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Selecting Communication Artifacts for Requirements Engineering

Miloslava PlachkinovaUniversity of Tampa
mplachkinova@ut.edu**Gregory Moody**University of Nevada, Las Vegas
gregory.moody@unlv.edu**Ken Peffers**University of Nevada, Las Vegas
ken.peffers@unlv.edu

Abstract:

In this paper, we identify and explicate the factors that lead organizations to select particular communication artifacts in the requirements engineering (RE) process and to determine the communication artifacts that they prefer in particular RE phases and with which RE methods. We do so to improve RE communication. Information systems (IS) projects often fail due to poorly specified or misunderstood requirements. We articulate a process framework for RE, which serves as a basis for our discussing and analyzing RE communication artifacts. In doing so, we extend the RE process by adding two transitional phases (pre-validation and pre-approval) to ensure that organizations identify all of the essential requirements. We employ qualitative methods to identify the criteria for selecting communication artifacts. We discover that organizational culture plays a key role in this process. Our findings suggest that the traditional phases occur more in organizations that use waterfall development processes than in organizations that agile development methods.

Keywords: Communication Artifacts, Requirements Engineering, Organizational Environment, Waterfall, Agile.

1 Introduction

Requirements engineering (RE) refers to the process in which a team in an organization elicits individual stakeholder preferences and needs and transforms them into detailed, documented, specified, and agreed-on requirements so that they can serve as the basis for systems development (Pohl 2010). This important process provides team members an opportunity to discover end users' needs and requirements at an early stage, so the final product or service can successfully satisfy them.

Successful communication among the individuals involved in the RE process is crucial (Gallivan & Keil, 2003). Thus, team members need to engage and actively participate in the RE process to effectively transfer knowledge and information across the various activities they perform as part of RE.

However, many organizations face difficulties in successfully integrating communication into the RE process, and poorly specified requirements often cause project delays and failures (Maruping, Venkatesh, & Agarwal, 2009). Further, differing motivations and expertise also contribute to poor communication during the RE process (Zin & Che Pa, 2009). The problem often results from RE participants' varied knowledge, beliefs, and values. Prior studies have established that end users, systems analysts, developers, and managers frequently face challenges when working together (Abelein & Paech, 2012; Karlsson & Dahlstedt, 2007; McGill & Klobas, 2008). Miscommunication can lead to profound challenges in adequately translating users' context and needs into user requirements (Bjarnason, Wnuk, & Regnell, 2011).

In this study, we identify communication artifacts or “metaphors” (Putnam & Boys, 2006)—that is, tools to support communication (Mason & Leek, 2012)—that organizations utilize in the RE process and associate them with RE methods and phases in order to better understand the communication process. The artifacts help to convey the information based on the communication channels, audience, and technology among others. We build on Plachkinova, Peffers, and Moody's (2015) work and focus on communication artifacts since prior research has established a connection between the success of IS and the value of tools for communication (Wolf, Rode, Sussman, & Kellogg, 2006). Specifically, we address the following research question (RQ):

RQ: What factors lead organizations to select particular communication artifacts for information systems requirements engineering?

To answer this question, we use qualitative methods and, more specifically, take an exploratory case study approach (Baxter & Jack, 2008; Yin, 2003). We conducted semi-structured interviews with nine participants to investigate the RE process in seven projects across five different organizations. With this method, we could obtain much deeper knowledge about communication artifacts in the RE process and compare and contrast practices across several organizations.

Contribution:

The paper contributes to information systems (IS) research in several ways. First, it presents a theoretical framework for how organizations should use RE communication artifacts. Both researchers and practitioners can use the framework as a guideline in developing new IS. We frame RE communication using the metaphors that Putnam and Boys (2006) propose. We present two hypotheses and test them to design a model that we informed by observing practice. Second, the study supports expectations that an organization's culture and the RE methodology it utilizes play an important roles in determining the communication artifacts that its team members use. It also partially supports the expectation that team members prefer communication artifacts that require higher levels of interaction for RE phases that require higher interaction. This expectation comes with a caveat that an organization's established and preferred customary communication artifacts may influence what communication artifacts it selects (i.e., the “we have always done it that way” factor). Third, we extend the RE process with two additional phases: pre-validation and pre-approval. We think and the literature supports the idea that breaking down the long and often complex practice of gathering requirements into smaller and more manageable steps may have a positive impact on an organization and its members who may not have even realized that miscommunication problems exist. However, we do not demonstrate practical effects for this feature in this study.

Our study extends knowledge on RE in several ways. We believe that better understanding the RE communication process will provides more insight into possible means to improve it. We center our work on exploring what factors lead organizations to select the particular communication artifacts because the wrong artifacts can often cause project failure. Thus, we first develop a theoretical framework to more adequately encompass the RE communication process. Our framework addresses the existing gap in the RE communication process by examining it on a more granular level. The metaphors that Putnam and Boys (2006) propose offer much insight about how participants perceive communication about how they understand the RE process. Second, to provide a possible solution to misunderstanding and misinterpreting requirements from one phase to another, we propose to extend the RE process with two additional phases: pre-validation and pre-approval. Breaking down the long and often complex practice of gathering requirements into smaller and more manageable steps can have a positive impact on an organization and its members who may not have yet realized that miscommunication problems even exist. To tackle this issue, we developed a theoretical framework that can solve a common problem in the practice of IS development and, thus, bridge the gap between theory and practice (Rosemann & Vessey, 2008). These substantial findings shed light on the problem of RE communication and suggest practical steps to improve practice by matching each stage of the RE process with specific communication artifacts and, thus, add value to the development effort.

2 Background Literature

2.1 Requirements Engineering Process

RE occurs at the start of the development process and involves analysis and negotiation about which capabilities and features a new IS should possess (Sommerville & Kotonya, 1998). Researchers have extensively investigated the RE process (Browne & Rogich, 2001; Nuseibeh & Easterbrook, 2000; Sommerville & Kotonya, 1998; Wieringa, Maiden, Mead, & Rolland, 2006). For this study, we build on the RE activity differentiation that Browne and Rogich (2001) propose, which other studies have also adopted as well (Benyon, Turner, & Turner, 2005; Markus & Mao, 2004; Tiwana & Mclean, 2005). We focus on the RE process insofar as it concerns gathering and documenting requirements prior to any development; thus, categorizations outside that scope do not pertain to our study. We adopt this classification scheme because it focuses on the RE process itself and does not involve more general IS development and maintenance issues.

We divide the RE process into three phases: discovery; analysis, and verification (Browne and Rogich 2001); and decision making (Ahituv, Igbaria, & Aviem, 1998; Barhki & Kao, 2010; El-Shinnawy & Vinze, 1998; Saaty, 1990). We include decision making in order to follow up on the earlier stages and better understand whether management has approved the proposed specifications. In addition, we identify two transitional phases (i.e., pre-validation and pre-approval), which we include to more accurately monitor the RE process and ensure that we capture all of the requirements and not miss any due to RE process gaps (Bjarnason et al., 2011). Figure 1 below presents the RE process. In the following paragraphs, we describe the purpose of the proposed stages in this RE process conceptualization.



Figure 1. Requirements Engineering Process

The discovery phase refers to the initial communication between the systems analysts and users and involves obtaining detailed and accurate data from users. This data serves as the foundation for the new system. During this phase, users and analysts communicate with each intensely, and analysts need to ask the right questions (Wilson & Sapsford, 2006).

The transition from natural language to requirement descriptions (i.e., pre-validation) represents a fundamental step in the object-oriented analysis model (Ilieva & Ormandjieva, 2005). The process ensures that the analysts and designers correctly understand the elicited requirements. Pre-validation also

reassures team members that they are on the right track and have properly understood the end users' primary requirements.

The analysis and verification phase occurs when users confirm the initially elicited requirements. During this phase, team members need to rigorously and meticulously analyze and evaluate the collected requirements to identify any missing requirements, inconsistencies, and requirement conflicts. This knowledge-verification process ensures the process succeeds (Browne & Ramesh, 2002).

The pre-approval phase, from analysis to decision making, also represents a crucial part of the overall RE process. Users have limited involvement in this transition phase since team members have already analyzed and structured the requirements and need only to decide which of them they will actually implement in the system. During the pre-approval phase, team members often interact less with each other than in previous phases because the systems analysts and designers have already prepared the results of the previous phases and they usually submit them in a written form to the management team in order to keep track of the process.

The final phase of the RE process involves deciding which requirements to include in the new system. The RE process does not only involve obtaining requirements from end users. Rather, once team members have obtained these requirements, they need to properly communicate them to the management team responsible for making decisions. From this last phase, we can obtain more information on how the communication interaction evolves from the earliest phase of discovery to the final decision point.

2.2 Communication Metaphors

In order to better understand and improve RE, we focus on the communication process since it forms a fundamental part of gathering and analyzing user requirements. One way to conceptualize communication involves using communication metaphors. A metaphor is a way to link abstract concepts to concrete things or to tie the familiar to the unknown (Cornelissen, 2006). One can decontextualize particular metaphors (at the linguistic level) in individual academic articles to bring them together in coherent categories of conceptual or cognitive meaning (Cornelissen, 2006). For this study, we adopt the eight metaphors that Putnam and Boys (2006) propose, which we Figure 2 summarizes.

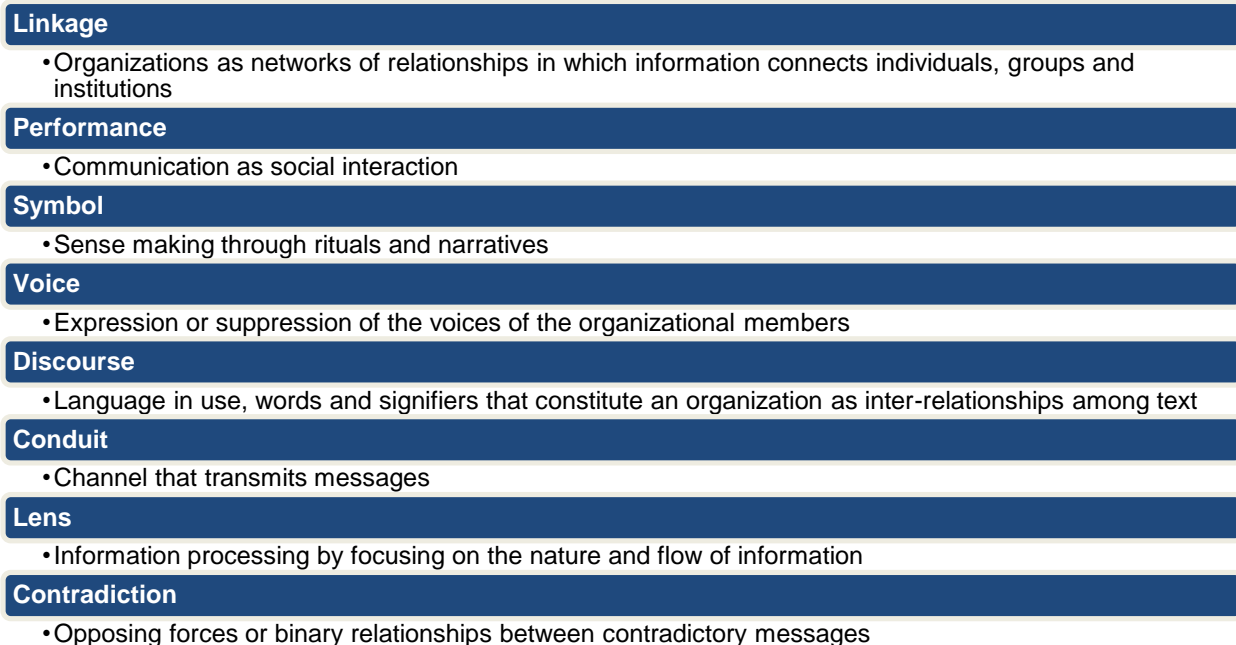


Figure 2. Communication Metaphors that Putnam and Boys (2006) Propose

For our study, we consider only the first five metaphors (i.e., linkage, performance, symbol, voice, and discourse) because they relate directly to RE, whereas the other three more generic metaphors (i.e., conduit, lens, and contradiction) do not. In the following paragraphs, we discuss the metaphors in more detail.

The linkage metaphor explores the connections between people and how they use these connections to form networks of relationships. The linkage metaphor relates to the discovery phase in the RE process because, in that phase, one needs to find end users and customers who want to develop a new information system.

The performance metaphor treats communication as an outgrowth of a collaborative process in which social and symbolic interaction is dynamic, interconnected, reflexive, and simultaneous. During the analysis and verification phase in the RE process, the performance approach facilitates communication between end users or customers and systems analysts or developers.

Team members utilize the symbol metaphor to interpret the communication process. This metaphor closely relates to the process of transferring verified user requirements to the decision making phase when the final product is accepted.

The voice metaphor focuses on communication as the expression or suppression of the voices of organizational members. This power dynamic usually relates to decision making and, depending on the company culture and traditions, can be more or less democratic (Bjerknes & Bratteteig, 1995). So, to analyze it, we need to pay more attention to the factors that shape the role of communication during the RE process.

The discourse metaphor refers to conversation as it focuses on both process and structure, on collective action as joint accomplishment, on dialogue among partners, on features of the context, and on micro and macro processes (Taylor & Van Every, 1993). This metaphor explains how participants share and learn from experiences (Eisenberg & Goodall, 1993).

2.3 Communication Artifacts and Levels of Interaction

Artifacts are tools that support communication (Mason & Leek, 2012). However, all participants need to properly understand artifacts in order for the latter to provide the necessary media richness (Daft, Lengel, & Trevino, 1987)

Based on communication artifacts' characteristics, we attribute a certain level of interaction to each one. To classify these levels, we refer to Leonard-Barton and Sinha (1993) who organize interaction in terms of low, medium, or high depending on its intensity and frequency. In the same way, we differentiate communication artifacts based on their level of interaction as follows:

- Low: narrative/story, spreadsheet, diagram/animation, observation.
- Medium: prototype, survey/questionnaire, conceptual model.
- High: interview/conversation, ideation workshop, meeting.

In the current work, we focus on the most commonly used communication artifacts in order to explore what role they have in the RE process, and we classify them based on their expected level of interaction among the participants in each stage.

Designing IS involves many communication activities that occur through different channels. Each channel uses certain artifacts that depend on the context. For example, interviews and conversations can provide detailed information about and personal interaction with participants but are time and resource consuming (Klein & Myers, 1999). On the other one hand, surveys and questionnaires are cheap and easy to conduct because participants generally know these formats; however, one has no control over the participants, and these formats may also involve issues related to data quality (Russ-Eft & Preskill, 2001). Conceptual models can represent the non-functional aspects of a new IS, but they are time and resource consuming to create, and one has no guarantee that they will provide the necessary specifications that end users request (Cysneiros, 2001). Ideation workshops can generate ideas from a large talent pool, but conducting such workshops involves difficulties in coordinating the schedule of multiple participants (Peffer & Tuunanen, 2005). Prototypes increase user confidence and involvement but can also be expensive and time consuming to create (Mohapatra, 2010). Narratives or stories can keep track of activities and participants generally know the format; however, they require constant updates, and employees can sometimes feel overwhelmed with information and experience cognitive overload (Martin, 1982). Many participants know spreadsheets, but, in some cases, they need specific skills to understand and interpret the presented data. Participants can more easily and comprehend diagrams and animations, but they typically see use as supplemental materials and not as a main form of communication. Meetings provide instant feedback and are relatively inexpensive, which explains why they see such widespread

use in the corporate world, but they require an agenda and a moderator to keep everyone on track (Peppers & Tuunanen, 2005). Finally, observations provide detailed information on user behavior but require time in the field, which makes them expensive since the observer often needs specific training and skills to remain objective (Myers, 1997).

Table 1 summarizes the characteristics of each communication artifact we investigate. The table describes the level of interaction associated with each tool based on its definition and usage and the advantages and disadvantages of using it for RE purposes.

Table 1. Communication Artifacts Summary

Communication artifact	Level of interaction	Advantages	Disadvantages
Interview / conversation	High	Detailed information, personal interaction	Time and resource consuming
Survey / questionnaire	Low to medium	Familiarity with the format, cheap, easy to conduct, fast	No control over participants, potentially inaccurate data
Conceptual model	Medium	Representation of non- functional aspects	Time and resource consuming, non-guaranteed outcomes
Ideation workshop	High	Generating ideas from a large talent pool	Hard to coordinate multiple participants
Prototype	High	Increasing user confidence and involvement	Expensive and time consuming
Narrative / story	Low	Familiarity with the format, keeping track of activities	Constant updates, overwhelming with information
Spreadsheet	Low	Familiarity with the structure	Specific skills to understand and interpret
Diagram / animation	Low	Easier to visualize and understand	Supplemental to other artifacts
Meeting	High	Instant feedback, relatively inexpensive, widely used	Need to be moderated, require agenda
Observation	Low	Information on user behavior	Requiring time in the field, expensive, supplemental to other artifacts

2.4 Organizational Culture

Organizational culture represents another important factor that one needs to consider when examining what communication artifacts organizations select for RE. Schein (1992, p. 12) describes organizational culture as:

A pattern of shared basic assumptions that a group has learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems.

Research has established that a healthy organizational culture reduces risk during the systems development lifecycle (SDLC) in organizations (Verma & Amin, 2010). Thus, in our study, we investigate organizational culture and its influence on what communication artifacts organizations select for different project methodologies such as waterfall and agile. We look into these two project methodologies in particular (i.e., waterfall and agile) because they differ greatly and require a different level of interaction. While the waterfall methodology is a sequential and linear process, the agile methodology is more flexible and typically responds quicker to changes in the requirements (Balaji & Murugaiyan, 2012). Exploring how the two different SDLC approaches influence the communication artifacts that organizations select may shed more light on the RE process and provide valuable insights to help them discover, analyze, verify, and make decisions related to IS requirements.

Prior literature indicates that organizational culture influences communication. Brown and Starkey (1994) point out that “culture conditions attitudes towards communication and communication processes and

systems. The resulting forms of communication impact upon attitudes to and the quality of information upon which organizations base their decisions” (p. 811). In addition, organizations need to communicate to exist since they use communication to share knowledge and interact (Keyton, 2010). Thus, we believe that exploring how the relation between culture and communication can influence the communication artifacts that organizations select for RE could provide interesting results as well.

3 Theoretical Model

Based on analyzing the literature, we expect to observe a certain pattern in or rationale for why organizations select some communication artifacts over others. We investigate what factors lead organizations to select communication artifacts for information systems requirements engineering.

We expect the level or amount of interaction among participants during each phase of the RE process to serve as a key factor. When selecting artifacts, participants consider the level of interaction because doing so can ensure they can effectively and efficiently communicate with one another (Burgoon, Bonito, Bengtsson, & Ramirez, 1999). Thus, we expect to observe a connection between the level of interaction and what communication artifact participants select because they relate to improving user satisfaction with new IS. To classify the level of interaction, we refer to Leonard-Barton and Sinha (1993).

We propose a theoretical model to categorize communication artifacts, metaphors, and level of interaction that corresponds to the phases of the RE process (see framework in Figure 1). We also provide a short rationale for our expectations.

In addition, we also expect to observe that the organizational culture or existing project methodology will play a role in what communication artifacts organizations select. Companies that use agile methodologies should prefer more flexible communication artifacts since they allow such companies to more dynamically and frequently communicate. However, firms that use waterfall methods should prefer communication artifacts that have more structure and support more robust and straightforward interactions. We also expect to observe more distinct transitional phases in waterfall projects than in agile ones because agile projects typically involve more iterations and overlapping phases compared to waterfall projects.

Based on the theoretical model that we present below (see Figure 3), we develop two hypotheses to answer our research question:

- H1:** An organization’s culture and established methodology (waterfall/agile) influence what communication artifacts it selects during the requirements engineering process.
- H2:** Organizations prefer communication artifacts that require higher levels of interaction for RE phases that involve higher levels of interaction.

In addition, in our case studies, we observed the two additional phases (i.e., pre-validation and pre-approval) to understand their role and to ensure that we capture all of the requirements (i.e., that none “fell through the gaps”).

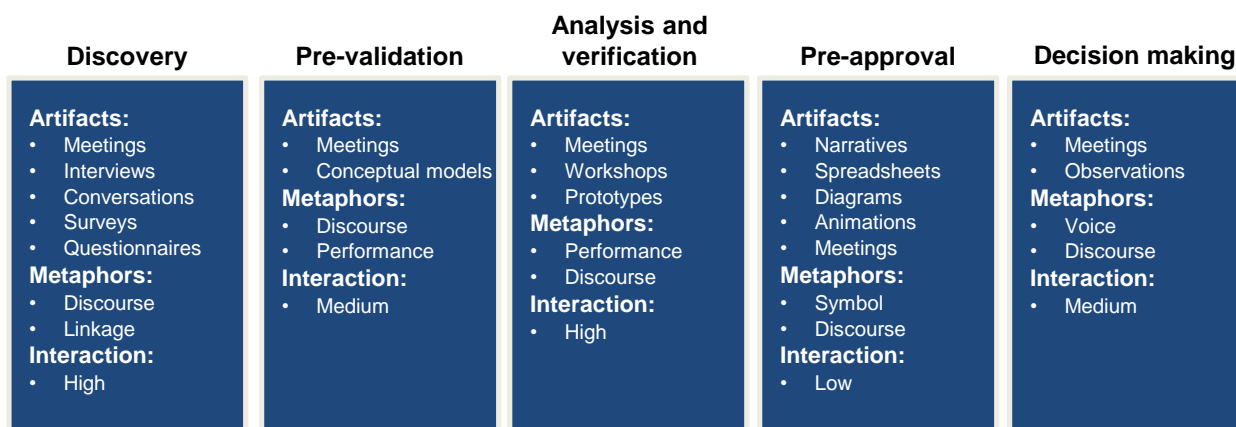


Figure 3. Theoretical Model

4 Methodology

We used exploratory case studies because, as Baxter and Jack (2008) point out, they focus on “answer[ing] a question that sought to explain the presumed causal links in real-life interventions that are too complex for the survey or experimental strategies” (p. 547). By using an explanatory case study approach, we can compare and contrast RE communication practices across organizations more adequately and potentially gain insight into the reasons behind participants’ decisions.

To collect data, we mainly used interviews. In total, we conducted nine semi-structured interviews about seven projects with participants across five different organizations in the US to better understand how the projects conducted the RE process and to evaluate our model. We used an interview guide to ensure we obtained more reliable and valid results (see Appendix A for all the questions we asked). We asked three main types of questions: 1) project characteristics, 2) project communication, and 3) project success. We used these questions to look for patterns in the seven case studies and test our two hypotheses. An institutional review board (IRB) at a major U.S. university approved the study.

We conducted the interviews both in person and via phone in cases when we could not physically meet with someone. The interviews took about 30-45 minutes each and we recorded them for data-analysis purposes.

We analyzed the content to gather the major themes and the relevant data regarding the communication artifacts that the participants reported their projects used in each stage of the RE process. We strived to contact multiple participants from each organization to increase the validity and reliability of the data we collected, but, due to high turnover and the fact that some projects finished several years ago, we could do so in all cases. We contacted key informants and, using the snowball technique, identified other members who took part in the projects. We chose a convenient sampling method in order to find participants who were familiar with the RE communication process and actively engaged with the projects in their respective organizations. Using the information from the respondents regarding the RE communication, we assigned metaphors to each RE phase based on the definitions that Putnam and Boys (2006) provide. Finally, we compared the results of the case studies with the proposed theoretical model to evaluate it and to demonstrate its relevance to practice.

5 Case Studies

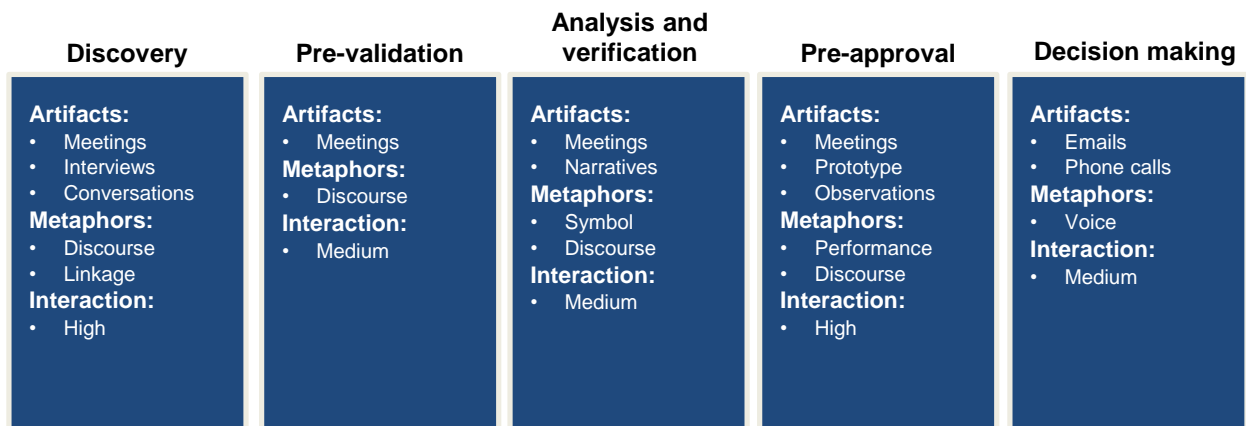
We contacted executives with experience in developing new IS and knowledge about gathering user requirements at both public and non-profit organizations to identify participants to interview. As such, we interviewed participants at a large public university (a vice provost of information technology (IT), a network operations center manager, and an administrator at a student housing complex), a local government (an IT portfolio and applications manager and a systems manager), an international hospitality corporation (a systems analyst), and a private company that supplied geographic information systems (GIS) software (two members of a spatial analysis team). In addition, we conducted an interview with an expert who worked for a private consulting company specialized in defining and managing requirements. We selected participants in varied positions to obtain rich data from multiple perspectives. Each of the interviewees discussed two projects from their organization in order to provide a wide variety of company practices. Table 2 summarizes the seven case studies and the common RE process that the outsourcing company experts observed.

Table 2. Case Studies Summary

Organization	Case #	Project name	Project type	Project goal
Local government	1	Licensing	Agile	To allow citizens to submit their business licensing applications online.
	2	E-plans	Hybrid	To allow citizens to upload plans for licensing and building permits online.
University	3	Copyright	Hybrid	To create the procedures for responding to copyright notices, to store the information in a database, and to provide information about the violations on an annual basis.
	4	Announcements	Hybrid	To consolidate all important announcements to students (deadlines, workshops, events, etc.) in a weekly newsletter format.
Hospitality company	5	Rewards cards	Waterfall	To allow employees to sign-up customers for loyal customer program via iPhone.
	6	Loyalty	Waterfall	To provide customers tier credits every time they purchase a ticket from an online tickets selling website.
GIS company	7	GIS analysis tool	Agile	To add customer value and to provide a Web-based solution for spatial analysis.
Outsourcing company	8	RE common process	Agile	To offer outsourcing solutions for RE.

5.1 Case 1: Licensing Project

The licensing project (see Figure 4) sought to allow customers to submit their business licensing applications online to save them time and resources. The city would also be able to track each application easier and faster, so the system would prevent document loss and accidental destruction.

**Figure 4. Licensing Project**

5.2 Case 2: E-Plans Project

The e-plans project (see Figure 5) sought to provide customers with the ability to upload plans for building permits online. In the past, customers had to print 15 sets of plans, one for each department—a costly and inefficient process because every single change required them to replace all 15 sets. Developers from the local community actively participated and provided their requirements for the new system.

Discovery	Pre-validation	Analysis and verification	Pre-approval	Decision making
Artifacts: <ul style="list-style-type: none"> • Meetings • Interviews • Conversations • Diagrams Metaphors: <ul style="list-style-type: none"> • Symbol • Discourse • Linkage Interaction: <ul style="list-style-type: none"> • High 	Artifacts: <ul style="list-style-type: none"> • Meetings • Narratives • Diagrams Metaphors: <ul style="list-style-type: none"> • Discourse • Symbol Interaction: <ul style="list-style-type: none"> • Medium 	Artifacts: <ul style="list-style-type: none"> • Meetings • Narratives • Diagrams Metaphors: <ul style="list-style-type: none"> • Symbol • Discourse Interaction: <ul style="list-style-type: none"> • Medium 	Artifacts: <ul style="list-style-type: none"> • Meetings • Prototype • Observations Metaphors: <ul style="list-style-type: none"> • Performance • Discourse Interaction: <ul style="list-style-type: none"> • High 	Artifacts: <ul style="list-style-type: none"> • Meetings • Emails • Phone calls Metaphors: <ul style="list-style-type: none"> • Voice Interaction: <ul style="list-style-type: none"> • Medium

Figure 5. E-plans Project

5.3 Case 3: Copyright Project

The copyright project (see Figure 6) sought to create a notification system to respond to students' copyright violations, to store information about the violators in a database, and to provide input to university representatives about these violations on a regular basis. The university began the project after changes in legislation, and the team members involved in the RE process mostly focused on eliciting requirements from the official documentation and transforming them into functional specifications.

Discovery	Pre-validation	Analysis and verification	Pre-approval	Decision making
Artifacts: <ul style="list-style-type: none"> • Meetings • Narratives • Interviews Metaphors: <ul style="list-style-type: none"> • Symbol • Discourse • Linkage Interaction: <ul style="list-style-type: none"> • High 	Artifacts: <ul style="list-style-type: none"> • Meetings • Narratives Metaphors: <ul style="list-style-type: none"> • Discourse • Symbol Interaction: <ul style="list-style-type: none"> • High 	Artifacts: <ul style="list-style-type: none"> • Meetings • Narratives • Diagrams Metaphors: <ul style="list-style-type: none"> • Symbol • Discourse Interaction: <ul style="list-style-type: none"> • High 	Artifacts: <ul style="list-style-type: none"> • Meetings • Narratives Metaphors: <ul style="list-style-type: none"> • Symbol • Discourse Interaction: <ul style="list-style-type: none"> • High 	Artifacts: <ul style="list-style-type: none"> • Meetings • Narrative Metaphors: <ul style="list-style-type: none"> • Voice • Symbol Interaction: <ul style="list-style-type: none"> • Medium

Figure 6. Copyright Project

5.4 Case 4: Announcements Project

The email announcements project (see Figure 7) sought to consolidate all important announcements to students (i.e. deadlines, workshops, events, etc.) in a weekly newsletter format. For a long time, students felt overwhelmed by the constant daily notifications they received, and they initiated a new announcement system. Students also took part in shaping the system's features and specifications and in developing the business processes: how to collect the announcements, which ones to send, who should send them, the best time to distribute the bulletin, and so on.

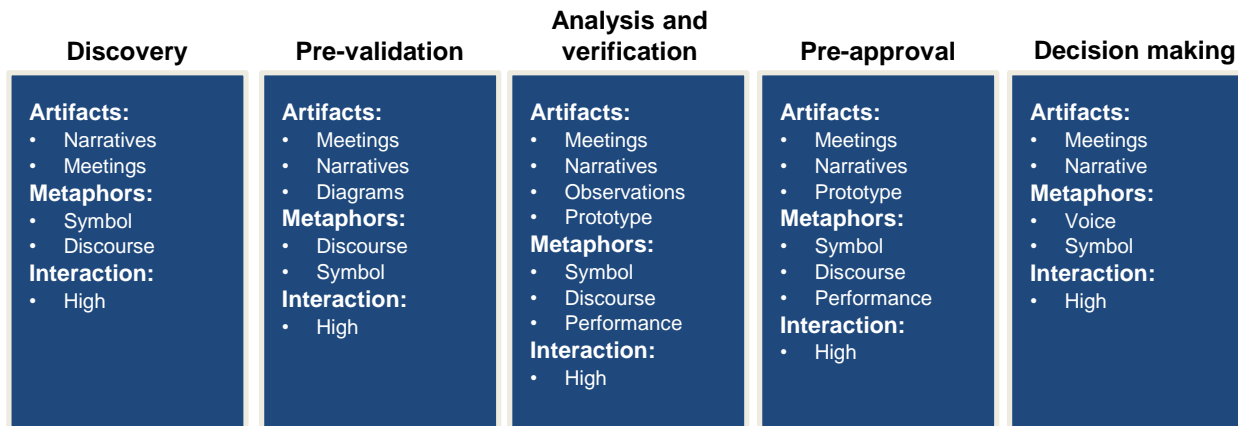


Figure 7. Announcements Project

5.5 Case 5: Rewards Cards Project

The reward cards project (see Figure 8) sought to improve customer service and add more value to customers. This project represented the first project in the organization that would allow employees to sign up customers for the organization's loyalty program via a mobile device. This project formed the second phase of a larger project that sought to increase customer satisfaction across over 40 casinos and resorts. The organization had adopted waterfall six years ago and, thus, used it as its main project methodology.

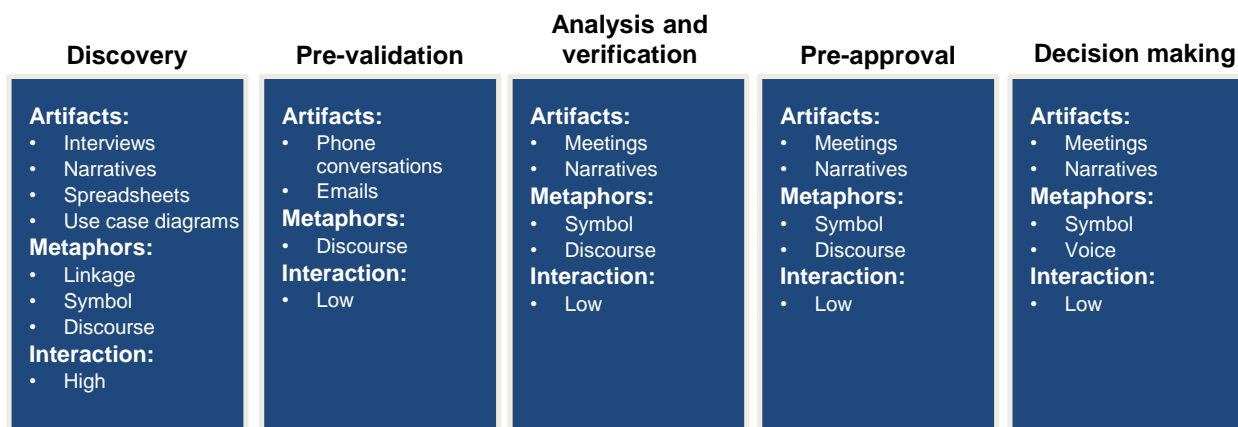


Figure 8. Rewards Cards Project

5.6 Case 6: Loyalty Project

The loyalty project (see Figure 9) sought to integrate the organization's customer loyalty program with an online ticketing website (Figure 9). The customers who used the program would receive tier credits every time they purchased a ticket from that website and would be able to spend their money at the casino or resort. This system formed part of a larger project and had to be integrated with the online ticketing system and the company's existing systems.

Discovery	Pre-validation	Analysis and verification	Pre-approval	Decision making
Artifacts: <ul style="list-style-type: none"> • Interviews • Narratives • Spreadsheets • Meetings • Use case diagrams Metaphors: <ul style="list-style-type: none"> • Linkage • Symbol • Discourse Interaction: <ul style="list-style-type: none"> • High 	Artifacts: <ul style="list-style-type: none"> • Meetings • Narratives Metaphors: <ul style="list-style-type: none"> • Discourse • Symbol Interaction: <ul style="list-style-type: none"> • Low 	Artifacts: <ul style="list-style-type: none"> • Meetings • Narratives • Interactive prototype Metaphors: <ul style="list-style-type: none"> • Symbol • Discourse • Performance Interaction: <ul style="list-style-type: none"> • High 	Artifacts: <ul style="list-style-type: none"> • Meetings • Narratives Metaphors: <ul style="list-style-type: none"> • Symbol • Discourse Interaction: <ul style="list-style-type: none"> • Low 	Artifacts: <ul style="list-style-type: none"> • Meetings • Narratives Metaphors: <ul style="list-style-type: none"> • Voice • Symbol Interaction: <ul style="list-style-type: none"> • Medium

Figure 9. Loyalty Project

5.7 Case 7: Online GIS Analysis

The online GIS analysis project (see Figure 10) sought to add customer value and provide a Web-based solution for spatial analysis. This project would allow multiple users to collaborate on the same project and would extend the current product offerings. The company relied on agile methods for IS development and had embraced scrum as its main approach. Due to the methodology the organization used, the participants did not have official titles.

Discovery	Pre-validation	Analysis and verification	Pre-approval	Decision making
Artifacts: <ul style="list-style-type: none"> • User conference • Workshop • User requests Metaphors: <ul style="list-style-type: none"> • Linkage • Symbol • Discourse Interaction: <ul style="list-style-type: none"> • Low 	Artifacts: <ul style="list-style-type: none"> • Design meetings • Mock design Metaphors: <ul style="list-style-type: none"> • Discourse • Performance Interaction: <ul style="list-style-type: none"> • Medium 	Artifacts: <ul style="list-style-type: none"> • Meetings • Observations Metaphors: <ul style="list-style-type: none"> • Symbol • Discourse Interaction: <ul style="list-style-type: none"> • Medium 	Artifacts: <ul style="list-style-type: none"> • Meetings • Online training Metaphors: <ul style="list-style-type: none"> • Symbol • Discourse Interaction: <ul style="list-style-type: none"> • High 	Artifacts: <ul style="list-style-type: none"> • Meetings Metaphors: <ul style="list-style-type: none"> • Voice Interaction: <ul style="list-style-type: none"> • Low

Figure 10. GIS Analysis Project

5.8 Best Practices from an RE Consulting Company

In addition to the case studies, we also conducted an interview with an expert who worked at a firm that provided consulting expertise, methodologies, standards, and resources for the IT and business departments in medium- to large-sized corporations and governments worldwide. In this way, it differed from the other case studies since it involved an external party's facilitating the RE process for other organizations rather than such organizations' performing the RE process themselves. Employees may not always have the necessary requirements-gathering knowledge and/or experience; thus, an organization's using a consulting service could increase the chances that it will successfully complete a project. Such an approach can also avoid office politics. The consulting company used predominantly agile methods and recommended this approach to its clients. During the interview, the participant outlined a common scenario for outsourcing the RE process (see Figure 11).

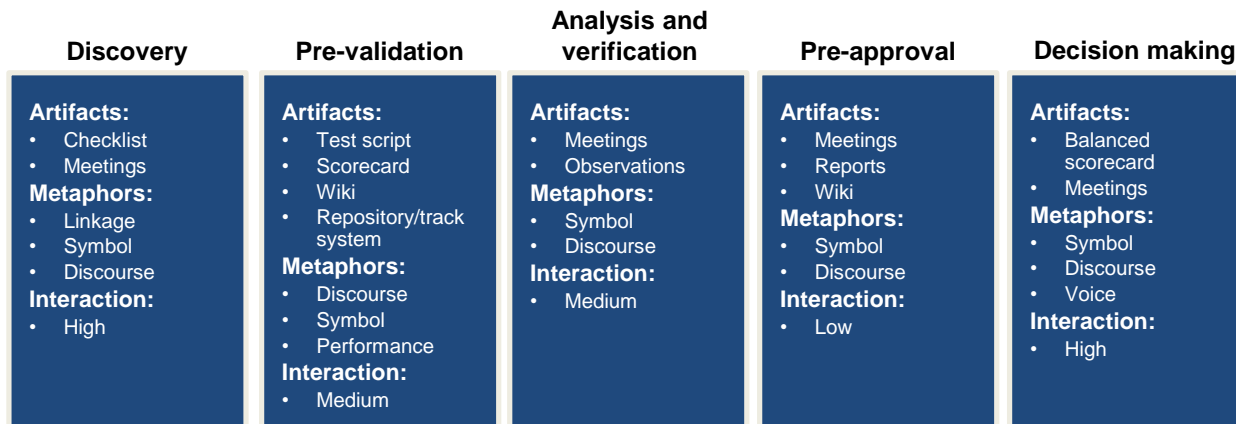


Figure 11. Common RE Process

6 Results and Discussion

Based on the data from these case studies, we could draw some inferences about our hypotheses and answer our research question. We found support for H1 since the studied organizations demonstrated that the organizational culture substantially influenced the communication artifacts they selected. The agile companies preferred faster turnover and results, more frequent meetings, and design iterations on a regular basis. On the other hand, the more traditional businesses looked for more structured artifacts that would support long-term projects that relied heavily on documentation and reports. These findings concur with previous studies. More specifically, they confirm the notion that agile methodologies focus on individuals and interactions rather than processes, working software rather than comprehensive documentation, customer collaboration rather than contract negotiation, and responding to change rather than following a plan (Fowler & Highsmith, 2001). Our study extends these concepts by identifying artifacts that organizations more commonly use in the requirements communication process and focuses on differences and similarities between agile and waterfall project methodologies. By identifying which artifacts correspond to agile and which to waterfall methodologies (Table 3), we assist decision makers in choosing a solution that matches their organization's needs and established culture.

Table 3. Communication Artifacts and Methodology

Methodology	Communication artifact	Level of interaction
Agile	Interview / conversation	High
	Prototype	High
	Meeting	High
	Ideation workshop	High
Waterfall	Meeting	High
	Survey / questionnaire	Low to medium
	Conceptual model	Medium
	Narrative / story	Low
	Spreadsheet	Low
	Diagram / animation	Low
	Observation	Low

We found partial support for H2. During the interviews, the participants confirmed the importance of a relationship between the levels of interaction in the RE process and the communication artifacts they selected, but they admitted that they selected communication artifacts mostly based on already established principles and methodologies in the organization. Further, the participants were familiar with the most common artifacts such as meetings, documentation, or prototypes and found no need or had no resources for additional training. Thus, for the interviewees, the need to have a corresponding level of

interaction of the communication artifacts came second after the organizational culture and established methodology. We hope that, through this project, we can demonstrate that current practices may not always be the best option, especially considering the extremely high number of failed IS projects (Cerpa & Verner, 2009). Thus, one needs to look at other factors such as the communication intensity and levels of interaction in addition to established project methodologies.

We also note that organizations that used traditional waterfall methodologies had more distinct transitional phases compared to agile companies that had more seamless transitional phases due to constant iterations and frequent software releases. We cannot yet say in which company setting our granular approach might provide the better results. A definite result will have to await a demonstration in a practical setting. In addition, participants in more agile organizations reported having less communication issues during the RE process perhaps due to the relatively small teams that worked on each project and the fact that the team members worked in geographic proximity. This finding demonstrates the need to focus more on the communication issues in waterfall projects where the granular approach we propose would better fit. Based on the collected data, we can conclude that organizational culture plays a more important role in the RE process than any other factor we investigated.

6.1 Practical Implications

The evidence in the case studies provides several implications for practice. First, some metaphors occurred more commonly in certain RE phases. The discovery phase frequently used the linkage metaphor, which supports the notion that organizations need a network to recruit end users and collect their initial requirements. We also observed the voice metaphor predominantly towards the end of the RE process, which suggests a relationship between making a decision about which requirements to implement and demonstrating power and superiority in the team.

Second, the two metaphors discourse and symbol saw more universal adoption and did not appear only in particular RE phases. These metaphors represent meetings, conversations, and document exchanges, which occurred in all RE phases. We can surmise that the projects we examined used these communication artifacts and metaphors due to their ease of use and general acceptance regardless of project methodology or culture, respectively.

Third, the fact that participants identified several important activities that occurred during the pre-validation and pre-approval phases implies that RE is a complex process with many underlying layers of communication. Thus, further research needs to investigate how RE activities gradually change and how one can more successfully transfer knowledge and information from one phase to another. In doing so, they can use such insights to improve RE communication and stop requirements from slipping through the gaps (Bjarnason et al., 2011).

Fourth, we identified what the RE process looks like for both agile and waterfall projects. Figure 12 illustrates the waterfall RE process and provides recommendations for the artifacts, communication metaphors, and levels of interaction based on the data that we collected. We identified that narratives and meetings appeared across the entire RE process because the waterfall methodology involves a higher level of documentation (Petersen, Wohlin, & Baca, 2009). We also found that the RE process included many different artifacts, which explains why the process can have a high cost and require much effort to complete (McBreen, 2002; Sommerville, 2004). Further, we found a high level of interaction when an organization began the RE process or when it tested a prototype or demonstrated software. In contrast, we found a lower level of interaction during the rest of the RE phases because the remaining phases focus more on creating and reviewing documentation. Finally, we found that the waterfall process used a variety of communication metaphors in different RE phases but that the symbol metaphor represented the most common one, which concurs with our findings about the high level of documentation in such projects.

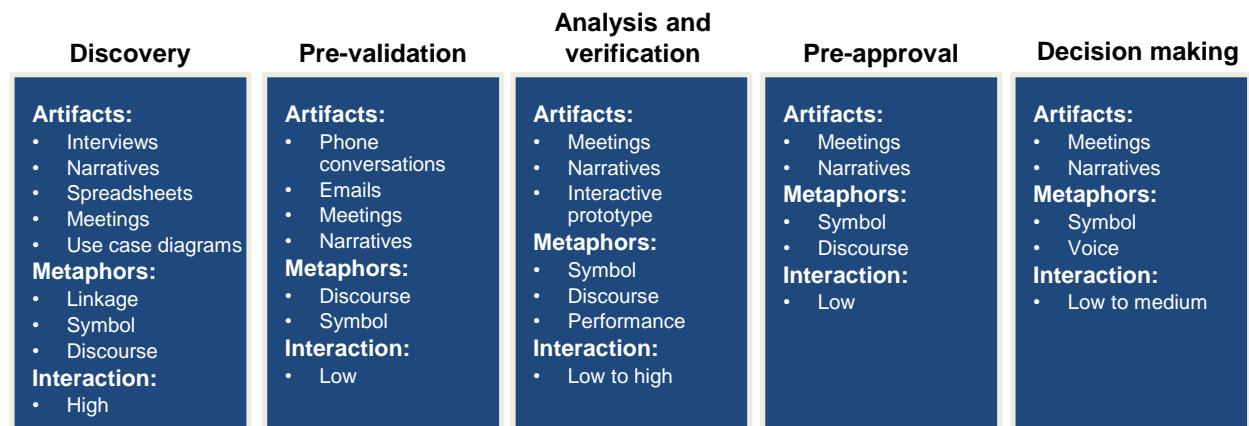


Figure 12. Waterfall RE Process

When it comes to the agile methodology, we observed some commonalities among the organizations in our dataset. Figure 13 presents the agile RE process and provides recommendations for the artifacts, communication metaphors, and levels of interaction based on the data that we collected. We identified that meetings appeared across the entire process due to the more intense communication, better team cohesion, and faster turnout time in agile projects (Cao, Mohan, Xu, & Ramesh, 2009). We found that both methodologies had a similar high level of interaction in the discovery and the analysis and verification phases. However, the remaining phases displayed a medium level of interaction with agile methods compared to a low level of interaction with waterfall methods. The frequent communication and feedback that agile methods typically involve may explain this finding. Finally, the agile process used a variety of communication metaphors in the different stages but discourse, symbol, and performance represented the most popular ones, which concurs with the notion of team work and rapid results (Moe, Dingsøyr, & Dybå, 2010).

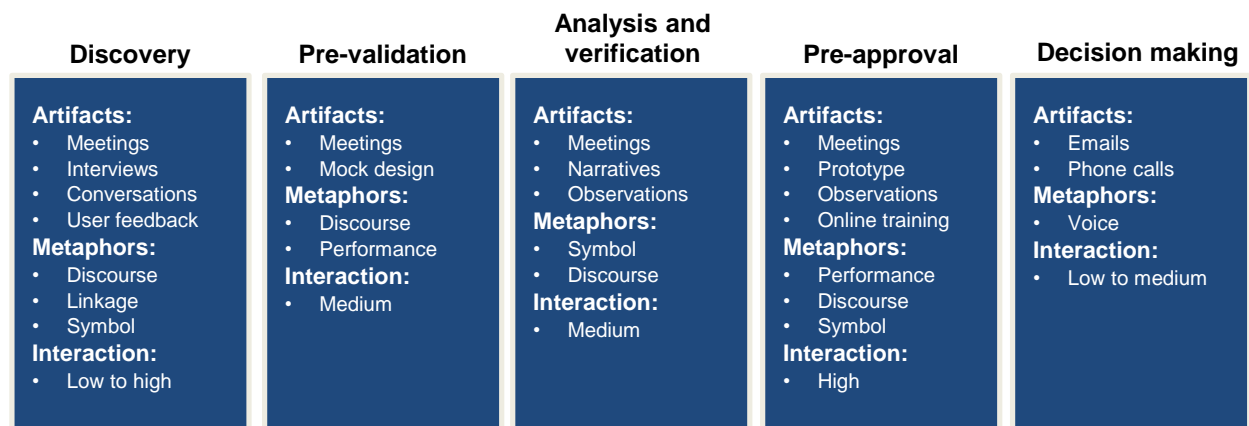


Figure 13. Agile RE Process

7 Conclusion and Future Research Directions

In this study, we present a theoretical model to help organize better interpret and understand end user requirements. By using a more rigorous scientific approach, practitioners can improve the communication during the requirements-gathering process. Such practices can lead to higher user satisfaction with the final products or services and can provide much richer and more meaningful communication among participants.

We developed a theoretical model to answer the research question that drove our study. We found that several factors lead an organization to select particular communication artifacts for RE. First, organizational culture plays an important role and determines to a great extent what communication artifacts team members use. Second, we discovered that, while participants found it important for an

artifact to match the intensity and frequency of communication, most did not consider it a primary concern. Instead, they followed established practices and project-management guidelines since they already had familiarity with them and, thus, did not need to undertake additional training or incur additional costs associated with adopting a new methodology. Finally, whether an organization prefers agile or waterfall methodologies determines whether their RE process includes more or less distinctive transitional phases. The agile organizations we examined typically had overlapping processes and their RE phases lacked boundaries. In contrast, the waterfall organizations we examined had more clearly differentiated RE phases and performed a substantial number of activities in them. We use these differences to outline the need of a theoretical model that can facilitate RE communication and offer practitioners a more scientific perspective to more effectively perform the requirements elicitation process.

This explanatory case study represents an initial step to address requirements engineering communication, and researchers need to conduct more research done in this area. We recommend that others extend our study by testing whether more clearly understanding the RE communication practices as per our study could actually lead to improved RE communication. Such work could take a design science research (Peppers, Tuunanen, & Niehaves, 2018; Peppers, Tuunanen, & Rothenberger, 2007) or action design research approach (Sein, Henfridsson, Puroo, Rossi, & Lindgren, 2011). These approaches lend themselves to the design of solutions in the form of methods and techniques that may have practical relevance. Finally, while we considered only communication among individuals, it may be beneficial to examine the RE process from a technological perspective and to consider how organizations use various types of software or hardware for RE.

One should also note our study's limitations. Most prominently, our study has limited generalizability due to the small sample size we used. However, with our data, we could still identify some primary reasons why organizations select particular artifacts for RE. We encourage others to replicate our study and collect more data across a larger sample of organizations. Another limitation concerns the fact that interviewees discussed only projects that their organizations considered successful. As such, one might obtain interesting findings from investigating whether the communication artifacts that an organization selects have any correlation with a project's success or failure.

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Appendix A: Interview Guide

Project Characteristics

- 1) What was the name of the project?
- 2) What was the goal of the project?
- 3) What was the project category (process improvement, cost saving, customer value, etc.)?
- 4) Was the project driven by the need of innovation?
- 5) Was the project developed in house?
- 6) How would you evaluate the complexity of the project?
- 7) Was the developed system independent or did you have to integrate it with existing software systems in your company?
- 8) How much money did the project cost?
- 9) How much time did the project take?
- 10) Who initiated the project?
- 11) What was your role in the project?
- 12) How many people were involved in the project team?

Project Communication

- 13) Did you talk to customers or stakeholders to gather their requirements? Why? Why not?
- 14) What kind of communication artifacts did you use and why (interviews, surveys, conceptual models, workshops, prototypes, narratives, spreadsheets, diagrams, meetings, observations, etc.)?
- 15) How would you describe the level of interaction among participants in the requirements discovery phase?
- 16) What did you do after you gathered the initial requirements? How did you proceed to the next phase?
- 17) During this transitional phase how would you describe the level of interaction among participants?
- 18) What kind of communication artifacts did you use in this transitional phase and why (interviews, surveys, conceptual models, workshops, prototypes, narratives, spreadsheets, diagrams, meetings, observations, etc.)?
- 19) Did you verify your requirements analysis with the customers or stakeholders? Why? Why not?
- 20) During this phase how would you describe the level of interaction among participants?
- 21) What kind of communication artifacts did you use in this phase and why (interviews, surveys, conceptual models, workshops, prototypes, narratives, spreadsheets, diagrams, meetings, observations, etc.)?
- 22) What did you do after you verified your requirements analysis with the customers or stakeholders? How did you proceed to the decision making phase?
- 23) During this transitional phase how would you describe the level of interaction among participants?
- 24) What kind of communication artifacts did you use in this transitional phase and why (interviews, surveys, conceptual models, workshops, prototypes, narratives, spreadsheets, diagrams, meetings, observations, etc.)?
- 25) Did you involve the customers or stakeholders in the decision making phase?
- 26) During this transitional phase how would you describe the level of interaction among participants?
- 27) What kind of communication artifacts did you use in this phase and why (interviews, surveys, conceptual models, workshops, prototypes, narratives, spreadsheets, diagrams, meetings, observations, etc.)?

Project Success

- 28) Did the project fit within the initial budget? Why? Why not?
- 29) Was the project completed within the initial scope? Why? Why not?
- 30) Did you change any of the requirements during the development of the project? Why? Why not?
- 31) Was the project completed within the expected time frame? Why? Why not?
- 32) Were the project objectives achieved? Why? Why not?
- 33) How would you evaluate the overall project's success?
- 34) Is the developed system still in use? Why? Why not?
- 35) Have you made any upgrades to the system so far? Why? Why not?

About the Authors

Miloslava Plachkinova is Assistant Professor at the University of Tampa. Her research interests include cybersecurity and, more specifically, how human behavior leads to security breaches. She also focuses on healthcare and the Internet of Things (IoT) issues from a security perspective. She often takes a design science approach when building and evaluating artifacts to solve real world problems. She is a reviewer for major conferences and journals in information systems, such as ICIS, ECIS, AMCIS, PACIS, HICSS, IEEE and DESRIST. She is mini-track chair for AMCIS and HICSS on topics such as security and privacy for healthcare and the Internet of Things (IoT).

Gregory D. Moody (PhD, University of Pittsburgh; PhD, University of Oulu) is currently a Lee Professor of Information Systems in the Management, Entrepreneurship and Technology Department in the Lee Business School at the University of Nevada, Las Vegas and Director of the Graduate MIS program. He has published in *ISR*, *MISQ*, *JMIS*, *JAIS*, *EJIS*, *ISJ* and other journals. His interests include IS security and privacy, e-business (electronic markets, trust) and human-computer interaction (Web site browsing, entertainment). He is currently an associate editor for *ISJ* and *THCI*, the President of SIGHCI, and the Managing Editor for *THCI*.

Ken Peffers (PhD) is an associate professor of MIS and chair of the MIS Department at the College of Business, University of Nevada, Las Vegas. He spent 15 years working as a manager before returning to academics, where he was determined to work on research that is applicable in real business situations. His current research focuses on making the right investments to build information systems for the firm, developing features for maximum benefit, and managing the portfolio of IS ideas and projects. He is a founding editor-in-chief of the IS journal *JITTA* (<http://www.jitta.org/>) and is a member of the Society for Information Management (SIM), the Association for Information Systems (AIS), and the Project Management Institute (PMI). He is a member of the Sault Ste. Marie Tribe of Chippewa Indians.

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