SUCCESS FACTORS OF SOFTWARE DEVELOPMENT IN A DISTRIBUTED SETTING: A COLLECTIVE CASE STUDY

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_____

Assoc. Prof. Dr. Nazife Baykal

Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

_____

Assoc. Prof. Dr. Yasemin Yardımcı

Head of Department

This is to certify that we have read this and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

_____

Prof. Dr. Semih BİLGEN

Supervisor

Examining Committee Members	Affiliations	
Prof. Dr. Semih BİLGEN	(METU, EE)	_____
Assoc. Prof. Dr. Onur DEMİRÖRS	(METU, II)	_____
Assoc. Prof. Dr. Kürşat ÇAĞILTAY	(METU, CEIT)	_____
Dr. Altan KOÇYİĞİT	(METU, II)	_____
Ali TÜRKER	(SEBIT)	_____

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Name and Surname: Burcu BULĞURCU

Signature: _____

ABSTRACT

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Bulğurcu, Burcu
M.S., Department of Information Systems
Supervisor: Prof. Dr. Semih Bilgen

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This study represents an attempt to address and discuss some of the most significant questions in the research on virtual software development work today. The research is held as a collective case study, including three cases with distinctive characteristics in both the software projects investigated and the types of collaborations. The study aims to reveal the success factors in virtual work, especially on the issues of communication, coordination and collaboration, by presenting the unfavorable experiences and major issues encountered in each case, as well as the favorable ones and lessons learned at the end of the development processes. The collective research focuses on both the global and non-global contexts. As a result, it points out the distinctive and opposite findings of the cases, and proposes discussions of those findings according to the properties of the development settings.

Keywords: Virtual Teams, Distributed Software Development, Virtual Organizations, Global Software Development, E-Collaboration

ÖZ

DAĞITIMLI OLARAK YAZILIM GELİŞTİRMEDE BAŞARI ETMENLERİ:
TOPLU ÖRNEK İNCELEMESİ

Bulğurcu, Burcu
Yüksek Lisans, Bilişim Sistemleri Bölümü
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Bu çalışma dağıtımlı ortamda yazılım geliştirme konusundaki önemli araştırma konularını belirlemeyi ve tartışmayı amaçlamaktadır. Araştırma, içerikleri ve işbirliği çeşitleri birbirinden farklı özelliklere sahip üç örneğin toplu incelenmesi biçiminde yürütülmüştür. Çalışma dağıtımlı yazılım geliştirmede, özellikle iletişim, koordinasyon ve işbirliği sorunlarını göz önüne alarak, başarı etmenlerini ortaya çıkarmayı amaçlamaktadır. Bu doğrultuda, örneklerdeki başarılı deneyimler ve öğrenilenler ile birlikte başarısız deneyimler ve genel problemler aktarılacaktır. Inceleme küresel özellikler gösteren ve göstermeyen örnekleri kapsamaktadır. Bu sayede, örneklerin farklı ve zıt bulguları ortaya konulmuş, ve örneklerin farklı özelliklerine göre bulgular tartışılmıştır.

Keywords: Sanal Takımlar, Dağıtımlı Yazılım Geliştirme, Sanal Organizasyonlar, Küresel Yazılım Geliştirme, E-İşbirliği

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AYESAŞ: Aydın Yazılım ve Elektronik Sanayii A.Ş.
DDM: Distributed Decision Making
DSD: Distributed Software Development
DXP: Distributed Extreme Programming
GSD: Global Software Development
IEEE: Institute of Electrical and Electronics Engineers
IS: Information Systems
ION: Informatics Online
ION 505: Information Systems On-Line Group Project course
IT: Information Technologies
METU: Middle East Technical University
RtB: RtB Eğitim Çözümleri Ltd. Şti.
SBS: Siemens Business Services
SDD: System Design Document
SRS: System Requirement Specification
STD: System Test Document
XP: Extreme Programming
XPWeb: Web Based eXtreme Programming Support Tool

CHAPTER 1

INTRODUCTION

Over the last decade, parallel to the consistent globalization of the world, the phenomenon of global software development has been intensified, and introduced increasingly dispersed development practices across geographical distances. Even though it is a highly challenging, complex and risk involving process, in today's competitive business environment, for many software development projects, multi-site, and even multinational and multicultural development settings are vitally demanded as a business necessity. However, global software development is a new phenomenon, which is still evolving and needs further research and work to understand and cope with the challenges and complexities, and especially to provide effective management across boundaries.

The global context creates complexities and challenges due to the impact of distances, time zones, diversity of culture and lack of communication and coordination infrastructures. In order to achieve intended quality measures and productivity in global context and to ensure a competitive advantage in today's IT industry, understanding the major issues of the development setting and providing effective software engineering processes is essential. Only after having a general view about the phenomenon, required technologies and infrastructures to support the development setting could be provided. Accordingly, research should first focus on the challenges of managing diversity in global software projects in terms of technology, people, and organization, managing cross-functional and boundary-

spanning virtual teams, and managing communication, coordination, collaboration and knowledge management practices. Thereafter, the questions regarding architecture designs and the collaboration infrastructures to support virtual teams such as project management, information sharing, change management, and quality control shall be discussed.

1.1. Purpose of the Study

The major purpose of the study was to understand the factors that enable virtual corporations working on software and IS development to operate successfully across geographic and cultural boundaries. To do so, the collective research focused on different kinds of collaborations and projects in both global and non-global contexts, and pointed out the distinctive and even the opposite findings of the cases. The study aimed to reveal the success factors, especially on the issues of *communication, coordination and collaboration*, by presenting the unfavorable experiences and major issues encountered in each case, as well as the favorable ones and lessons learned at the end of the development processes. Additionally, the facilities demanded from a collaboration tool utilized in a distributed development setting have been discussed.

1.2. Background and Scope of the Study

Virtual teams represent a new form of organization that offers flexibility and responsiveness and has the potential to revolutionize the workplace (Powell, Piccoli, Ives, 2004). Even though all the necessary technological infrastructures are available nowadays, how they could be utilized within those teams and the major issues surrounding them are not clearly proposed yet. While research focused on the issues of traditional teams also proposes an insight for the virtual teams, more specific research work is required to enhance their effectiveness.

This study firstly aimed to reveal factors to survive and succeed with the virtual teams. In this context, in the first phase of the study, the development processes and the projects of five different virtual teams of an online software development course were investigated. The major target of the investigation was to observe the ad-hoc development processes, especially the communication, coordination and group decision making practices, and then, based on the experiences, to understand the major issues and factors affecting those teams. Moreover, within the scope of the study were to enhance the development processes, especially planning, coordination and group decision making activities of the teams with an online collaboration support tool, called XPWeb, which is designed to support the DXP projects, and included planning and decision making facilities. The tool was selected after a comprehensive literature review on the needs of virtual teams and investigation on different online collaboration tools. Besides, several discussions were held with the instructor who has previously given the course for four educational terms.

Case one is somewhat different from cases two and three in its level of distributed operation. While in case one, individual team members located at different sites carried responsibilities within shared tasks, in cases two and three, different teams with specific task responsibilities were located in different parts of the world. Hence, in this study the definition of "distributed work" that was adopted can be stated as: Work in which either responsibilities or tasks that constitute a shared business goal are carried out by persons, teams, or organizations located at geographically distributed sites."

The projects investigated in the first phase of the study were small in size since they were developed during an educational term by four team members. Time and budget planning were not major considerations, but more significantly, the development setting did not include global, multicultural and multi-site properties. Therefore, studying the case indicated several issues about the virtual development context in terms of people and technology, though it missed the issues of global development in terms of organizations, and cross-functional and boundary spanning virtual teams. Besides, while the results of controlled experiments using small sized student teams may often be generalized to

organizational settings, the findings indicate that there is a disconnect between controlled setting and field base research (Powell et al., 2004). Moreover, in the literature it is stated that to gain a complete understanding of virtual teams, different methodologies and approaches should be used in a complementary fashion on distinctive cases. Therefore, more field based investigation on long term global virtual organizations and big sized projects was needed in order to determine how they differ from short term, non-global, small student based virtual teams and small sized projects. In this sense, two other cases have been selected and integrated to the study.

1.3. Outline of the thesis

In Chapter 1, first, the concept of distributed software development is introduced, and then the purpose, background and scope of the study are briefly explained.

In Chapter 2, a literature survey on distributed and global software development is given.

In Chapter 3, the methodology of work for this collective case study is specified in detail. The section first presents the research strategy by giving explanations about case study and collective case study research, as well as the rationale behind the case selection. Afterwards, it presents the implementation process by giving information about selected cases, and then, it presents the details of the application of qualitative research. In this subsection, the design of the study, research questions, data collection methods and validation criteria are presented.

In Chapter 4, first, the findings of each specific case are discussed in detail, then the data summary and findings of the cases are presented in tables. Lastly, major common and distinctive findings of the study are discussed.

In Chapter 5, first, main results, strengths and shortcomings of the study are presented. Next, further research opportunities are suggested.

CHAPTER 2

LITERATURE SURVEY

The last several decades have witnessed a steady trend toward globalization of business, and of software intensive high technology business in particular. Economic forces suggest new forms of competition and cooperation that reach across national boundaries. As a result, software development is increasingly multi-site, multicultural, globally distributed undertaking (Herbsleb & Moitra, 2001).

However, the phenomenon introduced numerous challenges on many levels, from the technical to the social and cultural. Accordingly, this chapter will present a comprehensive literature survey on the concept of distributed software development. The review will basically focus on the needs and challenges of distributed software development, as well as the necessary definitions of terms.

2.1. Distributed Software Development (DSD)

DSD is simply defined as the software development activities disturbed across multiple sites (Mockus & Herbsleb, 2001). Today, most major companies develop

software in a globally distributed fashion, though; DSD creates a number of unique challenges (Herbsleb & Grinter, 1999; Carmel, 1999; Mockus and Weiss, 2001).
The DSD concept will be investigated in the following subsections by proposing definitions for virtual and traditional teams, needs and challenges of DSD, and demands to enhance the effectiveness of DSD.

2.1.1. Virtual Organizations and their Processes

The term "virtual organization" describes forms of cooperation, where organizations as a whole or people belonging to different organizations establish a network in order to collaborate on a definite project. Determining characteristics of virtual organizations mainly are given by fast adaptation to changing market situations, division of labor in combination with high autonomy of collaborating partners and by concentration on a common goal. Since, virtual organizations are geographically dispersed, efficient information technology support, especially a common planning system, is an indispensable requirement of the coordinating system of virtual organizations (Czap, 2002).

2.1.1.1. Organizational Structures

Virtual organizations are constituted by an agreement of legally independent organizations with the goal to do a common task. The partners of a virtual organization are chosen by their specific competence, and the cooperation is dynamic. The partners of a virtual organization are autonomous, thus, they have their own organization, when the virtual organization is considered at the organizational level. If it is considered at the level of individuals, a virtual team, as a specific kind of a virtual organization, is formed by individuals belonging to different basic independent organizations. Members of virtual organizations are geographically dispersed, and the coordination mainly takes place by use of IT.

Organizational culture articulates the organizations by means of coordination, by degree of formalization, and by degree of delegation of decisions and responsibilities. Thus, processing the same work in different organizations will yield to specific activities; have different business processes; and have different data models as basis of IS at the operational level (Czap, 2002).

2.1.1.2. Distributed Work

A team is defined as a collection of individuals who are interdependent in their tasks, who share responsibility for outcomes, who are embedded in one or more social systems, and who manage their relationship across organizational boundaries (Cohen & Baily, 1997). Virtual teams are defined as; "Groups of geographically, organizationally and/or time dispersed workers brought together by information and telecommunication technologies to accomplish one or more organizational tasks (Alavi & Yoo, 1997)." Distinctive features of virtual teams from the traditional ones are basically their reliance on IT to communicate with each other, their flexible composition, and their ability, if necessary, to traverse traditional organizational boundaries and time constraints (Powell et al, 2001).

The success of virtual teams are strictly dependent on the ability to orderly and efficiently exchange information and engage in effective planning, establishment of shared norms, specification of clear team culture and structure.

2.1.1.3. Planning and Distributed Decision Making (DDM)

Planning is an example of unstructured decision making process that can not be described fully before the decision is made. The particular need in group planning and decision making tasks are to coordinate the activities of individuals or subgroups that may have different perspectives and priorities. Decision making is often identified with choice that is the selection of a specific course of action

from among two or more alternatives in order to maximize the expected value of a decision (Rathwell, Burns, 1985). Distributed decision making can simply be defined as the distribution of information and authority for decision making over several individuals or groups. In other words, DDM is a term refers to the techniques which can easily be applied to the distribute setting by IT tools, such as sharing information, jointly creating contingency plans.

Computer assistance has first been provided by online decision support systems (DSS) in eighties. DSS enables two or more decision making parties to cooperate in using DSS tools in DDM (Thomas and Burns, 1982). DDM is a mechanism for interacting DSSs in an organization to allow groups, not necessarily linked in a hierarchical manner, to cooperate with another (Rathwell, 1985).

2.1.2. Need for DSD

Today, successful organizations are the ones that organize in a dynamic network form, use IT as a primary enabler, quickly adapt to ever-changing competitive landscapes and customer requirements (Jarvenpaa & Ives, 1994). The global competition of today's large organizations, global market for software products, reengineered product life cycles, the increased need to respond quickly to customers' needs are only some of the factors which surges globalization forward and drives organizational change (Grenier & Metes, 1995). Notably, some of the factors essentially force companies to DSD, while others promise economic benefits (Mockus & Herbsleb, 2001).

Carmel (1999) listed the major reasons motivating DSD as, limited pool of work force, necessity of getting closer to customers and using locality specific expertise to customize the products, national policies in some countries for a condition of sale and favorable tax treatment, differences in development costs, and promise of round-the-clock development that could lead to shorter intervals.

While traditional teams' research offers valuable theoretical background and a starting point for virtual team research, virtual teams with their unique material, technical and social challenges call for additional, specialized research (Powell et al, 2001).

2.1.3. Challenges of DSD

Even though there are many good reasons to globally distribute development activities, due to the risks and drawbacks of the setting, success is not guaranteed. As the development trends will surge toward globalization for the next decade, people will work more in virtual and distributed team environments, but the phenomenon will introduce more formidable problems of miscommunication, lack of coordination, infrastructure, incompatibility, cultural misunderstandings, and conflicting expectations (Herbsleb & Moitra, 2001). Implementations will be at risk if organizations fail to adequately address the challenges present in virtual context (Lacono & Weisband, 1997).

The dimensions of the problems are presented as follows:

Socio-Emotional Issues: The relationship building, cohesion, and trust are presented as the fundamental socio-emotional processes to foster the effectiveness of the virtual teams, however; teams face significant difficulty in achieving them (Alexander, 2000; Kezsbom, 2000). Virtual teams tend to have more of a task focus and less of a social focus than traditional teams, but over time they also appear to lessen their task focus (Chidambaram & Bostrom, 1993; Walther, 1995). Virtual teams generally build weaker relation links to teammates as compared to the traditional teams, a fact which is attributed to the significant reliance of electronic communication and difficulties associated with those communication modes (Burke & Chidambaram, 1996; Sproull & Keisler, 1986). However, virtual teams require more social communication to achieve higher trust and better social and emotional relationships (Robey et al., 2000). Cohesion is presented as an important aspect of virtual teams since it is related with better

performance (Chidambaram, 1996) Studies have found that while virtual teams begin with lower cohesion as compared to traditional teams, over time virtual teams also exchange enough social information to develop strong cohesion. Without having met with team members, trust development in virtual teams is also very challenging (McDonough et al., 2001).

Issues of Communication: According to the numerous articles in the literature, the core of problems in DSD is the communication issues across sites. They discuss about the importance of communication focusing on the need to create a team of excellent communicators, selection of right technologies, and communication difficulties engendered by virtual environment (Powell et al., 2004). Different background, training, culture, language and experiences of participants across sites, time delays in sending feedback, lack of common reference for all members, differences in salience and interpretation of written text, and assurance of participation from remote team members are some of the series issues which contribute to the communication problems (Crampton, 2001; Powell et al, 2004; Mockus & Herbsleb, 2001). In addition, the participants are less likely to have unplanned contact, nonverbal and informal communication with participants of other sites which is particularly important in organizations with rapidly changing environments and unstable projects (Galbraith, 1997; Kraut & Streeter, 1995; Sproull & Keisler, 1991). Lack of mutual knowledge and the lack of shared language among team members hamper communication (Crampton, 2001)There are also fewer opportunities to interact with remote colleagues because the set of people with whom one communicates at a distant site tends to change rapidly over time (Herbsleb et al., 2000). Identifying the responsible of a particular feature in remote site, nonexistent overlap in working hours, sharing documents and applications, lack of trust and lack of willingness to communicate openly across sites are some other significant communication issues in DSD (Mockus & Herbsleb, 2001). Lastly, virtual team members have to rely heavily on information and communication technologies, however; those technologies tend to restrict the communication process because the electronic media are leaner than face-to-face communication and convey a limited set of communication cues (Sproul & Keisler, 1986).

Issues of Coordination: Coordination represents the degree of functional articulation and unity of effort between different organizational parts and the extent to which the work activities of team members are logically consistent and coherent (Cheng, 1983). Ebert and Neve (2001) specify three important terms; coherence, collocation, and allocation, related with the coordination of remote sites, and allocation. Coherence means splitting the work during development according to feature content and assembling a team that can implement a set of related functionality. Collocation means that engineers working on such a set of coherent functionality should sit in the same building. Full allocation means engineers working on a project should not be distracted by different tasks in other projects. The article of 'Surviving DSD' of Ebert and Neve emphasize the challenge of virtual teams in providing strong communication and coordination practices because of the difficulty in supplying those important terms.

The coordination problems are directly related with the performance of the teams. The major sources of problems are interdependencies among work items and difficulties in coordination. The interdependencies may arise if the architecture of the system does not involve relatively independent modules that can be assigned so that they do not span locations (Mockus & Herbsleb, 2001). The strategic issue involves the questions of how to divide up the work across sites. Solutions are constrained by the resources available at the sites, their levels of expertise in various technologies, the infrastructures etc. Herbsleb and Moitra (2001) suggest that an ideal arrangement would let the sites operate as independently as possible while providing easy, flexible, and effective communication across sites.

The coordination becomes an issue because of process non-uniformities, such as variances in the definitions may cause mismatched expectations and conflict. They also suggests several pitfalls in DSD which may arise from lack of differences in infrastructure in different development locations, including network connectivity, development environment, test and build labs, and change and version management systems (Herbsleb and Moitra, 2001; Sarker & Sahay, 2002).

Issues of Knowledge Management: Knowledge management is briefly defined as the elicitation, extraction, sharing and application of knowledge within organizations (Alavi, Leidner, 1999). Effective information and knowledge sharing mechanisms are one of the essences of DSD. Because of the ineffective knowledge management practices, needed expertise might be available but can not be located and exploited, managers fail to share information from the customers and development teams, teams can not determine the tasks of critical path, and teams miss many reuse opportunities to save cost and time (Mockus & Herbsleb, 2001).

Technical Issues and Process-Technology Fit: Availability of various technologies, the slowness and lack of reliability of networks spanning globally dispersed locations, using incompatible data formats and different versions of the same tools are some of the major technical issues of virtual teams (Herbsleb and Moitra, 2001, Powell et al., 2004). However, what is more significant than the technology selection is the evaluation of the possible fit between available technologies and the processes and tasks of teams to execute (Powell et al., 2004).

2.1.4. Demands for the effectiveness of DSD

As the technological infrastructure necessary to support virtual teams is readily available, further research on the range of issues surrounding virtual teams is required if we are to learn how to manage them effectively (Powel et al., 2004).

Mockus and Herbsleb (2001) summarize two approaches, which are de-coupling of work and creating a virtual site, that may reduce or eliminate problems associated with distributed work. De-coupling of work involves choosing appropriate development models and criteria division of the product according to implicit work-item based modular structure, minimizing and formalizing work handoffs, implementing appropriate coordination mechanisms and adapting development process. The creation of the virtual site involves tools, practices and processes. Setting a common development environment including change, problem and

versioning tracking, build, test, and project management, providing infrastructure for collaborative sessions, providing a presence awareness information through a common calendar and instant messaging, setting up common practices on how to respond to phone and email messages, giving a view of project information through regular updates of project management information through regular updates of project management information, FAQs, team web pages and expertise locators, and finally establishing relationships by supporting travel to project meetings, establishing common communication etiquette, and provide training at remote sites are some of the significant practices described for the creation of virtual sites. Herbsleb and Moitra (2001), additionally suggest training the team members with distributed software development in mind, and offer the educational programs including team-oriented work.

2.1.5. Effective Development Methodologies

Paasivaara and Lassenius (2004) suggest that iterative and incremental development is a viable approach providing several benefits in interorganizational distributed software development. They add that the advantages of using the practices overweigh the extra communication and coordination cost they incur. However, Ebert and Neve (2001) state that how to implement an entirely incremental approach to a legacy architecture that is primarily driven by heavily interacting subsystems is obvious yet, increments toward a stable build proved one of the key success factors in DSD. They explain the changes to achieve real incremental development on a specific case of DSD setting as; analyzing requirements from the beginning, analyzing the context (interfaces and data structures that are common for several modules), providing a project plan that is based on customer requirements and allocated development teams, developing each increment within one dedicated team, basing the progress tracking of development and testing primarily on the integration and testing of customer requirements.

2.2. Global Software Development (GSD)

Carmel and Agarwal (2001) explain that the marketplace is responding to the increased demand for IT labor through the construction of new commercial mechanisms. IT business-to-business intermediaries serve as exchanges between worldwide IT services vendors and small and medium size business needs with IT needs. They define two critical, strategic reasons for moving to offshore software development: cost advantage and a large labor pool.

Despite the demand for global development, coordinating over long distances still remains problematic. Even though the literature generally does not differentiate the issues of global software development from DSD, the two subjects have been separated in this study essentially because of the nature of the cases investigated. Indeed, DSD suffers more from the challenges of the development setting if it includes global features, such as national, cultural, linguistic differences. Therefore in a global development context, reducing issues caused by the need for intensive collaboration, and national, and cultural differences are more important (Carmel, Agarwal, 2001). The major dimensions of the distinctive problems are explained as follows:

National, Cultural, and Language related Issues: GSD requires a close cooperation of individuals with different backgrounds. Cultural and language differences are common in especially global virtual teams, but the subtle differences among team members from different regions of the same country may also negatively impact a virtual team (Robey et al., 2000). Cultural issues are significant since they have a direct affect on the determination of hierarchies and structures, sense of time and communication styles (Hofstede, 1997). Cultural differences and divides, divergent mental models, and differences in time zones often accelerate communication problems as well (Sarker & Sahay, 2002). People may be puzzled how to respond to odd sounding messages (Herbsleb & Moitra, 2001; Sarker & Sahay, 2002). Cultural differences also lead to coordination difficulties (Johansson et al., 1999).

CHAPTER 3

METHODOLOGY

In this section research strategy and the implementation processes of the study will be explained in detail.

3.1. The Research Strategy

The study was held according to one of the qualitative research strategies, called collective (multiple) case study. Justification of the research strategy will be attempted in the following sections:

3.1.1. Case Study Research

The IS field has a shift from technological to managerial and organizational questions, and consequently more interests in how context and innovations interact (Benbasat et al., 1987). Likewise; this study focused on managerial and organizational issues of distributed software development setting and deployment

of Information Communication Technology (ICT) innovations to understand the communication, coordination and collaboration needs of creative teams.

Qualitative techniques are widely accepted in administrative sciences. The shift to managerial and organizational issues also made the utilization of qualitative techniques popular in IS field (Benbasat et al., 1987). This study, targeting managerial and organizational issues also employed one of the qualitative techniques as a research strategy.

Additionally, Franz and Robey (1991) suggest idiographic research strategies (which attempts to understand a phenomenon in its context) rather than nomothetic research strategies (which seek general laws and draw solely on procedures used in exact sciences) in IS field.

Accordingly, case study research, as one of the qualitative research strategies, has been selected. Case study examines a phenomenon in its natural setting, employing multiple methods of data collection to gather information from one or a few entities: people, groups, or organizations (Yin, 1994, Benbasat et al., 1987).

Particularly for this study, case study technique was selected based on its following characteristics:

Yin (1994) states that case studies could be used to explain phenomena. Benbasat (1987) declares that case methodology is useful when a natural setting or a focus on contemporary events is needed. Similarly, the major targets of the study were to understand and explain the contemporary and indispensable events of distributed software development and virtual organizations in their natural contexts.

In addition, case research is appropriate where there exist a practice base problem and where the experiences of the actors are important and the context of action is critical (Bonoma, 1983). Moreover, research phenomena not supported by a strong theoretical base may be fruitfully pursued through case research. Before formalization takes place, case studies could be employed to document the

experiences of practice. Hence, case research strategy is well suited to capturing the knowledge of practitioners and developing theories from it (Benbasat et al., 1987). Similarly, presenting the experiences of the participants, as well as the common and distinctive findings of the proposals was the essence of the study.

3.1.2. Collective Case Study

Case studies can be either single or multiple-case designs. Single cases are used to confirm or challenge a theory, or to represent a unique or extreme case (Yin, 1994). Multiple-case designs are desirable when the intent of research is description, theory building, or theory testing. Multiple-case designs allow for cross-case analysis and better understanding or an improved ability to theorize about some larger collection of cases since they yield more general research results (Benbasat et al., 1987). They strive towards a holistic understanding of cultural systems of action (Feagin, Orum, & Sjoberg, 1990). Similarly Yin states that, multiple cases strengthen the results by replicating the pattern-matching, thus increasing confidence in the robustness of the theory.

This study employed multiple case study research, because the aim of the study was describing the issues and needs of virtual organizations. Investigating different organizational structures, projects and teams were important to present more triangulated data, and to gain more generalized results.

According to the literature, a single case used for exploration may be followed by a multiple case study. Researchers learn relevant jargon and context in which the phenomenon will be studied. In this study, also, exploration of the context in the first case helped the researcher understand the general characteristics of the setting. After the employment of the first case, research questions were redefined, and after, multiple case study were conducted according to renewed questions.

Multiple case studies follow replication logic. However, major researchers in the field, including Yin, Stake, Feagin assert that case study research should not be

confused with sampling logic. Selecting cases must be done so as to maximize what can be learned, in the period of time available for the study (Tellis, 1997). Each individual case should be held as a holistic study, in which facts are gathered from various sources and conclusions drawn on those facts (Yin, 1994). Accordingly, in this study, all the cases were examined as a single case, and a complete investigation was conducted on multiple cases for replication.

3.1.3. Rationale behind the Case Selection

The factors that dictate a single case design also determine site selection. However, when multiple cases are included in a study, choices must be made (Benbasat et al., 1987). This section will explain the rationale behind the selection of the cases for the study.

Yin proposes two criteria for selecting potential sites: “literal” replication and “theoretical” replication. Sites where similar results are predicted may be used as “literal” replications, and sites where contradictory results are predicted may be used as “theoretical” replications. The target of this study was not to make rigid generalizations but to understand the success factors and issues of development which are unique to selected cases. Still, revealing the common findings of cases was important to provide an initial point for external generalizability, and enhance further research facilities. Therefore, all sites were considered to have the common features of virtual development context for literal replication, but to have very distinctive features as well for theoretical replication. The cases were selected according to the differences in: The context of virtual collaboration (global vs. non-global, national vs. multinational, team based vs. multi-site or organization based), parties or teams in collaboration (size, characteristics, and types of collaboration), the projects investigated (context, size, development teams, and success).

3.2. Implementation Process

The selected cases will be described by presenting background information about the subjects, distinctive characteristics and justification of cases throughout this chapter.

3.2.1. Background Information about Cases

This section will present necessary background information about the subjects (the participants and projects investigated) of the cases. Firstly, significant properties of all cases will be presented in Table 1. Then, the development setting of virtual teams of the first case will be explained in detail. The setting of second and third cases will also be explained in the following sections, however; since the study has been conducted from the viewpoint of local parties, detailed information will only be given for them.

3.2.1.1. Case 1: ION

Participants of the case study were the students of ION 505 course, called Information Systems Group Project, in the spring semester, academic year of 2004-2005.

Information about ION: Informatics Institute, METU, has been established in 1997, with the purpose of carrying out inter-disciplinary studies with the people coming from distinct disciplines with different educational backgrounds. ION is the fully Internet based master's degree program of the IS department of the Institute. All courses of ION program are carried out asynchronously over an e-learning system; called Netclass (http://ion.ii.metu.edu.tr). The objective and the program structure of ION program are specified as follows:

Table 1 Properties of selected cases

Case #	Case1: ION	Case2: AYESAŞ	Case3: RtB - SBS
Participants of study	Teams: Five virtual teams of ION505 course	Organizations: AYESAŞ	Organizations: RtB, SBS
	People: Students of ION 505 course (for questionnaires), five people from three teams (for interviews)	People: Project manager from AYESAŞ	People: Content leader from RtB, project manager from SBS
Investigated Project(s)	Five different software projects of five virtual teams. Examples of distributed software development in non-global context.	Avionic software system development project. Example of global software development.	Malaysia e-learning projects; form2 and form 3. Examples of global software development.
Project Definition	Team 1: Library Automation System Team2: Scholarship Management System Team 3: Online Education Framework Team 4: Online PC Information Database Team 5: Debt Automation System	Avionic software system development project.	E-learning projects which were developed to support Malaysian formal education. They are used in schools of Malaysia, in second and third grade classes.
Distributed development setting	Five virtual teams (formed by 3 to 4 people) of ION 505 course. *Participants and characteristics of student based controlled research setting:* Small sized virtual teams and projects, geographically distributed team members, non-global development (no differences in nationalities, cultures, languages etc.)	Collaboration of one organization from Turkey, and one from USA. Customer is from USA. *Participants and characteristics of field based research setting:* Geographically separated organizations and several development teams in collaboration, big sized, very structured military project, global development	Collaboration of two geographically distributed organizations from Turkey, one Turkish project manager in Malaysia, the sub-contractor from Malaysia. Customer is Malaysian government. *Participants and characteristics of field based research setting:* Geographically separated organizations and several development teams in collaboration, global development

Informatics-Online aims to provide expertise on the rapidly developing subjects of information technology and systems. It is intended for working professionals who need continuing education without the need to come to the METU campus for lectures. ION is a non-thesis program in which course participation will be exclusively through the Internet. Courses cover fundamental and current concepts of information technology and systems in depth.

Information about ION 505 course: The description of the course is given as follows:

The course aims to integrate fundamental awareness and expertise obtained in earlier information systems and software engineering courses into a meaningful whole through an applied group project. Course material, in parallel with project stages, presents an overview of fundamental IS project planning and management techniques and approaches.

During the term in which the study was conducted, teams were formed with 3 to 4 people, and they developed software with DXP methodology. Besides implementing the iterative cycles of XP, teams were also required to submit formal documents with IEEE standards including SRS (IEEE 830-1998), SDD (IEEE 1016-1998) and STD (IEEE 829-1998). Teams updated their initial documents according to iteration plans in each cycle and created the documents iteratively. Hence, at the end of the fourth cycle, all teams were expected to submit one SRS, one SDD, and one acceptance test report with the running software.

The course started with two weeks of introduction. Introduction weeks involved the following critical activities:

I) Instructor introduced himself and identified objectives and requirements of the course, and his expectations. He informed students about the schedule, identified the development methodology, and asked students to read and learn about XP and its base practices. He asked students to introduce themselves by declaring their educational and professional background, interests, and preferred team roles for the group project. He asked them to form groups with 3 to 4 people.

II) Students formed their groups and gave a project proposal.

III) Group forums were created in Netclass system, and students were required to employ these private forums for inner group communications and decision making activities.

IV) Instructor commented on the proposals for revisions. After, he asked for the release plan.

V) Instructor introduced the support tool; XPWeb He asked students read the lecture notes of the first chapter which explains utilization of the tool and indicates success factors behind distributed software development. Students were required to employ the tool during the development. They used the tool for several purposes such as scheduling, planning, reporting, versioning etc. Instructor used the tool to follow the implemented work products every week. Besides he viewed roles and responsibilities of all team members in the group project.

VI) Students presented the release plans which consisted stories including validation criteria, priorities, risks, and weights. In later phases, instructor acted as the customer, and planning game were realized between project groups and the instructor.

After the introduction weeks, students were involved in project implementation cycles. There were four iterative cycles and two weeks time was reserved for each cycle. Iterative cycles involved four fundamental phases:

System Requirement Analysis Phase: Teams prepared and submitted iteration plans. Based on release plans, they selected critical stories to be implemented in the following iteration cycle. They updated the weight, priority, and risk indexes of stories from initial plans. They defined tasks for the selected stories and assigned those tasks to team members. The deliverables of the phase were iteration plan and (updated) SRS report.

System Design Phase: Teams implemented design activities for the stories of submitted iteration plan. The deliverable of the phase was (updated) SDD report.

Systems Implementation Phase: Teams developed working software for the selected stories. They updated the initial plans with actual plans in XPWeb tool, and reported team performance with individual performances. The deliverable of the phase was running code of the project.

Testing Phase: Teams created unit tests for testing. They also validated the working software with predefined validation criteria. The deliverable of the phase was debugged software, and (updated) acceptance test report.

Information about the support tool; XPWeb: A support tool was provided to the teams to enhance their planning, communication and coordination practices in distributed software development setting. XPWeb was a web based tool, designed to manage DXP projects. The sections and major facilities of the tool were:
Planning section: Planning game (prepare release plan, create user stories and tasks, discuss on the stories with the customer, create iterations, select stories and tasks for every iterations, assign team members to tasks), define roles and responsibilities, define the project schedule.
Calendar section: Visualize the tasks of weeks. Task information includes task definition, assigned team member, and due date
Reports section: Evaluate performance of the process and developers in every iteration, Provide feedback to team members and customer about the progress
Versioning section: Use current versioning system (CVC), Store and archive end products and make them available to all related parties.

Information about the participants: The participants of the case study were 18 students, and 5 virtual teams of ION505 course, who contributed from different provinces of Turkey and outside the country (11 from Ankara, 4 from Istanbul, 1 from Hakkari, 2 from Switzerland and Russia). The teams included 3 or 4 people, at least one of whom was geographically separated. Even the team members located in the same city stated that they could hold face-to-face meetings but they could be able to work from different locations. Besides, the instructor who acted as the customer during the development was also geographically separated from the teams.

3.2.1.2. Case 2: AYESAŞ

AYESAŞ (Aydın Yazılım ve Elektronik Sanayii A.Ş.), has been established in 1990 in Ankara. It has experience in the areas of real-time software development, C4I and avionics systems, electronic and mechanical manufacturing, telecommunications and information technologies. AYESAŞ holds National and NATO Secret Level Secure Facility Certificates, as well as ISO-9001:2000, AQAP-150 and CMM-3 Certificates. Total number of personnel is 180, including 75 qualified software and hardware engineers. The Turkish Vestel holds %60, and the American L-3 Communications holds %40 of the company.

The AYESAŞ software development department provides customized services to military and civilian sectors in command control systems, radar integration, tactical data links, avionics software development and independent verification and validation. AYESAŞ is a project oriented organization. Projects are under the supervision of project managers. Under project managers, there are two or three team leaders supervising senior engineers. At parallel level of senior engineers, there are junior engineers having less experience and knowledge.

AYESAŞ has been included to the investigated project in 2003 as subcontractor of a software development company in USA. The actors of the development setting and their responsibilities are as in Table 2:

Table 2 Development Setting of Case 2

Company/ Role	**Location**	**Responsibility**
SW Company/ Customer	USA	Testing and Verification
SW Company/ Developer	USA	All the development activities
AYESAŞ/ Sub-contractor	Ankara	Validation and verification at early phases. Additional implementation and integration activities at later phases.

The project was developed by the standards of the organization from USA, and development strategies of sub-contractor company; AYESAŞ. Even though AYESAŞ has first been included in the project as a subcontractor company, which is responsible of validation and verification activities, then the definition of work has been changed. A more collaborative development setting has been established after providing the mutual trust, mutual decision making, and cooperative project management, technical management, configuration management, and verification activities. AYESAŞ side has been included to the overall implementation and integration activities at later phases, especially after the termination of the first year. Even though the teams which are responsible of similar tasks worked together, all the executives and team leaders made weekly teleconferencing or other kinds of meetings. The communication between all the teams were intense, a phenomenon which composed the context of the distributed setting and resulted in several problems during the development.

The investigated project was a big sized military project with 300.000 lines of code. AYESAŞ was responsible for implementing 50.000, revising 100.000, and testing 300.000 lines of code. The project manager defined the development methodology as a hybrid methodology between revised waterfall and incremental. He stated that there were no formalized processes; rather they progressed on the "engineering drafts". All the feedbacks, prototypes, and updates were used to improve the drafts and bring them to a maturity level. The development processes of AYESAŞ were mature, as it can be observed from the quality certificates the company holds. Yet, the maturity of the development processes of the collaboration shall still be discussed apart from the maturity of processes of a single organization, since organizations in collaboration faced many problems during the development.

The time assigned for the termination of the project was two years. However, at the end of the first year, it was observed that the project would not catch up the schedule and turn out to be a failure; therefore critical managerial changes were executed. Three upper level managers were brought to enhance communication and coordination activities of parties. Consequently, the project successfully terminated with four months delay.

3.2.1.3. Case 3: RtB – SBS

RtB has been established in 2000 in Ankara. The company provides educational methods, solutions and practices, and the work is based on knowledge and technology. The company gets knowledge; transforms it into useful information to be presented via technology. RtB mostly develops the information (the raw material for e-learning solutions) for its permanent customer; Siemens Business Services (SBS). There are 33 people working for RtB which include 2 managers (founders), 4 administrative staff, 6 technical supporters and 21 instructional designers. Organizational structure of RtB is not rigidly standardized, but change according to the structures of projects. The structure of the organization is based on its productive cross functional teams.

For the investigated projects, RtB worked as the subcontractor of SBS. SBS provided economic power, technical support, and reputation, on the other hand, RtB provided content support to the projects. Collaborative teams of RtB and SBS were in Ankara; however they were in different locations. A Malaysian team and a customer executive were also the contributors of the projects. The actors of the distributed setting and their responsibilities are as in Table3.

Projects were contracted by SBS. Project managers from SBS and executives from RtB carried out the management of the projects. RtB was subcontracted for educational solutions and the company fully contributed to the projects with instructional designers group. The work definition of the group included providing the concepts and the general layout of the project, and responsibilities included; communicating with the customer to discuss the content, eliciting requirements, receiving feedback on prototypes and end products, designing, organizing, executing, and controlling the content, discussing the content with technical groups, writing text and questions scripts, and writing interaction storyboards. On the other hand, SBS was responsible for technical issues (besides project management), and contributed to the project with visual designers and multimedia programmers.

The teams in RtB and SBS, the executive and other development team in Malaysia worked in full collaboration during the development. Even though those teams that are geographically distributed from each other were responsible of different tasks, they had to communicate very often since all the tasks were highly dependent on each other, and had to be processed sequentially. Hence, the development setting did not compose of tasks performed in different locations, but still, intense communication and coordination practices let to name the development setting distributed.

The investigated projects; Form 2 and Form 3 were two successful e-learning projects, including mathematics and science courses, which were developed for the Malaysian Ministry of Education. Form 2 was terminated in 8 months, and Form 3 was terminated in 7 months. Additionally, SBS worked for 6 months on the first prototype of the product for the bidding. The projects aimed e-transformation in the Malaysian education system and accordingly, equipped education professionals with multimedia tools. The existing educational content was transferred into an attractive multimedia shape – including 3D animations and short movies. The programs were deployed in 2305 schools, including schools in China and Turkey.

3.2.2. Research Questions

Qualitative strategies emphasize an interpretative approach that uses data to both pose and resolve research questions (Kaplan, Duchon, 1988). The research questions of this study were also developed, posed and resolved iteratively because data collection and data analysis were interrelated processes. The initial understanding of the phenomenon was tested and modified through cycles of additional data collection and analysis (Kaplan and Duchon, 1988). Hence, the research questions have been modified in each cycle for each case, considering their specific characteristics, strengths and limitations. Though, there were three major research questions targeting very significant issues of the distributed software development setting:

Table 3 Development Setting of Case 3

Actor	Role	Responsibility	Location	Nationality
RtB (Provide educational solutions)	2 general executives	Administration	Ankara	Turkish
	2 instructional designers*	Instructional design (develop content, communicate with the customer)		
SBS (Make contract agreement, manage projects, provide technical support)	2 visual designers*	Visual design	Ankara	Turkish
	2 multimedia programmers*	Multimedia Programming		
	1 Project Manager	Project Management, technical support		
	1 Project Manager	Project Management, technical support	Malaysia	
Ministry of Education (MEM)	The customer	Approve end products	Malaysia	Malaysian
The customer executive (fully assigned to the projects)	Representative of the customer	Represents the customer, communicate with official executives of MEM, give feedback to developers	Malaysia	Malaysian
Subcontractor	Technical support	Provide technical support	Malaysia	Malaysian

* There were five cross functional teams including

1) Communication: The first question of the study was "What are the major issues and needs of virtual teams (or virtual organizations) to ensure effective communication practices?" What are the required communication infrastructures?"

2) Coordination and Collaboration: The second question of the study was "What are the major issues and needs of virtual teams (or virtual organizations) to ensure effective coordination practices and provide full collaboration between parties?" What are the required infrastructures?"

3) Tool support: The third question was "What is the significance of tool support in distributed software development setting? – If tool support is vital, what are the essential features and facilities of the tool?"

3.2.3. Overall Design of the Study

The research was designed as "iterative qualitative" which allows interrelationship between data collection and data analysis processes. According to Kaplan and Duchon (1998), researchers develop categories and meaning from data through an iterative process that starts by developing an initial understanding of the perspectives of those being studied. That understanding is then tested and modified through cycles of additional data collection and analysis.

The iterative research cycle will be explained in the following sections.

A. Initialization phase of the study:

1) Review the literature, specifically in the context of distributed software development. Global software development, virtual teams, decision making process of creative teams, use of communication information technologies, extreme programming, distributed extreme programming, team software process were other important titles of the review. Review of literature gave significant insight about the process of distributed software development, and issues of virtual teams and organizations.

2) Weekly discussions on the issues of distributed software development with the advisor who had been the instructor of the ION505 course for four educational terms. As experienced in the setting of the first case, he gave valuable information about the setting; general behaviors of the students, major problems encountered, and solution suggestions about the conflicts etc.

3) Analyze existing support tools and compare their strengths and weaknesses by considering initial understanding of the phenomenon.

4) Propose a tool which is designed to enhance distributed software development with extreme programming methodology, considering probable problems of virtual teams of Case 1.

5) Prepare a course chapter to inform students about the issues of distributed development and to explain the features of the proposed tool. Chapter also included a guide to use the tool and presented in the first week of the course.

6) According to constructed knowledge about the issue, define the research questions.

B. Investigation on Case 1

1) Direct observations of case 1 during the semester for four months as the teaching assistant of the course. Direct observations included observing and analyzing iteration cycles, and end products, observing inner group communications (join the mail groups, follow course forum), noting major problems that students encountered, and noting groups strengths and weaknesses considering their limitations.

2) Distribute a survey over internet at the end of the semester. Survey aimed to reveal the general insight of the students about the setting.

3) Interview with available team members. It was a group interview held by five people from three teams.

4) Analyze the data received by direct observations, surveys, and group interview. Discuss and summarize the findings and results.

5) Define more concrete and accurate research questions considering the experience and findings of the first case. Besides from accurateness, new research questions were defined to understand the phenomena in professional setting. For

instance, collaboration of geographically separated companies was not in the scope of case 1 since it was an educational setting and there were only virtual teams to be investigated. However, in the remaining cases, it was very critical, and this led the researcher ask new questions.

C. Investigation on Case 2 and Case 3

1) Select the participants (the organizations and people) of the interviews.
2) Analyze the available documentation about organizations and projects to be investigated.
3) Generate a question template to employ during the interviews of cases. Interviews were not strictly dependent on the questions of the template; rather they lead the course of discussions. Template included extra questions to understand the situation in professional setting. Moreover, it had specific questions for each case.
4) Interview with the selected participants to understand the issues of their distributed software development experience and receive their suggestions.
5) Note about the setting.
6) Transcribe the records of the interviews and acquire validation from the interviewees about the transcripts.
7) Analyze the documents, transcripts of the interviews, and data captured by direct observations. Discuss and summarize findings and results.
8) Obtain verification from the interviewees about the findings and results.

D. Closure

1) Discuss the overall findings of the cases.
2) Summarize the findings and discuss common and distinctive findings according to the specific characteristics of cases.

Below, Figure 1 presents the flow of the collective case study. Reference numbers in the figure reflect the numbering of the narrative. Table 4 outlines the schedule applied in carrying out this investigation.

3.2.4. Data Collection Methods and Reliability of Collected Data

Reliability can simply be defined as the extent to which studies can be replicated. Hence, internal reliability refers to the degree to which other researchers, given a set of previously generated constructs would math them with the data in the same way as did the original researcher. In order to ensure internal reliability, replicability of instruments, responses and analysis were highly considered. While explaining about the data collection methods, those considerations will also be explained below.

Multiple data collection methods are typically employed in case research studies. Ideally, evidence form two or more sources converge to ensure reliability of the research findings (Benbasat et al., 1987). Utilization of multiple sources of data also supports triangulation; cross-validation of information and conclusions through the use of multiple procedures of sources, and for these reasons it was selected as the research strategy.

According to Yin, not all sources are relevant for all case studies. Each case presents different opportunities for data collection. Accordingly, three main data collection methods of qualitative research were employed in the study. The methods were interviews, direct observations and, artifact and document analysis (Yin, 1994; Stake, 1995). These methods are also suggested to work well in case study research (Benbasat et al., 1987). Additionally, participant observation and archival documents (Yin, 1994; Stake, 1995) were utilized considering the opportunities of Case 1.

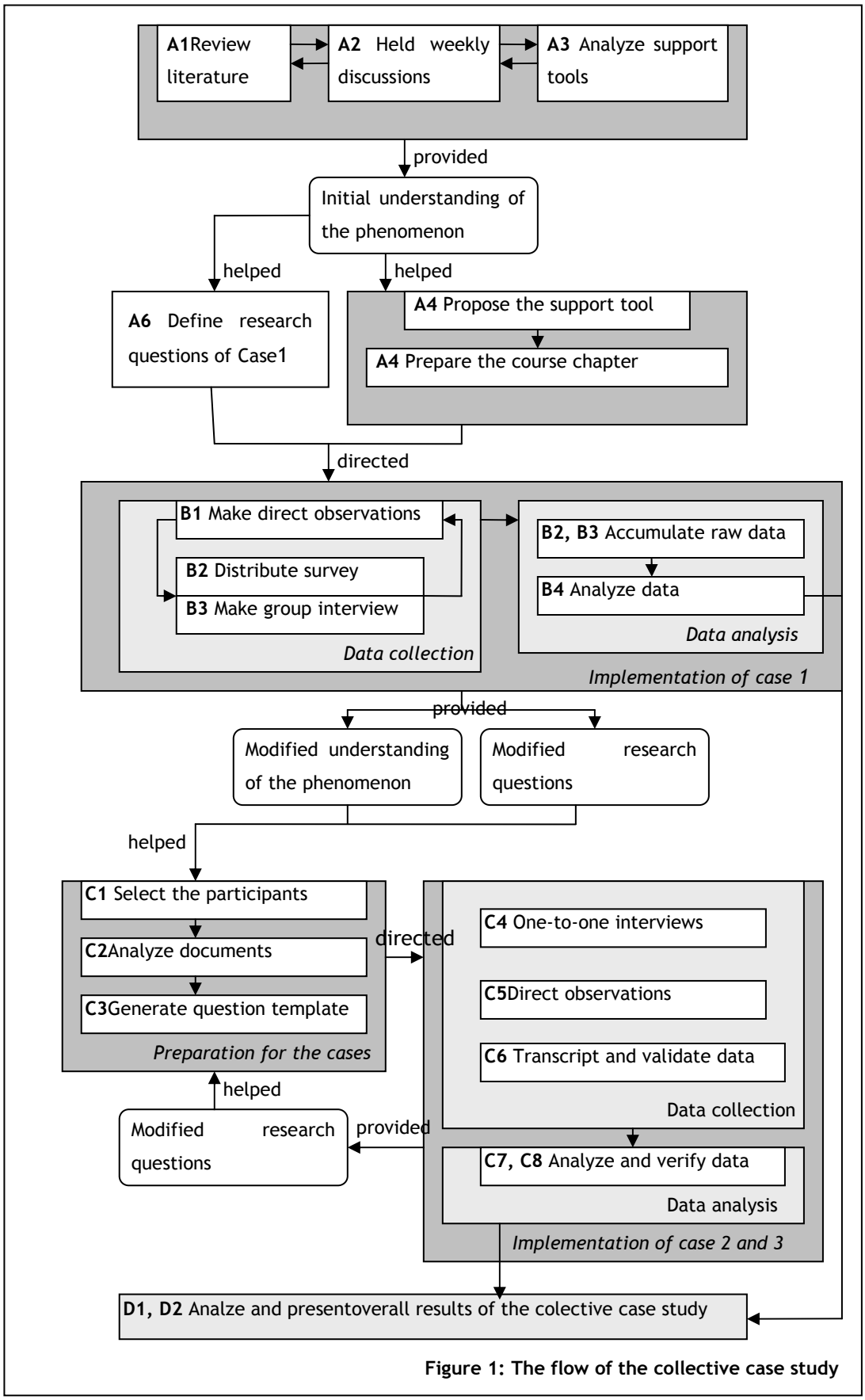

Figure 1: The flow of the collective case study

Table 4 Schedule of the Study

November	December	January	February	March	April	May	June
Initialization work of study			**Study of Case 1**				
Review of the literature (A1)							
Weekly discussions (A2)							
			Analysis of documentation (A2)				
	Define research questions (A6)						
	Analyze support tools (A3)	Propose selected tool (A4)	Prepare the course chapter (A5)				
			Direct observations (B1)				
						Distribute the survey (B2)	
							Collect survey data (B2)
							Group Interview (B3)

Table 4 (Continued)

July	August	Sept.	October	November	December
(cont.)	**Study of Case 2, 3**			**Closure**	

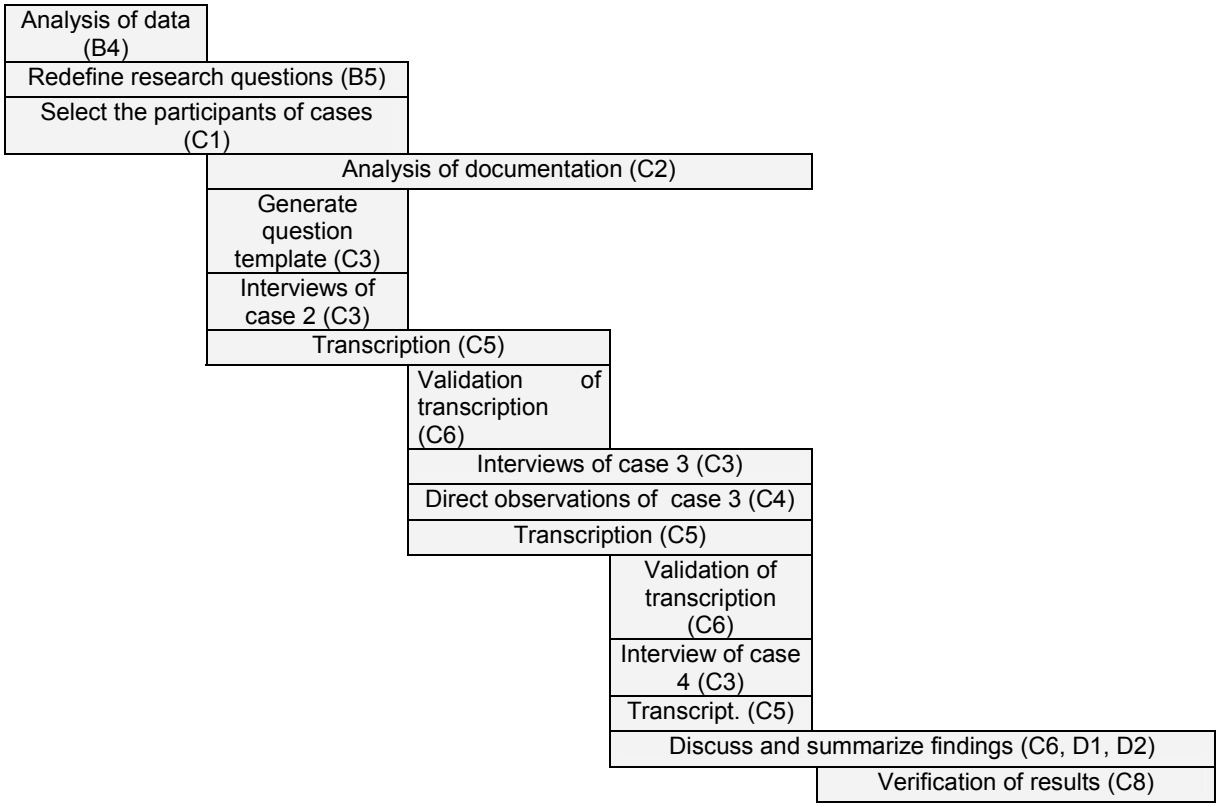

Table 5 shows employed data collection methods according to the cases:

Table 5 Employed Data Collection Methods

	Case 1	Case 2	Case 3
Participant Observation	√		
Archival Records	√		
Direct Observation	√		√
Documentation	√	√	√
Interviews	√	√	√

Specified methods were employed in the study as follows:

Interviews: The main data collection method of the study was semi-structured interviews. I asked open ended questions to make participants provide insight and propose solutions and comments about the setting. The main template of questions led the interviews, but I listened to the meanings of participants and asked further questions.

Interviews were held for three of the cases of the study. Group interview was employed in Case 1, because the participants were not available for one-to-one discussions. The group interview was held on the final exam day, which was the only available time. I could only be able to interview five people from three development teams. However, since the interview was complementary to the survey which was filled in by 18 students of the course, it was sufficient to receive the general insight of the group about the setting. The interview questions were prepared according to my observations during the course, and analysis of the answers helped me prepare a question template to use in other three cases.

For other two cases, interviewees were very much interested in the study and they were volunteered to participate. All the interviewees were well-educated, they understood the research questions well and almost all their discussions were within the context of the study.

It was only in the third case that I could talk with two different people having different roles. Even though their arguments were not totally different, they complemented each other, enhancing the reliability of the findings. Project manager presented a more general insight about the distributed setting. The content leader focused more on operational problems.

Table 6 Interviews Schedule

Case #	**Participant Organization**	**Participant Interviewees**	**About Interviews**
Case 1	Virtual Teams of ION 505 course	Five participants from three different project groups	1 group interview 1.5 hour
Case 2	AYESAŞ	Project manager	2 interviews, 2 hours each
Case 3	RtB	Content leader	3 interviews, 1 hour each
	SBS	Project manager	1 interview, 1.5 hour
	SBS	Project manager	1 interview, 1 hour

Interviews of case 3 were performed in the companies and enabled the researcher to make direct observations on the setting.

Documentation: In the first case, as the teaching assistant of the course, I investigated all the end products of the virtual teams to evaluate their work. All groups submitted a release plan in the fourth week, and then, submitted four iterative plans every two weeks. Moreover, they submitted a running part of software at the end of each iteration cycle. All the end products and their latest versions were located in the support tool called XPWeb, and therefore, they were available to me anytime. I investigated logs of communication. I followed forum of the course, and kept track of the problems and questions of the students. Besides, I was included to the project mail list of one group to follow their inner communication. For the other two cases, I obtained documents including the general information about the companies and projects before the interviews.

Direct Observations were held by observing and noting details of the field environment and behaviors of people. For the first case, development was totally held on Internet. As the teaching assistant of the course, I had the possibility to observe the actions of the groups from the course tool and support tool. Moreover, I joined the project mail list of one group and observed their inner communication. I also had the opportunity to observe the development setting of Case 3.

Participant Observations: In Case 1, I was the participant observer of the setting. Before the beginning of the course, I considered how to support the distributed setting. I searched for several alternatives of tool support and selected one open source support tool. I have prepared a course chapter explaining about the challenges in distributed setting and how that tool may help developers cope with the challenges. Then, I observed the utilization of support tool.

Archival Records: To understand the general insight of the participants in Case 1, I applied a survey including open-ended and short answer questions. Moreover, survey included an evaluation of the proposed tool according to its features. The survey was necessary to get the opinions of all participants since they were not available for interviews. Even though it did not turn out to be as effective as interviewing, it gave an insight about the setting.

3.2.5. Validity

There are three categories of widely accepted validity related to qualitative research; descriptive, interpretive, and theoretical. (Johnson, 1997, Maxwell 1996) According to Johnson, two other types of validity can be discussed for qualitative research; internal and external validity. The definitions and strategies to actualize these validity factors will be explained below:

Descriptive validity determines the factual accuracy of the results reported by the researcher to whether what is reported actually took place or researcher actually

reported what she saw or heard. My first strategy to satisfy descriptive validity was data triangulation. I used multiple data sources, such as questionnaires, interviews, direct observation, archival records and documents to understand the phenomenon.

Interpretive validity determines accuracy in reporting the facts. It can be a source of criticism because of potential investigator subjectivity. In order to ensure interpretive validity, one should avoid imposing one's own meaning rather than understanding the proposals of participants (Yin, 1994). My first strategy to understand the real meanings of the participants was asking open-ended questions. Secondly, for the interviews I prepared a question template, but the interviews were not strictly restricted to those questions, rather answers of the participants led the interviews. To understand their proposals, I asked further questions. Additionally, I tried not to ask questions to direct participants to receive the answers I expected. Thirdly, to interpret objective meaning of participants, I stuck to the proposals of the participants and abstained from throwing in my reflections and subjective expressions. Next, I sent the "Data analysis and discussions" and "Data summary and results" sections to the participants (except case 1) and received their feedback and approval. According to their feedback, I changed the misinterpreted or misunderstood points. Since participants all know English, verification was directly on English interpretations. Lastly, I used peer review strategy. I discussed my interpretations and conclusions with another researcher who is not directly involved to the field. She asked for solid evidences of the results she read, and drew attention to the gaps between raw data and my interpretations.

Theoretical validity determines credibility and defensibility of theoretical explanation developed from a research study. To enhance theoretical validity, I tried not to miss discrepant data and I considered alternative explanations and counter arguments. For instance, during the interviews of second case, the project manager expressed radically counter arguments about tool support and his point of view was presented and discussed under related sections.

Internal validity determines the causality of observed relation or setting. Actually, it was difficult to ensure causality in case 1, because it was an educational setting. For example, grading was an important factor in participants' behaviors. On the contrary, other cases were selected from professional setting and they were not influenced by external factors. Participants were sincere; however, I could only investigate the cases from their views by interviews and the documents they gave me.

External validity determines generalizability beyond the setting or group studied (Maxwell, 1996) Even though high level of generalization was not in the scope of this case, investigating multiple cases achieved a pattern in results.

CHAPTER 4

DISCUSSION OF FINDINGS

In this chapter, the findings in the individual cases will first be discussed in detail, then presented in summary form and then, the common findings of the overall study will be identified.

4.1. Case 1: ION

In this section, data analysis and discussions of the findings of the first case will be presented. Data analysis will be presented under the subsections of: Major issues of the case (4.1.1), Lessons learned on communication (4.1.2), Lessons learned on coordination (4.1.3), and Lessons learned on collaboration (4.1.4).

4.1.1. Major Issues of the Case

I) Issues caused by the nature of the selected case: The case was selected from an educational setting, and the participants of the study were students of an online software development course as described in the previous chapter.

Consequently, some major issues of the case, which will be listed and explained below, were directly related with the characteristics of the setting and the planning of the course itself.

Time limitation: Groups asserted that even though analysis phase of the development was the most critical one to consider, the reserved time was very limited. It was difficult for team members to know each other since they were geographically separated. Teams admitted that they could not form group dynamics, perform group decision making, and define clear roles and responsibilities in that limited time, and then, suffered from the deficiencies during the development.

Grading: Groups claimed that thinking about the time limitations and the grade they would receive from the course greatly affected their end products, project estimations, and planning. They declared that they avoided taking any risks in their decisions and implementations.

Difficulty of access to the customer: Since the projects were developed with XP methodology, groups had to access the customer very often. However, they declared that most of the time they had difficulties in accessing the customer.

Quality management: The teams argued that they could not be able to improve their development processes between the iteration cycles due to time limitations even though it was necessary. For instance, they could not redefine roles and responsibilities or provide a system to review work of other team members.

II) Issues of team work: Teams declared that they could not establish a team culture and provide team harmony because team members were unavailable most of the time, and had diverse work focuses; consequently, members of the teams lacked motivation and discipline, and had unbalanced work load.

III) Definitions of roles and responsibilities: Teams stated that lack of clear definitions for roles and responsibilities were one of the most significant causes of ineffective inner group communication and coordination since they were essential

to determine communication protocols and outline the activity based management plan.

IV) Comprehensive tool support: Teams declared that even though they had benefited from a support tool called XPWeb, they needed a more comprehensive communication infrastructure. They explained that even though XPWeb was adequate for planning purposes, it lacked necessary communication and coordination interfaces and decision making facilities. Since the tool did not satisfy the demands of the virtual teams, they also benefited from other primitive tools. In general, teams used the forum from the website of the course, benefited from XPWeb for planning, and used their private e-mails and instant messaging tools for inner group communication and coordination activities and decision making. However, using several different tools caused problems, especially time, data and motivation loss during the development.

4.1.2. Lessons Learned on Communication

Teams emphasized that ineffective communication introduced the hardest problems to handle. The issues of communication are listed and explained below:

I) Need for a communication plan: Teams agreed on the need for more scheduled activities of communication and a comprehensive plan which includes all issues of communication; such as protocols, meeting schedules, and available hours of team members. Teams also asserted that communication with the customer should also be enhanced for better requirement elicitation process, and therefore, the plan should comprehend the customer as much as possible.

II) Need for a communication leader: Teams pointed out that in distributed settings there should be a communication leader to coordinate the mass communication traffic. However, in such a distributed setting, the communication leader should not only take the role of data submission, but he also should work as a team leader and be an initiative taker as well.

III) Need to determine protocols of communication: Teams declared that they did not determine any communication protocols; however they vitally needed them during the development. Teams added that protocols should be defined in the initialization phase and inform the people about means of communication, their utilization, contact points, response time, and strategies for data keeping and knowledge management.

IV) Need to enhance synchronous communication: Teams declared that for the effectiveness of inner group communication they would prefer synchronous to asynchronous communication. They explained that since they could not settle the available hours of team members, they communicated asynchronously by written texts, however, they asserted, that hindered the effectiveness of the inner group communication. They listed and explained their problems as;

Delays and misinterpretations: While communicating over text messages, what is written, what is intended to be written, and what is understood generally introduces slight differences, but that brings significant problems. One of the teams explained that two of their team members were assigned for implementation and testing activities. However, they could not handle the necessary frequent communication in between because of the misinterpretations in messages and delays in answers, and then, assigned both of the tasks to one member. In consequence, the ineffectiveness of communication introduced other problems, such as, single line processing, idle time for some of the team members and unbalanced work load.

Delays in having response: In asynchronous communication, it is difficult to predict when the message will be read and responded, especially if teams lack strict communication protocols. The phenomenon usually resulted in slowness in rate of progress or rework. Teams explained that after attempting to communicate on any asynchronous communication medium such a forum message; they usually affirmed weather the message was received by a synchronous communication tool such as telephone.

4.1.3. Lessons Learned on Coordination

Teams expressed that particularly, inadequate analysis of the planning phase, ineffective teamwork and communication patterns introduced problems in coordinating the processes, tasks, and people during the development. The issues of coordination are listed and explained below:

I) Need to enhance parallel work: Teams declared that most of the tasks were highly dependent on each other, and added; they could not handle to work on the same task together, or to process several tasks in parallel because of the geographical distance of team members. As a result, teams suffered from single line processing, unbalanced work load, and delayed submissions. Team members either fully worked on a task or stayed idle. Moreover, each member to commit to the deadlines of his own tasks was vitally important, because any delay in single line processing resulted in bigger delays in later phases.

II) Need to provide feasible division of tasks and balanced work load: Teams explained that they could not divide the tasks and assign them to several team members since they could not manage to handle the coordination of events in the distributed setting. Teams asserted that, even if they divided the tasks, communication obstacles of the distributed setting caused much more work load on people and delays in the progress. For instance, one of the teams explained that they had two experienced coders in the team and assigned the coding tasks to them. However, because of the severe communication problems, after some time, one of the coders undertook the responsibility of the entire coding task. Similarly, in every team, one of the team members had all almost all the major responsibilities on his shoulders. The situation resulted in unbalanced and unfair work load.

III) Need to enhance inner group communication: Teams pointed out that almost all coordination problems were affected by ineffective and insufficient inner group communication. They emphasized that the communication plan should consider the relations of actors and tasks, considering scheduling of events, to enhance coordination as well as communication of virtual teams.

IV) Need for more analysis for the planning: Teams explained that providing accurate size estimations for user stories, taking correct decisions on the feasibility of stories, and dividing them into iterations were very difficult, since they had to perform those in the first two weeks; before settling the team culture and group decision making ability yet. Estimations and plans were not accurate and mature yet, so that they frequently had to deviate from the initial plan during the development, and this affected the coordination of activities.

4.1.4. Lessons Learned on Collaboration

Teams expressed that effective teamwork is the most important consideration to provide full collaboration in small virtual teams. The issues of collaboration are listed and explained below:

I) Need to agree on a common goal: Teams expressed that they had confronted several problems due to distinct work focus of team members, and added that providing a common goal for all team members should be the first step to support full collaboration, and harmony and motivation of virtual teams.

II) Need to enhance group decision making: One of the teams stated that they made all the group decisions after the inner group discussions to which all the team members contributed. Based on their experience, they expressed that group decision making and individual responsibilities on the decisions taken were the most significant factors for effective collaborative work in virtual teams.

4.2. Case 2: AYESAŞ

In this section, data analysis and discussions of the findings of the second case will be presented. The software investigated for the case was developed for the defense industry; hence, security and quality issues were two of the major

considerations. Consequently, the case revealed major discussions on globally developed highly security and quality demanding projects. Discussions and findings shall be interpreted in that context.

4.2.1. Major Issues of the Case

I) Time Differences: During the development of the project, collaborative parties suffered from eight hour time difference. As the project manager declared, providing necessary communication links to receive emergent feedback was frequently necessary during the project. The phenomenon, most of the time resulted in extension of work hours.

II) National, Cultural, and Linguistic Differences: Even though all the workers of AYESAŞ knew English, and had strong cultural backgrounds, use of language was problematic. National and cultural differences also contributed to the problems. The project manager explained their experience as;

> *We worked overtime when necessary, but could not see the same insight from our partner. For example, they were strictly dependent on national rules and regulations such as not to work one day every two weeks, or never work on national or religious holidays. Unfortunately, there were many times we had worked on weekends or on our religious holidays to catch up with the calendar. In addition, we always had problems between slide meaning differences of what we said, and what we intended to say. The differences in synonym words were hardly discernable to us, but caused difficulties for our partner. Linguistic problems caused delays in the progress of work.*

III) Work Harmony: Partners could not provide the harmony of work for a long time, mainly because of the differences in traditions, work styles and rate of progress. The project manager complained about slow progress of work of the collaborative party and differences in working traditions, and emphasized their negative contribution to the work harmony.

IV) Trust Issues: The issues of trust in AYESAŞ case were vital, because the project investigated was a strategic military project and governmental

considerations were very important. Trust related issues encountered during the project are explained as follows:

Content-related trust: Strategic projects, such as military projects, involve strategic decisions of the countries. Consequently, it was very difficult to establish full collaboration and trust between collaborative parties, because lack of trust even on any minor issue resulted in bigger trust problems. Interviewed project manager expressed that;

> *The reason they worked with us was that; people work harder and longer here, and labor force is cheaper. Actually they did not trust us but they were dependent on our work force; hence it was not possible to discuss a real partnership or collaboration in our case. After one year of work together, they still hid documents from us. I, as an executive project manager, could not visit their computer laboratories without an escort. Besides the escort, they put screen savers to the monitors of the computers. They had an organizational paranoia.*

Export Documents: The issue was related to sharing documents. Because of governmental rules that restrict document transmission to post with required export seal on it, the partner of AYESAŞ was unwilling to send required documents by e-mail even when they were urgently needed. The situation also caused delays in the progress of work several times.

Quality-related trust: The interviewee asserted that the partner was very suspicious of the quality of their work at the beginning and collaboration could only be provided at the end of the first year. Abolishing the prejudgments and providing mutual trust took too much time and effort.

Resistance to work in collaboration: Fear of job loss was one of the most important resistance factors. For instance, the employees in AYESAŞ side worked longer hours and demanded lower salaries. Although, the employees of the organization in USA knew that external resource utilization was highly needed, they resisted to work fully collaborated because of the fear of loosing their jobs.

V) Definition of roles and responsibilities: The project manager explained that proposing clear definitions is essential to support effectiveness of communication, coordination and collaboration activities of parties. He expressed that the definitions are vital to settle a complete communication plan and

determine protocols of communication, settle coordination of events and activities and work flow on the definitions, and determine roles of parties in collaboration. He added that they did not confront major problems due to the lack of definitions, since the organizational infrastructure of the collaboration and the related definitions were clear for all parties.

VI) Comprehensive tool support: In AYESAŞ case, the network of parties was under strict firewall control for security. Asynchronous communication tools, such as instant messaging were not permitted, but all the communication was held by formal teleconferencing meetings and e-mails. Project manager explained that even though a support tool was vitally needed for both communication and coordination activities, they did not utilize it during the first year. After the first year, the project is considered unsuccessful and critical managerial changes have been executed. One of the changes was the utilization of the system support tool; called virtual private network (VPN). The tool was proposed to project managers of AYESAŞ, and enhanced the effectiveness of activities.

4.2.2. Lessons Learned on Communication

Interviewed manager mostly focused on the issues of communication. He declared that the success of software development in any distributed settings is directly related to effective communication. He added that majority of their problems about the issue were resolved by the executed changes in the communication policy at the end of the first year. The issues of communication are listed and discussed as follows:

VII) Need for a Communication Plan and a Communication Team: The interviewee pointed out the certain necessity of a communication plan and a team assigned only for effective progression of communication activities. He asserted that;

> *A written communication plan, which is negotiated and concluded by the authorities of all parties, should be the prerequisite of the initialization phase. Communication plan should most critically include protocols of communication, and determine use of ICT support.*

VIII) Need to determine Protocols of Communication: According to the interviewed manager, *a successful set of communication protocols avoids violation of authority and reveals the communication interfaces, routing mechanisms (means of communication), and communication schedules so that communication links and point of contacts are clear for all the parties.* He asserted that protocols specified by the communication plan should reveal the following;

Routing protocols should specify the availability of information for all parties, teams, and actors. According to the project manager; *"it is not possible to make everyone aware of everything. Those definitions are vitally necessary to prevent information overload"* The question to be answered is "who will be informed about the information?"

Interfaces and Point of contacts; the question to be answered is "which parties, teams or actors will communicate with each other?" Defining interfaces and point of contacts prevents the chaos in communication, and saves time.

Routing mechanisms (means of communication); the question to be answered is "what are the tools to handle communication in different situations and how will we utilize them?" Defining routing mechanisms prevents confusion of employees in selecting appropriate tools and saves time.

Response time of communication; the question to be answered is "what will be the expected (allowed) response time of a communication request?" Project manager explained the need as; *"To catch up the calendar and project plan in distributed settings, people should be certain about the time of the response they will receive. In any case of delay, they should be informed about the progress and new duration."*

Communication schedules; the question to be answered is "what will be the regular scheduling of communication and schedules of regular meetings?".

IX) Need to eliminate ineffective meetings: AYESAŞ and the partner company held most of their communication with regular teleconference meetings. The project manager emphasized that those regular meetings were very ineffective and time consuming, because they did not have any focus, team leader and agenda. He explained that,

> *Team leaders or project managers had multiple works at several projects, so that, majority of their time were used up with meetings. Especially in such big projects, people meet more than they work. Due to lack of any meeting structure, parties held inner-group discussions during the meetings. Then, we started to hold our meetings in web environment and mutually proposed our presentations. The approach introduced much more structured and effective meetings.*

4.2.3. Lessons Learned on Coordination

I) Need to enhance parallel work: The tasks of collaborative parties were highly dependent and sequential, but at the same time, parallel work was compulsory to accelerate work, catch up with the schedule, and prevent idle time. Project manager explained their experience as;

> *When we received requirement document from other party, we passed on design, implementation or testing phases according to given requirements. However, frequently, the collaborative party changed the requirements while we are working on them. If we were not informed about the change, which was frequently encountered, we finished all our work according to pre-sent requirement set. If we were informed about the changes, rework is relatively diminished; however then, we stopped working and wait for the new coming requirements.*

II) Need for reasonable division of tasks: According to the interviewed manager, meaningful division of tasks is essential to prevent delays in the progress of work and provide the effectiveness of coordination. He explained the reasons as;

> *Tasks should be divided with the goal of creating minimum interfaces in between geographically separated parties and preventing sequential work as far as possible. If work plan expects requirement document from one partner, and the design, coding, and testing documents from others, that results in loss of time and work force. Delays and shift of work in one party should not cause dramatic delays in others work. Dependencies should be determined and interfaces between partners should be managed from the beginning. Project management is not solely enough to provide effective coordination, but we also do need a good activity or task plan and well defined work break down structure.*

III) Need to eliminate ineffective communication: Ineffective communication directly affected the issues of coordination, especially coordination of sequential work, and introduced rework. Project manager stated that; *"Communication plan should also help to manage informal communications for better coordination practices, and include protocols to handle changes in the processes."*

4.2.4. Successful Practices of the Case

The project did not catch up the calendar at the end of the first year, and considered unsuccessful. After the termination of the year, major changes have been executed in the processes. Three new executives have been introduced to be responsible of communication activities. The executives brought major changes to communication practices, such as reconfiguration in regular meetings and utilization of tool support. As a result, the project terminated successfully with an acceptable delay.

Enhancement of collaboration with tool support: The collaborative party in USA had a virtual private network (VPN) to support collaborative work, but the tool was not available to AYESAŞ side during the first year. Afterwards, VPN was introduced to project managers of AYESAŞ to enhance collaboration. The major facilities of the tool were to:

- Store the definition of roles, responsibilities and actors, and view the match between those definitions and actors.
- Store documents systematically.
- Route documents and work products to related pre-defined actors.
- Require comments from actors for documents in the system.
- Inform related actors about the progress (newly added documents, feedback request, schedules etc.).
- Set meeting time by collecting the programs of individuals and optimizing their available meeting hours.

The tool was actively used, and it facilitated the needs of co-work, organized the entire work traffic, and prevented information overload. The most critical success factor in utilization of the tool was its adaptation to the processes of organizations.

The project manager suggested the following about the tool support:

> *The tool should support e-management with its provided facilities. Moreover, the collaboration tool should have intelligent properties, such as decision making capabilities and classification facility. E-management is not storing all work products in a commonly available area, but coordinating the work processes intelligently.*

He also pointed out that the considerations of using the tool;

> *The administration of the tool may be very difficult and time consuming, and cause disorganizations if held by several actors. There may be actors assigned for the overall administration of the tool. However, tool administrator should not be only the submitter of work products, rather; he should understand both the technical and managerial issues and be a decision maker who is aware of all the processes of collaboration.*

4.3. Case 3: RtB – SBS

In this section, data analysis and discussions of the findings of the third case will be presented.

4.3.1. Major Issues of the Case

I) Time Differences: Global development brought differences in work hours and schedules. The project manager expressed that;

> *We coped with six hour time difference during the development, and tried to catch the calendar by proceeding in front of the project plan. Parties should be aware of possible scheduling problems, and take precautions on the master plan.*

II) National, Cultural, and Linguistic Differences: Because the projects developed were highly knowledge based which required development of courseware content for a different curriculum, nation and culture, with an

unknown language, the problems were severe and managing the multicultural project teams were very difficult. In addition to content related problems, it was difficult to provide familiarization, establish a project culture, and develop shared mental models. The critical issues are explained below:

National differences: Differences in nationalities brought different schedules of work hours, different style and rhythm of work and holidays. However, for that case, apart from the other examples of global development, the projects were directly related to legal and political sector: The customer was the Ministry of Education of Malaysia; hence, the courseware was developed based on their educational policies and curriculum maps. For example, the policy which declares inclusion of moral values in teaching should have taken into consideration during the development.

Cultural differences: To be aware about the differences in culture, traditions and conventions enhanced the motivation, work culture, and communication in the second phase of the project. Project manager explained;

> *Working with American, Chinese, or Malaysian were totally different experiences since they all have different characteristics, work styles, communication patterns and work discipline. For instance, Americans who do not accept gray tones, and insist on black and white. However eastern people prefer grays; behave emotional, like affiliation, and communication. Unfortunately, we could realize who we were working with only after the first year.*

Even though the content of the courseware which includes mathematics and science courses for second and third grade students; that are the universal truths, presentation of knowledge was difficult due to cultural differences. The content leader explained with examples;

> *We did not know that girls showing tongue is very shameful in Malaysia; we had to alter all the related pictures from the science courses. Another experience was with negative even numbers, they did not accept the negative numbers as even, we had to change all related narratives.*

Use of Language: Use of language was problematic since the knowledge based projects required frequent communication and feedback but the partners could not use their native languages and could not settle a common language of work until the end of the first year. The content leader explained their experience;

> *Communicating over formal documents was impossible, and we tried storyboarding. However it was not successful since they only represented the common language of our side. Most of the time, we have been misinterpreted. It was only at the later phases that we could develop an informal common language based on text scripts.*

III) Developing shared mental models: Shared mental models were defined as implicit mechanisms, particularly as a type of team knowledge that members have in common about tasks and each other. Having familiarity with the customer, partner and tasks was very critical in Malaysia projects due to highly knowledge demanding nature of the projects. The executives declared that due to the lack of shared mental models, they suffered from *revealing the implicit information in communication* and *adapting to the work styles* of partners. They explained the experience as;

> *Missing the mimics, expressions, and voice tone of communication engendered missing the priorities and focus of the projects. Considering the problem, we avoided result focused work, but tried to focus to the overall picture and understand the real meanings of partners until we established a project culture. In addition, adapting to the work style of our partner was tough for our site, since they were always stressful and panic about the deadlines. Only after the first year, they started to trust our punctuality. Furthermore, we believed that the way they communicated with us was very rude, since we do not have any information about them, but after sometime we understood that the problem was not directly related with us, and get used to that.*

IV) Issues of team work: Content leader explained that they have greatly suffered from ineffective teamwork during the first phase of the project. Employees were unmotivated, unhappy with long working hours, dissatisfied with the progress of work, and even they experienced health problems such as high blood pressure and noise bleeding, caused by the stress of work. She also expressed that only after the parties established the team culture, and assured shared mental models and common language of work; they could obtain satisfying results.

V) Trust issues: The interviewees explained that the fundamental reason behind the trust problems was the lack a system to follow up work progress of geographically separated parties. According to them, to establish trust, firstly, important documents such as project plan, activity based progress plan, agenda and logs of meetings should be available for all parties. The content leader explained the experience; *"Even when we worked days and nights long, the*

customer and the partners were always worried about our progress since they could not observe us, and view the work performed before the submission."

VI) Definition of roles and responsibilities: The project manager explained that in the second phase of the project, parties did neither substantially change the development methodology nor the technology support, but strengthen the structure of the collaboration by proposing clear definitions, and as a result, they achieved much more satisfying results. He declared that the lack of definitions directly concerned the effectiveness of communication and coordination activities. In addition, the content leader explained that the lack of definitions resulted in ineffective coordination patterns since it introduced dependencies on specific people and charged extra coordination work load on those people. They explained the negative influences of the lack on communication and coordination activities as;

> *It was impossible and also unnecessary to make everyone aware of everything. Forwarding all the information to their mail boxes does not necessarily mean people will know the information. On the contrary, you contribute to communication traffic, information losses its impact, and important messages become unreadable. For example, we frequently received feedback and change requests by e-mails, however since those requests were not targeted to specific actors but a group of people such as "visual programmers mailing list", no one not took the responsibility of the task. Instructional designers and project managers, who were aware of the content and entire development process, had to take extra work of communication and coordination management. The experience showed us that, in a distributed software development setting, people should choose the target and targeted message very carefully. To know "what to forward to whom", we should first be aware of the roles, responsibilities, tasks, and the links between them.*

The project manager explained how they resolved their problems in the second year;

> *We resolved almost all our major communication problems with concept maps, which proposed the definitions, and actors and tasks assigned on those definitions, communication links, and flows of information. People were informed about roles and responsibilities of the teams and actors whom they need to communicate from the geographically separated party. We eliminated questions we frequently encountered, such as; "Who is the responsible of that task?", "Who will I target my question?", "Whom I need to contact with to resolve my problem?" Consequently, we could be able to prevent information overload and dependencies on specific people, distribute communication, coordination and decision making activities on several actors, and enhance management of knowledge.*

VII) Need for a comprehensive tool support: The parties utilized primitive tools, such as e-mail, telephone, instant messaging, file transfer protocol, rather than a comprehensive ICT tool. Even though primitive tools seemed simple to use since they did not require an orientation time at the beginning, the content leader declared that, in the long run, they were much more time consuming. The problems were listed and explained below:

Lacking interfaces of communication: The executives of collaborative parties were the only interfaces for communication, a situation which introduced communication and coordination problems, caused dependencies on specific people, slowed down the progress of work, and hindered parallel work flow. The content leader expressed that; *"Not people, but a system should represent the overall interfaces of communication."*

Storing data and deployment of information: Primitive tools prevented storing and achieving logs of communication in a publicly available area. Unavailable data caused communication traffic, since the same questions have frequently been asked by different people, and caused data loss and re-work, since the work was interrupted by older information logs. Moreover, the utilization of primitive tools without any conventions, such as naming the subject of e-mail messages randomly, caused problems in classifying and organizing the messages. Individual attempts to have a systematic achieve were insignificant due to the lack of common protocols.

Versioning: Because of the lack of any common work area, the terminated work products were not available in a public place. Forwarding them with primitive tools, such as e-mail or file transfer protocol, without any versioning conventions exposed confusions on the last versions of the work products, besides, contributed to communication traffic, time and data loss, and rework.

Security: Logs of communication be stored in individual computers rather than a public place, caused security problems. Several communication logs were lost due to crashes of individual computers.

4.3.2. Lessons Learned on Communication

I) Need for a communication plan: The interviewees declared that they did not have a formal communication plan, but held all the communication activities with ad-hoc processes. However, difficulties in accessing to the geographically separated customer, delayed feedbacks, and disorganized meeting schedules introduced the need for a comprehensive communication plan. Still, the interviewees underlined the difficulties in proposing a structured communication plan as;

> *We could not establish a strong organizational structure for the collaboration in the beginning. The roles and engagements of parties and the customer were not clearly determined. As the result of being confused with fuzzy definitions and the ambiguity of the initiation phase, we could not compose and utilize any structured communication plan.*

II) Need for a communication team or leader: The interviewees emphasized the need for a communication leader or a team dedicated for communication activities for the success of development. The content leader explained their experience as;

> *People who were aware of the content and the overall processes, such as content leaders, instructional designers, or project managers unintentionally undertook non-specified communication work load. We frequently got lost in huge communication traffic, and the situation definitely hindered our creativity and the success of management.*

III) Need to compose a common language of work: The knowledge based projects required frequent feedback and collective decisions of parties. To provide frequent communication, the partner in Malaysia demanded the storyboards and text scripts of work products from RtB. Though, the content leader asserted that communicating over formal documents was problematical before establishing the common language of work. She explained that;

> *The customer and the partner who were geographically separated could not visualize the end products by storyboards, since they included all the implicit knowledge of our organization such as the common language and culture of work. For instance, they usually decided to alter the first drafts, but then, when they saw the end product, they generally demanded what we had proposed in the first draft.*

4.3.3. Lessons Learned on Coordination

I) Need to coordinate sequential and dependent work: Because the work was highly dependent on the feedback of the partner and the customer in Malaysia, lack of timely feedback from them frequently caused time loss and rework. On the contrary, RtB and SBS sites could execute the parallel work, even though the tasks were also dependent to each other, because they shared the tasks of different phases, and provided stronger communication in between related teams. Based on their experience the content leader pointed out a concern about the issue:

> *Especially for the projects which demands high level of customer feedback, the contact should also be arranged to protect rights of the developer side. Tough, our contract only stated that RtB would pay a fine for each late day of submission; however most of the time, the reason of delays were lately coming feedbacks from the customer and executive in Malaysia.*

II) Need for secure common work place to store and achieve work products: One of the major problems was the lack of a common area to store and archive the work products and to make them available to all parties. FTP was the only tool for submitting and storing the work products, however doing so caused many problems. The content leader explained their problems as;

> *During the development, five teams of our site sent completed products to the partner and customer by ftp for testing and feedback. The sequence was naturally missed, even sometimes some of the products got lost, or forgotten to be tested. There were times we were accused by not completing the work; however the reason was the executive could not find what he searched for. We were mailing, phoning, or messaging to make parties aware of the submission, however the situation definitely caused huge communication traffic. In addition, since I knew the entire development process and the content, I answered any question caused by any problem of any completed or uncompleted task. However following all people's work meant too much effort and time loss for me. The customer or the executive could have directly communicated with the responsible of the work if he could view the progress and the submitter from a common work area. Lastly, the lack of the common are caused major trust problems, since our partners could not view our progress, and were always panic and skeptic about the progress.*

III) Need for a versioning system: Because the parties did not utilize a versioning system, not only the geographically separated parties but also RtB or SBS sites sometimes confused the latest versions of products. Moreover, teams

generally forgot to inform the geographically separated parties about the changed work products because of the lack of an automated system and work stress caused by the need to catch up the calendar. However, apart from rework and time loss, the confusions also introduced greater problems, such as loss of trust and motivation.

4.3.4. Lessons Learned on Collaboration

I) Need to reveal the relations of collaborative parties: The project manager asserted that roles, responsibilities, and engagements of all collaborative parties, and the links and relations in between should clearly be revealed, and explained;

> *There are always implicit mechanisms to coordinate the relations of partners, such as commercial relations or managerial considerations. To minimize later conflicts, major roles, responsibilities, and relation sets of parties should clearly be revealed. We have to clear our minds from the questions: Which parties play technical, organizational, administrative, or commercial?*

II) Need to support full collaboration: According to the project manager, having a partner does not assure the collaboration or successful teamwork. Parties turn into cooperative teams only when they start to feel they will together be the actors of success or reasons of failure. Trust and effective teamwork are major facilitators of full collaboration.

III) Need for iterative approaches: One of the success factors of the second project was the shift to iterative development, and consequently, receiving more frequent customer feedback. Both the project manager and content leader emphasized the significance of iterative approaches in distributed development, especially for their case, to prevent misunderstandings and re-work:

> *In distributed setting, proposing end solutions, decisions or products alone was not sufficient to include partners into process, rather we had to propose the rationales, provide a common ground for discussions, and help them understand the process and visualize the releases. This could only be possible with stronger communication interfaces and iterative approaches.*

4.3.5. Successful Practices of the Case

I) Meeting when necessary: The interviewees stated that they did not arrange regular meetings, but met only when it was necessarily needed. They expressed the rationale as;

> *Including the separated parties in every meeting, and giving them the right to interfere our inner work caused great deal of time loss. On the contrary, before the meetings, all parties should have solved their inner problems, and be decisive on the issues. Therefore, we sent the results of our inner meetings to the other parties with asynchronous means of communication, and they sent us their comments. The approach was functioned very successfully for our case.*

4.4. Data Summary and Findings

In the following subsections, findings of the cases will be aggregated, summarized and presented in tables according to the research questions of the study.

4.4.1. Major Issues of the Cases

Major issues of the cases are presented in Table 7:

Table 7 Major Issues of the Cases

MAJOR ISSUES	Causes	Effects	Results and Recommendations
Time Differences	Geographical distance of parties and teams in collaboration	Not to be able to receive feedback to emergent questions	Delays in the progress of work, breakdowns in the project plan, extension of work hours *Recommendations: Be aware of the time differences between partners, be aware of working hours of partners and possible extensions, consider buffers in the project plan for emergencies, plan to collect and ask all the questions at the end of the day to be able to receive all the answers the next early in the next day*
National, Cultural, and Linguistic Differences	Differences in nationalities, native languages, cultures, work styles, use of language, perceived meaning differences in written communication	Difficulties in developing a project culture and shared mental models, ineffective communication	Delays in the progress of work, breakdowns in the project plan, extension of work hours, trust problems *Recommendations: Be aware of the nationality, culture, traditions and considerations of the collaborative parties*
Issues of teamwork	Lack of a common goal and diverse work focus of collaborative teams, lack of a settled team culture, shared mental models and common language of work, ineffective communication and coordination patterns	Lack of motivation and discipline, and unbalanced work load of teams, unhappy, dissatisfied, and stressful employees	Delays in the progress of work and submissions, extension of work hours *Recommendations: Feature the initialization phase of the project, try to develop shared mental models between collaborative teams, enhance synchronous communication between collaborative teams to make them know each other and build trust*

Table 7 (continued)

MAJOR ISSUES	Causes	Effects	Results and Recommendations
Work Harmony	Differences in the rate of progresses of collaborative parties, differences in working styles and traditions	Insufficient coordination of tasks, insufficient collaboration between collaborative parties and teams	Extension of work hours, unbalanced work load of parties, trust problems *Recommendations: See Issues of teamwork*
Developing shared mental models	Differences in nationalities, cultures, traditions and native languages	Difficulties in revealing implicit knowledge in communication and work products, difficulties in adaptation to work styles	Ineffective communication, coordination and collaboration of teams, problems in team work and work harmony *Recommendations: See Issues of teamwork*
Trust issues	Differences in nationalities, governmental considerations, the characteristics of the developed project; such as security demanding military projects	Content related trust problems	Trust crisis *Recommendations: Considering the needs of project, include terms in the master plan to clarify the share of information and documents between collaborative parties. Provide a publicly available project plan and activity based plan for all parties to reveal the work progress, accomplished activities and tasks*
		Problems in exporting necessary documents	
	Lack of trust to co-workers	Quality related trust problems	
	Fear of job loss	Resistance to work in collaboration	
	Lack of a system to follow up the progress of work of geographically separated site	Worried partners about the progress of work, panic before submissions even when the rate of progress is adequate to catch up with the project plan	
Comprehensive tool support to enhance communication, coordination and collaboration activities of geographically separated parties	Lack of a comprehensive tool which will fit to the organizational processes of parties in collaboration, ineffectiveness of utilizing several different primitive tools without determining any conventions for communication and coordination activities	Lacked communication and coordination interfaces, dependencies on specific people, data and time loss, mass communication traffic, information overload, problems in keeping and organizing the data and make them securely available for all parties.	Dispersed communication, coordination and decision making activities. Ineffective teamwork. *Recommendations:: Avoid using primitive tools without conventions, propose a collective working area which will fit the needs and work processes of organizations*

Table 7 (continued)

MAJOR ISSUES	Causes	Effects	Results and Recommendations
Definitions of roles and responsibilities	Chaos atmosphere of the collaboration during the initialization phase	*Ineffective communication between collaborative parties and teams*: Unclear communication links, difficulties in developing the communication plan, difficulties in determining protocols of communication, information overload, unfair distribution of communication work, unbalanced work load, dependencies on specific people	Problems in management of knowledge, delays in the progress of work, breakdowns in the project plan, extension of work hours *Recommendations: Propose concept maps which will present all necessary concepts, definitions and their relations by considering the roles, responsibilities, engagements and organizational structures of parties in collaboration. Propose the links and information flows on those links of maps. Determine and clearly define the activities and tasks and assign them to the actors of collaboration to enhance coordination activities.*
		Ineffective coordination between collaborative parties and teams: Problems and delays in collective processes of collaborative parties, difficulties in coordinating sequential activities and tasks, problems in coordinating parallel work, unfair distribution of coordination work, unbalanced work load, dependencies on specific people	
	Confusions in roles and commitments of collaborative parties	*Problems in collaborating and acquiring work harmony*	Trust crisis between collaborative parties *Recommendations: Propose clear definitions for roles and engagements of the collaborative parties before agreement.*

4.4.2. Lessons Learned on Communication

Table 8 Lessons Learned on Communication

NEEDS OF COMMUNICATION	CAUSES OF THE NEED	RECOMMENDATIONS
Need for a communication plan	To provide effective communication links and scheduled activities for communication	Propose clear definitions in the initialization phase, establish a strong organizational structure for the collaboration, define the roles, responsibilities and engagements of parties and teams in collaboration, determine protocols of communication, determine schedules and working hours of parties, teams and actors, determine meeting schedules, determine use of ICT support
Need for a communication leader, or a team dedicated to communication activities	To enhance the effectiveness of communication links, to manage mass communication traffic, to avoid rework which is caused by ineffective communication links, to diminish extra communication work load on project managers and team leaders, to organize the data and convert to meaningful information for other team members and for further use, to arrange scheduled activities for communication, to work on the effectiveness of meetings such as determining the scope, determining the necessity to meet, to lead the meetings	Provide a initiative communication leader to coordinate events and flows of communication, or provide a team dedicated to communication activities

Table 8 (continued)

NEEDS OF COMMUNICATION	CAUSES OF THE NEED	RECOMMENDATIONS
Need to determine protocols of communication	To propose available communication links between teams and actors, to provide communication channels, contact points and allowed response time for different types of communication channels and information requests, to organize the data and convert them to meaningful information for other team members and for further use, to avoid violation of authority by determining the contact points	Reveal routing protocols, communication interfaces, point of contacts, routing mechanisms, response time of communication, communication schedules communication channels, and make them available to all collaborative parties. Propose strategies and activities for data keeping of logs of communication and knowledge management.
Need to compose a common language of work	To provide effective communication, coordination and collaboration activities, to prevent misunderstandings	Reveal and share implicit knowledge of organizations, support shared mental models, develop a collective language based on diagrams such as storyboards
Need to determine utilization of ICT support	To provide effective communication links, to determine routing protocols and mechanisms, to enhance communication interfaces, decision making facilities and coordination activities, to prevent time and data loss caused by using several primitive tools	Determine the tools to be utilized at specified situations, specify the protocols of utilizing different tools
Need to eliminate ineffective meetings	To enhance effectiveness of meetings, to prevent time loss	Determine focus and agenda of the meetings, and assign a leader to coordinate and lead the meetings. Do not meet regularly but only when needed
Need to enhance synchronous communication*	To enhance interactivity among team members, to prevent confusions and delays of asynchronous communication, to establish team culture and support team harmony	Settle the available hours of team members, decide on the tools to be used for synchronous communication and make them available for team members

* The finding was the one of the major needs of the first case; however the second and third cases revealed just the opposite. The distinctions will be discussed under the subsection of 4.5.2; Discussions of distinctive findings.

4.4.3. Lessons Learned on Coordination

Table 9 Lessons Learned on Coordination

NEEDS OF COORDINATION	CAUSES	RECOMMENDATIONS
Need to enhance parallel work	To prevent single line processing, unbalanced work load, idle time of teams and actors, and late submissions, to accelerate work, to catch up the schedule	Provide effective communication links and clear division of tasks, reserve sufficient time to analysis and planning phases
Need to coordinate sequential (dependent) work	Need for prerequisite work products, such as requirements document, or the feedback of the partner on end products to continue to the next phases, such as implementation or testing, to prevent time loss and re-work	Provide effective communication links, carefully plan the division and share of tasks to geographically separated parties, and provide minimum interfaces in between for sequential work, make the divisions minor enough to provide balanced work load but also major enough to be able to coordinate the tasks
Need to provide feasible division of tasks	To prevent delays in the progress of work, to provide minimum interfaces between geographically separated partners in sequential work, to avoid single line processing, centralized work, unbalanced work load, and idle time of teams and actors	Determine dependencies of processes and work products, determine all the communication and coordination interfaces between geographically separated partners, and interfaces, minimize the interfaces between geographically separated parties, provide activity based management, eliminate communication obstacles, reserve sufficient time for analysis and planning phases
Need to provide balanced work load	To enhance parallel work, to prevent centralized work, to enhance motivation and teamwork	Provide reasonable division of tasks, eliminate coordination obstacles
Need to enhance inner group communication *	To provide effective coordination, to avoid centralized work, to coordinate sequential work	Propose relations of actors and tasks considering scheduling of events
Need to eliminate ineffective communication	To coordinate sequential work, and to prevent rework.	Manage informal communications, handle changes in the processes

Table 9 (continued)

NEEDS OF COORDINATION	CAUSES	RECOMMENDATIONS
Need for secure common work place to store and achieve work products	To prevent difficulties to handle disorganized work products, to prevent communication traffic, to prevent panic and stress	Provide a common work place to store and achieve work products
Need for a versioning system	To view the latest versions of work products, to handle change requests, to prevent re-work, to prevent trust crisis	Provide a versioning system

4.4.4. Lessons Learned on Collaboration

Table 10 Lessons Learned on Collaboration

NEEDS COLLABORATION	CAUSES	RECOMMENDATIONS
Need to support full collaboration	To succeed in teamwork	Provide trust and support effective teamwork
Need to agree on a common goal	To prevent distinct work focus of team members, to establish full collaboration, to provide harmony and motivation of the teams	Propose a common goal and make all team members agree on it
Need to enhance trust between collaborative parties	To enhance teamwork	Clearly propose the roles, responsibilities and engagements of parties
Need to enhance group decision making	To provide the effectiveness of collaborative work	Support inner group discussions, make people have responsibilities on the decisions
Need to reveal the relations of collaborative parties	To understand the rules of collaboration	Reveal roles and responsibilities, engagements and relations of collaborative parties
Need for iterative approaches	To provide more frequent feedback, to prevent misunderstandings and re-work	Provide stronger communication interfaces

4.5. Discussions

In the following sections, first, lessons learned from all three cases will be presented as the major findings of the overall study, and then, the distinctive and opposite findings of the study will be discussed according to the unique characteristics and considerations of the cases.

4.5.1. Major Lessons Learned

The study revealed common findings in all three cases, almost all of which can be found in GSD literature. The problems of ineffective communication, effects of unclear definitions of roles and responsibilities, issues of teamwork, need for a comprehensive tool support, and needs of concurrent processing are explained in many other articles (Carmel and Agarwal (2001), Chidambaram (1996), Cohen and Bailey (1997), Ebert and Neve (2001), Herbsleb and Grinter (1999), Herbsleb and Moitra (2001), Mockus and Weiss (2001), Powell, Piccoli and Ives (2004)). Parallel to this study, Çağıltay, Bichelmeyer, Evans, Paulus, and An (2005) especially focuses on the issues of culture and collaboration, multicultural virtual teams, motivation, user-interface design and communication.

The significant points will be presented below:

Finding 1

All the three cases pointed out that establishing strong communication infrastructure is the key success factor in both distributed and global software development settings. The first case, as a typical example of distributed software development with five virtual teams investigated, and the second and third cases, as typical examples of global software development, with collaborative partners around the world showed that ineffective communication in such development setting contributed to many other vital issues, even it may alone be the reason to fail.

The *major results of ineffective communication* are listed as follows:

- Issues of team work, work harmony and team culture. Insufficient interactivity among team members, insufficient group decision making, insufficient knowledge about the processes and work products of other teams and parties, undeveloped shared mental models.
- Difficulty in keeping and archiving the data, and making them available for further use for other parties and actors. Problems in knowledge management.
- Confusions about the interfaces of communication, violation of authority, formation of mass communication traffic and information overload.
- Extra communication work load and dependencies on specific people.
- Problems in following the progress of the other teams and parties.
- Coordination problems, rework, single line processing, unbalanced work load.
- Unscheduled activities for communication, ineffective meetings, time loss.
- Problems in the collaboration, trust issues.

The major issue emphasized in all the three cases was the significance of developing and utilizing a *communication plan* which will reveal *1) routing protocols, 2) interfaces and point of contacts, 3) routing mechanisms, 4) response time of different communication requests, 4) communication schedules*. Besides the communication plan, the need for *a communication leader or a team* is significantly underlined as one of the major success factor in all three cases. Even for the first case, when there were neither organizational structures nor any collaboration infrastructure but only the virtual teams, the need for a leader who will coordinate all the communication activities is highly emphasized.

Finding 2

The second major issue stressed in all three cases was the vital need for *clear definitions of roles and responsibilities*. The chaos experienced during the initialization phases hindered proposing clear definitions in all three cases. As a consequence, the lack revealed that clear definitions are directly related with establishing effective communication, coordination, and collaboration patterns in

distributed and global software development. Lack of definitions introduced 1) several *communication problems*; unclear communication links, difficulties in developing the communication plan, difficulties in determining protocols of communication, information overload, unfair distribution of communication work, unbalanced work load, dependencies on specific people, 2) several *coordination problems*; problems and delays in collective processes of collaborative parties, difficulties in coordinating sequential activities and tasks, problems in coordinating parallel work, unfair distribution of coordination work, unbalanced work load, dependencies on specific people, and 3) *collaboration problems*; proving the harmony of collaboration and trust crisis.

Finding 3

The other important finding of the study was the significance of *teamwork* in a distributed development setting. Issues of teamwork are also important in any software development setting; however, according to the experiences of cases of study, the issues are vital in a distributed setting. Even though there were no national, cultural and linguistic differences faced by the members of the virtual teams in the first case, the problems of teamwork was severe. However, in the second and third cases, the problems resulted in dramatic extensions in work hours, motivation problems, and even severe health problems of employees such as stress, blood pressure and noise bleeding. Both of the cases revealed that they could only get over the problems at the end of the first year, only after they knew the partners, their characteristics, considerations, work styles etc. In this light, organizations that attempt to develop software globally have to take precautions to support team work. The major precautions to provide effective team work have been listed below:

- Define the common goal of the collaboration and provide a work focus for all the parties.
- Be aware of the partners in collaboration, such as their nationalities, culture, characteristics, life and work styles, available working hours etc.

- Eliminate the chaos of the initialization phase and strengthen the organizational infrastructure of collaboration by clearly defining roles, responsibilities and engagement of parties in collaboration.
- Reserve necessary time for the initialization phase. Spend required time with team formation activities and provide harmony of teams.
- Provide effective communication patterns between teams in collaboration.
- Provide necessary tools to develop a common language of work such as storyboards.

Finding 4

The cases revealed that utilization of a *comprehensive tool support* would be a significant facilitator in any distributed software development setting. In the first case, even if there was a support tool, teams pointed out that the tool lacked many facilities that they needed, and therefore they could not fully benefit from the tool. Even, after some time, they abandoned using the tool. The third case also had the same experience; they implemented a tool considering only 'some' of their needs, however they could not include it to their development processes. Based on the experiences, it underlined that a tool should have the following characteristics at first sight to be utilized and deployed in a distributed development setting:

- *Need for a comprehensive tool:* The tool should include all the needs of collaborative parties and teams, if not; people refuse to it, and refer to other primitive tools to satisfy their needs.
- *Cohesion of the tool with development processes of the collaboration:* There is no definite solution for the selection of the tool. Even a very comprehensive tool may not be adapted to some organizational processes and be unsuccessful.
- *Need to fix the organizational infrastructure of the collaboration before the tool selection:* The tool should adapt to the organizational processes; trial of the processes to be adapted to the progress of the tool will definitely conclude with failure. Hence, *1)* The organizational structures of the collaborative parties and the organizational infrastructure of the collaboration, 2) Roles,

responsibilities and engagements of the collaborative parties, 3) Development methodology and processes should be considered before selecting the support tool.

- *Need to reserve time for adaptation:* The tool should be selected and deployed in early phases of the project to reserve adaptation time for all collaborative parties. The reserved time will also be important to strengthen the team culture.
- *Training:* Collaborative parties and teams should be trained about the usage of the tool, and besides, the favors of using the system should be explained.

According to the needs and issues of all three cases, the study showed that the tool utilized in a distributed software development setting should be a comprehensive online system solution which is able to adapt to the development processes and organizational infrastructures of collaborative organizations. The tool should mainly provide facilities to support communication, planning, decision making, storing and achieving, and coordination activities between geographically separated collaborative parties. The facilities expected from the support tool have been collected from the necessities of cases, and unified and summarized below:

Expected communication facilities:

- The tool should provide a communication interface between collaborative partners and prevent dependencies on people for communication.
- It should prevent mass communication traffic by preventing the forward of data to all actors. Only the necessary information should be forwarded to the required targets; such as actors, teams or parties who really needs the information. Hence, the tool should include all the communication links and ensure the flow of the data performed only on those predetermined links.
- The tool should enhance synchronous communication for small sized virtual teams of geographically separated parties to eliminate the negative effects of unavailability of face-to-face discussions and support teamwork.
- The tool should include communication mechanisms (the means of communication). The availability of all the necessary primitive tools in a unique common area will help to store, organize and achieve all logs of communication, make them available for all relevant actors, exclude the messages from other

personal communication, prevent data and time loss, and enhance management of knowledge.

- The tool should include a follow up mechanism for the responses to the communication requests. The tool should remind allowed response time to requested actors and demand the answers in a specific time interval. It might also inform other related actors, such as upper level management or communication team about the delays. The facility would support coordination of activities and rate of progress, and help to prevent existence of idle time and rework.
- It should collect the available meeting times of parties, teams or actors and determine tentative schedules for communication.
- The tool should also include a communication interface with the geographically separated customer to present end products and require feedback and comments on them.

Expected storing and achieving facilities:

- The tool should constitute the collective working area and information sharing system designed according to the needs of geographically separated parties. It should provide storage and organization of data for achieving and further use.
- It should include a versioning system to make the end products available for geographically separated customers and partners in collaboration. Availability of end products will enhance coordination activities, and visibility of the progress will enhance trust between geographically separated sites.

Expected planning and decision making facilities:

- The tool should critically enhance the initialization and planning phase of development by providing effective communication patterns and electronic group decision making facilities. The tool should prevent mass communication and information overload during the decision making, as opposite to what primitive tools does, keep the records of the results of the discussions and make the final decisions available to all relevant actors.
- The tool should keep necessary definitions such as roles and engagements of parties, responsibilities of actors for effective initialization an planning phases.

Expected coordination facilities:

- The tool should provide different interfaces for the parties, teams and actors having different roles, engagements and responsibilities in collaboration. Actors should only view the work products which are relevant to their responsibilities. Accordingly, the tool should include access rights and modification restrictions on work products.

Expected teamwork facilities:

- The tool should constitute an electronic common work place and it should eliminate the geographical distance by supporting the development of common language of work. It should provide all the necessary terminology, and facilities such as storyboarding and concept maps.
- The tool should view the progress of development to all parties and customer and consequently, enhance trust between parties in collaboration.
- The tool should enhance the harmony of work and development of shared mental models by supporting effectiveness of communication and providing synchronous communication facilities between teams in collaboration.

Finding 5

Another finding of the study was related with the establishment and assimilation of a properly defined process of operation, namely; the coordination of sequential and dependent activities and performance of parallel work for the success of distributed software development. The coordination problems caused delays, rework and idle time of teams in all three cases. The study revealed that major success factors in coordinating the events are: 1) Systematic division of tasks between geographically separated parties by carefully considering the flow and sequence of events. 2) Ensuring the possible minimum interfaces by preventing division of phases to several minor tasks and assignment of those sequential and dependent tasks to geographically separated parties. The tasks should be minor enough to provide the fair and balanced work load but at the same time they should be major enough to handle the coordination of sequential events. 3) Developing the project plan by considering the sequence of events, dependent and parallel activities, schedules of actors and their responsibilities, and available

resources. The plans should enhance parallel processing and assure all team members be fully occupied at the same time apart from exceptional situations. 4) Proving a strong communication infrastructure and preventing the delays caused by ineffective communication. 5) Providing a contract which is signed by all parties in collaboration and the customer to protect the rights of all sites about the possible delays. Especially for highly knowledge based projects, which demands high level of customer feedback as it is in the third case, joining the geographically separated customer to the agreement for possible delays should definitely be considered. This point can simply be stated as the definition of a mature process of operation and its assimilation by the organization.

4.5.2. Discussion of Distinctive Findings

The study revealed some distinctive and even opposite findings in each case, and in this section, discussions of those findings will be presented and explained according to the characteristics of the cases. There were two major reasons that generated the distinctive findings; the first reason was the differences in types and organizational structures of collaborations in selected cases, and the second one was the differences in the characteristics of software projects investigated. Distinctive and opposite findings of the cases should be interpreted by considering the major differences of the cases.

1) The first case was selected from an educational setting, therefore it also pointed out some important issues caused by the characteristics of the setting such as time limitation of the educational term, grading factor, difficulty of access to the customer, and issues of quality management.

2) The first case did not include the major issues of global software development, such as national, cultural, linguistic, and time differences. Moreover, the members of the teams were the students of an online course, hence they did not expose to any trust problems. However, even though they did not experience teamwork issues as harsh as the second and third cases, they also suffered from the lack of work harmony, motivation, team culture etc.

3) The issues of collaboration were significant only in the second and the third cases, since they comprised the issues of global development. The cases revealed that in order to discuss about full collaboration, roles, responsibilities and engagements of the parties and the links of relations should clearly be identified. Moreover, issues of trust should be eliminated. However in the first case, there were no organizational structures but only the actors, and besides there were no major factors to cause trust problems such as national and cultural differences. Therefore, the strength of the collaboration mostly depended on the effectiveness of teamwork, motivation of actors and effectiveness of communication and coordination activities.

4) Even though in all three cases the necessity was observed to propose clear definitions for roles and responsibilities, the participants of the second and the third cases emphasized the issue and declared that it was vital to assure effective communication and coordination patterns and to ensure the success of development. The reason behind the emphasis was again the distinction between virtual teams and structured organizations. On the contrary to the structured organizations in collaboration in the second and the third cases, the dynamic virtual teams of the first case could easily adapted to any changes, such as changes in the definitions of roles and responsibilities, the assignments of tasks to actors etc.

5) The virtual teams of the first case asserted the need to enhance inner group communication, synchronous communication, and group decision making, however, both the parties of the second and the third cases argued the opposite. In small sized virtual teams of the first case the inner group dynamics were the core of the development, intense inner group communication was highly required to enhance motivation, teamwork and progress of work, besides mass communication traffic was controllable, and it was possible to inform all group members about all the information or events. However, when the phenomenon is discussed considering the issues and needs of organizational infrastructures, the study revealed different results. First, the consideration in the second and the third cases was not the inner group communication, since the teams were in the same locations, but the communication between geographically separated teams that are in collaboration. Therefore, the coordination of events and communication patterns between those teams were the essence of the

development. In addition, just as the opposite of the first case, the second and the third cases argued that synchronous communication and group decision making caused troubles during the development and retarded the progress of work. Particularly, the third case revealed that intense synchronous communication resulted in time and data loss, mass communication traffic, and problems in management of knowledge. Similarly, the second case revealed that deploying the decision making activities to several geographically separated parties, teams or actors caused a great deal of time loss. The second case suffered from long ineffective teleconferencing meetings in which all the parties discussed the problems of their site but could not agree on a collective decision. On the contrary, in the third case, all the geographically separated parties or teams first agreed on their decisions, and then presented those solutions to the other parties. The discussions of the second and third cases revealed that if organizational structures and the infrastructure of the collaboration are the major considerations, the parties first should be decisive on their problems, and only then present those solutions and discuss on them with other parties for the effectiveness of the development.

6) The participants of the first case stated that they needed to held more synchronous meetings to enhance inner group communication, the participants of the second case stated that they held weekly teleconferencing meetings however they were ineffective and unnecessary, and the participants of the third case declared that they met only it is necessary and the approach was beneficial for the effectiveness for the meetings and prevented time loss. The findings of the cases again could be interpreted by considering the needs of the virtual teams and the organizations in collaboration. Because of the dynamic setting and frequent communication required for the virtual teams, the participants of the study declared they needed to meet more. Nevertheless, when the consideration was the collaboration of several structured organizations, meetings were labeled as ineffective activities and were perceived as time loss. The second and the third cases pointed out that the meetings should only be held for the necessity, to resolve determined agenda topics, but if written communication is sufficient, it should be preferred to save time.

7) Even though all three cases revealed the difficulty of knowledge management in the distributed software development setting, the second and the

third cases greatly emphasized the issue. The problems in virtual teams were possible to handle but they sometimes caused rework, and loss of time and data, however, the problems of the other two cases brought the project to a bend of failure. The cases showed that effective communication and coordination activities for managing knowledge are vital for the success of distributed development which will be held by several organizations in collaboration.

8) One of the findings of the third case was the need for iterative approaches, since the projects investigated were highly knowledge demanding projects which required frequent feedback from the customer. Therefore, frequent communication with the geographically separated customer and iterative approaches for development were required to prevent rework. Additionally, the virtual teams of the first case developed their projects with XP methodology, and declared that the development methodology was suitable for the distributed development setting. In that case, the teams were small sized, and they could handle the frequent communication and dynamic setting of the development. However for the second case, the project investigated was a bigger military project, and they needed more structured development methodologies, and more structured communication and coordination activities rather than a dynamic setting. Based on the discussions of the cases, the study revealed that, it is not possible to consider a unique development methodology in the distributed settings, rather; the development methodology should be determined according to the needs of the projects developed and the needs of the teams and organizations.

In addition to major lessons learned and distinctive findings of the study, the research showed that the maturity of the collaborative parties has a direct impact on success/quality of the collaborative work. At that point, the questions of “Do those findings reflect the general issues of project management or specific issues of distributed operation?” and “Do those findings reflect the problems of the organizational process maturity or problems of distributed operations?” should be asked. Actually, more research work, especially on organizations and projects having effective project management practices and mature development processes is needed to be performed in order to clearly answer those questions. Yet, this study emphasizes that, especially by considering the second case;

AYESAŞ, an organization which has several quality certificates and effective inner management and development processes, even though mature development processes and effective project management practices of each geographically separated party in collaboration are significant for the success of collaborative work, the effective management, communication, and coordination practices of the collaboration is much more important in a distributed setting.

CHAPTER 5

CONCLUSION

5.1. Main Results

This study aimed to reveal major success factors of distributed software development and the effectiveness of virtual teams, as well as the challenges that may surge them to a failure. In this context, a collective case study was held and the virtual teams of an online software development course and two global software development projects from different development settings were investigated. The study did not mention challenges and complexities of providing necessary technologies, infrastructures and collaboration tools in detail, rather it focused on the factors that enable virtual corporations and multinational collaborative organizations to operate successfully across geographic and cultural boundaries. Accordingly, the study focused on the most critical issues of distributed and global software development stated in the literature: the challenges of communication, coordination and collaboration practices.

First of all, the study revealed that there is a marked commonality in experiences, issues, needs and the approaches worked in all the cases investigated. Besides, those commonalities showed great similarities with the statements of literature. Independent from the development setting, those factors should critically be kept in mind before initiating the virtual development. No matter what the setting is,

both the effectiveness of communication and coordination practices should be ensured by necessary infrastructures. Only after deeply analyzing the case and revealing the basic needs of the virtual collaboration, any technologies to support the distributed work, such as; architecture designs, web technologies, collaboration tools and multimedia should be defined and provided.

The commonalities revealed in all three cases are presented with tables in section 4.4: 'Data Summary and Findings' and explained in detail in section 4.5.1: 'Major Lessons Learned'. The findings will very briefly be reviewed below:

1. Establishing *strong communication infrastructure*: Strong communication patterns were underlined as the major success factor by all cases of the study. The significance of a comprehensive communication plan was highly emphasized. Besides the communication plan, the need for *a communication leader or a team* is significantly underlined as one of the major success factor. According the findings, the communication plan should reveal:

- *Routing protocols*
- *Interfaces and point of contacts*
- *Routing mechanisms*
- *Response time of different communication requests*
- *Communication schedules*

The *major results of ineffective communication* are listed as:

- Issues of team work, problems in work harmony and team culture, insufficient interactivity among team members, insufficient group decision making, insufficient knowledge about the processes and work products of other teams and parties, undeveloped shared mental models
- Difficulty in keeping and archiving the data, and making them available for further use for other parties and actors, problems in knowledge management
- Confusions about the interfaces of communication, violation of authority, mass communication traffic and information overload
- Extra communication work load and dependencies on specific people
- Problems in following the progress of the other teams and parties

- Coordination problems, rework, unbalanced work load,
- Unscheduled activities for communication, ineffective meetings
- Problems in collaboration, trust issues

2. Ensuring *clear definitions of roles and responsibilities*: Lack of clear definitions introduced several problems:
   - *Communication problems*: Unclear communication links, difficulties in developing the communication plan, difficulties in determining protocols of communication, information overload, unfair distribution of communication work, unbalanced work load, dependencies on specific people
   - C*oordination problems*: Problems and delays in collective processes of collaborative parties, difficulties in coordinating sequential activities and tasks, problems in coordinating parallel work, unfair distribution of coordination work, unbalanced work load, dependencies on specific people
   - C*ollaboration problems*: proving the harmony of collaboration and trust crisis

3. Significance of *teamwork*: Several practices have been discussed to provide effective team work:
   - Define the common goal of the collaboration and provide a work focus
   - Be aware of the partners in collaboration, such as their nationalities, culture, characteristics, life and work styles, available working hours etc.
   - Eliminate the chaos of the initialization phase and strengthen the organizational infrastructure of collaboration by clearly defining roles, responsibilities and engagement of parties in collaboration
   - Reserve necessary time for the initialization phase. Spend required time with team formation activities and provide harmony of teams
   - Provide effective communication patterns
   - Provide necessary tools to develop a common language of work

4. Utilization of a *comprehensive tool support*: A comprehensive web-based system which is able to adapt to the development processes and organizational infrastructures of collaborative organizations, and which will provide facilities to support communication, planning, decision making, storing and achieving, and

coordination activities should be provided. The tool should firstly include the following characteristics:

- Comprehensive
- Cohesive with the development processes of the collaboration
- Fix to the organizational infrastructure of the collaboration.

Besides, collaborative parties and teams should be trained about the usage of the tool, and the favors of using the system should be explained before the deployment of the tool, and then necessary time should be reserved as the adaptation time for the tool. Facilities expected from the tool are listed in section 4.5.1.

5. Establishment and assimilation of a *properly defined process of operation*: Coordination of sequential and dependent activities and performance of parallel work were highly emphasized for the success of distributed software development. The coordination problems caused delays, rework and idle time of teams in all cases. Major success factors are listed as:

- Systematic division of tasks by considering the flow of events
- Proving the possible minimum interfaces between geographically separated parties
- Developing the project plan by considering the sequence of events, dependent and parallel activities, schedules of actors and their responsibilities, and available resources
- Proving a strong communication infrastructure and preventing the delays caused by ineffective communication
- Providing a contract which is signed by all parties in collaboration and the customer to protect the rights of all sites about the possible delays

Apart from the common findings, the study also concluded with another result, which was not clearly mentioned in the literature. The result was about the needs of different types of teams and organizational infrastructures in collaboration and the effects of the differences on the results of the research. With respect to the type of the team, research to date has mostly focused on new product, business development, and customer service teams, but the nature of the team project and

its interaction with other team design variables has not been addressed by previous research (Powell, et al., 2004). In contrast, this study tried to reveal the interactions between the nature of projects and types of teams design variables, and the effects of those relations on the findings of the study. The existence of distinctive and even opposite findings showed that, there are no certain truths in any global software development environment, but there may only considerations for any unique case which should be taken into account during the development.

The discussion of distinctive findings is held in section 4.5.2. The very significant ones were:

1. Teams did not expose dramatic trust problems when the development setting did not include the features of global software development; namely, when they did not have national, cultural, linguistic, and time differences. However, even though they did not experience teamwork issues as harsh as they did in global development context, they also suffered from the lack of work harmony, motivation, team culture etc.

2. The issues of collaboration were more significant in virtual organizations and in global context when they are considered to virtual teams and non-global context.

3. The issues caused by missing definitions of roles and responsibilities were more significant in virtual organizations and in global context when they are considered to virtual teams and non-global context. The dynamic virtual teams could easily adapt to any changes, such as changes in the definitions of roles and responsibilities, the assignments of tasks to actors etc. However, for the cases of virtual organizations in global context, clear definitions were vital to assure effective communication and coordination patterns and to ensure the success of development.

4. In small sized virtual teams the inner group dynamics; such as intense inner group communication, synchronous communication, and group decision making activities were the core of the development. Intense inner group communication

was highly required to enhance motivation, teamwork and progress of work; besides, mass communication traffic was controllable, and it was possible to inform all group members about all the information or events. However, when the phenomenon is discussed considering the issues and needs of virtual organizations, the study revealed that the ad-hoc and intense communication activities introduced severe problems and confusions to the development process; such as, time and data loss, mass communication traffic, and problems in management of knowledge.

5. One of the findings of the first and third case was the need for iterative approaches. The software projects developed in the first case were small in size, and they were developed by dynamic small virtual teams. The projects investigated in the third case were highly knowledge demanding projects which required frequent feedback from the customer. However for the second case virtual organizations needed more structured development methodologies, and more structured communication and coordination activities rather than a dynamic setting. Based on the discussions, the study points out that, it is not possible to consider a unique development methodology in the distributed settings, rather; the development methodology should be determined according to the needs of the projects developed and the needs of the teams and organizations.

Even though several questions, such as what projects are virtual teams best suited to work on, what are the appropriate size and skills composition for virtual teams approaching different project types, have remained unanswered. Yet, this study has led to the observation that the success of development is directly related with deep analysis of the unique needs, considerations and factors affecting the dynamic development setting.

5.2. Strengths and Shortcomings of the Study

The major strength of the study was analyzing different types of development settings as a collective case study. Investigating different settings having different considerations let to observe the phenomenon from different perspectives, and consequently led to common findings which are complementary to each other, as well as distinctive and opposite ones. Hence, the findings of this collective study can provide insight for further research for external generalization.

Even though global development is valid for many other sectors nowadays, this study was restricted to software engineering projects, which may constitute a shortcoming in understanding the overall global development concept. The other shortcoming of the study was related with the interviewee selection. In order to see the overall development process cycle, the interviewees were selected from the upper level management. However, better analysis could be provided by taking the opinions of people from different levels of the organization. The majority of the data have been collected by the interviews held, but utilization of the questionnaires to the overall organizations investigated could provide a better vision and more comprehensive results.

In addition to the shortcomings related with the methodology of the study, the study had shortcomings about the level of findings it presented. The study revealed the challenges of the global software development, as well as the experiences and lessons learned from each case. However, it did not clarify the actions needed in practice to overcome those challenges. For example, it did not mention any technical challenges of architecting products for distributed environments, necessary collaborative tools, web technologies and multimedia. Moreover, even though the study insistently discussed the necessity to provide effective communication and coordination, or concurrent engineering, it did not propose any principles to address those challenges. However, the aim was to propose a general overview about the challenges and success factors of global development, and those shortcomings could be interpreted as further research opportunities.

5.3. Further Research Opportunities

Virtual teams and global software development is a new, promising, interesting but a challenging phenomenon, which is in the early stages of investigation. Hence significant work to understand the organizational forms of future still remains undone. This study was distinctive from the other cases investigated in the literature, since it focused on both different types of virtual teams and organizations, and different natures of software projects. Hence the study showed that the dynamic nature of the distributed development setting, including differences in project size, duration, type, people, teamwork, national, organizational and cultural differences, has directly contributed to the findings of the cases. Therefore, to better understand the phenomenon, more analysis should be executed with different types (duration, size, people, design, structure of collaboration etc.) of teams, organizations and software projects. In other words, the studies should more specifically focus on the issues such as; appropriate size of the projects for any distributed setting, skills to approach different size of projects, relations with team design variables, distance and speed, effectiveness of practices in different development settings etc.

In addition to investigating different cases, further research may focus on the necessities derived from the common findings of this study. Even though the issues and needs of the distributed development settings are proposed in this study, the question of how to mitigate the issues of these issues is still unanswered. Therefore, further research is needed to consider the improvements for these cases, such as mitigating communication and coordination difficulties, fostering an information sharing culture, reducing national, organizational, cultural differences. Another area of research may be the implementation of the support tool, the requirements of which are presented based on the experiences of the cases investigated, and observation of the effectiveness of the tool and proposing additional requirements. Lastly, this study showed that more research work on organizations having effective project management practices and mature development processes is required to differentiate the specific needs of distributed settings from the general issues of project management practices.

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