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Applying Q-methodology to analyse the success factors in GSD

Aurora Vizcaíno *, Félix García, José Carlos Villar, Mario Piattini, Javier Portillo

Instituto de Tecnologías y Sistemas de Información, University of Castilla-La Mancha, Paseo de la Universidad 4, 13017 Ciudad Real, Spain

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ABSTRACT

Context: The context of this paper is Global Software Development (GSD) which is a current trend concerning the development of software in a distributed manner throughout different countries. This paradigm has several advantages, but unfortunately there are a number of challenges that hinder projects' successful development.

Objective: The main goal of this paper is to discover which factors affect the success of GSD projects and how these are ranked by researchers and practitioners.

Method: This paper analyses the relevant success factors reported in literature. These were collected by conducting a literature review, as a result of which 39 GSD success factors were selected. Q-methodology was then followed to conduct a survey from which the opinions of 21 experts in GSD were collected.

Results: The data indicated that the best ranked GSD success factors are staff motivation, skilled human resources and the identification of roles and responsibilities. The lowest scores were, surprisingly, language barriers, time zone differences between sites, cultural differences and geographical distance which, to date, have frequently been considered by researchers as the most influential factors in GSD. This study additionally shows the results according to the different points of view of the respondents involved and the context of the projects.

Conclusion: This study indicates that there are different points of view as regards which issues are most important to success when setting up a GSD project. For instance, some experts prefer a knowledge focus, while others prefer a project management approach in which the most important issues are those related to management (risks, coordination) and so on.

Conclusion: The results obtained have also shown that the challenges of GSD are changing, since the critical issues were initially related to the various types of distances (geographical, temporal, socio-cultural, language). However, there is now a greater concern for the team members' features and skills.

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1. Introduction

Global Software Development (GSD) is a current trend owing to the various advantages that this kind of development involves: Organizational benefits, such as savings in costs, access to large multi-skilled workforces, reduced time to market, proximity to market and customer, resource allocation, innovation and shared best practices; and process/task benefits, such as a formal record of communication, improved documentation and clearly defined processes [1]. However, several studies show that approximately 40% of offshore projects fail to deliver the expected benefits [3]. The reasons for this failure could be: a lack of theoretical basics [3], an ignorance of the risks involved in an outsourcing software development project [3], the use of the same methods, processes and tools used in traditional projects [7] and incomplete or under-specified requirements [14]. Other problems that practitioners have encountered when managing distributed software development projects are described in [10]: The learning curve (people are not familiar with new technology and tend to resist when they need to learn a new means of working), poor interoperability between tools, responsibilities and roles are not properly defined, lack of knowledge and the high cost of investment for companies. As is mentioned in [25], there are currently few papers which provide empirical evidence showing, for instance, what issues help success to be achieved in a project. Nevertheless, various interesting systematic literature reviews focused on studying the different problems that occur in GSD and possible strategies with which to solve them have been published. For instance, Prikladnicki et al. [23] obtained five steps to minimize risks. These are: building trust, assessing offshore partners' capabilities, proving operational efficiencies, enhancing effectiveness, and reengineering the offshore partner into a more responsive development. A more recent work by da Silva et al. [7] gathered challenges and mitigation strategies in GSD, and the authors also proposed a model for project management. Moreover, in [20] a wide set of challenges and

* Corresponding author. Tel.: +34 926295300; fax: +34 926295354.
E-mail addresses: Aurora.Vizcaino@uclm.es (A. Vizcaíno), Felix.Garcia@uclm.es (F. García), JoseCarlos.Villar@uclm.es (J.C. Villar), Mario.Piattini@uclm.es (M. Piattini), JPortillo@indra.es (J. Portillo).

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mitigation strategies were detected through a systematic literature review and one survey. This increase in the systematic literature reviews related to these topics shows the current concern as regards knowing how to perform a GSD project successfully. However, since literature reviews are based on previous publications and the GSE field is still immature, in addition to the amount of empirical studies being relatively small [25], we preferred to confirm these previous literature reviews and the results obtained in them by asking experts to rate the information obtained. We have therefore attempted to analyse the factors which practitioners and researchers consider to be important for the success of a GSD project with the objective of helping to decrease the percentage of projects that fail in GSD.

We achieved our research goal by following the stages stated below: A literature review was first conducted in order to collect all the relevant factors. The factors obtained were then analyzed by the researchers who have participated in this study, and the initial list of factors was refined. The third and the most important step was the development of a survey which was answered by practitioners and researchers involved in GSD projects. Their responses were analyzed to obtain a ranking of GSD success factors as perceived by overall respondents, and to compare the researchers' perceptions with those of the practitioners'. Since it is useful to provide an idea of the different approaches or people's point of view as regards a particular topic, the results were then analyzed using the Q-methodology. The development of the survey allowed us to analyse whether there is consensus between software engineers with regard to the success factors, and the conclusions obtained may serve to inform novice practitioners of those factors that might facilitate the success of a GSD project. An additional analysis was also performed to provide further insights into the factor scores according to the experts' (researchers' and practitioners') profiles and the contextual characteristics of the projects in which practitioners have been involved.

The remainder of the paper is structured as follows: Section 2 describes how the selection of factors was carried out. In Section 3 we explain the application of the Q-methodology in our study. The results obtained are then described and analyzed in Section 4. Section 5 indicates the strengths and limitations of the study. Finally our conclusions are outlined in Section 6.

2. Selection of factors

Our first goal was to capture as many representative factors for GSD as possible. We were not initially concerned about whether these factors affect the success of a project in a positive or a negative manner. We simply wished to detect factors or issues that influence the result of a GSD project. The factors were collected by analyzing nine systematic reviews related to GSD [13,16–18,21–25] and the proceedings of ICGSE 2009, 2010 and 2011 with the goal of discovering those factors that affect GSD.

The selection criterion was: "An item is considered to be a factor when the authors of the papers indicate that this particular item affects/influences the GSD project". After this analysis, 267 factors were found (see Appendix 1).

The second step was to filter out solely the GSD success factors. A factor might be considered to be a success factor when it has a positive influence on a GSD project since it helps to save money, time or coordination, control or communication efforts.

This filtering was performed by sending a list containing the 267 factors to four researchers with more than 5 years of experience in researching this topic, and who had actually collaborated with companies working in global development. These researchers had to mark (with Yes/No) those factors that could, in their opinion and experience, be considered as success factors. Once the four lists completed by the four researchers had been obtained, we analyzed the level of agreement by applying an inter-rater reliability analysis using the Kappa statistic, which determines the consistency among raters. To be more precise, we used the Fleiss Kappa statistic, which can be applied to 2 or more raters (in our case 4). A general Kappa value of 0.731 was obtained for the whole group of factors, signifying a substantial agreement in the classification. Finally, we extracted a list of 39 success factors (see Appendix 2, Table 1). Some of these factors are reported in literature in a "negative manner" such as a country's instability, language barriers and cultural differences. These factors might therefore appear to be against the interests of GSD projects rather than being considered as success factors. It would therefore be more appropriate to re-write them in a positive manner using terms such as country's stability, good language skills and cultural similarity. However, we wished to respect the manner in which these factors appear in literature and we have therefore left them in this "negative manner" but the interpretation of these factors was as follows: for instance the lower the cultural differences the greater the chance of success in a project.

3. Q-methodology application

Q-methodology combines qualitative and quantitative research methods and provides a scientific foundation for the systematic study of subjectivity, such as people's opinions or preferences [28]. Q-methodology has had a place in science for almost 75 years [15]. However, it is not as yet very frequently used in software engineering [28,10]. The goal of this methodology is "to reveal principal views on a certain topic" [15]. In order to use this technique, the respondents should order a set of statements about a topic from their point of view. The individual rankings, called Q-sorts, are then analyzed to seek correlations in order to reveal similarities in viewpoints. The Q-methodological study was conducted by following the three steps shown below.

3.1. First step: Collection of statements (Q-set)

As is stated in Section 2, 39 statements (factors) were collected from an exhaustive analysis of GSD success factors. The list of statements is shown in Table 1 of Appendix 2.

3.2. Second step: Participants

Q-methodology provides a scientific method with which to identify perception structures that exist within certain individuals or groups [11]. The role and function of the participants is clearly an essential aspect in this methodology. In this step we therefore had to choose the participants in the study. It was necessary to involve people with experience in GSD, and we thus decided to contact the program committee members of the most important conferences on GSD. There were 50 people on this committee, 19 of whom were practitioners working at important multinational companies and 31 of whom were researchers. Since these people were from more than twelve countries, there was a good sample of different cultures and backgrounds.

3.3. Q-sorting

A survey was prepared which contained two parts (see Appendix 2): the first part contained some questions concerning the respondents' information, such as name, gender, age, nationality, native language and professional characteristics (affiliation/company, years of experience in GSD and the number of GSD projects on which the subject has worked as a researcher and/or a

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practitioner). In the second part the respondents were asked to rank-order the Q-sort statements according to a distribution with five positions (columns) from low level of success to high level of success. They therefore had to fill in a matrix composed of 39 cells in five numbered columns.

The survey was sent by email, and the participants had a week to complete the survey and to send back it. However, only four complete surveys had been received by the deadline date, and we therefore decided to send a second email encouraging the participants to fill it in. This second email was more effective, as 14 other surveys were received and three people wrote to us asking for more time. This request was, of course, granted. 21 surveys were therefore eventually collected, with a response ratio of 21/50.

3.4. Third step: Q-analysis

Upon beginning to analyse the surveys, we realized that three of them were not valid as the respondents had included more than one statement in the same cell (this was not permitted, as Q-methodology requires only one statement per cell), and there were therefore cells that did not contain any statements. Thus, we eventually obtained 18 surveys for analysis. Ten surveys were from practitioners and eight were from researchers. However, it is important to stress that three of these researchers also had some experience in working with companies in GSD. We can therefore state that 13 participants had practical knowledge of GSD challenges. The classification of the participants was transferred to a spreadsheet for further analysis. These results were then analyzed using a factorial analysis with IBM SPSS statistics 19. The objective of this analysis was to obtain a limited number of corresponding means in order to sort the statements [15].

4. Analysis of results

This section presents the analysis of the results obtained. The ordered rankings of GSD factors according to the perceptions of the subjects who participated in the survey are presented first, followed by the results of the application of Q-methodology, which involves the extraction of factors and the evaluation of the experts' ratings grouped by each factor. Finally, a qualitative discussion is shown.

4.1. Ranking of GSD success factors

The first step in the quantitative analysis was to prepare the data collected for its statistical analysis. Fig. 1 shows an excerpt of the spreadsheet prepared, in which each row represents each GSD success factor, the columns represent the experts and the cells are the experts' answers for each statement (from 0 to 5 according to the column in the Q-matrix in which the expert placed the factor).

Table 1 shows the ordered average of the scores collected for each GSD factor.

As can be observed in Table 1, the human resource perspective is perceived by respondents to have the highest influence on GSD processes, as they considered success factors to be the fact of counting on motivated and skilled staff with well defined roles and responsibilities in the GSD project. The second group of most significant GSD factors provides some insight into the need to foster: trust; communication management (personal visits, synchronous communication, suitable tools, ease of contact of project members, etc.); coordination; effective management of teams; project and risk management; knowledge management, and people and process maturity. Moderate influence is considered for factors regarding geographical and cultural distance; proximity to customer and market; knowledge of team ethics and personality of team members; delays in deliveries; number of sites and size of teams; policies, standards, intellectual property management and training in culture and communication processes. Finally, language and time differences, along with a country's instability on some sites, are perceived as having a low influence on a GSD project's success.

In addition to the results presented in Table 1, separate rankings of GSD success factors were also calculated in order to compare the perceptions of practitioners as opposed to those of researchers (see Tables 2 and 3). The "top ten" list of statements was compared in the two tables in order to detect differences between practitioners and researchers. We realized that they coincided in eight statements out of ten, although the position in the ranking was not the same in both tables. For instance, Skilled Human Resource Process was in the first place in the case of the practitioners, and in the seventh position in the researchers' table. However, Process Maturity was in the fourth place for the practitioners and in the eleventh place for the researchers. More differences exist in the case of the

	Succes Factors GSD	Experts Answers																	
Id	Name	EXP1	EXP2	EXP3	EXP4	EXP5	EXP6	EXP7	EXP8	EXP9	EXP10	EXP11	EXP12	EXP13	EXP14	EXP15	EXP16	EXP17	EXP18
1	Geographical distance between sites	4	5	1	5	1	1	1	2	1	1	1	1	2	1	2	3	2	2
2	Cultural differences between sites	2	2	4	1	1	1	1	2	3	4	1	1	2	3	1	1	1	5
3	Time Zone Differences between sites	5	1	5	2	1	1	2	3	1	1	1	1	2	1	1	1	1	2
4	Number of sites	5	3	5	3	1	1	1	1	4	2	1	2	2	3	2	3	2	3
5	Language Barriers	3	1	4	5	1	1	1	2	1	3	1	1	2	1	1	1	1	1
6	Training on International Culture	1	4	3	3	3	5	4	3	4	3	1	2	1	2	3	5	3	1
7	Training on Communication Processes	2	4	2	2	2	4	5	3	3	2	2	3	1	2	3	5	3	2
8	Selection of Communication tools to be used for	2	3	1	4	2	4	5	1	4	3	2	3	3	3	4	4	3	3
9	Synchronous Communication	4	1	5	2	4	2	3	4	3	1	2	5	4	5	1	5	5	5
10	Planning of meetings	2	4	1	2	2	3	2	4	3	2	1	2	1	4	2	3	2	1
11	Frequency of Personal visits	4	5	5	3	3	5	3	5	4	5	2	4	4	1	4	5	4	4
12	Onsite coordinator	4	4	2	5	5	4	5	1	5	5	2	4	4	4	4	3	4	5
13	Proximity to customer	1	2	2	1	2	5	2	3	2	2	2	5	3	1	3	2	3	4
14	Proximity to market	1	2	1	1	2	2	2	4	3	1	3	2	3	2	2	2	3	1
15	Knowledge Management	2	2	4	2	3	3	3	5	3	4	3	4	2	3	4	3	5	3
16	Knowledge of team ethics	3	1	1	2	4	2	2	3	5	3	5	4	3	2	4	2	3	2
17	Knowledge of the Client's Language and Culture	2	3	3	1	3	3	5	2	2	4	2	4	3	4	5	3	3	5
18	Fostering Trust	5	5	5	4	4	5	4	5	2	4	2	4	5	3	5	1	5	3
19	High level of Coupling between tasks	3	1	4	2	2	2	1	1	2	4	5	3	1	1	2	2	1	1
20	Teams' maturity	4	5	4	3	4	5	4	2	3	2	3	4	5	4	5	5	4	3
21	Process Maturity	1	5	3	4	3	3	4	4	2	4	3	5	4	3	4	5	5	4
22	Policies and Standards	1	5	1	3	3	1	4	1	4	1	4	3	3	2	1	2	2	3
23	Management of Intellectual Property Issues/Cor	2	1	1	3	3	2	2	3	2	2	5	1	2	3	2	2	2	1
24	Identification of Roles and Responsibilities	4	4	3	4	5	3	4	4	5	5	4	3	5	5	3	4	5	2

Fig. 1. Excerpt of spreadsheet with prepared data for statistical analysis.

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Table 1
Ranking of GSD success factors.

Id	GSD success factor	Avg. score
32	Staff motivation	4.11
29	Skilled Human Resources	4.06
24	Identification of Roles and Responsibilities	4.00
18	Fostering Trust	3.94
11	Frequency of Personal visits	3.89
12	Onsite coordinator	3.89
34	Ease with which other team members can be contacted	3.89
36	GSD Project Management (Planning, Tracking, Control)	3.89
20	Teams' maturity	3.83
21	Process Maturity	3.67
31	Commitment to the Shared Goals	3.67
26	History of working together	3.61
25	Creating team spirit	3.44
9	Synchronous Communication	3.39
33	People Management/Conflict Resolution	3.28
37	Risk Management	3.28
15	Knowledge Management	3.22
17	Knowledge of the Client's Language and Culture	3.17
35	Configuration Management	3.11
30	Knowledge of application domain	3.06
8	Selection of Communication tools used to exchange information	3.00
27	Personality characteristics of the specific team members	2.89
6	Training in International Culture	2.83
16	Knowledge of team ethics	2.83
7	Training in Communication Processes	2.78
28	Team size	2.67
13	Proximity to customer	2.50
4	Number of sites	2.44
22	Policies and Standards	2.44
10	Planning of meetings	2.28
39	Delays in Deliveries	2.22
23	Management of Intellectual Property Issues/Confidentiality and Privacy	2.17
19	High level of Coupling between tasks	2.11
14	Proximity to market	2.06
1	Geographical distance between sites	2.00
2	Cultural differences between sites	2.00
38	Country's instability on some sites	1.89
3	Time Zone Differences between sites	1.78
5	Language Barriers	1.72

statement Creating Team Spirit, which is in the ninth position in the practitioners' ranking, but does not appear to be as relevant for the researchers, as they placed it in the 19th position. A similar result was obtained with regard to the ranking of the ten lowest ranked statements. The researchers and practitioners agreed on eight statements, although some statements were placed in different positions. There was a disagreement regarding the statement Planning of Meetings, which was positioned in the 37th place in the case of the practitioners and in the 27th place in the case of the researchers. The Number of Sites also appeared to be less important to the practitioners than to the researchers, as in the former case it is in position 33 and in the latter it is in position 26.

4.2. Q-methodology quantitative analysis

Once the rankings of the GSD factors had been analyzed, the analysis of results was carried out according to the Q-methodology. The following statistical analysis procedures were applied to the Q-sort data: a factorial analysis to find patterns in the dataset was carried out first, and the factor scores were then computed. The following subsections summarize the statistical procedures applied and present the main findings.

4.2.1. Q-factor analysis

In accordance with Q-methodology, the factorial analysis was conducted on the variables EXP 1 to EXP 18 which represent the experts' opinions of the GSD statements (GSD success factors) (see Fig. 1). The factorial analysis therefore determines how many different Q-sorts are in evidence, in other words, it indicates how many different families or factors there are. It is important to clarify that in this case, the word "factor" has a completely different meaning to that used in the first part of the paper. In this case, we are referring to clusters, families or groups (principal components in statistical jargon). The number of factors is thus purely empirical and depends on how the Q-sorters are performed.

The IBM SPSS statistics tool (version 19) was used to perform the statistical analysis. The syntax defined to carry out this analysis is shown in Appendix 3 (Table 1). The KMO and Bartlett Test of Sphericity were applied to test the adequacy of the data to be used in the factorial analysis. The result was satisfactory, as the KMO value was near to 1 and the significance level of the Bartlett test was 0.00 (see Table 2 in Appendix 3), signifying that the data are suitable for use in a factorial analysis. The method selected for the factorial analysis was the correlation method, which performs the principal component analysis of the selected cases. The results of

Table 2
Ranking of GSD success factors according to practitioners.

Practitioners			
Rank	Statements	Rank	Statements
1	Skilled Human Resources	21	Knowledge of the Client's Language and Culture
2	Frequency of Personal visits	22	Personality characteristics of the specific team members
3	Onsite coordinator	23	Training in International Culture
4	Process Maturity	24	Proximity to customer
5	Identification of Roles and Responsibilities	25	Knowledge of team ethics
6	GSD Project Management (Planning, Tracking, Control)	26	Team size
7	Commitment to the Shared Goals	27	Training in Communication Processes
8	Teams' maturity	28	Policies and Standards
9	Creating team spirit	29	Management of Intellectual Property Issues/Confidentiality and Privacy
10	Ease with which other teams members can be contacted	30	Delays in Deliveries
11	Fostering Trust	31	High level of Coupling between tasks
12	Staff motivation	32	Geographical distance between sites
13	Knowledge of application domain	33	Number of sites
14	History of working together	34	Cultural differences between sites
15	Risk Management	35	Proximity to market
16	Selection of Communication tools used to exchange information	36	Language Barriers
17	Synchronous Communication	37	Planning of meetings
18	Knowledge Management	38	Country's instability on some sites
19	People Management/Conflict Resolution	39	Time Zone Differences between sites
20	Configuration Management		

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Table 3
Ranking of GSD success factors according to researchers.

Researchers			
Rank	Statements	Rank	Statements
1	Staff motivation	21	Knowledge of team ethics
2	Fostering Trust	22	Training in Communication Processes
3	Identification of Roles and Responsibilities	23	Selection of Communication tools used to exchange information
4	Ease with which other teams members can be contacted	24	Personality characteristics of the specific team members
5	Frequency of Personal visits	25	Knowledge of application domain
6	Onsite coordinator	26	Number of sites
7	Skilled Human Resource	27	Planning of meetings
8	GSD Project Management (Planning, Tracking, Control)	28	Team size
9	History of working together	29	Policies and Standards
10	Teams' maturity	30	Proximity to customer
11	Process Maturity	31	Cultural differences between sites
12	Commitment to the Shared Goals	32	High level of Coupling between tasks
13	Knowledge Management	33	Delays in Deliveries
14	Knowledge of the Client's Language and Culture	34	Time Zone Differences between sites
15	People Management/Conflict Resolution	35	Proximity to market
16	Risk Management	36	Management of Intellectual Property Issues/Confidentiality and Privacy
17	Synchronous Communication	37	Geographical distance between sites
18	Configuration Management	38	Country's instability on some sites
19	Creating team spirit	39	Language Barriers
20	Training in International Culture		

the correlation analysis are shown in Appendix 3 (Table 3). As can be observed in the table of correlations, significant correlations were found between the participating experts. As will be observed, five factors were obtained as being the most representative of the data since their Eigen value is greater than 1. Fig. 1 in Appendix 3 shows the Eigen values of each principal component. As is illustrated, from the fifth factor on, the line is almost flat, signifying that the remaining factors account for smaller and smaller amounts of the total variance and are not therefore significant.

Table 5, in the paper, shows the selected rotated components and experts belonging to each factor. The rotation method was selected to facilitate the interpretation of results. The subjects who belong to each of the extracted factors are marked in bold type. The five factors found were:

- **Factor 1.** This factor accounted for 33.3% of the variance (see Table 4), and is therefore the most significant factor to consider. It groups the opinions of experts 6, 8, 12, 15, 16 and 17.
- **Factor 2,** which accounts for 11.48% of data variance, and represents the scores of experts 7, 9, 10, 14, 18.
- **Factor 3,** which accounts for 8.97% of variance, and groups experts 1 and 3.
- **Factor 4,** which involves 8.61% of variance, and represents experts 5, 11 and 13.
- **Factor 5,** which accounts for 6.95%, and groups experts 2 and 4.

The following section provides a detailed analysis of each of the factors according to their scores.

4.2.2. Factor scores

The interpretation of factors in Q-methodology proceeds primarily in terms of factor scores rather than in terms of factor loadings. A factor score is the score for a statement as a kind of average of the scores given to that statement by all of the Q-sorts associated with the factor [4]. In this study, a final score was obtained for each statement in each factor (extracted components) by using the arithmetic mean of all the scores of the participants belonging to the factor. Table 6 and Fig. 2 show the average scores for each statement and factor. The results are analyzed below, and are focused mainly on the results found in the extremes of the scale, i.e., statements with a low, intermediate or high level of success.

4.2.2.1. Factor 1: Knowledge focused. This factor groups the opinions of experts 6, 8, 12, 15, 16 and 17. We decided to call this factor "Knowledge focused", as the experts in this group consider Knowledge acquisition (training) and Knowledge management to be important to the success of a GSD project. Moreover, they also considered the ways in which knowledge is shared to be important, since they chose as important statements: synchronous communication, ease with which other team members can be contacted, and frequency of personal visits. In other words, it is therefore possible to state that for this group the different processes of the Nonaka and Takeuchi Knowledge Management cycle [19] are a means of achieving success in GSD, since the internalization process converts or integrates shared and/or individual experiences and knowledge into individual mental models. This process could be carried out through training (a statement that was considered to be important for this group of people). On the other hand, the socialization process using face-to-face communication (i.e., personal visits in our context) involves arriving at a mutual understanding through the sharing of mental models. Moreover, for knowledge management (another statement chosen), the other two processes of the Nonaka cycle are also necessary: combination and externalization. It is interesting to note that for this group, the

Table 4
Total variance explained by selected factors.

Factors	Extracted sums of squared loadings			Rotation sums of squared loadings		
	Total	% of Var.	Cum.%	Total	% of Var.	Cum.%
1	5.997	33.314	33.314	3.469	19.270	19.270
2	2.067	11.484	44.798	3.287	18.260	37.530
3	1.615	8.973	53.771	2.008	11.154	48.683
4	1.551	8.615	62.386	1.956	10.864	59.547
5	1.252	6.954	69.341	1.763	9.794	69.341

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Table 5
Rotated components matrix (rotation converged in nine iterations).

	Factors				
	1	2	3	4	5
EXP1	−.065	−.050	**.835**	.117	.233
EXP2	.502	.091	−.122	−.205	**.555**
EXP3	.042	.105	**.856**	−.136	−.162
EXP4	.038	.059	.149	.040	**.831**
EXP5	.358	.549	.053	**.642**	.207
EXP6	**.817**	.120	.027	−.021	.058
EXP7	.521	**.635**	−.174	.063	.043
EXP8	**.545**	−.171	.331	.375	−.009
EXP9	.039	**.575**	−.306	.306	.418
EXP10	.127	**.733**	.058	.027	.150
EXP11	−.015	−.026	−.090	**.777**	−.156
EXP12	**.587**	.423	.087	.188	−.419
EXP13	.405	.305	.433	**.446**	.114
EXP14	.115	**.528**	.144	.508	.296
EXP15	**.610**	.531	.010	.126	−.007
EXP16	**.645**	.166	−.203	−.049	.327
EXP17	**.703**	.317	.146	.332	.010
EXP18	.150	**.827**	.113	−.036	−.176

statements Cultural differences, Time zone or Language differences are considered to have a low level of success in GSD projects. The same occurs with other statements, such as Number of sites, High level of Coupling between tasks, or Delays in deliveries.

4.2.2.2. Factor 2: Project management focused. This factor represents the scores of experts 7, 9, 10, 14, 18. We have called this group "Project Management focused" as its components consider as relevant those statements for GSD success that are mainly related to project, configuration or risk management. The statement "onsite coordinator" could be also considered within the category of management.

It is interesting to note that, although the people in Factors 1 and 2 do not in general coincide with regard to the statements that could lead to a high level of success in GSD projects, they agree as regards four of the statements, which are considered to have little influence on this kind of projects. These are: Time zone differences, Language barriers, Number of sites and Management of intellectual property issues. However, they disagree in their opinions of training, since it is considered to be of little relevance for the success of GSD projects. It is also important to note that in this group of experts there was no consensus as to the actors who have a high level of success. No factor (on average) with a score of 5 was therefore obtained.

4.2.2.3. Factor 3: Project team focused. In this case, the population of this group was composed of two experts: 1 and 3. The experts in this group consider the features of the project team members to be very important to the success of a GSD project, as can be deduced from those statements classified with the values 4 and 5. Some of these are: Language barriers (which was considered to be of little importance in the previous groups), Teams' maturity, Identification of roles and responsibilities, Personality characteristics of the specific team members, Team size, Time zone differences between sites, Number of sites, History of working together, Staff motivation. Other important statements are synchronous

Table 6
Factor scores.

Id	Statement	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
1	Geographical distance between sites	2	1	3	1	5
2	Cultural differences between sites	1	3	3	1	2
3	Time Zone Differences between sites	1	1	5	1	2
4	Number of sites	2	2	5	1	3
5	Language Barriers	1	1	4	1	3
6	Training in International Culture	4	2	2	2	4
7	Training in Communication Processes	4	2	2	2	3
8	Selection of Communication tools for exchanging inf.	3	3	2	2	4
9	Synchronous Communication	4	3	5	3	2
10	Planning of meetings	3	2	2	1	3
11	Frequency of Personal visits	5	3	5	3	4
12	Onsite coordinator	3	4	3	4	5
13	Proximity to customer	4	2	2	2	2
14	Proximity to market	3	2	1	3	2
15	Knowledge Management	4	3	3	3	2
16	Knowledge of team ethics	3	2	2	4	2
17	Knowledge of the Client's Language and Culture	3	3	3	3	2
18	Fostering Trust	4	3	5	4	5
19	High level of Coupling between tasks	2	2	4	3	2
20	Teams' maturity	4	3	4	4	4
21	Process Maturity	4	3	2	3	5
22	Policies and Standards	2	2	1	3	4
23	Management of Intellectual Prop. Issues/Confid. Privacy	2	2	2	3	2
24	Identification of Roles and Responsibilities	4	4	4	5	4
25	Creating team spirit	4	2	4	4	4
26	History of working together	4	3	5	4	1
27	Personality characteristics of the specific team members	3	2	4	3	3
28	Team size	3	2	4	3	2
29	Skilled Human Resources	4	4	3	4	5
30	Knowledge of application domain	4	2	2	3	4
31	Commitment to the Shared Goals	3	3	4	5	4
32	Staff motivation	4	3	5	5	5
33	People Management/Conflict Resolution	3	3	3	4	3
34	Ease with which other teams members can be contacted	4	4	3	4	3
35	Configuration Management	3	4	2	3	3
36	GSD Project Management (Planning, Tracking, Control)	4	4	3	4	3
37	Risk Management	3	4	3	3	5
38	Country's instability on some sites	1	2	3	3	2
39	Delays in Deliveries	2	1	5	2	4

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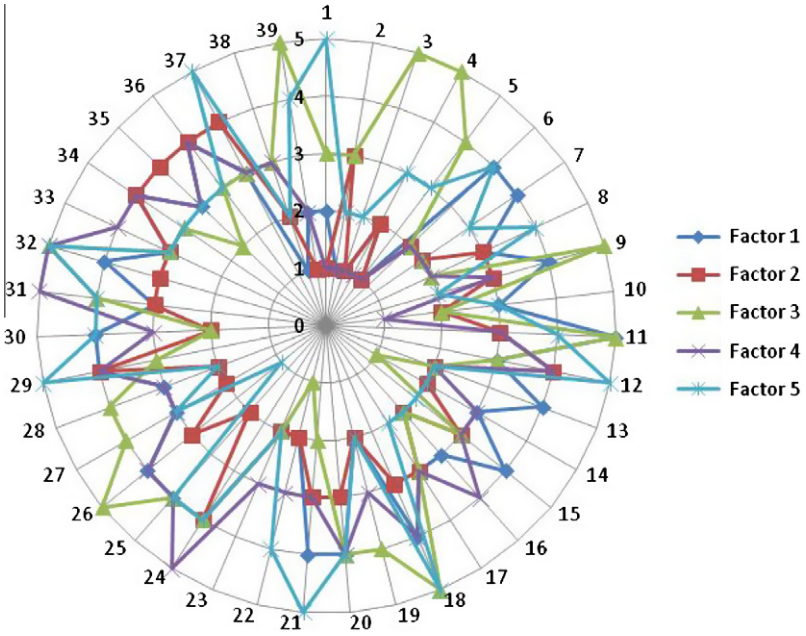

Fig. 2. Radial graphs of factor scores.

communication and frequency of personal visits, which is coherent with their selection of time zone differences and language barriers, since for synchronous communication it is necessary to manage time overlap and a suitable domain of the common language.

We found a great variety in the statements that are considered to have a low influence on the success of a GSD project, such as Proximity to market or customer and Training. This heterogeneity of types of statements makes it difficult to obtain a particular pattern for these answers.

4.2.2.4. Factor 4: Staff skills focused. Factor 4 represents the opinions of experts 5, 11 and 13. This group considers that the team members' personal features and skills are important to the success of a GSD project, since its components chose the following success factors: People management/conflict resolution, Teams' maturity, Staff motivation, Skilled human resources, Commitment to the shared goals. This opinion stream complements the perception of Factor 3 with regard to the influence of project team maturity on GSD project success by highlighting the importance of team members' skills and motivation, along with their commitment to achieving the goals of the GSD project. In the case of those statements with a low level of success, we found all those related to distance and differences between sites, namely: Geographical distance, Cultural, language and Time zone differences. This group also considered training to be of little relevance.

4.2.2.5. Factor 5: Miscellaneous. This final factor groups the opinion of experts 2 and 4, who consider that all the 'ingredients' (statements) are important to achieve success in a GSD project. The perception of these experts is that the group features are important, as is reflected in their statement selection: Teams' maturity, Creating team spirit, Commitment to the shared goals, Geographical distance between sites, Fostering trust, and Skilled human resources. They also consider the selection of the communication tools used to exchange information to be important, a statement which is of less importance to the experts belonging to the other factors as they rated it with a value of 2 or 3. The same occurs with the statement policies and standards, which was only rated as important by the experts in this factor. Moreover, Risk management, was only rated as having a high level of success by the experts in this factor, who also believe that it is relevant to have an onsite coordinator. It is interesting to note that they rated cultural differences between sites and the client's language and culture with an average score of 2. However, they considered "training in international culture" to be a successful statement. Time zone differences, Team size or High level of coupling between tasks were not considered to be very important for a GSD project's success. Finally, it is interesting to note that the experts in Factor 5 rate the History of working together as having a low level of success in contrast with the opinion of the experts in the other factors.

4.2.2.6. Researchers' perception vs. practitioners' perception. An additional analysis was performed to compare the results obtained from the practitioners with those obtained from the researchers in order to detect important differences in their criteria. In this

Table 7
Researchers' opinions vs. practitioners' opinions.

Statements		Results		Difference
		Researcher	Practitioner	
2	Cultural differences between sites	1	5	−4
9	Synchronous Communication	1	5	−4
35	Configuration Management	3	5	−2
29	Skilled Human Resources	3	5	−2
28	Team size	2	4	−2
18	Fostering Trust	5	3	2
20	Teams' maturity	5	3	2
33	People Management/ Conflict Resolution	5	3	2
22	Policies and Standards	1	3	−2
16	Knowledge of team ethics	4	2	2
6	Training in International Culture	3	1	2

case, the average scores of the practitioners (experts 4, 6, 10, 11, 13, 16, 17, 18) and the researchers (experts 1, 2, 3, 5, 7, 8, 9, 10, 12, 14, 15) were computed.

Table 7 shows those statements in which the difference between both groups was greater than or equal to two units. It will be noted that cultural differences between sites is much more important for practitioners than it is for researchers. The same occurs with the means of communication. Practitioners consider synchronous communication to be an issue that has a high level of success in GSD projects. The policies and standards statement was rated as having a low level of success in the case of researchers. However, for the practitioners this issue is of slightly more relevance, although it is not one of the better ranked statements. A different situation occurs in the case of Team size, Skilled human resources and Configuration management, which were evaluated as intermediate or almost intermediate by the researchers, but were ranked as having a high level of success in GSD by the practitioners. However, training in international culture or having knowledge of team ethics seem to be issues with more or slightly more influence on the success of a GSD according the practitioners. On the other hand, aspects which, according to Table 10, are critical for researchers in general, but that are perceived as intermediate for the practitioners are: Fostering trust, Teams' maturity and People management/Conflict resolution.

4.3. Qualitative analysis

4.3.1. Experts profiles

This study shows that not all the experts share common ideas about the issues that influence the success of a GSD project. We have therefore seen that some experts are more concerned about knowledge sharing and management, others about the features of the teams or their skills, others about the project management, while yet others consider all the issues to be of some importance, thus making it difficult to characterize them with only one label. Moreover, upon comparing the practitioners' and researchers' opinions we also found some differences, although it is important to note that they had similar opinions in general, which may indicate that there is not a huge disagreement between the two groups, as was also stated when comparing the practitioners' and researchers' rankings in Section 4.1. The complete table of the differences is shown in Appendix 4 and can therefore be consulted by those who are interested in seeing all the similarities and differences in opinions.

In order to shed more light on this topic, we decided to analyse the profiles of the experts belonging to each factor. We wish to clarify that this is not the goal of Q-methodology, as this methodology is useful to provide an idea of the different approaches or people's points of view as regards a particular topic, which in this case concerns the issues that affect/influence the success of a GSD project. However, we believe that an analysis of the experts' profiles might be complementary and interesting information for this study. Let us begin by analysing the members of Factor 1.

As Table 8 shows, this factor was composed of three practitioners and three researchers. It includes one female, while the rest were male. This group was highly heterogeneous as regards nationality, as there were two people from Brazil, one from Britain, one from China, one from Germany and one from India. Their age was between 34 and 50, with an average of 39.6. Most of them have been project managers, and the average amount of time working in GSD is 6.9 years.

The practitioners involved often played the role of project manager in their projects. They were concerned about knowledge management and the training of the people involved in the project. However, the typical issues which researchers mention as key aspects for GSD, such as Cultural differences, Time zone or language differences, are considered as having a low level of success for GSD projects. The same occurs with other statements, such as the Number of sites, the High level of coupling between tasks, or Delays in deliveries.

Factor 2 includes two researchers and three practitioners who have had at least 5 years of experience in GSD (industrial or research projects).

In the case of Factor 3, the only features in common between the members are that both of them are practitioners and they have similar experience (in years) in GSD. These two experts consider that team features are critical to the success of a GSD project, as was seen when analysing this factor.

The European group (members of Factor 4) coincide in having a similar age and experience in GSD. In this case, there is one practitioner and two researchers, and they focus on team skills.

The profile of the experts in Factor 5 is heterogeneous as there was only one research and one practitioner (male and female) of a similar age but with a different amount of experience in GSD.

4.3.2. Context characterization

Another very important aspect to consider is the context of the GSD projects in which the practitioners who participated in this study have been involved. Ref. [24] provides an interesting classification scheme for GSD-related empirical studies which have served as the basis to characterize the projects in which our experts were involved. An additional survey (see Appendix 5) was therefore prepared in order to obtain this context information from the 10 practitioners who participated in this study. As a result, eight responses were received which are summarized in Table 9.

We analyzed the data by taking into account the context of the projects in order to know what issues were considered to be the seven best scored and the seven worst scored by the experts, thus obtaining the results shown in Table 10. The cultural difference values of "low-medium" or "medium-high" signify the midpoint in the two scale values. This is owing to the fact that some experts directly provided these answers or that the median value was calculated by considering the answers provided by experts for each GSD project in which they had participated.

According to the data, four researchers have usually worked with 2 or 3 sites. For these researchers the most important issues were those related to maturity, such as Process maturity or Teams'

Table 8
Features of members.

Factor	Affiliation		Gender		Nationality	Age Min/Max (average)	Exp. GSD Min/Max (years average)
	Researchers	Practitioners	Male	Female			
1	3	3	5	1	German, British, Chinese, Brazilian (2), Indian	34–50 (39.6)	2.5–11 (6.9)
2	2	3	5	0	Japanese, German, Indian, Singaporean, American	34–57 (39.4)	5–16 (8.9)
3	0	2	1	1	American, Swedish	32–64 (48)	8–9 (8.5)
4	2	1	2	1	German, Spanish, Finnish	34–39 (35.6)	8–9 (8.3)
5	1	1	1	1	Australian, German	42–47 (44.5)	4–15 (9.5)

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Table 9
Context of the projects.

Context Factor	EXP4	EXP11	EXP13	EXP14	EXP15	EXP16	EXP17	EXP18
Avg. number of distributed sites per GSD project	3	6	5	6	2	3	2	3
Name of the countries or cities in which these sites are usually located	Germany, USA, China, India, Korea	Kenya, Rumania and Colombia	Finland, Other EU Countries	India, US, Germany, Singapore, Netherlands and Japan	Brasil, Germany	Brasil, USA, India, China	India, USA, Japan, China	USA, India, China, Egypt
Avg. Rating of Cultural Difference	High	High	Low–Medium	Low-Medium	Low-Medium	Medium-High	Medium	High
Collaboration Mode	Intra-Organizational	Intra-Organizational	Both	Both	Inter-Organizational	Intra-Organizational Collaborator	Intra-Organizational	Intra-Organizational
Perspective	Originator	Originator	Originator	Collaborator	Originator	Collaborator	Collaborator	Collaborator
Reason for GSD	Cost and competences	Cost and Extra People	Extra knowledge	Researching	Extra knowledge, extra people, problem complexity	Global Market	All of these, also to have visible market presence in specific geographies, it helps to have local teams	Cost talent, defect support covering after hours timeslots
Outsourcing Direction	Both	Outsourced by others	Both	Multinational company	Outsourced by others	Outsourced by others	Multinational company	None

maturity, and they also considered it important to have an Onsite coordinator and to Visit the other sites. On the other hand, Cultural differences, Time zone differences or a Country's instability, amongst others, were not so important for these researchers. These results make more sense if we also bear in mind that only one expert follows an Inter-Organizational collaborative mode.

In the case of working with 5 or 6 sites the results change, as it would appear that the more sites there are, the more important it is for there to be clarity as regards, i.e., the Different roles and responsibilities, the Commitment to the shared goals, People management and Ease with which other team members can be contacted. Surprisingly, those factors that have classically been considered important in literature, such as Geographical distance between sites, Time zone differences, Language barriers or Training in international culture are the least important for our practitioners. This could be because two of the three experts stated that the cultural difference between the sites was low-medium, and only one answered that it was high. However, upon viewing the part of the table in which cultural differences are studied and focusing on the medium-high row it will be noted that these factors are again those statements with low scores, they are: Time zone differences between sites, Language barriers and unexpected Cultural differences between sites. Perhaps for our experts the fact of working with people with high or medium cultural differences does not imply a problem. In the case of the top scored statements there are also some coincidences with the results of medium-high culture since several factors are repeated, such as Identification of roles and responsibilities, Skilled human resource, Commitment to the shared goals and Staff motivation.

When studying the differences concerning the collaborative model is also quite important, as Poikolainen and Paananen [26] argue, to note that it is fair to assume that the findings and theories made for intra-organizational GSD projects may not directly apply in global inter-organizational software development projects. Ref. [24] therefore emphasizes the need to describe a collaboration mode for GSD studies. Unfortunately, in our research there was only one inter-organizational case, so it is not possible to generalize the results. However, it is quite interesting to note that there is no coincidence between the top seven factors chosen by people working on the intra-organizational case and the ones chosen by those experts working on inter-organizational. In this last case there is most concern about, for instance, the history of working together or the people management/conflict resolution. On the other hand, there are four coincidences in the case of the seven factors which the worst ratings. These are: Country's instability on some sites, Cultural differences between sites, Language barriers and Time zone differences between sites. These two last are also considered to be of little importance by the two practitioners who had worked on both kind of projects.

On the other hand, according to the practitioners' answers, when a site is the originator of the GSD it would appear that they consider the successful factors to be principally those related to human features such as skills, motivation, trust, people management, commitment to the shared goals. However, when the site is a collaborator, other factors are also important such as Process maturity, the ease with which other members can be contacted or the possibility of having asynchronous communication.

In the case of the less important statements, we can deduce from the table that the practitioners did not deem factors such as the Number of sites, Training on culture or communication processes or Time zone differences to be important. In the case of being a collaborator, the political issues such as Management of intellectual property or a Country's instability are not very relevant, and the Delays in deliveries and the High level of coupling between tasks were not considered to be important either.

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Table 10
Classifications of factors according to context.

	Experts	Avg. top scored statements	Avg. down scored statements
Avg. number of sites			
2–3	4, 15, 16, 17, 18	Process Maturity	Cultural differences between sites
		Onsite coordinator	Language Barriers
		Skilled Human Resource	Proximity to market
		GSD Project Management	Delays in Deliveries
		Frequency of Personal visits	High level of Coupling between tasks
		Teams' maturity	Time Zone Differences between sites
		Commitment to the Shared Goals	Country instability in some sites
			Planning of Meetings
5–6	11, 13, 14	Identification of Roles and Responsibilities	Proximity to Customer
		Skilled Human Resource	Training on Communication Processes
		Commitment to the Shared Goals	
		Staff motivation	Geographical distance between sites
		History of working together	Time Zone Differences between sites
		People Management/Conflict Resolution	Language Barriers
		Ease with which other teams members can be contacted	Training on International Culture
Avg. cultural difference			
Low-Medium	13, 14, 15	People Management/Conflict Resolution	Team Size
			Country instability in some sites
		Teams' maturity	Geographical distance between sites
		History of working together	
		Ease with which other teams members can be contacted	Time Zone Differences between sites
		Fostering Trust	Language Barriers
		Identification of Roles and Responsibilities	High level of Coupling between tasks
		Skilled Human Resource	Delays in Deliveries
Medium-High	4, 11, 16, 17, 18	Skilled Human Resource	High level of Coupling between tasks
		Process Maturity	Proximity to market
		Commitment to the Shared Goals	Country instability in some sites
		Staff motivation	Cultural differences between sites
		Synchronous Communication	Language Barriers
		Onsite coordinator	Planning of meetings
		Identification of Roles and Responsibilities	Time Zone Differences between sites
Collaboration mode			
Intra	4, 11, 17, 18	Skilled Human Resource	Country instability in some sites
		Staff motivation	Cultural differences between sites
		Commitment to the Shared Goals	Language Barriers
		Onsite coordinator	Training on International Culture
		Process Maturity	Proximity to Market
		Knowledge of application domain	Time Zone Differences between Sites
		Identification of Roles and Responsabilities	Planning of Meeting
Inter	15	Knowledge of the Client's Language and Culture	Cultural differences between sites
			Time Zone Differences between sites
		Fostering Trust	Language Barriers
		Teams' maturity	Synchronous Communication
		History of working together	Policies and Standards
		People Management/Conflict Resolution	Country instability in some sites
		Ease with which other teams members can be contacted	Delays in Deliveries
		GSD Project Management (Planning, Tracking, Control)	
Both	13, 14	Identification of Roles and Responsibilities	Geographical distance between sites
		Skilled Human Resource	Time Zone Differences between sites
		People Management/Conflict Resolution	Language Barriers
		Synchronous Communication	Training on International Culture
		Teams' maturity	Training on Communication Processes
		History of working together	Knowledge of application domain
		Commitment to the Shared Goals	Delays in Deliveries
Perspective			
Originator	4, 11, 13, 15	Skilled Human Resource	Country instability in some sites
		Staff motivation	Number of sites
		People Management/Conflict Resolution	Training on International Culture
		Fostering Trust	Training on Communication Processes
		Teams' maturity	Time Zone Differences between sites
		Identification of Roles and Responsibilities	Planning of meetings
		Commitment to the Shared Goals	Cultural differences between sites
Collaborator	14, 16, 17, 18	Synchronous Communication	Proximity to Marquet
		Skilled Human Resource	Management of Intellectual Property Issues
		Process Maturity	Country instability in some sites
		Commitment to the Shared Goals	Time Zone Differences between sites
		Ease with which other teams members can be contacted	High level of Coupling between tasks
		Onsite Coordinator	Delays in Deliveries
		Teams' Maturity	Language Barriers

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5. Strengths and limitations of the study

There are several threats to the validity of this study, particularly as regards data collection procedures, subject sampling and external validity.

With regard to data collection, the GSD factors included in the survey were selected from publications concerning the most important Global Software Development conference (ICGSE) and nine existing systematic reviews on the topic. A possible bias might have been the omission of some relevant sources but, to the best of our knowledge, the most relevant literature was considered. It should be noted that the experts who participated in this survey did not appear to believe that any additional GSD factors were missing from the list, as they did not indicate any new ones in the "additional comments" section. The revision of the papers from the aforementioned relevant sources was carried out by two of the authors of this paper, and it was then sent to research experts on the topic to obtain the final list. This greatly mitigated possible data collection bias. Moreover, since after our analyses the paper by Verne et al. [27] was published in which the authors analyzed 37 papers reporting 24 GSD SLR studies, we also reviewed these papers. However, no additional factors were found.

The subjects who participated in the survey were chosen for convenience, which may have caused some bias as compared to random sampling. However, it was necessary to select people with significant experience in GSD in order to empower the significance of the conclusions. The respondents all have experience in GSD (most of them with more than 5 years, 83%) and consisted of a heterogeneous group: their ages are between 32 and 64 (average 42.2), and they are from 12 different countries. We therefore believe that the population of the study was sufficiently heterogeneous to provide significant results.

Furthermore, the Q-methodology has been rigorously applied as described in relevant sources such as (Brown, 1993). The Q-set was carefully designed in order to cover all the issues which, according to literature and expert opinion, might influence the success of a GSD project.

With regard to conclusions and external validity, of the 50 possible respondents, 21 surveys were received, of which three were discarded. 18 surveys were therefore analyzed, which could be seen as a sample size limitation. However, the Q-methodology was used with the intention of providing a view of the perspectives that exist among the population, and consequently relies on purposive sampling and smaller sample sizes [6]. In relation to external validity, we consider that the five extracted factors in this study provide a good coverage of different experts' points of view. The heterogeneity of the participants' sample may also help to reinforce the capability of generalizing the results obtained.

Finally, it is worth noting that some of the respondents provided valuable additional feedback which will be used to improve future replications of this study. What is more, some of them were not comfortable with the Q-Methodology restriction of placing only one statement per cell. We consider that this is a positive point in favour of using Q-Methodology, as it "forces" experts to discriminate as regards their preferred GSD factors.

6. Conclusions

Our preoccupation with the failures in GSD led us to verify what issues affect this kind of projects and which of these issues could be considered as success factors. As a result, in this paper an exhaustive analysis of GSD success factors was performed to select those which are most relevant as documented in the most significant literature sources. In order to reinforce the analysis obtained, we wished to discover practitioners' and researchers' opinions of these factors, and a survey was therefore developed according to Q-methodology. We collected the opinions of 21 experts in GSD, and this allowed us to create a ranking of GSD success factors. It was very interesting to see that, according to the respondents, the most significant GSD success factors were Staff motivation, followed by Skilled human resources and the Identification of roles and responsibilities. They then rated Fostering trust, Frequency of personal visits or the fact of Having an onsite coordinator as being of slightly less importance. On the other hand, and surprisingly for us, the five factors with the least influence according to the experts' evaluation are: Language barriers, Time zone differences between sites, the Country's instability on some sites, Cultural differences between sites and Geographical distance between sites. This finding was not expected, as literature related to GSD classically considers language, cultural differences and geographical distance as key influence factors in GSD [5,9,2,8,12]. One reason for these findings may be that these distances have been decreased through the use of suitable technology and by improving the process of developing software in a global manner, and that new challenges or new issues are currently appearing which determine the success of a factor, such as team members' features and skills.

This study has also shown the different points of view as regards which issues are most important when setting up a GSD project, i.e., following a knowledge focus when people are concerned about this, and learning/training processes. On the other hand, other experts preferred a project management approach in which the most important issues are those related to management (risks, coordination). Another point of view is the project team focus, which concentrates on the team members' features. A further variation is the staff skills focus, which concentrates on the abilities that team members have. We have denominated the last point of view as "miscellaneous", because some aspects of all the issues are taken into account.

We consider that this research may be useful for both practitioners and researchers. From the perspective of the former, practitioners could discover some success criteria that they had not previously taken into account, but may consider in their future projects after analysing the findings presented herein. People are usually aware of what they have learnt from their own experience. However, seeing other points of view helps to prevent future problems that could take place in projects with new features that would have to be confronted. Moreover, as the data have been also analyzed according to the context of the projects, practitioners can check whether they have the same opinion as the practitioners who took part in our surveys. This study is also useful for researchers, as they can learn from the practitioners' contributions and can also reflect upon whether the issues that concern researchers and that are dealt with in research papers coincide with the issues (in this case success factors) that concern practitioners. This paper might therefore provide the opportunity to carry out more research on the topics that have been considered to be most relevant by the practitioners.

Moreover, the results presented here show that the challenges of GSD are changing, since the critical issues were initially the various types of distances (geographical, temporal, socio-cultural, language) and, according to the data, there is now a greater concern about the team members' features and skills. It would therefore be very interesting to repeat this study in 5 years' time in order to verify what issues influence the success of a GSD project at that moment.

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Appendix A. Supplementary material

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