# An Empirical Study on Improving Shared Understanding of Requirements in GSD

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***Abstract***

***Purpose*** *– To investigate the role of clear organizational structure with communicating responsibilities, a practice of Knowledge Management, in developing shared understanding of requirements in GSD-an area that is very important but has, to date, not been addressed adequately.* ***Design/methodology/approach*** *– A controlled experiment was performed in an academic setting with two groups of geographically distributed students; the duration of the experiment was three months. The understanding patterns of both groups were observed by conducting multiple concept-mapping exercises.* ***Findings*** *– The results of the experiment revealed that clear organizational structure with communicating responsibilities helps to improve shared understanding of requirements in GSD.* ***Research limitations*** *– The sample size was rather small as only two groups of students participated in the experiment and each group consist of eight members from two different countries.* ***Practical implications*** *– The results of the study shows the importance of clear organizational structure with communicating responsibilities in GSD settings, these preliminary results will motivate the researchers to replicate the results in the future to contrast results using large sample size. Academic can use the results to build the definition of organizational structure with responsibilities and communication means between team members in GSD projects.*

***Keywords:*** *Global software development, knowledge management practice, Requirement engineering, shared understanding, organizational structure, Concept-mapping, Analysis constructed shared mental model*

## 1. Introduction

GSD is becoming a leading operational model for developing software systems. Software development organizations are now rapidly shifting from collocated development towards GSD in search of the benefits achieved from GSD; these benefits include global resource pool, low cost, high quality and the right talent to develop large and complex software systems. However these benefits are associated with some challenges and most common of these are cultural diversity, inadequate communication, temporal difference and knowledge management. Although these challenges affect all activities of software project development but requirement engineering activities are more affected by these challenges as stakeholders corresponds to different background and interest and they have to complete the requirement activities collectively. In practice, the success of a software system is dependent on the successful completion of its requirement engineering activities, which is a challenging phase of software development and it becomes even more challenging in case of GSD due to the inherited challenges of GSD [1, 2, 4, 10].

One of the major barriers in success of RE in GSD is lack of shared understanding of requirements. Shared understanding is crucial and helpful in resolving conflicts and clearing ambiguities, it occurs when all the individual working on a project have the same understanding of every requirement. This shared understanding helps significantly in the successful completion of RE in GSD and can be promoted through affective client-developer relationship [1, 2, 8].

There exist plentiful studies and empirical evidences which supports the usefulness and importance of implementing Knowledge management practices in GSD organizations and consider it significantly helpful in solving communication problems, overcoming cultural issue and developing mutual trust and shared understanding of requirements [4,7,14].Hence, keeping in view the importance of KM and shared understanding of requirements in GSD; in this paper, we examined the impact of a commonly used practice of KM named as "A clear organizational structure with communicating responsibilities" on shared understanding of requirements in GSD [3, 10, 11, 12, 13, 17, 18]. We collected data through a controlled experiment which was performed in an academic setting with two groups of students separated geographically. Our analysis shows that "A clear organizational structure with communicating responsibilities is helpful in developing and promoting shared understanding of requirements in GSD.

## 2. Knowledge Management and Shared Understanding of Requirements

This section overviews the literature on KM and its relation with shared understanding of requirements in GSD.

KM is a process of creating, sharing, acquiring and managing knowledge, knowledge acquisition and sharing helps in developing shared understanding of requirements among the stakeholders distributed geographically [3]. Further, the problem of lack of shared understanding in GSD can be resolved to some extent by using diverse knowledge and market proximity [5]. In GSD projects, shared understanding of the system can be achieved through sharing, transferring and integrating knowledge about business context, infrastructure, and project related activities [17].

Inadequate communication and coordination is a challenge faced by almost all GSD organizations due to the diversity of stakeholders in different geographical locations. Lack of communication about how to communicate changes harms the trust relationship and causes lack of shared understanding, in such situation, KM is significantly helpful to cope with the communication and coordination problems of GSD and exchange of knowledge is indispensable to keep the people up-to-date and to develop shared understanding among team members [4, 9].

Organizational characteristic is a key enabler in the success of knowledge management, as organizations provides the way and context for knowledge exchange and sharing among its employees. Clear and apt organizational structure helps and facilitates knowledge exchange within organization and provides an environment in which the members of the organization may feel comfortable, work better and learn quickly [21]. A clear specification of responsibilities is indispensable for knowledge exchange and sharing. In an environment of clear organizational structure with communicating responsibilities, stakeholders know that to whom they need to contact in case of any problem, so it helps and promote knowledge sharing , this knowledge sharing ultimately promotes shared understanding of requirements among GSD team members [3, 22].

Researches argues that clear organizational structure with communicating responsibilities helps in sharing knowledge, building trust , reducing delay, clearing ambiguities , removing

conflicts and improving shared understanding. Organizational structure should be transparent so that it may help the employees in locating the right person at right time. This structure can be developed by creating roles and assigning responsibilities to these roles in GSD environment. Further, it should be specified that which roles need to communicate with each other. This kind of organizational structure will finally help the stakeholders to better understand their problems and to achieve the desired level of common understanding [11, 18, 24].

## 3. Research Methodology

The following research question will be addressed in this paper

***How "A clear organization structure with communicating responsibilities" impact shared understanding of requirements in GSD?***

In order to answer the research question, we have carried out a controlled experiment in an academic setting. Data for this experiment was collected from two groups of students each consisting of eight members, these students belongs to two different universities located in Pakistan and China. The reason for choosing the students from these two universities was that the authors work at these universities and the variable of this choice were suitable for our experiment as we need two GSD teams where the cultural, linguistic and temporal difference is involved. Table1 shows the details of our experiment

**Table 1. Experiment Details**

| | |
|---|---|
| Total Participants | 16 |
| Location | Pakistan and China |
| Education | Master degree students |
| Project assigned | Web-site development |
| Project duration | 3 months each |
| Groups/Teams | Group A, Group B |
| Group A members | 4 Pakistani student and 4 Chinese students |
| Group B members | 4 Pakistani student and 4 Chinese students |

Two Groups were named as Group A and Group B, A clear organizational structure was defined for Group A in which the roles and responsibilities were assigned clearly. Group A consist of one Project manager from china and one from Pakistan, the duties of the project manager were to assign the task to the other team members, to monitor the team members and to discuss the issues and problems with the remote project manager. Further, group A include two developers and a software engineer from Pakistan and one designer, a tester and a quality assurance engineer from china. Hence, a clear organization structure with communicating responsibilities was created for Group A in which every team member know that what he/she has to do? And to whom they need to contact in case of any problem? While Group B team members were asked to complete the similar type of project using joint team effort. However, no structure and responsibilities were defined for Group B.

Literature was studied to select the suitable method for measuring shared understanding. Researchers use the term shared understanding, shared knowledge and shared mental model interchangeably so we discuss here the methods of measuring mental models The commonly used methods of measuring mental models as discussed in literature are pair wise rating [27], Repertory grid technique [20, 19, 25], causal mapping [26] and concept mapping [26]. Now

we discuss these techniques briefly and finally Table 2 compares these techniques on the basis of their pros and cons as discussed in the literature

### 3.1. Pairwise Rating

In this method a pool of concept is presented to the participants. All possible pairs of concepts from this pool are given to the participant one pair at a time, and the participants are expected to provide the similarity/relatedness rating for each pair. In this way a matrix of Pairwise rating is obtained and then with the help of some algorithm networks are derived and these networks are compared with an expert network [16].

### 3.2. Repertory Grid Technique

In this method the respondent is presented with three of the study objects/elements, typically written on cards. These three elements constitute a triad and in the language of repertory grid technique, we have to establish a construct–contrast pairs via the triad method. The members of these first and subsequent triads that are presented to the interviewee are determined by the researcher before administration of the grids to respondents. For recording purpose the member of each triad are represented by circles in each row of the grid. The respondent is now asked to consider the presented triad and to state one way in which any two of the triad elements are similar with each other and yet different from the third member. Similar pair of available triad is considered to be the respondent's choice. This process is repeated to establish construct-contrast pairs [17].

### 3.3. Causal Mapping

In causal concept mapping list of concepts is identified from the initial project document and is given to the participants. The participants are asked to map these concepts on the basis of causal relationships exist between these concepts. This map generates a diagrammatic mental model; the maps drawn by different participants are compared in order to measure the level of shared understanding [18].

### 3.4. Concept Mapping

Like causal mapping, in concept mapping also a list of concepts is identified from the initial project document and is given to the participants. The participants are asked to map these concepts on the basis of their understanding. These maps are used to extract the knowledge of the individuals.

In order to select a suitable method for measuring shared understanding, the pros and cons of above mentioned measurement methods were compiled from the literature as shown in Table2. Based on the results of Table 2 Concept mapping technique was selected and used in this experiment to extract the data about shared understanding of development team members. Analysis Constructed Shared Mental Model (ACSMM) method was then used to analyze the data. ACSMM technique translates the individuals map into a team sharedness map without losing the original perspective of the individual; thereby it represents a more accurate representation of team sharedness [16].

**Table 2. Pros and Cons of Mental Models Measurement Techniques**

| Method | Pros | Cons |
|---|---|---|
| Pair wise rating | Thorough method | 1. Time-consuming<br>2. Labor intensive<br>3. Fails to capture the uniqueness of mental models<br>4. Complex |
| Repertory grid technique | Thorough method | 1. Time-consuming<br>2. Labor Intensive<br>3. Not flexible<br>4. Complex |
| Causal mapping | 1. widely used method in organizational and management settings<br>2. easy method | 1. The nature of the link is only causal<br>2. Not flexible |
| Concept mapping | 1. Most widely used technique<br>2. Flexible<br>3. Reduces miscommunication<br>4. between individuals<br>5. Take less time<br>6. Easy to use | Not found |

## 4. Data Collection

In order to collect data for the measurement of shared understanding from both teams and to study the impact of clear organization structure with communicating responsibilities following tasks were performed

### 4.1. Concept Identification

The first step in the construction of concept map is the identification of concepts; the list of concept was identified in the following way

1. Requirement specification document of both projects A and B was studied in detail.
2. Some important concepts were identified using Noun-phrase technique
3. Initially the number of concepts identified from both projects was more than 15, too much concepts make the concept map complex so the number of concepts were reduced to 10 for both projects.
4. A subject matter expert was requested to review these concepts so that no important concept may remain missing in the list.
5. During concept mapping exercise the team members working on both projects were given the original list of concepts for mapping, but before performing ACSMM analysis we changed the names of these concepts and used the symbols A, B, C ….for our ease.

### 4.2. Shared Criteria

In order to identify that whether a particular concept is shared or not, shared criteria should be determined. For this experiment we set this criterion to 50 % which means that if a particular concept is used by more than 50 % of the team members in constructing the concept map than this concept will be declared as shared. For determining shred criteria, researchers argue that initially this criterion should be set to 50 % but it can be changed according to the results obtained from the concept maps [16].

### 4.3. Team Training

A guided practice was provided to both GSD teams prior to the start of the project, so that the individuals who are not familiar with concept maps may understand that how to construct a concept map. This guided practice was provided through a multimedia presentation in which the tem members were introduced with basic elements of concept map and the way of constructing this map. Below we discuss the key elements of concept maps for the understandability of readers

**4.3.1. Concept:** A concept can be defined as an object or event, or record of object or event, represented by a label. This label is mostly a word but sometime it can be a symbol or the combination of more than one word. Some examples of object are admin, user, facilitator etc.

**4.3.2. Link:** Link is used to join two concepts or to represent the relationship between two concepts. It consists of two concepts and a connector. It is a node-connector-node combination which is used to indicate the relationship between two nodes. Two kinds of link are mainly used in a simple concept map

**4.3.2.1. Unidirectional Link:** A link with arrows at the end is known as directional link. A link with single headed arrow is unidirectional link and it indicates a unidirectional relationship between two concepts. In Figure 1 the link from concept C to concept E is unidirectional which shows the relationship flow from concept C to concept E, but not from concept E to concept C.

**4.3.2.2. Bidirectional Link:** Double headed arrows at the two ends of a connector indicate bidirectional relationship between two concepts. Bidirectional link indicates that the relationship between two concepts flow in either direction. In Figure 1 the relationship between concept A and B is bidirectional, similarly the relationship between concept C and D is bidirectional.

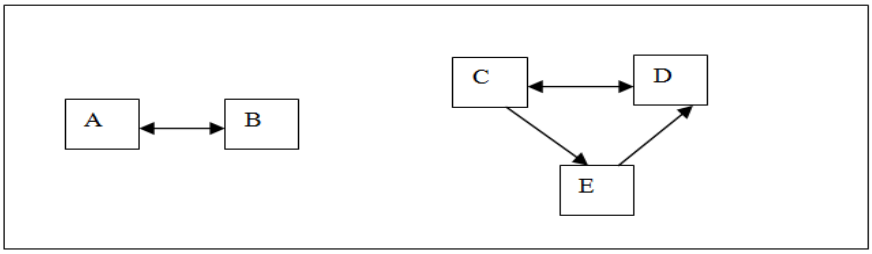


**Figure 1. Examples of Links**

### 4.4. Construction of Concept Maps

In order to measure shared understanding of two GSD groups, concept mapping exercise was conducted thrice for both projects each with a gap of one month. The rationale behind conducting multiple exercises was that shared understanding is a dynamic attribute of the team and it changes with the passage of time.1st concept mapping exercise was conducted when both teams started working on their projects, 2nd exercise was conducted during the middle of the project and the 3rd and final exercise was conducted after the completion of both projects. Each time the participants were given the list of concepts and they were asked to map these concepts according to their understandings of the project.

At the end of each concept mapping exercise, the concept maps were collected from the participants of both GSD groups. During three months duration of the projects, both groups performed concept mapping exercise thrice. However, each time the strict confidentiality was ensured before giving the team members list of concepts. The eight Chinese students (four from G***roup A*** and four from G***roup B***) performed the concept mapping exercise in the presence of first researcher while the students in Pakistani University were asked to email their concept maps to the researcher within three days.

## 5. Results

At the end of each concept mapping exercise 16 maps were obtained, a list of concepts and links used in these maps were compiled into a single spreadsheet table along with the frequency of each concept and link where frequency refers to the number of team members who used a particular concept or link. Almost all the students used all the concepts that were given to them; in this way all the concepts were shared at 50% criteria of sharing therefore only the percentage of shared link was used for analysis. Table 3 shows us a sample spreadsheet table for the understandability of readers.

Following the same procedure as mentioned in Table 3, aggregate shared understanding of both Group A and Group B was calculated for all three concept mapping exercises. The results of which are shown in Table 4.

**Table 3. Sample Coding Spreadsheet**

| Concepts | Team Members N=8 | | | | | | | | Concept using | Percentage using |
|---|---|---|---|---|---|---|---|---|---|---|
| A-Admin | Y | Y | Y | Y | Y | Y | Y | Y | 8 | 100 |
| B-User | Y | Y | Y | - | Y | Y | Y | Y | 7 | 87.5 |
| **Unidirectional Links** | | | | | | | | | | |
| A→B | Y | - | Y | Y | Y | - | Y | Y | 6 | 75 |
| C→D | - | - | Y | - | Y | - | - | - | 2 | 25 |
| **Bidirectional Links** | | | | | | | | | | |
| C↔E | Y | Y | Y | - | Y | - | Y | Y | 6 | 75 |
| D↔F | Y | Y | - | - | - | Y | - | Y | 4 | 50 |

**Table 4. Aggregate Shared Understanding of both Groups**

| Concept mapping exercises | Shared understanding of Group A | Shared understanding of Group B |
|---|---|---|
| Ex: 1 | 17.13% | 17.64% |
| Ex: 2 | 29% | 24% |
| Ex: 3 | 44.55% | 35% |

In order to check the impact of geographical distance on shared understanding of requirements in GSD, the overall change in the level of shared understanding of local and remote team members was compared separately. The results of which are shown in Table 5.

Note that here the local team members refers to the students who were Chinese and the word remote team members refers to the students who were in Pakistan.

**Table 5. Shared Understanding of Local and Remote Team Members**

| Projects | Concept mapping Exercises | SU of local team members | SU of remote team members | Difference |
|---|---|---|---|---|
| Group A | Ex 1 | 29% | 27% | 2% |
| | Ex 2 | 34% | 32.5% | 1.5% |
| | Ex 3 | 39.5% | 37.9% | 1.6% |
| Group B | Ex 1 | 27.71% | 27.80% | -.09% |
| | Ex 2 | 31.8% | 29.31% | 2.67% |
| | Ex 3 | 36.15% | 32.21% | 3.94% |

## 6. Discussion

Figure 2 compares the shared understanding of two GSD projects' team members for three concept-mapping exercises. Three concept mapping exercises from one to three are labeled along X-axis and shared understanding that was calculated in percentage from 100 is shown along Y-axis. The results displayed in Figure2 shows us that, in exercise 1 the level of shared understanding of both Group A and Group B teams was almost same but in exercise 2 shared understanding of Group A's team was 5% more than that of Group B and further, in exercise 3 it was 9% more than that of Group B. The results of Figure 2 show that the level of shared understanding in Group A was comparatively high from that of Group B. Further, the level of shared understanding of Group A increased with the passage of time which shows the positive impact of clear organizational structure with communicating responsibilities on building and maintaining shared understanding in GSD settings.

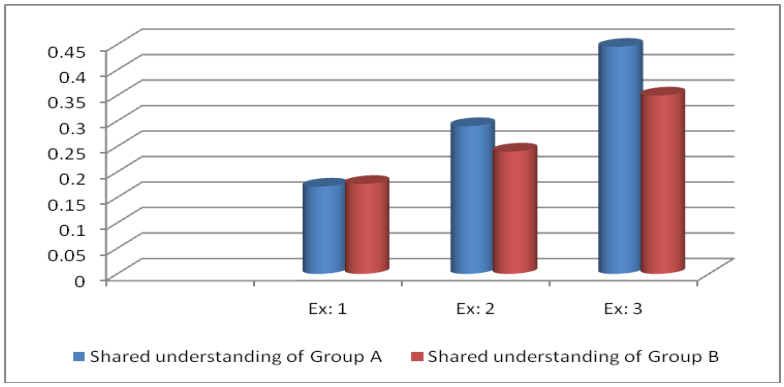


**Figure 2. Showing the Shared Understanding of Two GSD Groups (Results of the Table 2 are Plotted on this Figure)**

Third column of Table 5 which is plotted in Figure 3 shows us the aggregate shared understanding of local team members of both Groups A and B. According to the results of Figure 3, the level of shared understanding increased for both Groups A and B with the passage of time from exercise 1 to exercise 3. However, increase in group A was more than that of group B in all three concept mapping exercises.

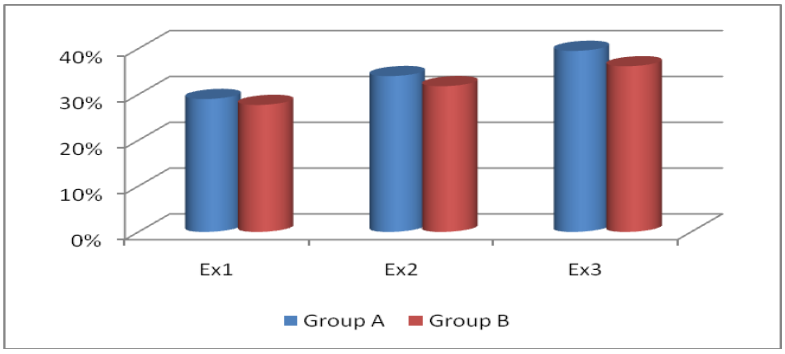


**Figure 3. Showing the Shared Understanding between Local Team Members of Two GSD Groups (SU: Shared Understanding)**

Fourth column of Table 5 which is plotted in Figure 4 shows us the aggregate shared understanding of remote team members of both Groups A and B. The results of Figure 4 show that, initially the level of shared understanding of Group B was higher than that of Group A in exercise 1. On contrary to that, as the projects progress the level of shared understanding in Group A was comparatively higher than that of group B in next two concept-mapping exercises.

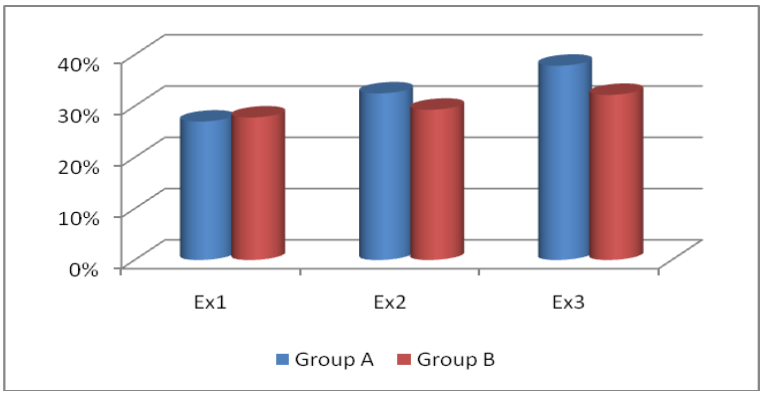


**Figure 4. Showing the Shared Understanding between Remote Team Members of Two GSD Groups (SU: shared understanding)**

In order to measure the mutual understanding of both groups' local and remote team members, the difference between the shared understanding of local and remote team members of each group was calculated separately, as shown in the last column of Table 5. The high difference between the shared understanding level of local and remote team members means there exist less mutual understanding between the local and remote team members while on the other hand low difference refers to high mutual understanding between local and remote team members. The results of overall mutual shared understanding of both groups are shown in Figure 5.

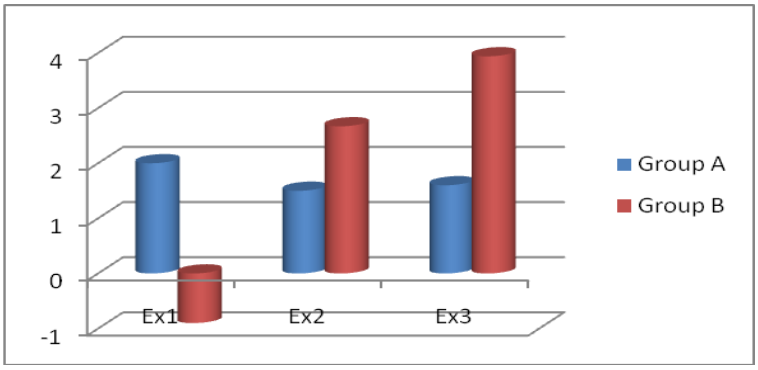


**Figure 5. Showing the Shared Understanding Difference between Local and Remote Team Members of the Two GSD Groups (SU: shared understanding)**

The results displayed in Figure5 shows that; initially, when first concept mapping exercise was conducted from both Groups, the difference between shared understanding of local and remote team members of Group B's team was in negative which shows a high positive mutual understanding between local and remote team members of project B. On the other hand the difference between shared understanding of local and remote team members of Group A was 2 %, which is very low but in comparison to Group B it was a great difference. However, when the projects progress with the passage of time and second and third concept mapping exercises were conducted , a declining trend was seen in the shared understanding difference of group A's team while an increasing trend was seen in the understanding difference of group B's team.

## 7. Findings

Some important findings obtained from this experiment are

1. Clear organizational structure with communicating responsibilities practice help the team members in getting information timely because the team members know the concerned person in case of any problem and thus the problem of delay in getting information can be solved using this practice .
2. Clear organizational structure with communicating responsibilities practice facilitates requirement knowledge sharing due to the existence of open communication lines between defined stakeholders role, this knowledge sharing mechanism ultimately improve shared understanding of requirements.

## 8. Conclusion and Recommendations

GSD has become an important business phenomenon due to the benefits and incentives achieved from it; however, these benefits are associated with some challenges and lack of shared understanding of requirements is one of them that need to be solved in order to accomplish GSD projects timely and successfully. This paper contributes by providing a solution of overcoming the problem of lack of shared understanding to some extent. The literature suggests that clear organizational structure with communicating responsibilities is helpful in achieving shared understanding of requirements in GSD but it is not tested empirically.

In this paper we have tested the impact of clear organizational structure with communicating responsibilities on shared understanding of requirements in GSD by conducting a controlled experiment in an academic setting with two groups of students. The results of this experiment show that clear organizational structure with communicating responsibilities helps to improve shared understanding of requirements among GSD team members.

## 9. Limitations

Few limitations of this study should be noted

1. There can be many other factors in GSD that affects shared understanding of requirements in GSD but we have only observed the impact of organization structure; although the impact of other factors have been eliminated to some extent by selecting similar Groups of students working on similar projects.
2. The projects selected for this experiment were web-based projects so our results may not be generalized or be applied to other types of software development projects such as desktop & mobile applications.

## 10. Future Work

This paper only study the impact of single knowledge management practice on shared understanding of requirements by conducting a control experiment, in the future there is a need to study the impact of other knowledge management practices on shared understanding of requirements.

In the future, there is a need to study the impact of clear organization structure with communicating responsibilities on shared understanding of requirements by applying it on the studies of GSD organizations in real settings

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