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Empirical studies of geographically distributed agile development communication challenges: A systematic review

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ABSTRACT

There is increasing interest in studying and applying geographically distributed agile development (GDAD). Much has been published on GDAD communication. There is a need to systematically review and synthesize the literature on GDAD communication challenges. Using the SLR approach and applying customized search criteria derived from the research questions, 21 relevant empirical studies were identified and reviewed in this paper. The data from these papers were extracted to identify communication challenges and the techniques used to overcome these challenges. The findings of this research serve as a resource for GDAD practitioners and researchers when setting future research priorities and directions.

1. Introduction

The combination of geographically distributed development and agile practices [5], known as "geographically distributed agile development" (GDAD), seems to offer many benefits, such as low production cost, the opportunity to involve the most talented developers around the world and faster time to market [2,25,35]. Specifically, GDAD refers to agile development that involves teams or/and team members working together to accomplish project goals from different geographic locations [29,50]. GDAD teams or team members may be "locally distributed" in different physical locations within the same country or "globally distributed" around the world in different time-zones or countries [42,50]. Despite the abovementioned lucrative benefits, GDAD also involves many challenges [2,12,27,29,45]. Among these challenges, communication between distributed teams and customers is considered to be the most important [4,18,24,26]. According to Herbsleb and Moitra [27], poor communication (e.g., delivering an incomplete, inaccurate or inadequate message) is a major risk to GDAD. Similarly, human communication and knowledge sharing are highlighted as important concerns for GDAD [4,18,24].

Malone and Crowston [38] defined communication as the management of relationships between different concerned parties. Communication also refers to the process of exchanging information between senders and receivers [41]. These definitions draw our attention to the importance of the effectiveness of communication (i.e., delivering clear and understandable message [13,14,36]) between the parties included in agile development. Clark and Brennan [14] defined communication as a collective activity that "requires the coordinated action of all the participants. Grounding is crucial for keeping that coordination on track." Communication grounding facilitates efficient communication (i.e., rapid communication with minimum effort [14,36]) and effective communication [43].

Agility, the core of agile development, identifies how the agile team should communicate and respond to requirement's changes. Lee and Xia [36, p. 90] defined software development agility "as the software team's capability to efficiently and effectively respond to and incorporate user requirement changes during the project life cycle." Qumer and Henderson-Sellers [49, p. 281] define agility as "a persistent behaviour or ability of a sensitive entity that exhibits flexibility to accommodate expected or unexpected changes rapidly, follows the shortest time span, uses economical, simple and quality instruments in a dynamic environment and applies updated prior knowledge and experience to learn from the internal

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and external environment." Conboy [15] systematically examined various agility definitions and facets from related disciplines and provided by far the most comprehensive definition of software development agility. He defined software development agility as a continued readiness "to rapidly or inherently create change, proactively or reactively embrace change, and learn from change while contributing to perceived customer value (economy, quality, and simplicity), through its collective components and relationships with its environment" [15, p. 340].

It is clear from the above agility definitions that agile team members need to communicate efficiently and effectively. Therefore, agile methods require efficient and effective communication among team members and customers to achieve the highest software quality and customer satisfaction [5,47,S10]. To achieve efficient and effective communication among agile team, agile approaches depend heavily on face-to-face communication and coordination among co-located team members and customers [1,2,37,48], which is difficult to implement in GDAD environments due to communication constraints (challenges) [1,21,52]. Communication challenges refer to the characteristics of each medium that decrease communication efficiency and effectiveness [14,16]. The fewer challenges incurred by a medium, the better it is for communication process [14,16].

The extant literature reports a number of concepts, such as physical distance, time-zone differences, cultural diversity and language differences, which contribute to the complexity GDAD communication (e.g., [3,29,52]). The literature also recommends some techniques for mitigating the impact of GDAD communication challenges, which range from using available communication tools to following certain communication practices (e.g., [3,S11]). Despite the growing interest in adopting GDAD, little is known about how efficient and effective GDAD communication is achieved in practice and what techniques can be used to enhance GDAD communication [17,23,25,S9]. Many of the suggestions for the improvement of GDAD communication tools, techniques, and practices have come from experienced practitioners [2,4,18,17,19]. Hence, this research paper aims to fill this literature gap by systematically reviewing the empirical studies of GDAD to identify, synthesize and present the GDAD communication challenges and techniques that address these challenges from existing studies published in the public domain.

To the best of the authors' knowledge, there are no recent studies published in the public domain (at least, at the time that this study was initiated) that systematically review the empirical studies in the context of GDAD communication challenges. The most recent study systematically reviewing traditional process and documentation driven global software development [45] focused on generic global software development communication challenges and social computing tools. Traditional distributed software development is different from interpersonal collaboration and communication driven GDAD. Further, we assessed the quality of the literature sources in our study, which seems to have been overlooked by previous studies of GDAD communication. GDAD has attracted more interest from the software industry community in recent years. The previous papers stated the need for empirical evidence of how agile practices enhance GDAD communication and how GDAD communication challenges can be mitigated (e.g., [4,31]), which is the main aim of this study. Therefore, this paper attempts to shed more light on the empirical studies conducted in the field of GDAD communication and thereby identify the practical GDAD communication challenges and relevant mitigation techniques. Non-empirical (e.g., theoretical and conceptual) studies are beyond the scope of this paper. Hence, this paper focuses on the following main research question:

RQ: What is empirically known about GDAD communication? (main research question).

This study also tries to answer the following two sub-questions related to the main research question:

RQ1. What are the challenges or factors that limit GDAD communication?

RQ2. Which techniques have been used to overcome these challenges and enhance GDAD communication?

The main contributions of the paper are as follows. First, this study provides a granular understanding and yields pragmatic guidance for project leaders about GDAD communication. It helps researchers and practitioners understand GDAD communication challenges and adopt techniques to address these challenges. This study represents an initiative for developing and testing theories for guiding communication in a GDAD environment so that organizations can effectively build and sustain communication, which will ultimately improve their GDAD projects.

Second, unlike prior agile development communication reviews that have not explicitly distinguished between the different dimensions of communication, we investigate the multidimensional communication concept, which is comprised of different capabilities. We identify two key agile development communication dimensions, namely, communication efficiency and communication effectiveness, by applying the *Common Ground* communication concept [14]. Indeed, agile development approaches promote communication between all stakeholders in an efficient and effective manner [36,37,57].

Third, this study extends the previous findings in the context of agile communication (e.g., [31]) by distinguishing new challenge categories for GDAD communication (i.e., organizational factors and human factors). These two categories distinguish "locally distributed" GDAD from "globally distributed" GDAD. This identification has been achieved using the guides and concepts of the *Unified Model of Information Software Development Success* [53].

Finally, this research uncovers the relationship between the two dimensions of agile development communication and software development success in a GDAD environment. Although the efficiency and effectiveness of communication will decrease in GDAD, a positive effect of these dimensions on GDAD success has been found in the literature [18,54].

This paper is organized as follows. First, the research background and related work are presented in Section 2. The research method is discussed in Section 3. Section 4 discusses the research results. Section 5 discusses the research implications and limitations. Finally, conclusions are presented in Section 6.

2. Background and related work

Agile development practices focus on informal communication among team members. Informal communication can be defined as personal, interactive and peer-oriented communication [10,S9]. Additionally, it can be defined as the communication that takes place outside the official structure and without the knowledge of management [10,27], which seems helpful for quickly identifying and auctioning issues and risks [22,58]. While agile development prefers informal communication to formal communication in co-located teams, formal communication could be of great importance in GDAD environments [24]. Formal communication refers to explicit, clear communication, such as the agile requirements backlog, plans and card walls [10,26].

Because agile approaches depend heavily on face-to-face communication among co-located team members and customers, physical proximity is essential for participants to engage in informal communication [42,44,48,50]. This type of communication, in the co-located and local context, saves time and effort and