiple-choice answer for each subquestion measures the frequency with which the respondent plays the subquestion's asserted role.

Figure 1 shows a graph with four bars, laid out horizontally, one for each of the four asserted roles, each bar divided into four size-significant, color-coded sub-bars, one for each of the four possible frequency answers. In this figure, and in many others, the legend "in X" is an abbreviation for "in X [of] our projects". The four regions of a role's bar shows the distribution of the 92 respondents' frequency answers for the role. Thus, the bars in the figure show the distributions of the 92 respondents' four frequency answers for the four roles. Observe that (1) the two largest "in none" regions are for the roles of being directly involved as a software engineer and involved in ReqElic as a representative of the client or customer and (2) the two smallest "in none" regions are for the roles of supervising ReqElic as a project manager or similar role and being directly involved as a BoRA. Consequently, in the respondents' companies, almost none of the respondents is ever not being directly involved as a BoRA, and a majority of the respondents are never being directly involved as a software engineer. So, it is clear that almost all of the 92 respondents are precisely the kind people the survey was targeting, namely BoRAs. This conclusion establishes the reliability of the questionnaire's answers.

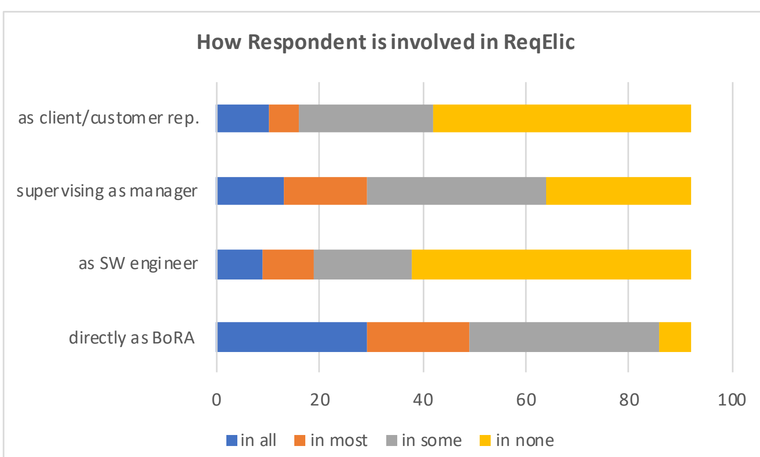

Fig. 1. Responses to Q1

3.3.2 Q2

Q2 is the most important question. Its three subquestions determine the frequency with which requirements identification is done in the respondents' companies in each of three different configurations of working individually or in a group:

- Requirements are identified as an individual activity, by a single BoRA, working alone
- Requirements are identified as an individual activity, by more than one BoRA, each working separately
- Requirements are identified as a group activity.

The bars in Figure 2 show the distributions of the 92 respondents' four frequency answers for the three configurations. Observe that about one and a half times as many respondents are identifying requirements as an individual activity, in any configuration, than as a group activity, in at least some of their projects.

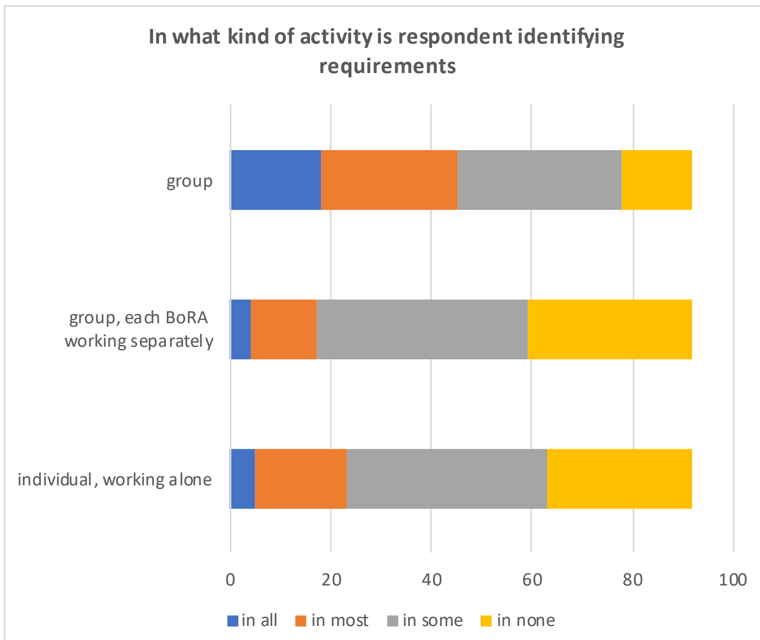

Fig. 2. Responses to Q2

3.3.3 Q3–Q5

The subquestions of Q3–Q5 determine the frequency with which requirements identification is done in the respondents' companies as a group activity for a different one of three different kinds of projects:

Q3: Requirements are identified as a group activity in large projects
Q4: Requirements are identified as a group activity in tight-deadline projects
Q5: Requirements are identified as a group activity in complex (innovative or multi-disciplinary) projects.

The bars in Figure 3 show the distributions of the 92 respondents' four frequency answers for Q5, Q4, and Q3, about the three kinds of projects. Observe that more respondents are identifying requirements in groups when the project is large or when the project is complex than when the project has a tight deadline.

To explore requirements identification as a group activity in in large, tight-deadline, and complex projects more deeply, we conducted pair-wise crossings among Q3, Q4, and Q5. The next section reports the results.

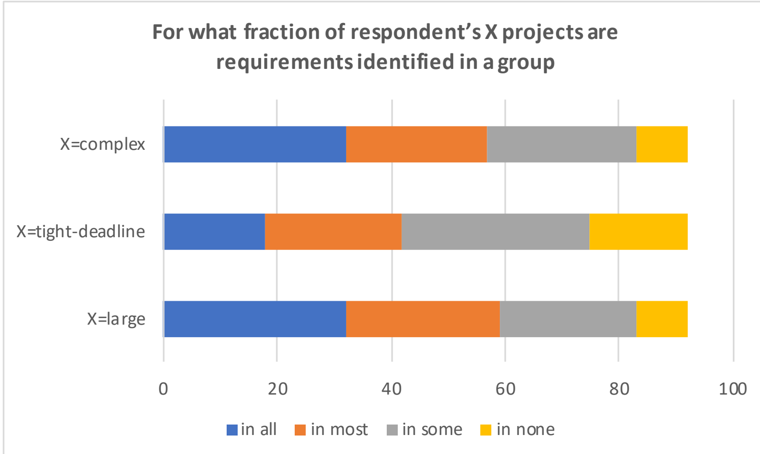

Fig. 3. Responses to Q3 – Q5

3.3.4 Q3, Q4, and Q5 Crossed with Each Other

The graphs of Figures 4, 5, and 6 show the three pair-wise crossings among Q3, Q4, and Q5. In this figure, and in many others, the legend "in X Y" is an abbreviation for "in X [of] our Y projects". Each of these graphs shows the crossing of a question, about how often requirements identification is done in groups in one kind of project, with the same question, but with respect to a different kind of project. These graphs show that there is a strong association between how often requirements identification is done in groups in different kinds of projects.

The more requirements identification is a group activity in one type of project in a company, the more requirements identification is a group activity in other types of projects in the same company. The leftmost bar of the graph in Figure 4 shows that about 48% of the companies that do requirements identification as a group activity in all their large projects, do requirements identification as a group activity in all their tight-deadline projects. The leftmost bar of the graph in Figure 5 shows that about 78% of the companies that do requirements identification as a group activity in all their complex projects, do requirements identification as a group activity in all their large projects. The leftmost bar of the graph in Figure 6 shows that about 53% of the companies that do requirements identification as a group activity in all their complex projects, do requirements identification as a group activity in all their tight-deadline projects.

In addition, the graphs in Figure 3 show that between 9 and 17 of the 92 respondents said that none of the requirements for each kind of project are identified as a group activity in their companies. An examination of the respondents' answers to the survey establishes that the same 9 respondents answer "none" for every kind of project.

3.3.5 Q6

The three subquestions of Q6 determine the frequency with which each of the ReqElic techniques specified in the subquestions is used in ReqElic group activity sessions in the respondents' companies:

- We use JAD in group ReqElic sessions
- We use brainstorming in group ReqElic sessions
- We use other creativity techniques in group ReqElic sessions.

The bars in Figure 7 show the distributions of the 92 respondents' four frequency answers for the three ReqElic techniques. Observe that about five times as many respondents are using brainstorming and other[15] creativity techniques than JAD in group ReqElic sessions, and in fact, in about 80% of the projects. Thus, other creativity techniques *are* being used during ReqElic in RE, probably to help elicit, identify, and generate requirement ideas.

[15] In the context of Q6, "other" means "anything but JAD and brainstorming".

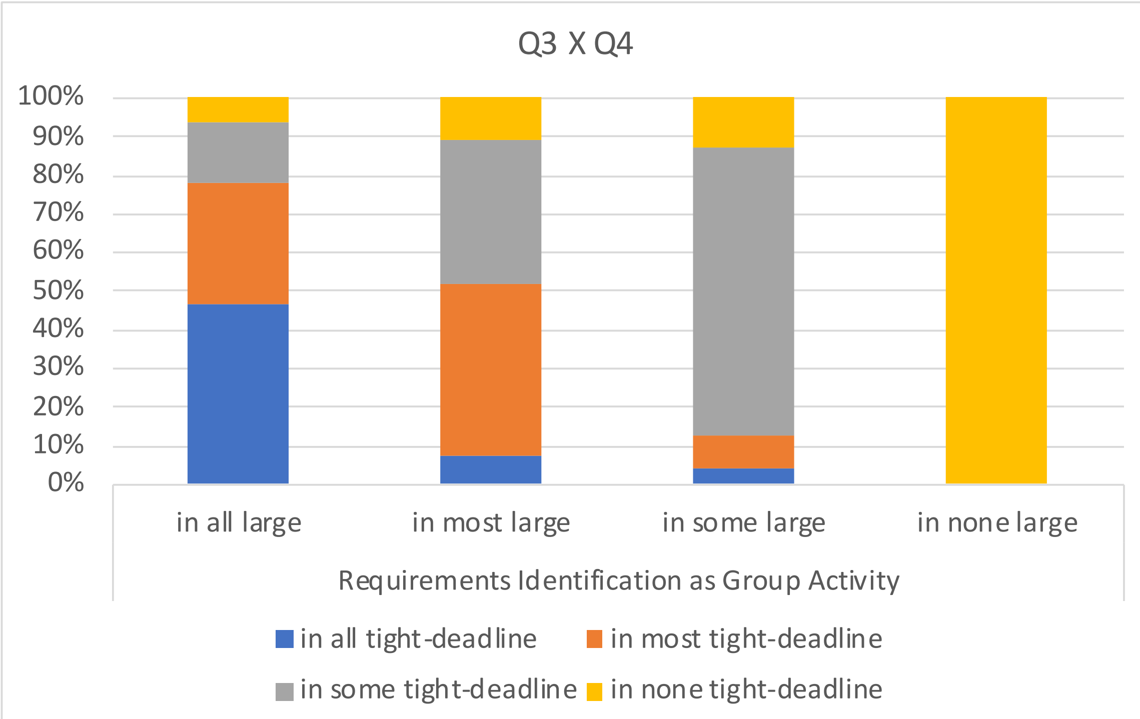

Fig. 4. Q3 × Q4

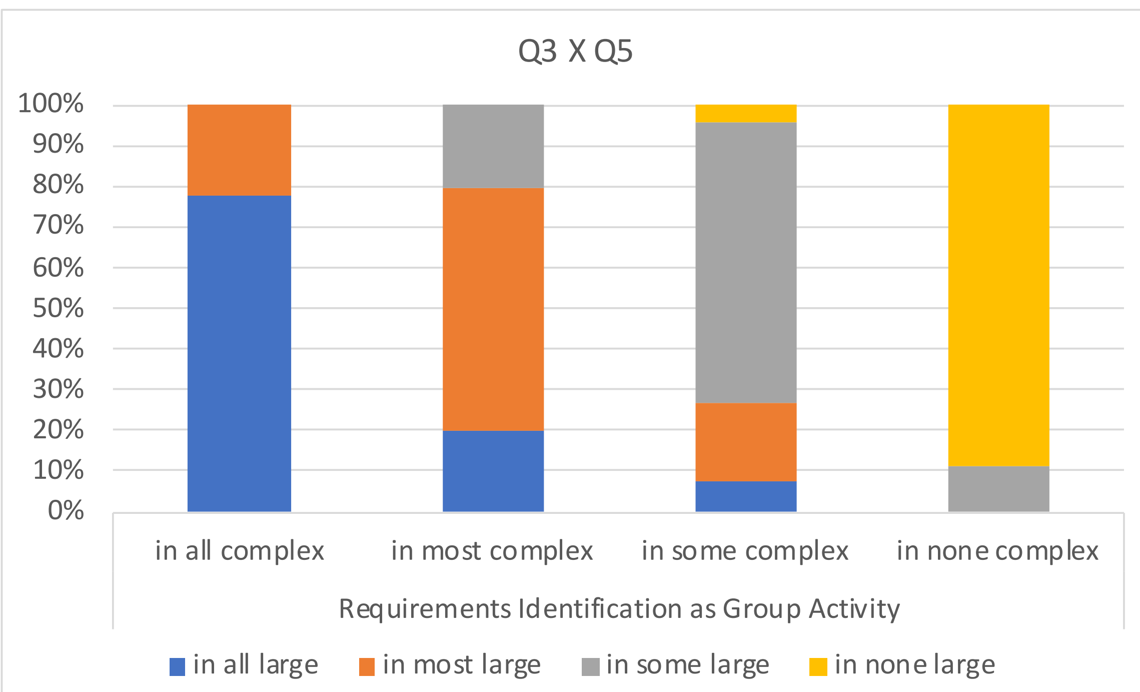

Fig. 5. Q3 × Q5

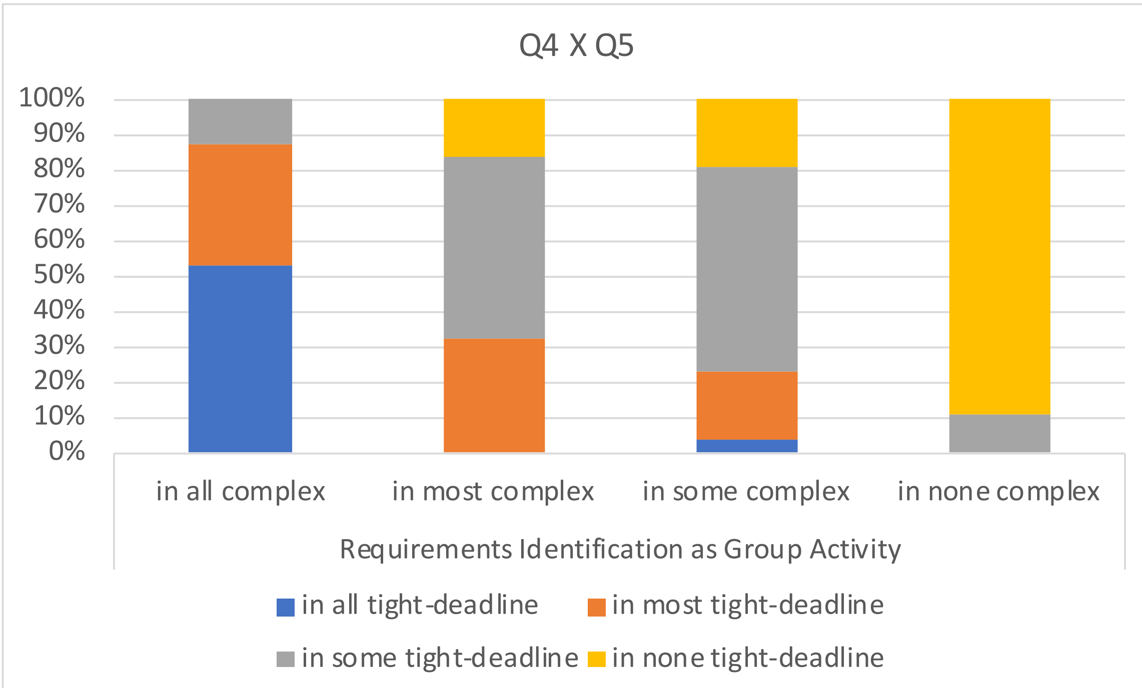

Fig. 6. Q4 × Q5

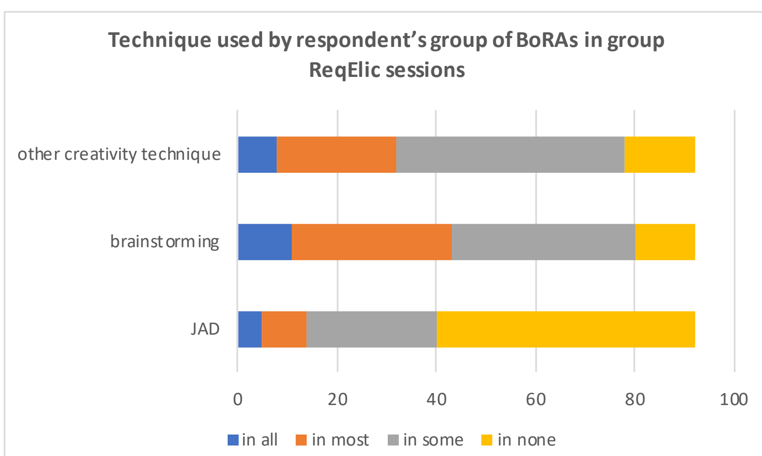

Fig. 7. Responses to Q6

To determine how characteristics of projects, namely size, complexity, and tightness of its deadline, affect the choice of ReqElic techniques, namely JAD, brainstorming, and other creativity techniques, we did a number of cross tabulations.

3.3.6 Q6 Crossed with Q3–Q5

First, we crossed the answers to the subquestions of Q6, about how often specific ReqElic techniques are used in groups, with the answers to Q3, Q4, and Q5, about how often requirements identification is done in groups in each of three kinds of projects, The results of these comparisons are shown in Figures 8, 9, and 10, about large projects, tight-deadline projects, and complex projects, respectively. In the legend of these graphs, “RIG” means “Requirements are Identified in Groups”, and “in X [of] our Y projects” is abbreviated as “in X Y projects”. Appendix A explains how to read and interpret the graph that results from a crossing, using the graph of Figure 8.

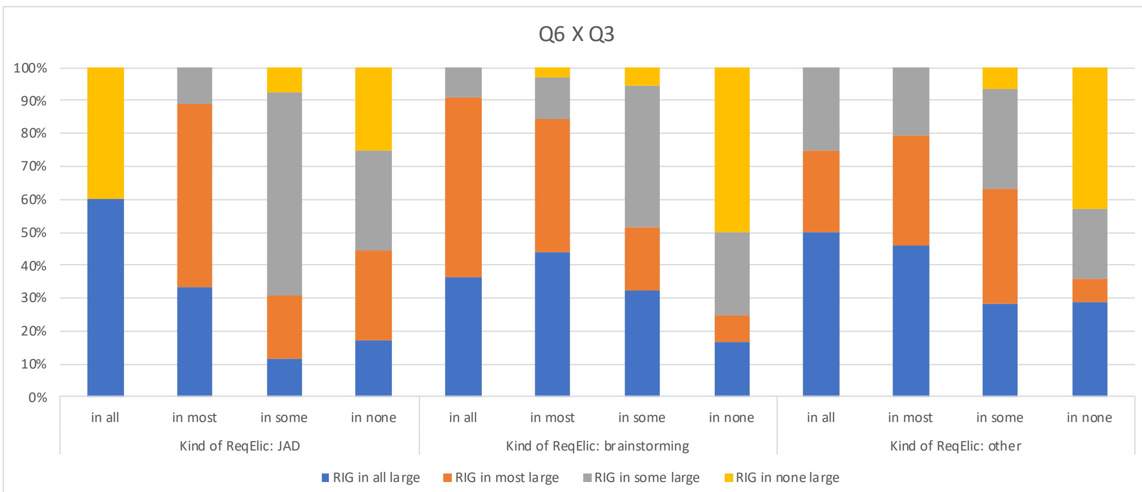

Fig. 8. Q6 × Q3

The graphs of Figures 8, 9, and 10 show that there are differences between the kinds of projects in which JAD is used and the kinds of projects in which brainstorming or another creativity technique is used. The graphs show that independently of the kind — large, tight-deadline, or complex — of project, among the companies in which JAD is used for group ReqElic in all their projects, requirements identification is done in groups in either all projects of the kind or in no projects of the kind.

The graphs of Figures 8 and 10 show also that for two kinds — large and complex — of projects, in each company in which brainstorming is used for group ReqElic in all its projects, requirements identification is done in groups mostly in all or most projects of the kind. In other words, in those companies in which brainstorming is used for group ReqElic in all large and complex projects, whether requirements identification is done in groups is mostly polarized.

In fact, in general, bar-by-bar, the graphs of Figures 8 and 10, about large and complex projects, are similar and are different from the graph of Figure 9, about tight-deadline projects.

3.3.7 Q7

Q7 determines for each of five different sizes, measured in numbers of BoRAs,

- 2 BoRAs,
- 3 BoRAs,
- 4 BoRAs,

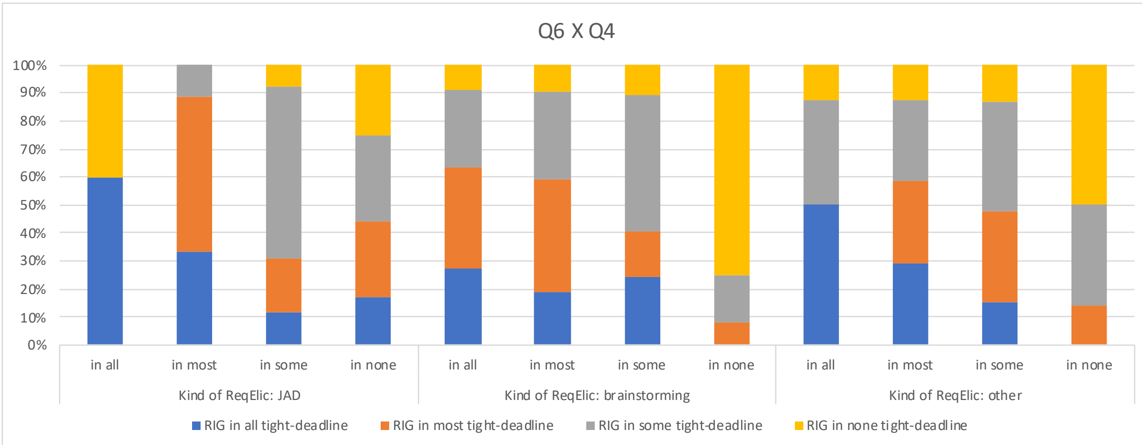

Fig. 9. Q6 × Q4

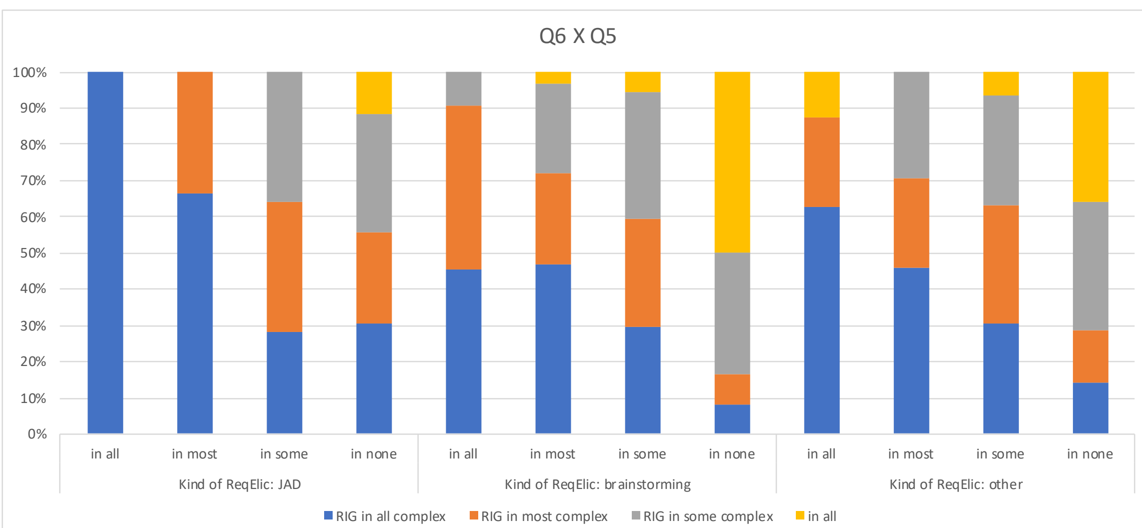

Fig. 10. Q6 × Q5

– 5 BoRAs, and
– >5 BoRAs,

the number of respondents who say that groups in their companies are usually of the size.

The bars in Figure 11 shows the distribution of the group sizes in the companies of the 92 respondents. Clearly, the length, 12, of the bar for “>5 BoRAs” is so much bigger than the length, 1, of the bar for “5 BoRAs” because the bar for “>5 BoRAs” captures all group sizes greater than 5, and probably, the bar for any specific group size greater than 5 would be shorter than the bar for the group size 5. In any case, the sum of the lengths of the “5 BoRAs” and the “>5 BoRAs” bars is less than the length of the “4 BoRAs” bar. Therefore, in the respondents’ companies, the usual group sizes, in order of decreasing occurrence, are actually 2, 3, 4, and >4. In the rest of this paper, “>4 BoRAs” is occasionally denoted as “5 BoRAs or >5 BoRAs”, and in considering graphs involving Q7, the bar for “5 BoRAs” is occasionally ignored.

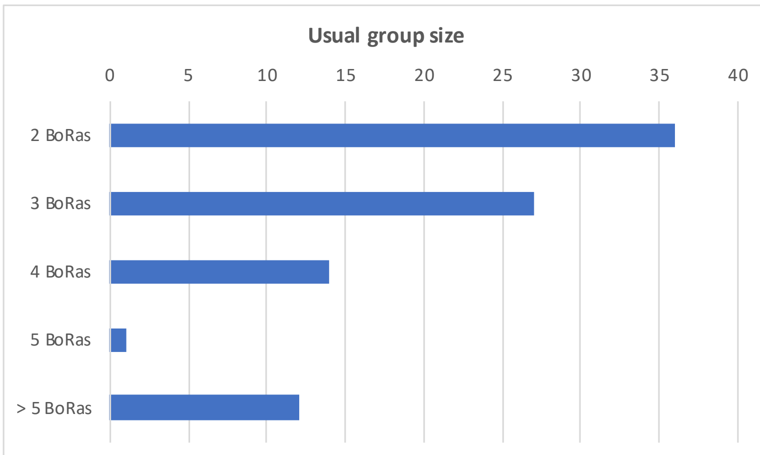

Fig. 11. Responses to Q7

3.3.8 Q8

Q8 determines ideal group sizes in the respondents’ companies, i.e., for each of three different configurations,

– “4 individuals”,
– “2 groups of 2”, and
– “1 group of 4”,

the number of respondents who say that the ideal groups in their companies have the configuration.

The pie graph in Figure 12 shows the distribution of the ideal ReqElic group sizes in the companies of the 92 respondents. In these companies, the ideal ReqElic group sizes, in the order of decreasing frequency, are:

– “2 groups of 2”,
– “1 group of 4”, and
– “4 individuals”.

That is, groups are preferred to individuals, and among groups, smaller groups are preferred. Thus, when there are four individuals available to do a ReqElic activity, they are used to form two groups of two to do the activity more often than to form one group of four to do the activity, and still more often than to leave the four individuals to do the activity alone and separately.

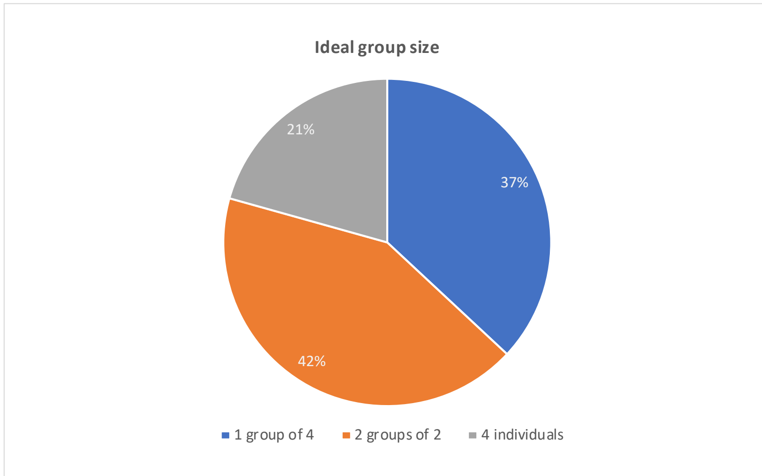

Fig. 12. Responses to Q8

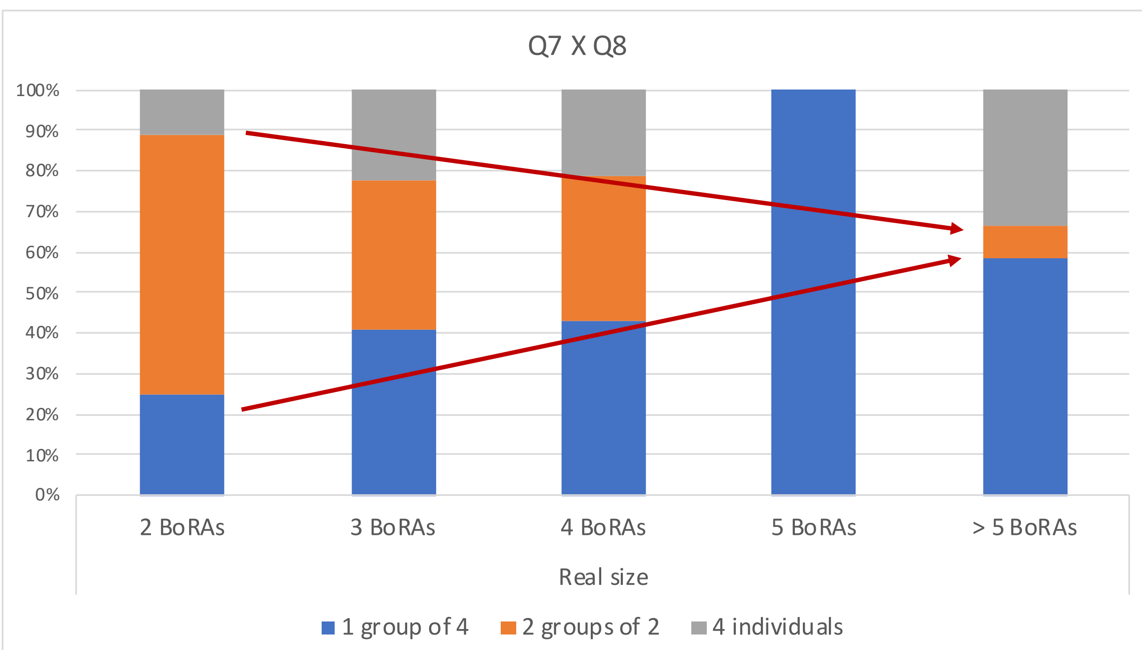

Fig. 13. Q7 $\times$ Q8

3.3.9 Q7 Crossed with Q8

Figure 13 plots the results of crossing the answers to Q7, about usual group sizes, with the answers to Q8, about ideal group sizes. It shows that the larger the usual group size a respondent chose, the less often he or she chose the "2 groups of 2" ideal group size. In fact, 64% of the respondents who chose "2 BoRAs" as the usual group size, chose "2 groups of 2" as the ideal group size, while only 35% of those who chose "3 BoRAs" or "4 BoRAs" as the usual group size, chose "2 groups of 2" as the ideal group size, This percentage shrank to 8% for those who chose ">5 BoRAs". At the same time, as the percentage of the respondents who chose "2 groups of 2" as the ideal group size shrank, the percentage of those who chose "1 group of 4" or "4 individuals" as the ideal group size increased. The arrows superimposed on the graph of Figure 13 show the relation between usual group sizes and ideal group sizes.

3.3.10 Q2 Crossed with Q8

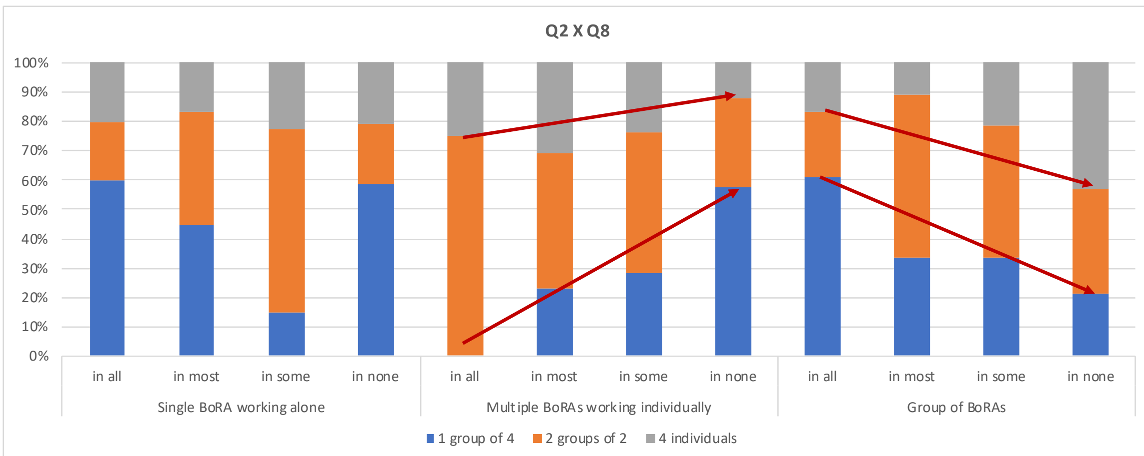

Fig. 14. Q2 × Q8

In the graph of Figure 14, which crosses the answers to the three subquestions of Q2 with the answers to Q8, observe that the "in none" bars in the leftmost two four-bar subgraphs and the "in all" bar of the right most four-bar subgraph are very similar. These bars show that respondents that

1. work more frequently in groups in all their projects, and therefore,
2. work more frequently in other configurations in *none* of their projects,
3. tend to chose "4 individuals" least often as their ideal group size, and
4. tend to chose "1 group of 4" most often as their ideal group size.

The explanations these respondents give in Q9 for these answers mention both (1) problems related with individual work and (2) advantages of group work, and they say, for example:

- "Without working together on the req base, there's going to be lots of inconsistencies and gaps."
- "When 4 individuals are involved in the same project, they must cooperate."
- "I think a group up to 4 members is more creative than one alone. In discussions the members have more new ideas than thinking alone."
- "Each person contributions can build on the others."

On the other hand, the respondents who say that they work in companies in which requirements are identified as an individual activity by more than one BoRA, each working separately do not chose "1 group of 4" as their ideal group size. These respondents chose "2 groups of 2" as their ideal group size more often than "4 individuals". A deeper analysis of the open questions shows the reasons why some people would prefer to work in a configuration that is different from the configuration in which they actually work.

3.3.11 Q3–Q5 Crossed with Q7

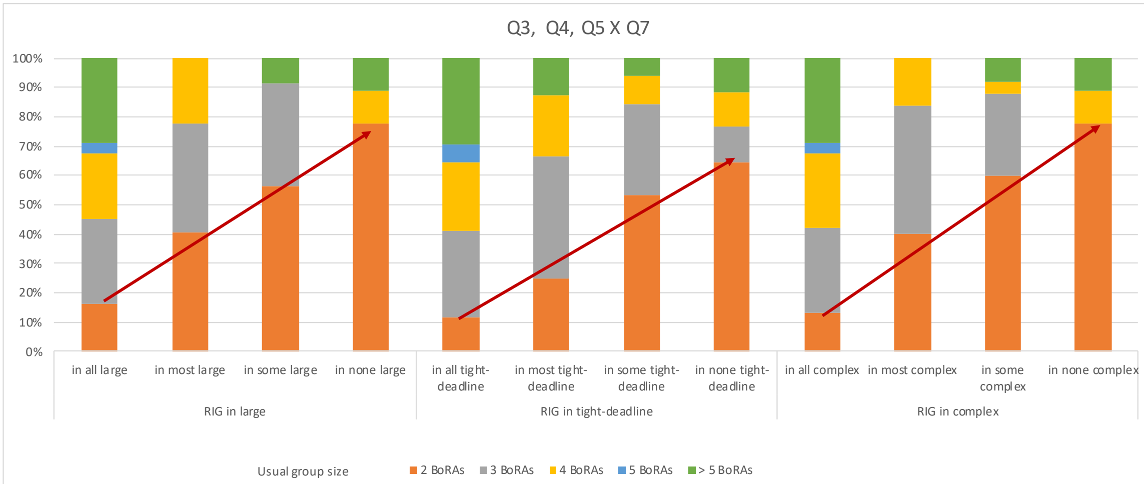

Fig. 15. Q3, Q4, and Q5 × Q7

The graph of Figure 15 shows the result of crossing Q3, about how often requirements identification is done in groups in large projects, Q4, about how often requirements identification is done in groups in tight-deadline projects, and Q5, about how often requirements identification is done in groups in complex projects, together with Q7, about usual group sizes. Bar-by-bar, the three four-bar subgraphs are very similar. In addition, regardless of project type, as illustrated by the arrow skimming the top of the orange subbars in the four bars in each subgraph, the less often requirements identification is a group activity in a company, the more often the usual group size is "2 BoRAs". Conversely, the more often requirements identification is a group activity in a company, the more often the usual group size is one of the larger numbers of BoRAs. In each subgraph, the usual group size of ">5 BoRAs" occurs when requirements identification is a group activity all projects of any kind in a company.

3.3.12 Q9

Q9 is an open question, and it asks each respondent to explain his or her answer to the previous question, Q8, about ideal group sizes. That is, each was asked to explain his or her choice for the ideal group size, "4 individuals", "2 groups of 2", or "1 group of 4". The analysis of the answers was carried out in two passes.

In the first pass, authors Mich and Sakhnini worked together to identify concepts used in the answers that could be used to build a list of factors that would be used in the second pass to classify every explanation by all factors mentioned in it. In this pass, the two authors worked together iteratively. They discussed about ten answers in detail to define a first set of factors. Then, using this set, they tried to classify some additional answers. Whenever they discovered a new factor, they added it to the set. They continued to discuss additional answers until they felt that no new factors would be needed to classify all the answers.

These factors were then grouped into 4 categories:

Relations, including all factors related to communication, coordination, collaboration, responsibility, and viewpoints[16]. All these factors are cited in the literature to support the recommendation to keep groups small, i.e., to be able to trade off between reducing the number of people to minimize the number of relationships and increasing the number of people to maximize the coverage of needed skills.

[16] For an explanation of the relational and individual factors, see Watzlawick et al [60].

People, including factors charactering an analyst as an individual, for example, by his or her expertise and self-confidence.

Project, including all factors related to project management, e.g., project size, timing, and complexity, and available human resources and other costs.

Output, including factors used to described the expected results of requirements idea generation, often described in terms of qualities of requirements specifications, e.g., better coverage, fewer duplicate or conflicting requirements.

In the second pass, the first author worked alone, working directly from the thoroughly-discussed set of factors created in the first pass. She read each answer and classified it with all the factors that appeared in it.

The bars in Figure 16 summarize the answers given to Q9 by showing the number of times factors of each category appeared among the answers. Note that ten respondents did not answer Q9 at all, many answers mentioned factors in more than one category, and some answers mentioned multiple factors in one category. Hence, the sum of the lengths of the bars is not expected to be 92, the number of respondents.

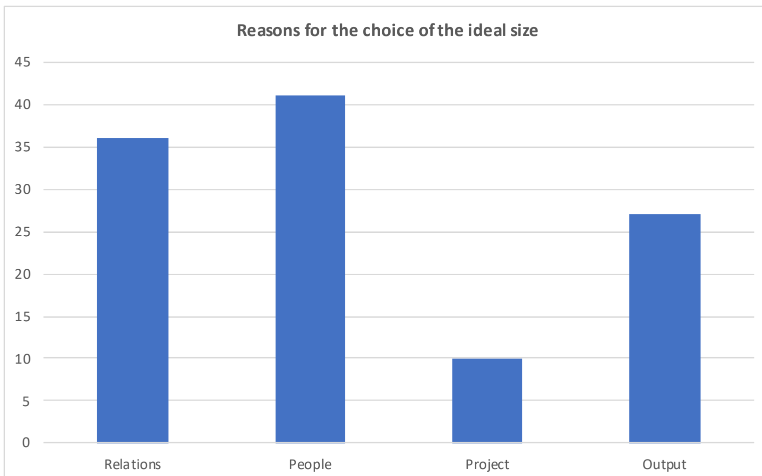

Fig. 16. Responses to Q9

The categories of factors mentioned in participants' answers to Q9 were, in order of decreasing frequency, "People", "Relations", "Output", and "Project". We consider the reasons given, grouped by category:

People: People factors such as "expertise in the project domain" and "expertise in SE methods and tools" are considered to have positive effects on group configurations. The people factors, "self-confidence" and "responsibility", are considered improved by individual configurations.

Relations: The individual and the small-group configurations are considered ways to reduce conflicts. On the other hand, relation factors are considered to have a positive impact by those that suggest the large-group configuration. Good collaboration is considered to have a positive effect on a group's ability to reach better solutions, and it allows the presence in a group of more stakeholders to present more viewpoints. In fact, these human factors, both individual and relational, are the most frequently cited reasons for respondents' answers.

Output: Group configurations help avoid the negative output factors of "duplicates" and "inconsistencies". Individual configurations help achieve the positive output factor of "more original ideas". The "productivity" positive output factor improves in the small-group configurations only if conflicts are avoided.

Project: While project factors were rarely mentioned in the answers, some answers did indicate that it's essential to have more than four in a group that is building a large, complex, or interdisciplinary system.

Interestingly, the terms defining the four categories chosen to classify sentences in the answers given by the respondents to the open questions are factors mentioned in the descriptions of group work in the textbooks reviewed in Section 2.

3.3.13 Q10–Q11

Each of Q10 and Q11 is an open question. Q10 asks the respondent to list three factors that would cause him or her to recommend using groups of BoRAs for ReqElic, while Q11 asks the respondent to list three factors that would cause him or her to recommend *not* using groups of BoRAs for ReqElic. For each respondent, one of these questions would force him or her to play devil's advocate for the position opposite that which he or she took in Q8 and Q9. The answers to these open questions were classified by the factors that were identified for Q9. The results of this classification, abstracted to categories of factors, are shown in the bars in Figures 17 and 18.

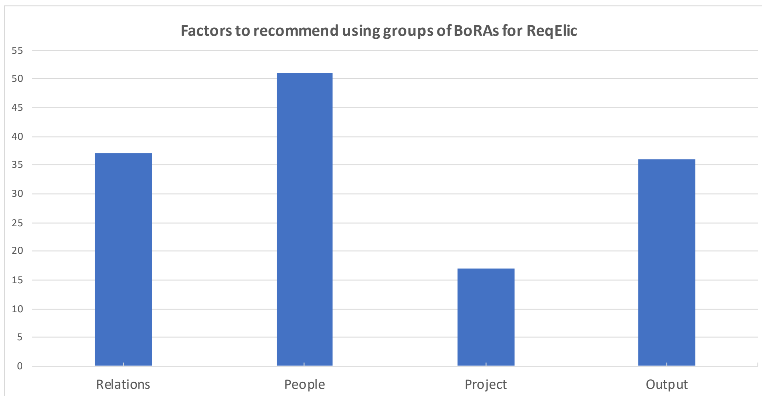

Fig. 17. Responses to Q10

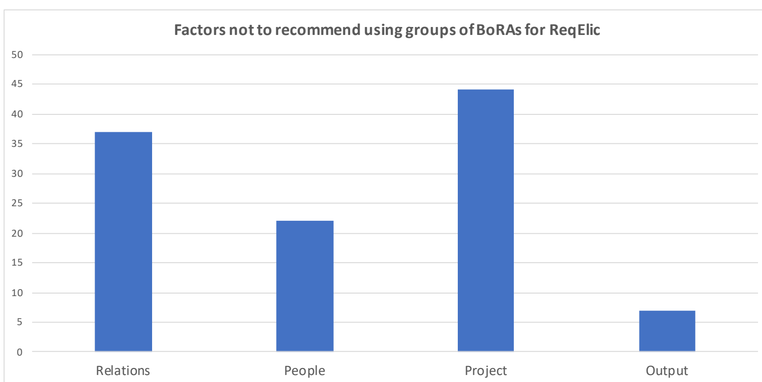

Fig. 18. Responses to Q11

Since 78% of the respondents chose a group configuration as their ideal group size in their answer to Q8, it is no surprise that the graph in Figure 17, giving reasons for his or her recommending using groups of BoRAs for ReqElic, is similar to the graph in Figure 16, giving reasons for his or her choice for the ideal group size. It is no surprise, then, that the graph in Figure 18 differs in three of the four bars from that of each of Figures 16 and 17.

3.3.14 Q12

Q12 asks the respondent to list three keywords that characterize the domain or sector of his or her company's software system development projects. Unfortunately, many a respondent answered with information on the types of systems he or she worked on, and not the domain or sector, per se. So, we followed a two-pass coding procedure similar to that we followed for Q9 through Q11, to identify three main types of projects:

- Information systems (ISs), e.g., Enterprise Resource Planning (ERP) systems,
- Software systems (SWSs), e.g., embedded systems, and
- Web sites, e.g., e-learning sites, e-commerce sites, portals, recommendation systems, user interface systems.

The bars in Figure 19 show the frequencies of these project types among the responses. There is nothing particularly noteworthy in this graph.

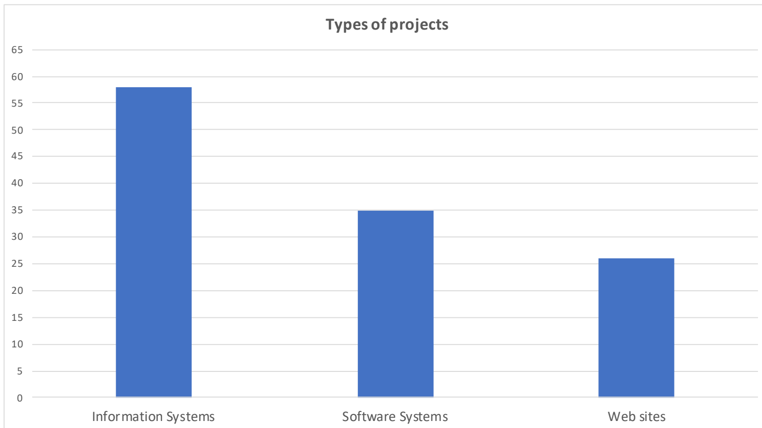

Fig. 19. Responses to Q12

4 Discussion of the Results

The analysis of the answers to the 12 questions in the questionnaire allows illuminating some specific aspects of the GvsI issue in requirements elicitation.

First of all, almost all of the 92 respondents are precisely the kind of people the survey was targeting, namely BoRAs. The answers to Q1, plotted in Figure 1, show that only 7% do not play the BoRA role in any of their projects. An examination of the answers given by each of the 92 respondents to all the subquestions of Q1 [35] shows that many of the respondents play different roles, and among those that play only a single role, all but four play the BoRA role. The role of representative of the client or customer is never the sole role played by a respondent. The percentage of respondents playing this role in all projects is 11%, and the percentage playing this role in at least some projects is 46%.

In Figure 1, the bar for the role of software engineer resembles the bar for the role of representative of the client or customer, and each bar is very different from that for the role of BoRA. The percentage of respondents playing this role in all projects is 10%, and the percentage playing this role in at least some projects is 41%.

An examination of the answers given by each respondent to all the subquestions of Q1 shows that many of the respondents play more than one role. In particular, many respondents that are directly involved in ReqElic as BoRAs are directly involved also as software engineers and as representatives of the client. Respondents' playing multiple roles in a CBS project indicates that in their project, an individual is working in multiple parts of the CBS development lifecycle, and that, in turn, the projects can avoid the need of a large group to provide all the needed domain knowledge and expertise [44].

The answers to Q2, plotted in Figure 2, show that only 15% identify requirements in groups in none of their projects. Thus companies do adopt group work for requirements identification. However, the same graph shows that, in about $\frac{2}{3}$ of the companies, requirements are identified in at least some of their projects as some sort of individual activity, as carried out by more than one BoRA, each working separately, in 68% of the companies, and as carried out by a single BoRA, working alone, in 64% of the companies.

The answers to Q3, Q4, and Q5, plotted in Figure 3, show that requirements are identified in groups more frequently, in large and complex projects, i.e., in 90% of each kind of project, than in tight-deadline projects, i.e., in 82% of the kind of project. An examination of the answers given to Q2, Q3, Q4, and Q5, showed that 6 respondents answered Q2 that requirements are never identified as a group activity in their companies but nevertheless answered the questions Q3, Q4, and Q5 about group activity in ReqElic as a function of project types. This apparent contradiction is resolved by examining the 6 respondents' answers to the open questions, Q9 – Q12. They apparently consider individual requirements elicitation as preparation for subsequent activities, such as adding and discussing new ideas, which are done naturally in groups.

The answers to Q6, plotted in Figure 7, show that

- 87% of the respondents say that brainstorming is used, and
- 85% of the respondents say that other creativity techniques are used, while
- 43% of the respondents say that JAD is used

in group ReqElic sessions, in at least some of the projects. Increased creativity or something similar is cited in many of the explanations given as answers to Q9, for preferring the use of groups instead of individuals as ideal sizes and in many of the factors given as answers to Q10, to recommend using groups of BoRAs for ReqElic. Words related to "creativity" or "brainstorming" appear in 29 answers to Q9 and Q10. Words related to "viewpoints" and "stakeholders", mainly in connection with JAD, appear in 17 and 15 answers, respectively, to Q9 and Q10.

The answers to Q7, plotted in Figure 11, show that companies adopt different usual group sizes, but 68% of the respondents say that the usual group size is one of the two smaller group sizes, 2 or 3.

The core question of the survey is Q8, about ideal group sizes, whose answers are plotted in Figure 12. The question was formulated to have respondents choose one of three configurations of 4 analysts: 4 individuals, 2 groups of 2, and 1 group of 4. Among the respondents, 39, 42%, chose 2 groups of 2, 34, 37%, chose 1 group of 4, and 19, 21%, chose 4 individuals.

The results of crossing the answers to Q7, about usual group sizes, with the answers to Q8, about ideal group sizes, plotted in Figure 13, show that those whose usual group size is "2 BoRAs" tend to select an ideal group size of "2 groups of 2", and similarly, those whose usual group size is "5 BoRAs" or ">5 BoRAs" tend to select an ideal group size of “1 group of 4”. Those whose usual group size is “3 BoRAs” or “4 BoRAs” tend to select ideal group sizes of “2 groups of 2” and of “1 group of 4” equally often, The fact that no bar in Figure 13, except the one-person bar for “5 BoRAs”, is one-colored, says that some respondents suggest, e.g., “2 groups of 2” as their ideal group size, even if their usual group size is “>5 BoRAs”, or, vice versa, “1 group of 4” as their ideal group size, even if their usual group size is “2 BoRAs”.

A crossing of the answers to the subquestions of Q6, about how often specific ReqElic techniques are used in groups, with the answers to Q7 and Q8, about usual and ideal group sizes, showed no significant associations (and is therefore not shown). In other words, the technique used for ReqElic is not correlated with sizes of groups. This result is reasonable given that many creativity techniques are applicable both by individuals and by groups. The only exception among the techniques studied is for JAD, which by its very nature requires a group.

As described in Section 3.3.12, we divided into four categories, “Relations”, “People”, “Project”, and “Output”, the factors assigned to the respondents’ answers

1. to Q9 to explain their answers to Q8 about ideal group sizes,
2. to Q10 to give three reasons to recommend using groups of BoRAs in ReqElic, and
3. to Q11 to give three reasons to recommend not using groups in ReqElic.

The actual answers to those questions were very different from each other, both in length and in structure; also, not all the respondents gave three reasons in their answers to Q10 and to Q11. However, the answers to Q9 and Q10 are very similar, as can be expected from the fact that each is asking for a reason for some decision, for or against using groups of BoRAs for ReqElic. Therefore, the focus of this discussion is on the answers to Q10 and Q11. In fact, some respondents answered Q11, asking three reasons to not recommend using groups in ReqElic, by saying that there is no reason to recommend not using groups of BoRAs for ReqElic.

For each of the factors, there are advantages and disadvantages, so that factors in any one category can be offered both for and against using groups of BoRAs for ReqElic, in kind of an antisymmetric way. Project factors are the least frequently mentioned in recommending using groups, but are the most frequently mentioned in recommending not using groups of BoRAs for ReqElic. However, output and people factors are more frequently mentioned in recommending using groups, but are less frequently mentioned in recommending not using groups of BoRAs in ReqElic. Finally, relations factors are mentioned with the same frequency in recommending either using or not using groups of BoRAs in ReqElic.

The following list gives some examples of quotations from respondents’ answers, grouped by the factors into which they were categorized; by whether or not they recommended using groups of BoRAs for ReqElic; and by reasons for recommending not using, for the Relations factor.

- Factors related to Project mention characteristics of the respondents’ projects and the costs and benefits of having many people.

  Examples of quotations from respondent answers that involve Project factors and that recommend using groups of BoRAs for ReqElic include:
  - “sufficient time, budget allows, new projects (including lack of experience in domain)”

  Examples of quotations from respondent answers that involve Project factors and that recommend not using groups of BoRAs for ReqElic include:
  - “small enhancements/bug fixes, small project size, budget disallows”
  - “increased *cost* associated with additional personnel”

- Factors related to Output mention the quality of the requirements, often in terms of the coverage of different stakeholders needs or requirement details.

  Examples of quotations from respondent answers that involve Output factors and that recommend using groups of BoRAs for ReqElic include:
  - “4 eyes see more details than 2.”

- "2 groups are good for X-checking each other's work."

Examples of quotations from respondent answers that involve Output factors and that recommend not using groups of BoRAs for ReqElic include:
- "It can be very difficult to reach conclusions which are coherent."
- "frustrated with team member output; maybe we expect more but the team member gives a low quality output"
- "The group sessions are tiresome, slow, unfocused. Individual requirements elicitation is much more productive and can be reviewed later by the group members."

– Factors related to People mention having people with the right skills and expertises.

Examples of quotations from respondent answers that involve People factors and that recommend using groups of BoRAs for ReqElic include:
- "A group working as a team brings the best mix of skills and experience to the table."
- "Every person has different skills."
- "They are professionals who have the necessary skills and competencies to effectively manage the requirements elicitation process as well as fulfilling other tasks or activities required."
- "Interesting. . . . If you are working as a group, you really need to have the right mix of skills and experiences."
- "No single individual has sufficient breadth and depth of knowledge to develop a full set of unambiguous requirements."
- "No one knows all there is to know about a product or service. Groups are the only solution."

Examples of quotations from respondent answers that involve People factors and that recommend not using groups of BoRAs for ReqElic include:
- "knowledge-intensive and complex environments with only one analyst with necessary skills"
- i.e., when "there is a person with good overall picture" so that it is possible to have an individual BoRAs

– Factors related to Relations mention communication, collaboration, responsibility, agreement, debates, and personality.

Examples of quotations from respondent answers that involve Relations factors and that recommend using groups of BoRAs for ReqElic include:
- "Team collaboration is important."
- "Collaboration works."
- "Collaboration encourages competition."
- Groups support "confrontation, cooperation and better analytical phase through explicit verbalization".
- Groups are also described as useful to "provide support on difficult or dysfunctional teams (members)".
- "to increase the knowledge of the dynamics between people"
- for a "collective responsibility for success or failure"

Examples of quotations from respondent answers that involve Relations factors and that recommend not using groups of BoRAs for ReqElic, . . .
- because of the communication and relational problems and personality conflicts that arise when people work in groups, include:
  * "Putting people together as a team does not mean you have a team."
  * "communication overhead"
  * "interpersonal issues"
  * "communication — the more people involved the more communication challenges"
  * "too much chance of miscommunication"
  * "Multiple people can end up in endless debates."
  * "Too many BoRAs can go in conflict each other."

  * "BoRAs tend to have strong personalities (in my experience), a group or BoRAs can be intimidating for the customer."

- because of the negative impact of disagreement within and between groups, include:
  * "In some cases, groups are in disagreement."
  * "lots of disagreements to work through, possibility that opposing views may slow down the work"
  * "... analysis paralysis if no one can make decisions on group disagreements. If there's an internal conflict between different business goals, then a team may get sucked into that conflict."
  * "group dynamics: Unwillingness of analyst to work in the attributed roles, risk the meeting gets out of control because every analyst wants to be involved possibility of creating a leader who makes decisions independently."

Table 3 gives some examples of quotations from respondents' answers, grouped by the factors into which they were categorized; by whether or not they recommended using groups of BoRAs for ReqElic; and by reasons for recommending not using, for the Relations factor.

The results of the study, in particular those concerning factors to be considered when deciding whether to form ReqElic groups are integrated with the results of the textbooks reviews in the conclusion of the paper, Section 6.2.

5 Threats to Validity and Limitations of the Results

There are two main potential limitations to be considered for the study described in Section 3. The first is the limited number of respondents, and the second is the long time elapsed between the date on which the questionnaire was made available online and the date on which the 92nd, and last, respondent had fillled out the questionnaire.

The limited number of respondents is one threat to the validity of the conclusions. With only 92 filled-in questionnaires, the study represents only an exploratory study of the GvsI issue in ReqElic, and its results cannot be considered representative of the population. First, it is impossible to know the number of BoRAs in the world, and it is impossible to know the number of companies that employ BoRAs. So it is impossible to know the sizes of the populations that the 92 respondents and their companies represent, and thus, how representative the respondents and their companies are.

Second, as described in detail in Section 3.2, we posted an announcement on many online platforms inviting BoRAs to fill out the questionnaire, and we used e-mail, newsgroups, etc. to inform potential respondents of the existence of the questionnaire. So, it is impossible to know the number of BoRAs that saw the requests to fill out the questionnaire, In turn, it is impossible to calculate any response rate. A comparison with similar online studies can give ideas of both (1) how typical a response of 92 is and (2) the difficulties of having a larger number of respondents. An online survey focused on SE practices — a wider scope than GvsI in ReqElic — in 2003 got 194 completed responses [39]; a follow-up survey, for a master thesis, got interactions — an interaction is an entry into one or more data fields — from 93 respondents [30]. A broader survey — including international participants — by two of the authors of the 2003 survey, got 119 respondents [22][17]. Thus, the number of respondents to our questionnaire is in the same ballpark as the number of respondents to other similar SE surveys.

The long elapsed time of the study is another threat to the validity of the conclusions in the sense that the world changes over time, and perhaps later respondents think differently from earlier respondents. The long elapsed time is a direct result of our effort to achieve at least 100 filled-in questionnaires. In this effort, we left the questionnaire online 2.75 years, from Autumn 2012 until Spring 2015. During that time, we actively promoted the questionnaire to potential respondents three times, in Autumn 2012, in Summer 2013 and in Winter 2014. We never quite achieved the goal of 100 filled-in questionnaires, receiving only 92, the last of which arrived in January 2015.

When we had received 35 filled-in questionnaires, we analyzed the data we had for incorporation as corroborating data into a workshop paper about controlled experiments for deciding the GvsI issue with respect to one particular creativity enhancement technique, POEPMcreate [49]. By the time we had enhanced this workshop paper for journal

[17] One of the questions in this 119-respondent survey concerns issues investigated in our study, namely, a question about techniques "used for requirements elicitation". Among a list of 18 techniques, brainstorming was used by 65% of the respondents and JAD was used by 15% of the respondents, while in our study, brainstorming was used in all through some projects by from 47% to 87% of the respondents and JAD was used in all through some projects by from 15% to 43% of the respondents. Even if results of this and our study cannot be directly compared, they are consistent with each other.

Table 3. Example Quotations From Respondent Answers That Are Relevant to Factors

<table>
<tr><th rowspan="2">Factors related to</th><th rowspan="2">Mention</th><th colspan="3">Examples of quotations from respondent answers that recommend X = [using|not using] groups of BoRAs for ReqElic</th></tr>
<tr><th>X</th><th colspan="2">Quotations with a possible reason for recommendation</th></tr>
<tr><td rowspan="2">Project</td><td rowspan="2">characteristics of the respondents' projects and the costs and benefits of having many people</td><td>using</td><td colspan="2">• "sufficient time, budget allows, new projects (including lack of experience in domain)"</td></tr>
<tr><td>not using</td><td colspan="2">• "small enhancements/bug fixes, small project size, budget disallows"
• "increased cost associated with additional personnel"</td></tr>
<tr><td rowspan="2">Output</td><td rowspan="2">the quality of the requirements, often in terms of the coverage of different stakeholders needs or requirement details</td><td>using</td><td colspan="2">• "4 eyes see more details than 2."
• "2 groups are good for X-checking each other's work."</td></tr>
<tr><td>not using</td><td colspan="2">• "It can be very difficult to reach conclusions which are coherent."
• "frustrated with team member output; maybe we expect more but the team member gives a low quality output"
• "The group sessions are tiresome, slow, unfocused. Individual requirements elicitation is much more productive and can be reviewed later by the group members."</td></tr>
<tr><td rowspan="2">People</td><td rowspan="2">having people with the right skills and expertises</td><td>using</td><td colspan="2">• "A group working as a team brings the best mix of skills and experience to the table."
• "Every person has different skills."
• "They are professionals who have the necessary skills and competencies to effectively manage the requirements elicitation process as well as fulfilling other tasks or activities required."
• "Interesting.... If you are working as a group, you really need to have the right mix of skills and experiences."
• "No single individual has sufficient breadth and depth of knowledge to develop a full set of unambiguous requirements."
• "No one knows all there is to know about a product or service. Groups are the only solution."</td></tr>
<tr><td>not using</td><td colspan="2">• "knowledge-intensive and complex environments with only one analyst with necessary skills"
• i.e., when "there is a person with good overall picture" so that it is possible to have an individual BoRAs</td></tr>
<tr><td rowspan="3">Relations</td><td rowspan="3">communication, collaboration, responsibility, agreement, debates, and personality</td><td>using</td><td colspan="2">• "Team collaboration is important."
• "Collaboration works."
• "Collaboration encourages competition."
• Groups support "confrontation, cooperation and better analytical phase through explicit verbalization".
• Groups are also described as useful to "provide support on difficult or dysfunctional teams (members)".
• "to increase the knowledge of the dynamics between people"
• for a "collective responsibility for success or failure"</td></tr>
<tr><td rowspan="2">not using</td><td>because of the communication and relational problems and personality conflicts that arise when people work in groups</td><td>• "Putting people together as a team does not mean you have a team."
• "communication overhead"
• "interpersonal issues"
• "communication — the more people involved the more communication challenges"
• "too much chance of miscommunication"
• "Multiple people can end up in endless debates."
• "Too many BoRAs can go in conflict each other."
• "BoRAs tend to have strong personalities (in my experience), a group or BoRAs can be intimidating for the customer."</td></tr>
<tr><td>because of the negative impact of disagreement within and between groups</td><td>• "In some cases, groups are in disagreement."
• "lots of disagreements to work through, possibility that opposing views may slow down the work"
• "... analysis paralysis if no one can make decisions on group disagreements. If there's an internal conflict between different business goals, then a team may get sucked into that conflict."
• "group dynamics: Unwillingness of analyst to work in the attributed roles, risk the meeting gets out of control because every analyst wants to be involved possibility of creating a leader who makes decisions independently."</td></tr>
</table>

publication, we had received 53 filled-in questionnaires. A similar analysis of these data were incorporated as the corroborating data into the journal paper [50]. When we had 92 filled-in questionnaires and had hopes that we might receive more, we analyzed the data we had for a paper about just the questionnaire [33]. These two analyses had goals that were more limited than those of this paper, which includes also a review addressing the GvsI issue in SE and RE textbooks and an analysis of the open questions, which were not analyzed before. The effect of the long duration is partially mitigated by the observation that the frequency structure—distribution—pattern of the answers for the first 53 is similar to that of the full 92. We found that the order, among the first 53 respondents and all 92 respondents, of the the chosen frequency answer from most chosen to least chosen, is the same for almost all the questions. For example, for Q1,

- among the first 53 respondents,
  - 45% chose “some of our projects”,
  - 26% chose “all our projects”,
  - 19% chose “most of our projects”, and
  - 9% chose “none of our projects”,

  while
- among all 92 respondents,
  - 40% chose “some of our projects”,
  - 32% chose “all our projects”,
  - 22% chose “most of our projects”, and
  - 7% chose “none of our projects”.

In addition, recall the observation at the end of Section 3.3.1 about how often the respondents play different CBS development roles that include three RE roles that, in turn, include two ReqElic roles, we concluded that almost all of the 92 respondents are precisely the BoRAs the survey was targeting. This conclusion establishes the reliability of the questionnaire’s answers.

The issue for each open question, Q9–Q12, is whether the 92 answers received contain all possible answers that one might see in any larger collection answers, i.e., whether *thematic saturation* has been reached with the 92 answers received. Recent studies that investigated *the saturation point*, the number of data that are necessary to be certain that no new results or themes will emerge if more data were to be gathered, indicate that 92 answers may be enough to have reached saturation. Weller *et al.* have determined that this number is 50 for many sectors [61]. Tran *et al.* have shown that in each doubling of the sample size, the number of new emergent themes got geometrically smaller. Specifically,

- with the samples of 25, 50, 100, and 200 data,
- the numbers of emergent themes were 93, 107, 114, and 116 respectively,
- so that numbers of *new* emergent themes emerging in the doublings were 14, 7, and 2, respectively [58].

These results indicate that in the 92 filled-in questionnaires, we probably have enough data to achieve thematic saturation in the open questions. In particular, the sets of reasons given as the answers to Q10 and Q11, to recommend using and not using groups of BoRAs for ReqElic, respectively, would probably not change with additional respondents. As a matter of fact, saturation can be confirmed also by a manual examination of the first 53 filled-in questionnaires. The answers given to Q10 and Q11 in the first 53 questionnaires covered all four factors introduced to classify the answers in the analysis of the same questions for all 92 questionnaires.

Other potential limitations to be investigated in future work include

1. the need to work remotely due to the Covid-19 pandemic, and
2. the emergence of new technologies, e.g., the Cloud, IoT, and AI systems.

Each of them may have changed the way in which a company elicits requirements, possibly weakening the applicability of this paper’s results.

6 Conclusions

6.1 Conclusion for the SE and RE Textbooks Review

Section 2 reviews the most successful SE and RE texts with respect to how they treat the GvsI issue, i.e., whether a process should be carried out by a group or by an individual, and if by a group, how big is the group. Because the SE textbooks deal about the whole of the SE process, the SE textbooks could deal with the GvsI issue for all stages of CBS development. One would expect that the RE textbooks would focus their discussions of the GvsI issue on the stages of the RE process, including ReqElic. However, according to the reviews of Section 2.2, the most successful RE textbooks barely even address the issue. In fact, the most successful SE and RE textbooks, the ones most likely to be on the bookshelves of a BoRA, the question about the ideal number of analysts for ReqElic remains almost unanswered.

The SE and RE textbooks agree on the need for group work for CBS development activities in general, but usually fail to consider the specific ReqElic activity. Many a textbook says that groups are useful for large projects, to have the necessary expertise, or to get new ideas or requirements. Group dynamics are often considered as risks that could reduce the efficiency and effectiveness of group work [14]. As a consequence, anyone staffing a group has to consider the tradeoff between (1) having the right skills and roles, which is more easily achieved with larger groups, and (2) mitigating group overhead, which is worse with larger groups.

With regard to ReqElic techniques, only a few textbooks provide any information about the number of people to involve in performing any technique. In any SE or RE textbook that gives suggestions for the size of a group for any process, the suggestions are given as rules of thumb, probably based on the professional experience of the textbook's authors. In many a technique description, a suggestion for the size of a group can be inferred from information given about the technique. For example, Glass and DeMarco [18] discuss the problem of sizing of groups in the context of Agile approaches, arguing that those approaches are more compatible with creativity than upfront-waterfall approaches. They suggest that Agile approaches are applicable for small projects that require 2–8 people, working in a room [8]. From this observation, one may surmise a suggestion about group sizes. Only an occasional textbook provides specific, as opposed to vague, information about the number of people to involve in performing any technique.

The need of creativity techniques to support elicitation, discovery, or invention of requirements is recurrent in the reviewed textbooks. However, the older SE textbooks deal neither with inventing new and innovative requirements, nor with classifying existing requirements by their newness and innovativeness. On the other hand, each of the RE textbooks deals with these issues to some extent. The creative nature of ReqElic is emphasized in a number of popular books that do not meet the criteria for being listed in Table 2, among them those by Gause and Weinberg [15, 16] and by Bray [6]. In another successful textbook, *Software Creativity 2.0*, which many RAs have and consult for advice, Glass and DeMarco [18] recommend organizing non-goal-oriented meetings, to exploit synergism and to support rapid decision making. They suggest staging creativity workshops using brainstorming or other creativity techniques. Brainstorming is suggested by many of the textbooks to support requirements elicitation, however, the word "brainstorming" is often used in the current parlance, as a synonym of "meeting", when it is used as a noun, or of "inventing", when it is used as a verb.

Regardless of how explicitly a suggestion about group size is given, most critical is the lack of empirical data to support advice and guidelines for the GvsI issue in any context. A noteworthy exception to this lack of empirical data is the data reported by some of the textbooks, namely those by Pfleeger and Atlee, by van Vliet, by Wiegers and Beatty, and by Kotonya and Sommerville, about recommended sizes for software inspection groups. However, even if inspection of a document is thought of as brainstorming for defects in the document, the scope of and the artifacts for ReqElic and inspection of an arbitrary CBS development document are quite different. Looking for defects in, e.g., a computer program is a well-defined problem, and it is possible to introduce measures, such as the number of defects found, the time spent, etc., to compare the effectiveness of groups involving different numbers of people or using different techniques, etc. Experiments to determine how group size affects software inspection showed that even if groups of two or four inspectors were more effective than an inspector working alone, four inspectors did not find significantly more defects than two inspectors [45]. The problem with these experiments[18] is that [24] "... without knowing the real saving gained by finding the defects, it is impossible to define the optimal team size, which would be relevant also in practice ..."

[18] See also Laitenberger *et al* [25].

To integrate the results of the SE and RE textbook reviews, we assume that a BoRA could broaden any search by browsing the SoftWare Engineering Body of Knowledge (SWEBOK) [5], which specifies the SE core content and skills. The SWeBOK points out that a complex CBS development project needs both group work and creativity:

> Many, if not most, software engineering problems are too complex and difficult to address as a whole or to be tackled by individual software engineers. When such circumstances arise, the usual means to adopt is teamwork and problem decomposition .... Teams work together to deal with complex and large problems by sharing burdens and drawing upon each other's knowledge and creativity.

Therefore:

> A software engineer must be able to interact cooperatively and constructively with others to first determine and then meet both needs and expectations. Knowledge of group dynamics and psychology is an asset when interacting with customers, coworkers, suppliers, and subordinates to solve software engineering problems.

With regard to group RE techniques, the SWEBOK cites only facilitated meetings, in which "a group of people can bring more insight into their software requirements than by working individually. They can brainstorm and refine ideas that may be difficult to bring to the surface using interviews". However, the SWEBOK gives no advice for group size in ReqElic and in creativity techniques. In fact, it does not even mention any specific creativity technique.

Another successful topic-focused professional book that an RA could have on his or her bookshelf is *Peopleware: Productive Projects and Teams* by DeMarco and Lister [13], which is in its 3rd edition, the first of which was published in 1987[19], before RE had crystallized into a named field[20]. This book observes that a typical developer works alone 30% of the time, works with at least one other person 50% of the time, and works with two or more persons 20% of the time. In discussing the staffing of CBS development teams, DeMarco and Lister suggest specifically that to mitigate the risk of overstaffing, the initial activities of a project — analysis and design — are best carried out by smallish teams of 3–5 people.

Altogether, the final conclusion is that none of the textbooks in Table 1 and Table 2 provides real help, based on empirical data, in making decisions about the GvsI issue and about the size of a group for ReqElic.

6.2 Conclusion for the Online Survey

The second part of this paper, in Section 3, offers the results of an online survey as an attempt to remedy the current lack of empirical data to support requirements engineers in deciding

1. whether to use groups or individuals for ReqElic, the GvsI issue, and
2. if to use groups, what size they should be, the group size issue.

The main result of the survey is that there is no one pair of answers to the GvsI and group size issues. Thus, the GvsI and group size issues must be decided in each case, taking into account

1. the configuration of factors in the case and
2. the relative weights of these factors that exist for the case.

This concluding section follows the order of the online survey's questions and brings in relevant results from the textbook reviews.

The online survey results say the following:

- The roles, including that of BoRA, related to ReqElic are adopted in the respondents' companies while the role of BoRA was not explicitly named in the SE textbooks.
- Groups are used for ReqElic, but there are still projects in which individual BoRAs are used for ReqElic. This fact is reported in SE and RE textbooks, usually in connection with a discussion of techniques available to support ReqElic.

[19] The book's number of editions and that the third edition is published in Addison-Wesley's Professional Series makes it reasonable to assume that people working in SE or RE could have it and use it.

[20] There were already publications dealing with RE topics as early as 1983 [4].

- Large, complex, and to a lower extent tight-deadline projects tend to adopt group ReqElic. In RE and SE textbooks, however, the large size of a project is the most often cited reason for forming groups, while the complexity of a project is rarely explicitly mentioned as a reason for forming groups. They usually say that for a complex project, a large group is needed to cover all the necessary expertises needed.
- However, recommendations found in textbooks are given for an entire project, and not specifically for ReqElic. Interestingly, two of the answers to Q10, about the reasons to recommend using groups for ReqElic, explain that groups are formed for an entire project, not considering at all ReqElic as a specific step in the project that might require its own skills.
- Brainstorming and other other creativity techniques are adopted in many companies as group ReqElic techniques. These results are consistent with the suggestions given in the most recent SE textbooks and in the RE textbooks.
- The answers to Q7, about usual group sizes, say that companies use small groups for ReqElic whenever a project's characteristics permit a small group size. On the other hand, respondents' answers to Q10 and Q11 say that companies would actually prefer to have larger groups. However, they cannot afford the costs of larger groups, and they cannot always find the right person for a needed role; so they settle for small groups.

Finally, respondents' answers to Q8 about ideal group sizes confirm the main result, i.e., that there is no one pair of answers to the GvsI and group size issues. The data say that among the respondents,

- 21% consider 4 individuals
- 42% consider 2 groups of 2, and
- 37% consider 1 group of 4

as ideal. The contingency table crossing the answers to Q7, about usual group sizes, with the answers to Q8, about ideal group sizes, which is plotted in Figure 13, shows that many a respondent chose an ideal group size close to the usual group size that he or she chose. On the other hand, there are some respondents, each of whom chose a large usual group size and a small ideal group size.

What are the factors to be considered in forming ReqElic groups, and how can the group size for a given project be optimized? The answers to question Q9 to Q11 allow formulating some guidelines. First, recall that the categories of factors identified in the reasons given to recommend using or not using groups of BoRAs in ReqElic are Relations, People, Project, and Output. Factors in each of these categories can help or hinder group activities in ReqElic. Among factors in the

Relations category, group communication and collaboration can help ReqElic, while conflicts and group dynamics can hinder it.

People category, skills, expertise, and other personal traits can be relevant to to the effectiveness of ReqElic groups. Groups also support knowledge transfer between analysts, and provide some protection against the loss of a key person.

Project category, in particular those investigated in the survey, e.g., usual group sizes, tightness of deadline, complexity, affect whether or not groups are used in ReqElic.

Output category, usually described in relation to quality and quantity of the requirements, are cited to justify groups because group ReqElic can potentially (1) reduce redundant, duplicated, or conflicting requirements and (2) give better requirements coverage and accuracy.

In general, the explanations given by the respondents in Q9 through Q11 allow saying that

1. it is better to aim for small groups [46],
2. to have individual BoRAs,
3. but large groups are necessary in some cases.

In conclusion, the most interesting results of our study are about the factors that are to be considered in deciding the GvsI issue in ReqElic. According to the survey, four categories of factors can be used to help decide the GvsI issue in ReqElic. In fact, for each recommendation, (1) to use and (2) to not use, groups for ReqElic, the recommendation's column in Table 4 lists the categories, from top to bottom, in order of decreasing relevance to the recommendation.

The textbook review shows that all of the factors listed above are mentioned as relevant to the GvsI issue in both SE and RE. The most frequently considered factors are in the relations category, usually in describing the detrimental

Table 4. Recommendations of Factor Categories

Categories Relevant to Recommending Using Groups	Categories Relevant to Recommending Not Using Groups for ReqElic
People	Project
Relations	Relations
Output	People
Project	Output

effects of communication overhead in groups, but also in describing the synergies created in groups. Many RE textbooks describe also the need to have and staff groups to cover skills and knowledge in SE, RE, and the domain of the system to be developed. In the project category, the size of the system to be developed is often considered as relevant in deciding the GvsI issue. However, the advice is often given in connection with an entire project and not specifically for ReqElic.

Costa *et al.*, in a recent study investigating the state of the practice in group formation in SE, identified two categories, technical and non-technical, of factors relevant to group formation [10]. They emphasize that the technical factors are considered more often, but they are often not enough to allow making a good GvsI decision. Given that non-technical factors are concerned mainly with relations, Costa *et al.*'s results are consistent with those of this paper.

The conclusion of our study is that each of individual and group ReqElic has advantages and disadvantages. As a result, answering the GvsI issue requires dealing with the tradeoffs related to each group size. The problem can then be formulated in terms of decision making in which diverse factors have to be optimized [23]. Our study gives a preliminary answer to the research question, supporting with empirical data recommendations found in SE and RE textbooks. Future studies could exploit the results of the analysis given in some recent papers that review the staffing of SE groups [10, 12], but focusing on ReqElic activities.

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A How to Read a Crossing Graph

To help the reader understand these graphs and all the others arising from crossing answers of one group of subquestions with those of another, we give a detailed explanation of the graph of Figure 8 that crosses the answers to the three subquestions of Q6, about how often specific ReqElic techniques are used in groups, with the answers to Q3, about the frequency of the use of groups for large projects. Understanding the relationship between

1. the vertical bars of Figure 8, about Q6 $\times$ Q3, and

2. (a) the horizontal bars of Figure 7, about the answers to the three subquestions of Q6, and
   (b) the bottom horizontal bar of Figure 3, about the answers to Q3,

is easiest when one sees the data for all of the bars.

Consider the bottom horizontal bar of Figure 3, which is about “large” projects. For example, the length of the blue sub-bar, for “in all projects” is proportional to the number of respondents, 32, out of 92, that indicated by their answers to Q3 that “requirements are identified as a group activity” “in all our large projects”. A similar claim can be made for each of the other colored sub-bars, but with a different number. The four numbers represented by these sub-bars are 32, 27, 24, and 9, which, of course, add up to 92. The actual data can be seen also in the bars and data for Q3 in the print out of the data from the 92 responses from the questionnaire (hereinafter, “92 responses”) [34]. Similarly, the four numbers represented by the sub-bars of the bottom horizontal bar of Figure 7 are 5, 9, 26, and 52, which add up to 92, which, in turn, are the data for the first subquestion of Q6 in the print out of the data from the 92 responses.

		Kind of Group ReqElic: JAD				Kind of Group ReqElic: Brainstorming (BS)				Kind of Group ReqElic: Other			
	Q6 vs Q3	JAD in all our projects	JAD in most of our projects	JAD in some of our projects	JAD in none of our projects	BS in all our projects	**BS** in most of our projects	BS in some of our projects	BS in none of our projects	Other in all our projects	Other in most of our projects	Other in some of our projects	Other in none of our projects
Requirements Identified in Groups (RIG)	RIG in all our large projects	3	6	10	13	4	14	12	2	4	11	13	4
	RIG in most of our large projects		3	7	17	6	13	7	1	2	8	16	1
	RIG in some of our large projects			8	16	1	4	16	3	2	5	14	3
	RIG in none of our large projects	2		1	6		1	2	6			3	6

Fig. 20. Contingency Table in the Form of an Excel Matrix for Q6 × Q3

Figure 20 shows the contingency table, in the form of an Excel matrix, that generates the graph of Figure 8. Notice that this matrix has thee sub-matrices one for each kind of group ReqElic technique, JAD, Brainstorming (BS), or Other. Consider the left-most sub-matrix, which covers the cross product of (“Kind of Group ReqElic: JAD” × “Requirements Identified in Groups (RIG)” in “large projects”). Consider the number 10 in the cell at the intersection of the row for “RIG in all our large projects” and the column for “JAD in some of our projects”. The 10 is the number of respondents that indicated

1. by their answers to Q3 and
2. by their answers to the JAD subquestion of Q6

that for them, *both*

1. “requirements are identified as a group activity” “in all our large projects” and
2. the “Kind of Group ReqElic” technique is “JAD in some of our projects”.

Therefore, it can be expected that

1. the sums of the four columns of this left-most sub-matrix are, from left to right, 5, 9, 26, and 52, which are the four numbers represented by the sub-bars of the bottom horizontal bar of Figure 7, about the JAD subquestion of Q6. and

2. the sums of the four rows of this left-most sub-matrix are, from top to bottom, 32, 27, 24, and 9, which are the four numbers represented by the sub-bars of the bottom horizontal bar of Figure 3, about Q3 that is about large projects.

Just as the matrix of Figure 20 that generates this graph has three sub-matrices, one for each kind of group ReqElic technique, JAD, Brainstorming (BS), or Other so does the graph of Figure 8 have three sub-graphs, one for each kind of group ReqElic technique, JAD, Brainstorming (BS), or Other. The left-most sub-graph plots the data of the left-most sub-matrix, etc. Each vertical bar in a sub-graph plots the data from one column of the sub-graph's sub-matrix, while all the sub-bars of each color in a sub-graph plot the data from one row of the sub-graph's sub-matrix.

Thus, the 10 considered above is proportional to the length of the blue — denoting "RIG in all our large projects" — sub-bar, at the bottom of the vertical bar for "JAD in some of our projects", which is the third from the left in the "Kind of Group ReqElic: JAD" sub-graph of the graph of Figure 8. This length represents the percentage, 10.87, that 10 is out of 92. Therefore, this sub-bar means that 10.87% of the 92 respondents say that in their companies, both that requirements identification is done in groups in all their large projects and that JAD is used for group ReqElic in some of their projects. In other words, 10.87% of the 92 respondents say that among those companies in which requirements identification is done in groups in all their large projects, JAD is used for group ReqElic in some of their projects. In still other words, 10.87% of the 92 respondents say that among those companies in which JAD is used for group ReqElic in some of their projects, requirements identification is done in groups in all their large projects.

If you want to use the graph of Figure 8 to examine the distribution of the frequencies in which companies do requirements identification in groups in large projects among the companies that use JAD for group ReqElic in none of their projects, look at the fourth bar from the left labeled "JAD in none of our projects". You will see that among the companies that use JAD for group ReqElic in none of their projects,

– requirements identification is done in groups in large projects in the 92 companies, with all four frequencies, and
– requirements identification is done in groups in large projects in the 92 companies, with all, most, and some of these large projects in about the same number, n, of companies, and it is done with none of these large projects in about $\frac{1}{3} \times n$ of companies.

On the other hand, if you want to use the graph of Figure 8 to examine the distribution of the frequencies in which companies use JAD for group ReqElic in projects among the companies that do requirements identification in groups in all their large projects, look at the four bottommost, blue sub-bars in the four leftmost bars, which constitute the leftmost sub-graph, which is labeled "Kind of Group ReqElic: JAD". You will see that among the companies that do requirements identification in groups in all their large projects,

– JAD is used for group ReqElic in projects in the 92 companies, with all four frequencies, and
– JAD is used for group ReqElic in projects in the 92 companies, with each of all and most of these projects in about twice as many companies as it is used with each of some of and none of these projects.

As a final example, consider the leftmost bar in Figure 8. It shows that among the companies that use JAD for group ReqElic in all their projects, requirements identification is done in groups in large projects in the 92 companies, with only all or none of these large projects, and it is done in all these large projects in more than twice as many companies as it is done in none of these large projects.