Success factors during requirements implementation in global software development: An empirical study

Zahid Ali

Engineering Research & IT Services Provider (Pvt) Ltd
Peshawar, Pakistan
engineerzahidali@gmail.com

Muhammad Yaseen

Engineering Research & IT Services Provider (Pvt) Ltd
Peshawar, Pakistan
yaseen_cse11@yahoo.com

Atta Ur Rahman

Department of Computer Science,
COMSATS University Islamabad, Islamabad Pakistan
attaurrahman513@gmail.com

Abstract — **Requirements collection and management is not easy task especially in global software development (GSD) where clients and vendors are far away from one another. There exist significant challenges in GSD. For successful implementation of requirement engineering process in GSD, these challenges should be tackled and for this purpose success factors are suggested by researchers that can reduce the effect of these challenges in GSD. In this research study, success factors that were previously identified are validated through empirical study from software industry. From industrial survey, we found several success factors that are marked as most critical and important. The aim of this research work is to identify success factors that are most critical. The results of survey are analyzed on the basis of experience of experts.**

Keywords - *Global Software Development; Requirement Engineering; Success Facotrs;*

I. INTRODUCTION

Requirement Engineering (RE) deals with user requirements collection in more systematic way for any software system [1][2][3]. In elicitation phase, requirements for software systems are collected from clients [5]. Requirement analysis is the phase where collected user requirements are analyzed from different perspective using different models e.g. use case models are used to analyze high level user requirements from user perspective and object oriented models are used to analyze functional requirements from internal system perspective [5][6]. Requirement specification is the third phase where collected requirements from users are specified in document SRS while verification of requirements is done in last phase of RE [7][8]. In verification phase requirements are tested [9]. If the cause of an error or failure of software is traced back to RE then it becomes very much costly and difficult to fix errors [10]. GSD is development of software product across the globe where vendors and clients are far away from one another [11]. In GSD, requirements collection face a lot of problems like improper communication, culture issues, time zone and language barriers [12][13]. Coordination and proper communication in GSD is not easy [14] [12]. Using collaborative tools and technologies are essential in GSD [15][16]. In our previous study [17], we identified critical challenges during requirements implementation in context of GSD and our extended results with more analysis are now published in our next paper [18]. We conducted systematic literature review (SLR) to identify critical success factors during requirements collection in GSD to reduce the barriers and challenges [19].

II. BACKGROUND STUDY

According to Wesley James Lloyd [5] collaboration is considered to be the most critical success factor and frequent meetings with customers are essential for enhancing collaboration while collecting requirements from users. The usefulness of elicitation techniques is explained by author in detail. There are two ways of communication among vendors and clients. They can communicate synchronously with devices such as video links or can use asynchronous ways of communication such as emails, fax etc.

Yvonne Hsieh [20] emphasis on knowledge sharing. Knowledge about requirements should not be preserved as stationary but must be shared with others. Cooperative knowledge will rise collaboration in GSD. Along with theoretical knowledge, it is necessary to practice it.

Daniela Damian [21] state the significance and practice of innovative technologies and use of modern tools for GSD. For requirements to better manage in GSD, it is essential to implement modern technologies. For effective communication, organization structure play a significant role. When interconnecting with others, clear roles and duties must be allocated. Few authors have argued about the role of semantic web and ontologies for management and prioritization of requirements to eliminate requirements inconsistences and to handle disappeared and improper requirements [22][23].

According to Arif Ali Khan [24], In GSD, requirement change management (RCM) frameworks are essential to deal with changes in requirements. At initial phase, change request from clients will come and then evaluation of variations in requirements will occur in next phase and steps will be considered in decision phase.

Daniela E. Damian[21] argue the negative influence of culture variances on requirements during elicitation. For reducing the influence of culture issues, proposed model is presented by author. The model will recommend the practices necessary for reducing the issues and risks while communication of requirements in clients and vendors.

According to Gabriela N. Aranda arranging training sessions are necessary for stakeholders of GSD. It is compulsory to provide training to professionals for gaining skills [16]. Appropriate risk management should be implemented for handling threatens during RE [25].

III. RESEARCH METHOD

3.1. Survey Design

Survey is empirical study that is conducted to validate our outcomes from results of SLR that was formerly conducted [19]. When maximum responses in short time are to be collected, questionnaire survey is best choice. In this research work, online survey is led with software engineering experts. Structured questionnaire method is adopted for gathering data from the experts working in GSD projects.

The questionnaire consists of success factors that were identified through SLR. Five point scale was used to state the importance of the identified intercultural challenges. The respondents were requested to choose one of the seven options i.e. strongly agree, agree, slightly agree, not sure, disagree.

3.2. Data sources

Only those software organization were selected that work on GSD projects. Different organizations were finalized for this purpose and questionnaire were distributed amongst them.

3.3. Data analysis

A total of 45 participants responded to the survey, among them 5 responses were rejected because of our quality criteria. Final list of responses contain 40 experts. Percentages of strongly agreed, agreed, slightly agreed, not sure and disagreed responses will be calculated for every success factor. This calculation is necessary to analyze these factors and to identify factors that are more critical. Critical factors are those that bears more importance as compare to rest of the factors. The experts are categorized on the basis of their experience. For this study, we have divided into two categories i.e. experts with experience greater than five years and experts with experience lower than five years. There can be some factors where experts with difference in experience can have different opinions.

IV. RESULTS

Table 1 shows success factors and how much they are agreed by software industries which include feedbacks from all experts who filled questionnaire. Total experts responses are 40.

Table1: Response of all experts for success factors in GSD

	Expert Responses = 40				
	Strongly agree	Agree	slightly agree	Not sure	Disagree
Effective and strong communication system	28	12	0	0	0
3C (coordination, cooperation and collaboration)	17	23	0	0	0
Using collaborative tools	20	20	0	0	0
Knowledge management and sharing	4	10	18	6	2
Global project management	6	19	10	5	0
RE modelling	5	10	7	15	3
Proper discussion on requirements	15	21	4	0	0
Software engineering process maturity	5	15	16	4	0
Mutual Trust	7	19	10	4	0
Requirement change management	7	18	15	0	0
Training sessions	8	22	10	0	0
Use of modern web technologies	7	20	9	3	1
Social networking	20	18	2	0	0
Infrastructure and organizational setup	5	17	10	3	5

Table 2 shows success factors and how much they are agreed by software industries which include feedbacks of experts with experience below 5 years. Total experts with less than five years of experience are 25.

Table 2: Response experts with experience greater than 5 years

	Experience below 5 years (Expert Responses = 25)				
	Strongly agree	Agree	slightly agree	Not sure	Disagree
Effective and strong communication system	20	5	0	0	0
3C (coordination, cooperation and collaboration)	7	18	0	0	0
Using collaborative tools	15	10	0	0	0
Knowledge management and sharing	1	5	12	5	2
Global project management	3	10	10	2	0
RE modelling	0	4	5	13	3
Proper discussion on requirements	13	10	2	0	0
Software engineering process maturity	1	5	15	4	0
Mutual Trust	2	11	8	4	0
Requirement change management	3	10	12	0	0
Training sessions	5	13	7	0	0
Use of modern web technologies	2	13	7	2	1
Social networking	14	11	0	0	0
Infrastructure and organizational setup	2	12	6	2	3

Table 3 shows success factors and how much they are agreed by software industries which include feedbacks of experts with experience greater than 5 years. Total experts with less than five years of experience are 15.

Table 3: Response experts with experience less than 5 years

	Experience above 5 years (Expert Responses = 15)				
	Strongly agree	Agree	slightly agree	Not sure	Disagree
Effective and strong communication system	8	7	0	0	0
3C (coordination, cooperation and collaboration)	10	5	0	0	0
Using collaborative tools	5	10	0	0	0
Knowledge management and sharing	3	5	6	1	0
Global project management	3	9	0	3	0
RE modelling	5	6	2	2	0
Proper discussion on requirements	2	11	2	0	0
Software engineering process maturity	4	10	1	0	0
Mutual Trust	5	8	2	0	0
Requirement change management	4	8	3	0	0
Training sessions	3	9	3	0	0
Use of modern web technologies	5	7	2	1	0
Social networking	6	7	2	0	0
Infrastructure and organizational setup	3	5	4	1	2

Case 01 is considered for table 1, case 02 is considered for table 2 and case 03 is considered for table 3 for all figures that are shown below.

Figure 1 shows effective and strong communication system and how much this factor is agreed by different experts. The percentage of strongly agreed is above than 50% in all cases. None of the expert is disagreed with importance of effective and strong communication system in GSD.
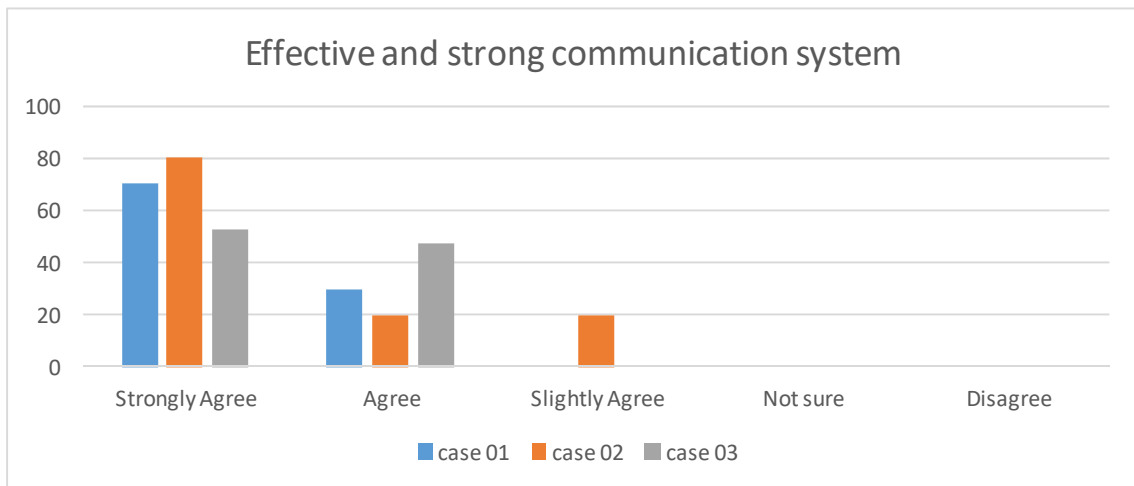

Figure 1: Comparison of effective communication as success factor for different cases

Figure 2 shows coordination and collaboration and how much this factor is agreed by different experts. The percentage of strongly agreed is above than 50% for case 03 where experts experience is above 5 years. Based on the opinions of highly experts, this factor is marked as strongly agreed with 67%. None of the expert is disagreed with importance of effective and strong communication system in GSD.
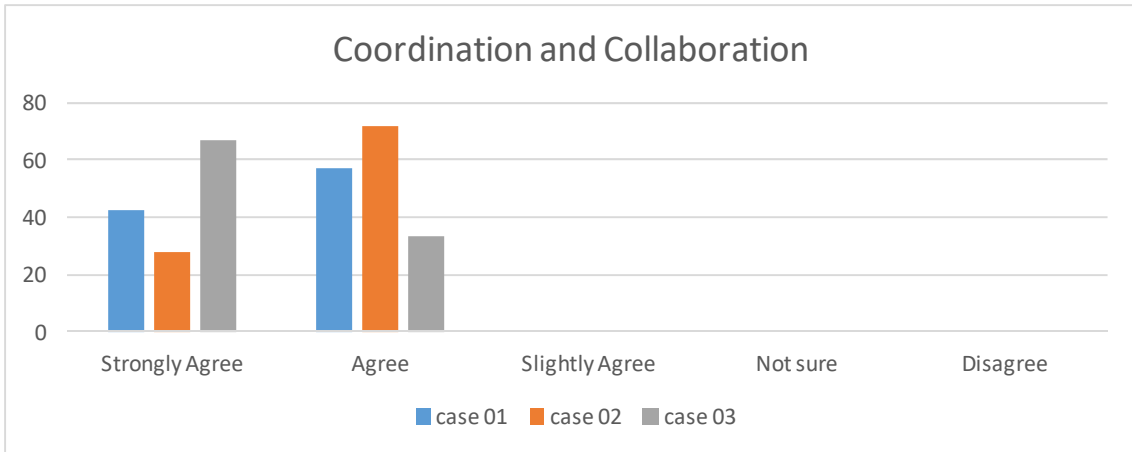
Figure 2: Comparison of coordination and collaboration as success factor for different cases

Figure 3 shows using collaborative tools and how much this factor is agreed by different experts. The percentage of strongly agreed is above than 50% for case 02 where experts experience is less than 5 years. Based on the opinions of experts with low experience, this factor is marked as strongly agreed with 60% while highly experienced experts frequency is 33%. This may be due to their experience that doesn't allow them to use such tools too much and they collect requirements based on their experience quite easily. None of the expert is disagreed with importance of effective and strong communication system in GSD.
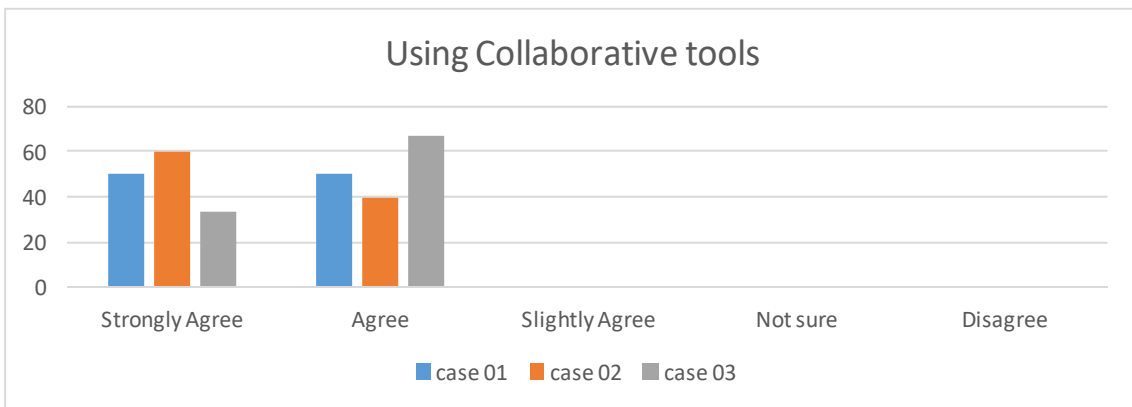
Figure 3: Comparison of using collaborative tools as success factor for different cases

Figure 4 shows knowledge sharing and management and how much this factor is agreed by different experts. The percentage of strongly agreed is less than 50% for all cases which shows it is equal important for all experts either experience is above or below 5 years. The frequency of slightly agreed is maximum in all cases. Few experts were not agreed with this factor.
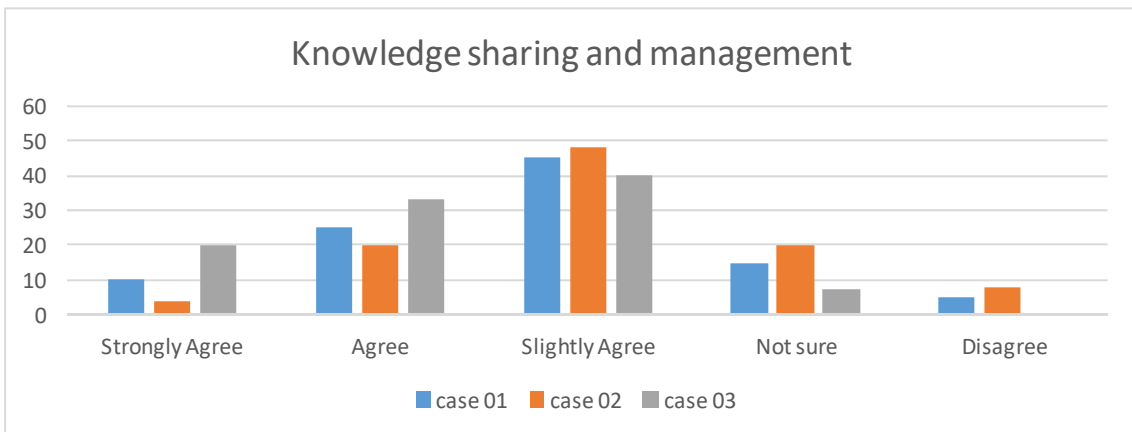

Figure 4: Comparison of knowledge sharing and management as success factor for different cases

Figure 5 shows role of global project management in requirements collection and how much this factor is agreed by different experts. The percentage of strongly agreed is less than 50% for all cases which shows it is equal important for all experts either experience is above or below 5 years. The frequency of agreed is maximum in all cases. None of the experts were disagreed with this factor.
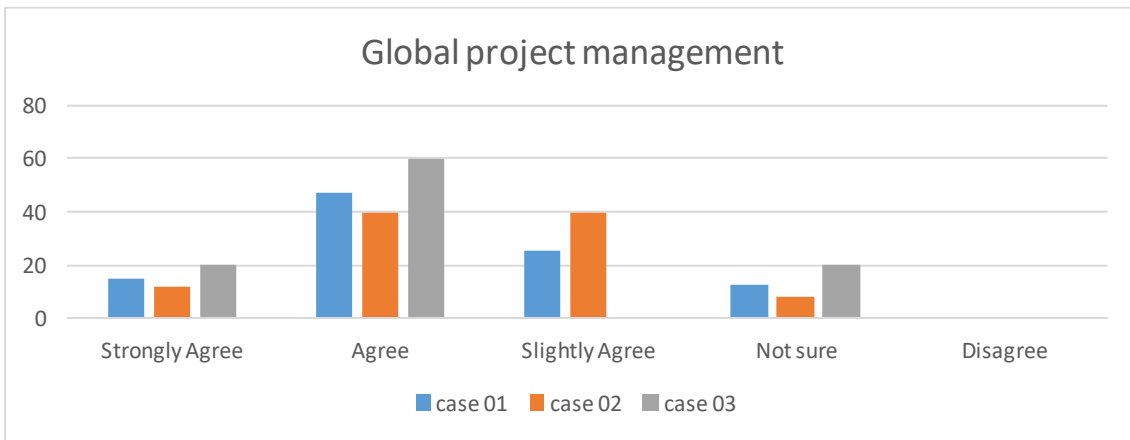

Figure 5: Comparison of global project management as success factor for different cases

Figure 6 shows role of RE modelling in requirements collection and how much this factor is agreed by different experts. We can see that for case 02, its percentage is zero and for case 03, it is 33%. This may be due to the reason that non expert doesn't know much about how to use RE modelling for requirements collection in GSD. Majority of experts especially in case 02 are not sure about this success factor.
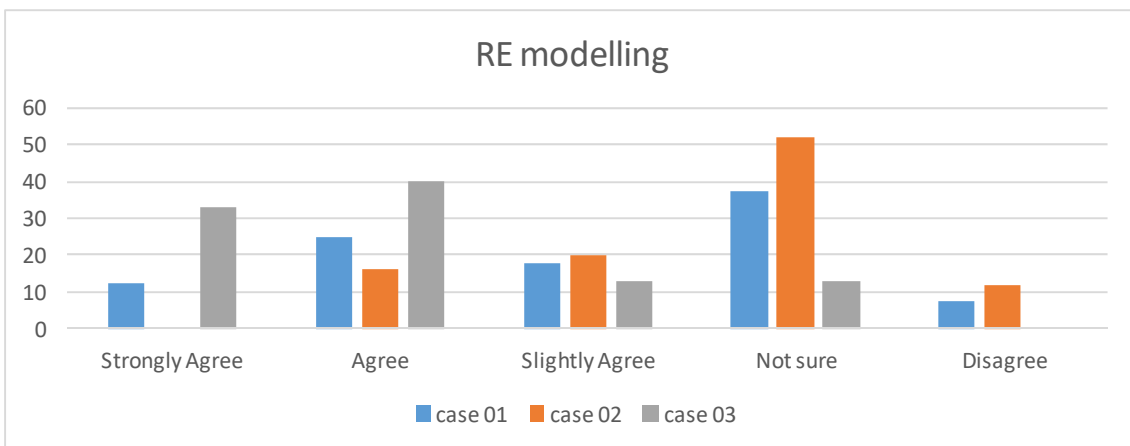

Figure 6: Comparison of RE modelling as success factor for different cases

Figure 7 shows role of proper discussion on requirements in requirements collection and how much this factor is agreed by different experts. We can see that for case 02, percentage of strongly agreed is above than 50 and for case 03, it is 13% only. There exist a huge significance difference between two cases. Expert with high experience may doesn't need to discuss or negotiate too much on requirements as they have a lot of experience. None of the expert is disagreed with this factor.
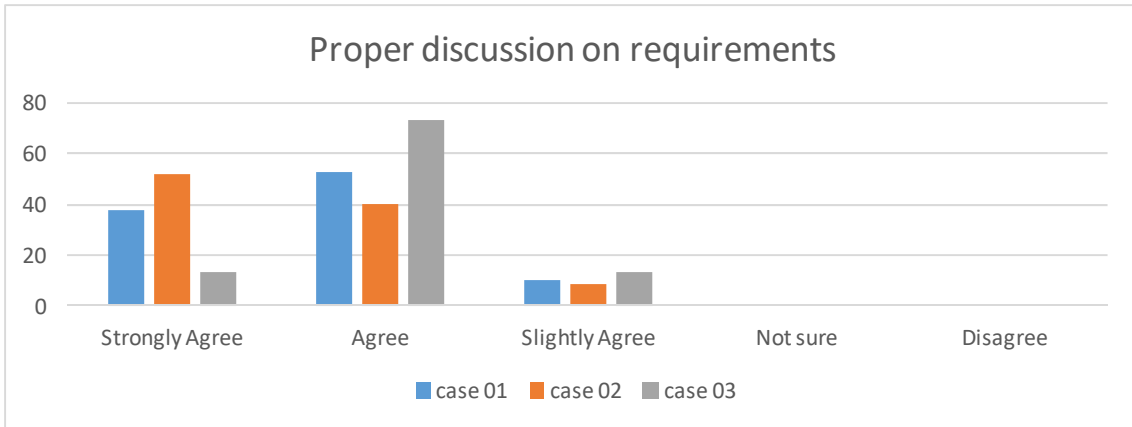
Figure 7: Comparison of proper discussion on requirements as success factor for different cases

Figure 8 shows role of process maturity in requirements collection and how much this factor is agreed by different experts. We can see that for case 02, percentage of strongly agree is 4% for case 02 and for case 03, it is 27%. There exist a huge significance difference between two cases. Similarly percentage of agree is 20% for case 02 and for case 03, it is 67%. There exist huge difference in opinions of experts with high experience and one with low experience. Process maturity such as selection of modern process models e.g. agile are necessary in GSD and only experienced persons can use these processes. Models such as agile are difficult to used and followed by non-experienced developers.
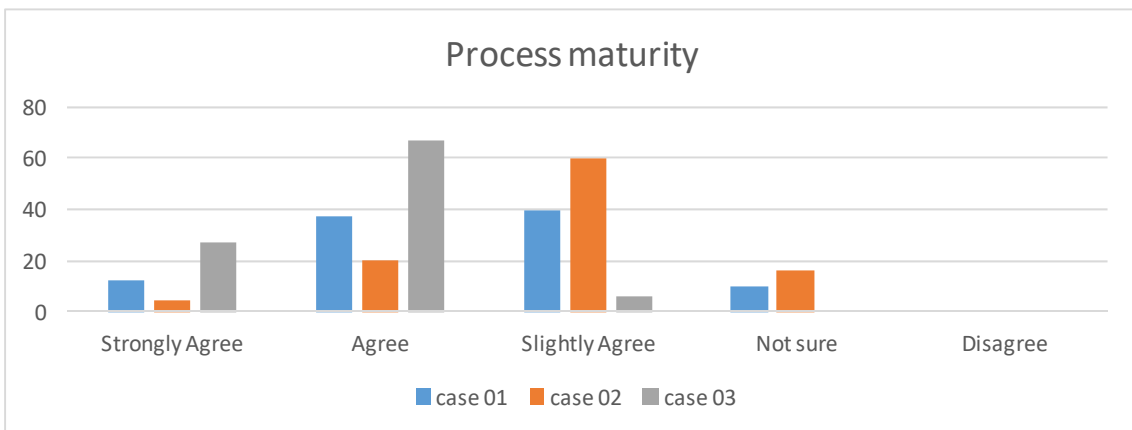

Figure 8: Comparison of process maturity as success factor for different cases

Figure 9 shows role of training sessions in requirements collection and how much this factor is agreed by different experts. It is strongly agreed in all cases equally. It is almost agreed and slightly agreed same in case 02 and case 03 almost. In neither case, it is marked as disagreed.
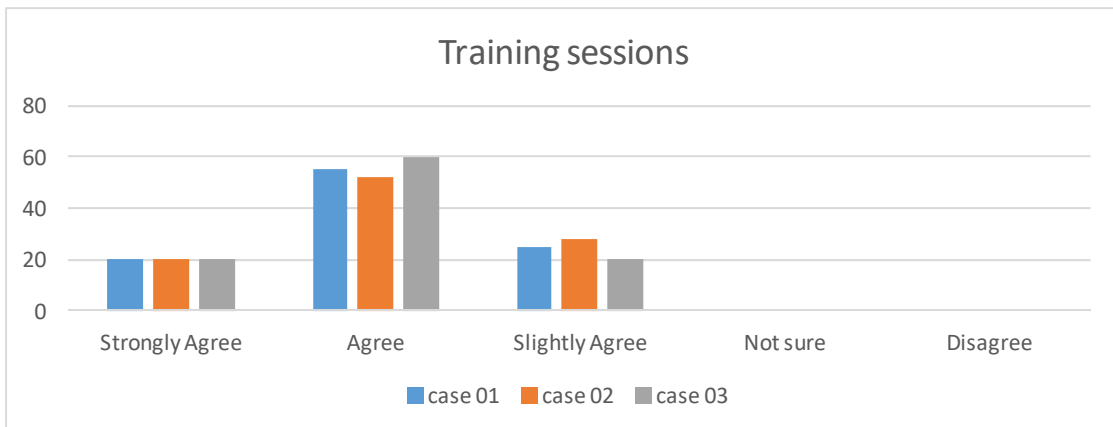

Figure 9: Comparison of training sessions as success factor for different cases

Figure 10 shows role of use of web technologies in requirements collection and how much this factor is agreed by different experts. For strongly agree, there is a significance difference between case 02 and case 03, while for the rest of options, there is no such difference in opinions of experts with high and experts with low experience. Use of modern web technologies such as semantic web are difficult to use by non-experienced people. Normally experts with low experience rely mostly on direct communication and discussion with clients rather than using modern web technologies that are difficult to use. It is almost agreed and slightly agreed same in case 02 and case 03 almost. In neither case, it is marked as disagreed.
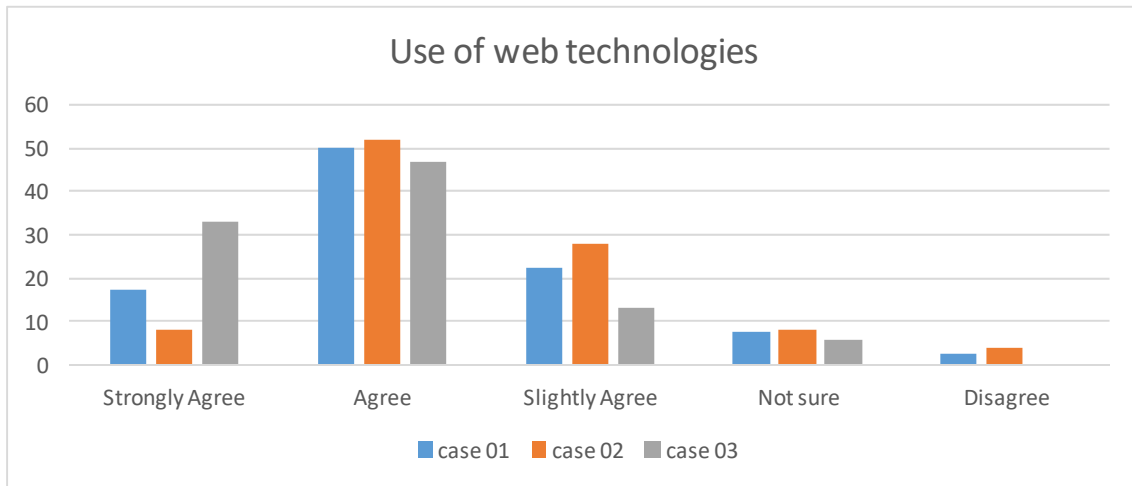

Figure 10: Comparison of use of web technologies as success factor for different cases

Figure 11 shows role of social networking in requirements collection and how much this factor is agreed by different experts. For strongly agree and agree, there is no significance difference between case 02 and case 03.
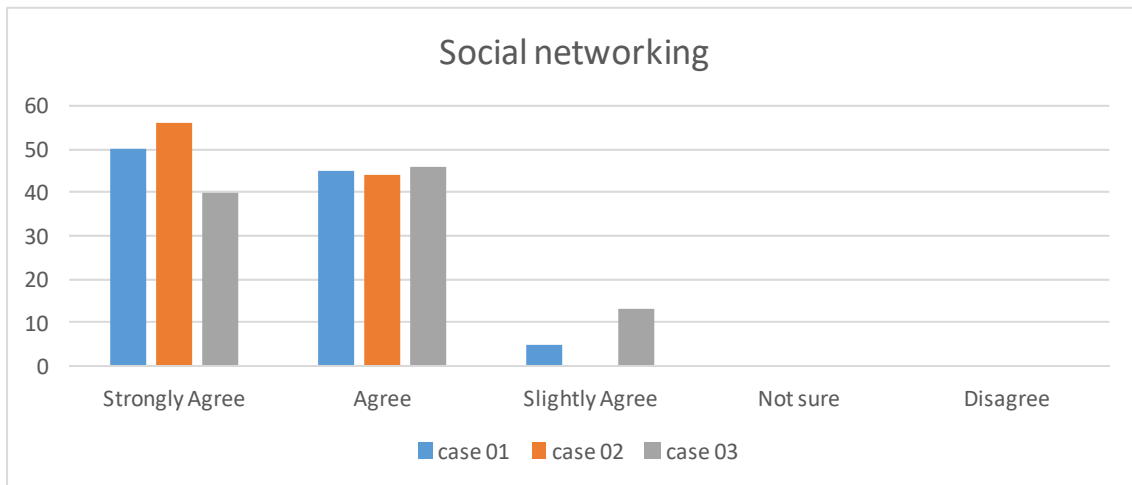

Figure 11: Comparison of social networking as success factor for different cases

Figure 12 shows role of infrastructure and organizational structure in requirements collection and how much this factor is agreed by different experts. We can see that there is no significance difference in any case.
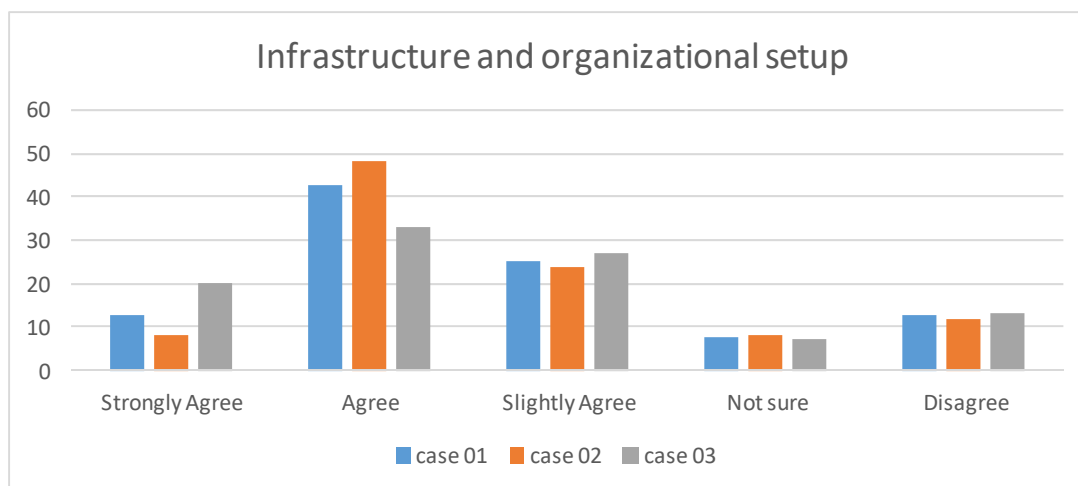
Figure 12: Comparison of Infrastructure and organizational setup as success factor for different cases

V. CONCLUSION

A questionnaire survey was conducted to validate success factors that were previously identified with SLR. Purpose of this empirical study was to explore how much these factors are agreed in real software development environment. Questionnaire survey was conducted from 40 responders. We have found that effective communication is factor that is most strongly agreed while factors like coordination, collaboration and use of collaborative tools in GSD are second and third most strongly agreed factors. In future, we will find practices for these success factors and will validate them from software industries. Our research work will help vendors to better implement success factors during requirements implementation in context of GSD.

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