Towards an Understanding of Enabling Process Knowing in Global Software Development: A Case Study

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ABSTRACT

Shared understanding of Software Engineering (SE) processes, that we call process knowing, is required for effective communication and coordination and communication within a team in order to improve team performance. SE Process knowledge can include roles, responsibilities and flow of information over a project lifecycle. Developing and sustaining process knowledge can be more challenging in Global Software Development (GSD). GSD distances can limit the ability of a team to develop a common understanding of processes. Anecdotes of the problems caused by lack of common understanding of processes in GSD are pervasive, but there is no reported empirical effort aimed at exploring the solutions to enable process knowing in GSD. We report a case study aimed at understanding an effort to enable process knowing for improving processes in GSD. The findings provide useful insights into the potential challenges of lack of process knowing and how an organization can enable process knowing for achieving the desired results that also help in increasing social interactions and positive behavioral changes.

Categories and Subject Descriptors

D.2.9 [**Software Engineering**]: Management

General Terms

Human Factors, Management

Keywords

GSD, Knowledge Management, Empirical Software Engineering, Case Study, Process Improvement.

1. INTRODUCTION

With the widespread adoption of Global Software Development (GSD) paradigm, Software Engineering (SE) researchers and practitioners have been increasingly focusing on identifying and reporting potential challenges of successfully implementing GSD and devising appropriate solutions [1]. The key GSD challenges are usually characterised by distribution factors (i.e., temporal, geographical, socio-cultural, processes, and knowledge).

Whilst there has been significant research on GSD challenges and solutions related to temporal, socio-cultural, and geographical distances, there has been a little work on understanding the

distances; ambiguity in responsibilities, roles, and assigned tasks problems and devising solutions related to knowledge and process and agreed upon processes to be followed by different sites [2, 3] are some of the examples of process distance. GSD needs to be supported by appropriate technologies (i.e., methods, approaches, and tools) for Knowledge Management (KM) [4] and Software Process Improvement (SPI) [5]. We assert that one of the key causes of GSD challenges can be process knowledge distance. SE process knowledge could include knowledge about workflows, deliverables, team structures, and responsibilities of members in regard to the process [6].

Studies show that shared understanding of process knowledge, that we call process knowing, results in effective coordination [7, 8], communication, and cooperation [8] within a team and contribute to improved performance [6, 8]. Shared understanding of anticipated interactions (e.g., flow of information, roles, and communication pattern) enables team members to predict each others' actions that could also engender trust among members [8]. It is relatively easy to develop shared understanding and awareness about processes and people when team members are collocated. However, developing shared understanding of processes is more challenging in GSD due to distance factors [8-10]. Lack of frequent and effective communication [2, 3], conflicting internal organizational processes at distributed sites [3, 11] and thin spread of process knowledge to different hierarchical levels of teams [12] can be some of the factors that can inhibit the development of process knowing in GSD teams. Organizational research has identified a set of practices (e.g., facilitating face-to-face interaction, developing shared identity and aligning efforts of distributes sites) that can enable organizational knowing within large distributed enterprises [9]. However, there has been no known effort aimed at exploring and understanding the problems and potential solutions for enabling process knowing in GSD.

Our motivation for this research was to use the lens of organizational knowing for exploring how Small to Medium sized Enterprises (SMEs) can enable process knowing for improving processes in GSD. This paper reports an exploratory case study aimed at understanding the problems caused by lack of process knowing and the strategies that can help organizations to enable process knowing in a distributed software development teams. Our findings are expected to provide useful insights for enabling process knowing to address the problems caused by process knowledge distance and stimulate GSD researchers to explore different aspects of the reported problems and solutions associated with process knowledge distance in GSD.

2. BACKGROUND

An effective operation of an organization depends on collective knowledgeability of members from work and environment [7-10]. There are two main perspectives of organizational knowledge: knowledge as distinct entities, objects, or properties that is transferrable; and knowledge as a construct of people's actions [9,

13]. The latter view focuses on knowledgeability and purposefulness of actions (knowing) rather than how true is a fact (knowledge) [9]. It challenges Nonaka [14]'s statement (i.e., conversion of knowledge between tacit and explicit) and argues that tacit knowledge is always a part of knowledge that is not separable [9, 13]. Orlikowski argues that tacit knowledge is a form of *"knowing"* that is not detachable from action [9].

Krein et al. [12] enumerate process unawareness and inexperience as some of the key barriers to private information sharing problems in large software organizations. Furthermore, research [12] shows that members at lower layers of organizational hierarchy (e.g., specialists) usually lack broader view on organizational process and contribution of other functional teams. The authors conclude that coordination of different functional teams could take place through a group of cross-functional stakeholders; missing key roles (e.g., due to sickness or turnover) in absence of process awareness of other members could cause coordination breakdowns.

The importance of KM in software engineering has been recognized since long. Hundreds of efforts have been dedicated to develop knowledge-based approaches to SE and supporting learning organizations. KM has been identified as an important area of research for supporting GSD as identifying, capturing, and sharing the required knowledge in GSD is quite challenging. For example, lack of face-to-face communication and social interactions make it difficult to have a smooth flow of information and share knowledge that may be tacitly or locally held at one site. Since KM is considered important for supporting an SPI effort, we assert that lack of process knowledge may make an SPI effort in GSD quite difficult to achieve the desired results.

Ebert and De Man [6] consider process knowledge as one of three types of SE knowledge (i.e., product, project, and process) that is defined as *the knowledge about business processes, workflows, responsibilities, supporting technologies and interfaces between processes*. We refer to **process knowing as knowledgeability and purposefulness of team members' actions for learning and applying software development processes**. That means team members continuously learn and make shared understanding of the roles (who), activities (how), milestones (when) and work products (what) of a software development project [6] through communication and engagement. A GSD team's knowing of processes can be negatively impacted by well-known GSD distances (i.e., geographical, temporal and socio-cultural). The challenges caused by GSD distances are known to impede effective and efficient knowledge sharing in distributed teams. For example, lack of face-to-face communication may lead to an increased effort to know who is involved in process, what activities are being performed by whom, when the milestones are set, and what are the artifacts to produce/consume. In the absence of lack of knowledge and visibility of defined process, team members can develop misunderstanding that usually lead to incorrect implementation of processes at different sites [2, 3] causing delays and frustrations [3]. GSD also introduces process non-uniformities [3, 11, 15] across different development sites. This situation leads to mismatched expectations and coordination breakdowns[15]. The key motivation of this research is to provide an evidence-based understanding of enabling ***process knowing*** in GSD teams for SPI and social interactions in a GSD team.

3. RESEARCH METHOD

SE is intertwined with human interactions that are equally important to study alongside the technical aspects. It is considered that qualitative research methods can enable SE researchers to explore the socio-technical dimension in depth and interpret the complexities involved in human behavior [16]. Hence, we decided to use qualitative research that generates rich data of text or video [16, 17]. Our research method was case study that studies a phenomenon in a real-life context [18]. We investigated our research objective through an exploratory case study [18] of a team in a GSD setting. We consider our unit of analysis as integrated virtual organization including offshore and onshore sites. We aimed to explore the following research question:

RQ: What strategies an SME can adopt to enable process knowing in GSD?

3.1 Organizational Context

We studied a software development team distributed between Denmark and Pakistan forming an Extended Team Model (ETM). ETM is a customized offshore outsourcing collaboration model based on long-term partnership of two sides in which offshore site considered as an extended arm of the core team at onshore. The ETM emphasizes on building a unified team with close interactions across the locations beyond client-vendor relationships [19, 20]. The onshore site with 20-25 individuals represents the IT department of a large organization in Denmark within the domain of publishing. The offshore site is an SME in Pakistan with similar team size where most of the development activities take place. The companies have been following the ETM for the last 4 years. A majority of the projects are demanded by internal customers in Denmark (e.g., automation of a business process, integrating systems, and websites). Figure 1 shows the structure of distributed teams.
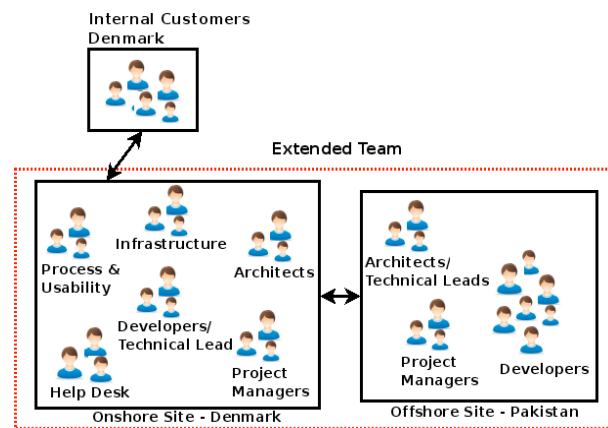

Figure 1 - Structure of distributed teams

While different roles (e.g., project manager, architect, technical leader and developer) exist at both sites, being an extended team, the organizational boundaries are blurred in forming teams for different projects. That means the projects could be setup with different team structures and utilization of resources at each location (e.g., a project's leader may be located either in DK or in PK). However, having customers in Denmark, the onshore team members are assigned to interact with customer for tasks such as requirements elicitation, and architectural analysis.

3.2 Data Collection and Analysis

This study is part of a longitudinal case study in which we have been exploring distributed teams for around 2 years by collecting data at different occasions in different projects' lifecycles. Some of the findings have already been published in [19, 20]. Given our

familiarity with the case company, we used ethnographically inspired observations and semi-structured interviews as the main data collection approaches for this part of the study. Our findings are based on the analysis of qualitative data of 5 hours of observations of a virtual joint workshop and 8 semi-structured in-depth interviews (4 onshore and 4 offshore members). Figure 3 shows a snapshot of the observed virtual joint meeting in which around 23-25 people participated at each site. The conference rooms at both locations were equipped with high-speed Internet connections, video-conferencing equipments, two big screens, microphones, and speakers. The virtual joint workshop purported to clarify the changes that had been initiated for improving organizational processes over the last one year. The workshop was an opportunity for team members to gain a better understanding of the new processes, roles, and responsibilities that have been incrementally implemented over the one last year. Both authors of this paper observed the workshop from Denmark; another researcher was engaged to observe the workshop concurrently from Pakistan. The whole workshop was audio recorded at both sites. The recordings were transcribed and analysed along with other data from this study.

We also conducted semi-structured interviews with selective team members of both sites. Our interview questions were mainly focused on process related challenges that teams have been facing and the strategies implemented to address those challenges in general and the challenges related to lack of awareness and misunderstandings about processes in particular. Moreover, we also steered the interviews with questions about the observed and potential achievements from the introduced strategies for improving **process knowing**.

We analysed the data using the qualitative data analysis techniques inspired by grounded theory [21]. We applied open coding for analytically breaking down the data and interpreting the phenomenon reflected within data. [21]. We also utilized the axial coding technique to identify the relations between the categories. We coded the data segments associated with process related challenges as well as adopted strategies by organizations that facilitate learning and applying organizational process for team members. Our inductive coding and categorization led us to a set of adopted strategies and associated achievements. Our comparison of the categories against the whole data set enabled us to establish the relationships between the strategies and achievement categories. While we performed in-depth analysis of interviews transcriptions, we did shallow analysis on transcription of workshop session to support our observations as well as our findings from interviews. One of the significant actions in this phase was to analyse the power point slides (i.e. 50 pages) that were used to facilitate the session. Those slides along with workshop transcriptions helped us to deeply understand virtual organizational structure as well as introduced improvements. Our use of different data collection methods and listening to perspectives from both sites enabled us to have data triangulation.

4. FINDINGS
In followings, we present the challenges caused by lack of process knowing, adopted strategies to enable process knowing, and the results from for improving the processes and social interactions.

4.1 Observed Problems
Our studied case has also experienced typical GSD challenges due to geographical, temporal, linguistic, and cultural distances. However, we keep our focus on challenges that our analysis of the data associated with lack of process knowing. We also report how

that situation had caused severe misunderstanding about the roles and responsibilities to take the required actions at appropriate phases in different software development projects.

4.1.1 Lack of Visibility and Predictability of Upcoming Tasks
The organization has been following a dynamic work structure model according to which team members expected to work on multiple projects varying from Greenfield to enhancement and maintenance of legacy systems. The dynamicity of work structure causes lack of visibility and predictability of upcoming tasks and potential assignees for those tasks; this situation also inhibit team members from gaining clarity of organizational development processes to follow. Internal customers' increasing demands for supporting more business processes by developing new or enhancing existing software systems results in numerous projects running in parallel without appropriate control on the initiation of different projects. And the project teams find it extremely difficult to sufficiently plan and allocate the required time to gain a good understanding of mutual tasks and processes to manage them.

"There are a lot of projects which we are doing in parallel and we have so many parallel teams, some team of two persons, three, four, five persons depending upon the parallel projects. So there can be a mess and lack of visibility and predictability at that time. At one time I was not aware of, for example, after two months what we are doing." PK-Lead1

Our findings revealed that the lack of vision of upcoming tasks negatively impacts quality of deliverables in different phases of software development processes. It affects the team members' ability to perform appropriate analysis of requirements, architectural assessment before initiating a project. A general lack of attention to ensuring quality of specifications and the related documents frustrate development team who are rushed to meet unrealistic deadlines for providing all the deliverables.

"Previously the project details didn't come to us in the initial stages. It came to us when the deadline was near. The bottleneck was at the PM's end there. So, suddenly the requirements started coming and we were told - ok, this is the project, you have to do this in one month- and then we suddenly rushed to work on the deliveries and no point of giving estimates." PK-Developer1

Furthermore, assignments to multiple projects in general and to a maintenance projects in particular result in severe *context switching* caused by unpredictable nature and number of issue fixing tickets for developers who are expected to interleave work on the current tasks and attend the issues that need to be fixed. The context switching also negatively affect team members' ability to sufficiently know the processes and people for the projects on which they work.

"So there was a lot of time being wasted while we were context switching between two scenarios where we have to work on the full fledged projects and then suddenly we have a popping up issue from the production and we have to switch back to the old work that we have done."PK-Developer2

Our analysis of the data also revealed that lack of domain knowledge, limited or no direct access to customer, and challenges in smooth interaction with remote colleagues in GSD projects can result in a general lack awareness of and low common understanding of development processes to be followed.

4.1.2 Communication Breakdowns
Our study reveals that a lack of understanding of development process can cause communication breakdowns among distributed team members. A variety of situations in which team members can be involved in various projects that may be running using

different approaches make it challenging task to remember all the stakeholders who are expected to be informed about different decisions and status updates. For example, one project may be set up with a project manager, an architect and a technical leader in Denmark and all the developers in Pakistan; while another projects may only have a requirements engineer in Denmark and the rest of the team in Pakistan. These kinds of different team structures introduce various modes and patterns of communication needs and information flow to ensure sufficient understanding of the solutions to be made and the processes to be followed by different stakeholders. It is inevitable that such scenarios eventually lead to incidents when some stakeholders may not be informed about the design solutions early enough to avoid misunderstanding that usually impact process and product quality.

"*We have several incidents when the infrastructure team [onshore] remained unaware of the design decisions making process and the selected design solutions until the time of deployment of the developed solutions; then they found issues in the architecture of the implemented solutions. These kinds of incidents are painful and lead to rework that could be avoided by bringing the infrastructure team into the design decision making communication.*" *DK-Architect*

Communication breakdowns could also be caused by difficulties to get access to stakeholders for reviewing solution. Lack of clear understanding of the roles and tasks to be performed in ongoing projects introduces bottlenecks in reviewing solutions. It introduces ad-hoc mitigation solutions and neglecting broad analysis of different technical concerns.

"*Previously we used to get some mock ups and requirements that would drive our communication with [architects in DK], then we noticed unanticipated bottlenecks in communication with the architect without knowing who else can be contacted if he was having less time; we had to come up with the design by ourselves in order to avoid further delays.*" *PK-Lead1*

4.1.3 Interpersonal Conflicts

Dynamic work structure necessitates frequent interactions and cooperation among team members to coordinate their tasks and keep each other updated. Lack of process visibility on the one hand and being distant from each other on the other hand can potentially have negative impact on collaboration in a GSD team. Whilst lack of clarity and agreement about the processes, roles, and responsibilities decreased management's ability to quickly pinpoint the problems, the limited social interactions due to geographical distance led to increased blaming and pre-judging remote colleagues.

"*It could be instability, it might be bugs, it might be a developer's time used on support, and what is very common about this situation is that whenever we talk to anybody, everybody has an explanation for why this is an issue, but very few agree. So what we need now is to sort of stop talking about what the other guys need to do and create a situation where it is no longer possible to say that it is the other guy's problem.*" *DK-Architect*

Lack of familiarity and knowing of people at the other ends, specially between offshore development team and other departments at onshore (e.g., operation, infrastructure, and project management) have introduced hesitation in initiating contact with remote members and resolving misunderstandings. That means the work structure dynamicity and the need of close interactions between distributed teams introduced interpersonal clashes, irrespective of familiarity of individuals with each other. We

found that team members have made a classification of team members as "cool guy vs. ego guy" based on the level of cooperation and understanding about the proposed solutions. There were also uneasy feelings caused by lack of understanding and agreement about certain control strategies of managers on remote site; these were some of the antecedents of personal conflicts that team members experienced in close collaboration within integrated teams.

"*They work in their way, they have their level of care, their level of control. How can I control a guy over there [DK] to say you have to do this when he/she refuses to acknowledges that I have certain responsibilities for the completion of the tasks assigned to him.*" *PK-Lead1*

Our analysis discovered that the interpersonal clashes in the studied team have had roots in poor cross-site communication and implicit definition of responsibilities, disagreements on what to do in certain circumstances, and lack of common ownership of process, social and behavioural will was also lacking:

"*Some people are very easy to talk to and throw ideas at, and some are not, and nobody is changing and that's why I don't think time [familiarity] will matter a lot.*" *DK-Developer*

4.2 Enabling Process Knowing

In this section, we report the strategies that have been implemented for supporting process knowing in order to address the generic GSD challenges in general but the abovementioned challenges in particular. Our analysis of the interviewees' perceptions and views and the observational data revealed that the implemented strategies have enabled team members to improve process knowing. We call the strategies enablers of the process knowing that have resulted in better awareness, experiences, and understanding about the development processes, roles, and responsibilities through social and behavioral interactions. Figure 2 shows a representational model of our findings from this study to show the relations between the process knowing enablement strategies and the reported outcomes that are perceived to have increased process knowing of software development teams at both sites. In the following sub-sections, we present the findings for each of the implemented strategy and how it has helped to achieve the desired outcomes that have contributed to improve the process knowing in the studied case.

4.2.1 Introducing Meta-Level Process Improvement

The organization has gradually gained a better control on the project initiation phases by introducing meta-level process improvement strategies and widely communicating them among all the projects. For example, making the managerial and reporting structures at the organizational and projects levels clearly visible and understood by all team members who are expected to be fully aware of what need to be done in which situation. The introduced changes for improving process knowing have been minimally documented (i.e., a pictorial diagram) and have been integrated in the daily project practices without any micro level instruction or methodological formalism about how to manage projects or socio-technical interactions in teams.

Instead, the introduced meta-level process improvement guidelines resembles a blueprint of the activities that need to be done before project kick-off including the deliverables and required communication practices among different parties (e.g., architects, usability, project manager, and technical leader) to
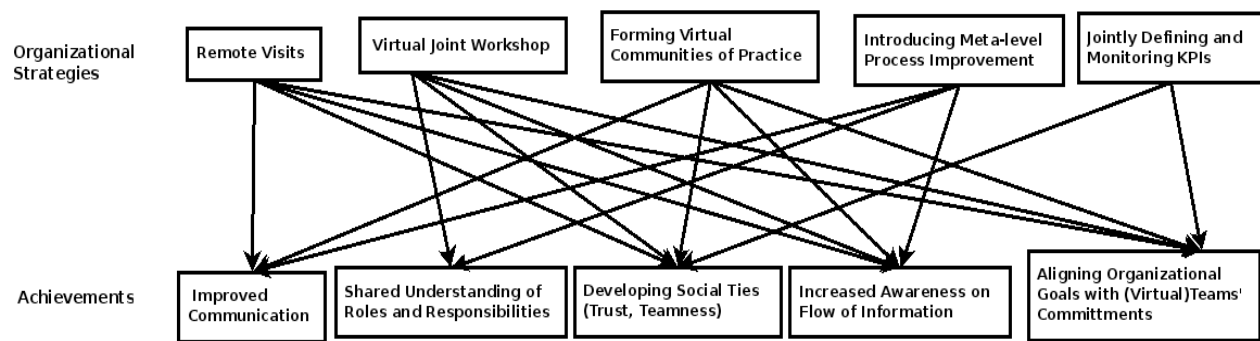
Figure 2 - Enabling process knowing in GSD teams - strategies and achievements

review requirements and proposed solutions. The meta-level practice is to start a project by explicitly expecting collaborative engagements between usability team and architects to analyze requirements, to maintain discussion between stakeholders on proposed solutions, and refining technical solutions, and finally having clarification phase for development team to understand proposed inputs (i.e., requirement and design solution) for kicking off a project.

We note that the meta-level process improvement highlight the role of different functional teams and their responsibilities with regards to deliverables, irrespective of the location of a team member. A key element of the introduced change is a virtual community of practice *(i.e. WhatTeam, described later)* that is responsible to lead the distributed teams in following the processes. The introduced changes are used as a blueprint for tailoring and applying those practices to various team setups based on project needs. One of the key practices is continuous dialogues and engagements among team members and among projects to improve social interactions and encourage behavioral actions that can support open communication and awareness about different aspects of the product being developed and the processes. The new changes in project initiation process have led to improvements in awareness of flow of information across distributed sites. It enables dialogues among offshore technical lead/architect with onshore architecting team and other stakeholders (e.g., infrastructure team) on proposed architectural solution at early phases. Furthermore, it has assured the offshore development team that are being engaged right from beginning in a project that is important for forming a strong bound among the members of a software development project.

"We used to do a normal model, getting the requirements in a word document and start working on development. Now it has totally changed and we are following a process. I mean the requirement has to be on a certain level of details before we start talking about technical specification. The guys who will be developing the system have to approve the requirements so that they understand that all the requirements before the start of a project. Before we give our estimates no deadline is finalized. That means no more scenarios like when we used to get the project and were advised that you have to do it and sign on this."PK-Developer1

Our findings show that clarification of roles and responsibilities and increased awareness of the needed flow of information have been proving quite useful in increasing the visibility and predictability of process and delivery time.

"For long time, we used to have situations where there was unpredictability with respect to what projects we would be working on. There were a lot of disturbances and basically what

we wanted to do was to do something about that because the overall aim for entire IT department is to increase predictability in product and process quality. We wanted to do something to make our work more predictable for our customers. It also includes predictable delivery so that with a lot more confidence we can say to customers when something is going to be delivered" DK-Architect

4.2.2 Forming Virtual Communities of Practice

Another key strategy adopted by the studied organization is to set up and sustain a very active and dynamic virtual cross-functional community to support knowledge sharing between functional teams. They call it *"WhatTeam"* that is expected to play a significant role in monitoring and supporting the activities of project initiation and final delivery. This group includes the head of development department (i.e., offshore technical project manager), the head of architecture team (i.e., onshore senior architect) and the head of project management team (i.e., onshore senior project manager). The main mandate of the *WhatTeam* is to enable social interactions and behavioural changes through open and candid communication to improve the knowledge sharing across distributed teams. This group also actively work on identify the gaps in common understanding of the expected technical specifications for the system being developed and processes to be followed and their status. They promote dialogues within project teams as well as across the organization.

Each member of this group is responsible for proactively ensuring to minimize the potential risks to the projects as a result of misunderstandings about the technical requirements and process unawareness within their associated team members working on different projects. The head of project management at onshore represents the customers in this community to ensure alignment of solutions with customers' concerns. The head of architects is mainly accounted for analysing and reviewing proposed technical solutions. Given the seniority and experience level, he could analyse interdependencies of systems and suggest the process changes that need to be put in place for gracefully handling the tasks, people, and process interdependencies to avoid any potential risk. The head of development represents the development team in early project phases. He is responsible for closely monitoring the project inputs, ensuring the quality of the requirements and the proposed solutions, and the suitability of the processes before the development team can start working on devising the technical solutions to be implemented.

"My responsibility starts [after project kick-off], but to get in there I have to make sure that input we are [getting] is accurate and good enough that we can produce good results. These are the
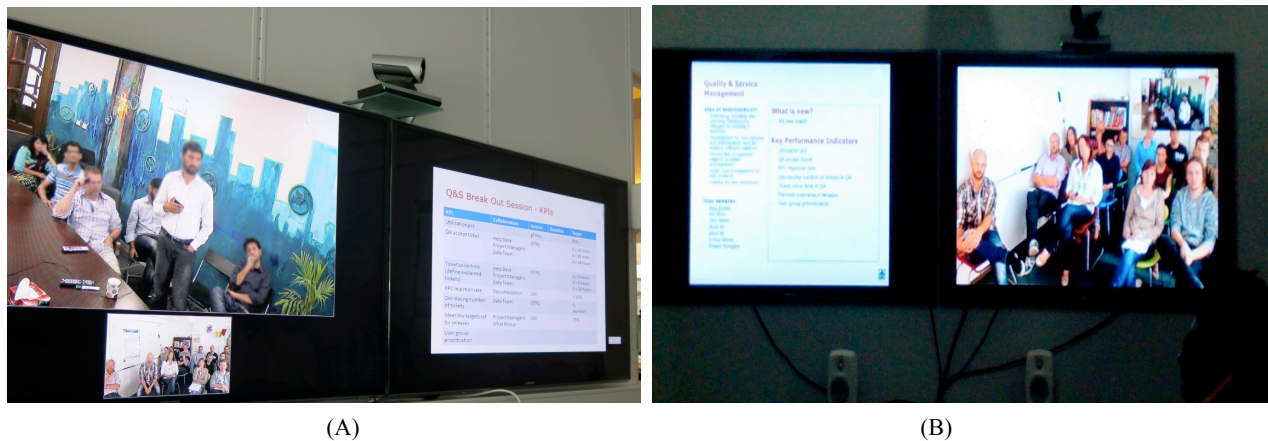
Figure 3 - Joint Virtual Workshop - showing presentation slides on one screen and participants on the other. A) Snapshot taken from DK while presentation is given from PK, B) Snapshot is taken from PK with a view of participants at DK

areas we are really focusing on: do we have right initiation document? And when I look into it what I'm trying to see is what if I give these documents to my team? Would they be able to understand? Would they be able to understand the specifications and processes to be followed for delivering what we are expecting?" PK-Technical PM

We found that a close collaboration and frequent interactions (i.e., meeting 3 times each week) among *WhatTeam* members enable active and continuous engagements among the members of cross-functional teams working on each project during the early phases of software development processes. The resulting social interactions and behavioural understanding and modifications help team members to increases their awareness of the people working on different projects.

WhatTeam is also responsible for identifying the stakeholders from other functional teams who should be involved in designing and discussing technical solution. Given the variety of projects (e.g., internal integration, Greenfield, and enhancement), different stakeholders (e.g., infrastructure, operations, project managers and leaders) could have stakes in proposed solutions for which their teams are expected to work, hence, their involvement can play a critical role in increasing the ownership of the technical solutions and process knowing within different teams who are expected to collaborate on a project.

The members of the *WhatTeam* are distributed and senior members of the organization's management group, hence, they are expected to have the visibility into the knowledge sharing and communication needs of different projects and appropriate support the team members for that purpose.

Furthermore, *WhatTeam* enables formation of other temporary virtual communities for devising and supporting processes and practices for negotiation, review and analysis of requirements and technical solution. For example, Architecture Board (i.e., *HowTeam*) is such a temporary community formed for each of the project and is responsible for strategic analysis of requirements and proposing solutions. This community consists of team of architects (i.e. including head of architects) as well as head of usability team. While the members from the architecture and usability groups located in DK are always included in "*HowTeam*" because of their proximity to the problem domains and product owners, *WhatTeam* identifies other groups from where the members (e.g., offshore technical lead/ architect) are drawn for this group for closely collaborating on technical solutions. This ongoing dialogue appears to be quite helpful in getting offshore leaders in touch with architects at early stages to

gain a good understanding of the proposed solutions and the processes to be followed.

Setting up these communities and explicitly stating their roles and mandate to actively support software development processes have increased all the team members' awareness of the contact points for different responsibilities and the needed flow of information within distributed teams. Furthermore, bridging the gap between different functional teams has improved social interactions and feeling of team-ness across the sites. For example, *WhatTeam* maintains close interaction with management and customers and their presence in all project phases for supporting process monitoring and work progress have enabled the studied organization to align organizational goals with commitments of the teams.

4.2.3 Virtual Joint Workshop (VJW)

The studied organization has introduced virtual joint meetings to enable process knowing and social interactions. Whilst there are regular VJW for clarifying misunderstandings and promoting collaborations, a large VJW is held when the gradually introduced changes in development organization and project teams structures and process improvements (e.g. project initiation) reaches a level of maturity. At that stage, it is important to increase the awareness about the changed roles and responsibilities in regard to process changes and setting inter-team expectations and common goals for different organizational and projects, especially the long running ones.

In one of the main VJWs, we observed that through a joint talk, the managers (i.e., both onshore and offshore) gave a shared message to distributed team members as common goal and ambition of the companies with emphasizing on shared identity of team, necessity of teamwork and delivering high quality services to customers and internal stakeholders. The brief presentations in the main VJW are designed to provide enthusiasm and motivation for the changes required in the social structure and the behavioural interactions.

"Along the way we have two things that have been always the focus. One thing is quality of the service that is about what we deliver, the processes, the execution and the metrics we use. And the workplace, that is the environment and values that we want to have at both sites. How we have to work together, what kind of relations we want to have. So these two have always been the main things"- VJW, part of presentation talk

Furthermore, the observed VJW also informed the distributed team members about organizations' strategies to achieve high-

level goals for ensuring product and process qualities and the steps being taken to achieve those goals. The participating members at both sites gained briefings on the vision of changes in virtual team structures, process improvements, and the rationale behind the introduced changes in alignment with organizational goals.

"We always try to set goals that are ambitious. What we plan to do today and share with you is that we believe it's going to work but it's going to be challenging. We'll have to practice it and try it. We'll fail at times. We'll talk about virtual team organization and the changes that we need to do to get even better. For each virtual team we'll talk about KPIs, how we measure our improvement over time." – VJW, part of presentation talk

The VJW helped the participants of the integrated project teams from both organizations to gain a good understanding of the structure of the virtual organization (i.e. integration of both companies) from viewing and discussing the integrated organizational chart showing different functional teams (e.g., development team, usability team, architects, infrastructure) consisting of members located at both locations (i.e., DK and PK). The learning and knowledge about the members of different teams and how they are drawn into different projects were reinforced through brief introductions to team members by the head of each team. These introductions specifically focused on the names, brief background information, and the area of responsibilities of team members of every team. Whilst the functional teams had been working together for a while before the observed VJW, the format and information shared during the workshop enable the participants to increase their inter-team awareness of who is who in a friendly environment as many of the participants reported to have been able to put faces on names first time. The explanations and clarifications about the organizational structures and processes were designed to help distributed team members to locate themselves within the whole virtual organization and knowing the functional teams whom they need to closely collaborate. The VJW was also used as an opportunity to introduce new faces (i.e., newly joint members) to all participants by giving them the microphone to introduce themselves and say hello to everybody.

One of the noticeable activities designed to improve the common understanding and process knowing about the processes and responsibilities for different projects by walking through the process improvements needs and initiatives and clarification of the assigned responsibilities and expectations. Another activity to improve the learning and understanding of the participants about the goals and changes in the processes during the VJW was a joint explanatory session in which the members of *WhatTeam (i.e. technical PM from offshore and Senior Architect and Product manager from onshore)* explained the new changes and the areas and roles to be affected by the changes and the expected benefits from the changes. This activity got team members from both locations actively engaged in question and answer types of discussions for seeking and providing clarifications about the changes in the processes from the owners of the different process areas. Given the challenges and needs for process improvements, the team members got clarified on workflow of project initiation before kick-off as well as format and schedule of making and getting project plans approved for improving the management of change requests. The sought and provided clarifications included: which teams should be acting where, what should be expected input to start with, what should be a deliverable (e.g., documents) to the other teams and whom they need to contact and consult during different phases of the software development process. Whilst the

changed processes and practices had been in operation in different projects for more than a year, it was felt important to organize a joint process briefing and learning session to increase the knowledge and awareness about what is done by whom and when. Different teams in the changed process took this opportunity to disseminate their organizational responsibilities and agenda. For example, *WhatTeam* used the workshop to clarify their critical role to monitor and run successful projects.

It is WhatTeam's responsibility to make sure that whatever comes close to kick-off is accepted. We need to make sure beforehand that you [development team] have heard if what we think will make success…we are involving the people needed to play [the process] in more right places. So we are not [perfect] but we have implemented the main ideas here that's basically [us] making sure that this happens in a timely manner and also a nice quality and the report I take from you guys, the re-planning has decreased and we do not re-plan as much. So if you have any issues with things like documentation or information about how the solution looks like you need to tell [us]. VJW, part of presentation by WhatTeam members

VJW was also motivating the team members to be proactive in seeking inputs, communicating with each other, and speaking out their ideas/concerns to fulfill their responsibilities.

"You guys [development team] are involved when you get the project initiation document and it will have the solution portion there that you can review it and if you don't like it, it can be rejected if you have doubts. Once you accept a solution, you take the responsibility that is why it's very important that you need to be able to evaluate what you accept."

Our analysis of data revealed that the main VJM organized for helping all the team members to achieve common understanding of the changes in the development processes and roles has contributed to achieved the desired goal of improving process knowing in several ways, for example, building trust, increasing social interactions, encouraging positive changes in behavioral perspective, increased awareness of flow of information. These types of outcomes have enabled all the team members on both sites to gain a shared understanding of roles, responsibilities and commitments of teams. This type of joint gatherings with friendly environment and highlighting necessity of collaboration also increase team-ness and ease further social interactions.

4.2.4 Jointly Defining and Monitoring KPIs

Another strategy to enhance the process awareness and sense of common ownership of the process is to have all the team members to define a set of high-level Key Performance Indicators (KPIs) to promote joint self monitoring and self-assessment of a team's own performance. Each functional team is expected to come up and discuss their high-level KPIs and then put those KPIs in place for regular monitoring and assessment that is expected to provide the team members an objective mechanism of measuring and adjusting their performance irrespective of their location or organizational affiliations. This joint definition and monitoring KPIs also act as one of the key enablers of increasing awareness and knowledge about development processes and how they are being implemented and followed. In order to share the importance of joint definition and monitoring of KPIs in the changed processes, the management has allocated one session for breakout group discussions for each functional teams to define an initial set of KPIs and present and discuss in a plenary session in order to make the members of all the functional teams become aware of the KPIs of other teams as the achievements of

the KPIs were interdependent upon each others. Hence, it was important for all the team members to have an opportunity to gain a good understanding of the KPIs of all the teams including their own. The breakout groups used communication technologies like videoconference and Skype for defining and discussing their high level KPIs.

This activity enabled the participants to initiate discussion and share reflections on possibility and usefulness of each of the presented KPI by each team. Each of the team is expected to organize separate follow up virtual sessions to refine and finalize their respective KPIs and put them in place for monitoring purpose. We observed that the participants were very excited about this activity and were actively taking part in each of the task for defining and refining KPIs within their team. The observed enthusiasm and interest is expected to help them to formulate common goals and shared identity for distributed team members for raising their responsibilities and commitments towards the defined goals and associated processes to achieve the set goals.

4.2.5 Remote Sites Visits

Another significant strategy for improving organizational process knowing building common understanding of the strengths and weaknesses of different teams is arranging regular physical visits of a selected set of members from different functional teams geographically distributed. Such visits in the studied case include having offshore team members (e.g., 4-5 people) visit Denmark with a space of a few months and having representative of management from Denmark (i.e., manager and architect) frequently visit Pakistan (e.g. every 2-3 months).

The analysis of the reported experiences from the remote visitors and their close colleagues who have learned about the work activities and social engagements during the visits reveal that these visits have been instrumental in enabling open communication within different functional teams (e.g. helpdesk, infrastructure, usability, project management) for addressing the challenges caused by misunderstandings and miscommunications. These visits have enabled visitors and their colleagues (i.e., onshore and offshore) to know remote colleagues closely, gain a good sense of cultural differences and how to leverage those differences and work ethics, and develop social relationships that have helped to improve cross-functional knowledge sharing through social interactions.

"Since the visit we've seen more trust and signs of teamness [...] we see stronger relationships between operations and the team in Pakistan. They Skype a lot, they SMS each other if something is not working [...] There's a very good contact and more social interactions for helping each other to share the processes we follow for performing our respective activities. We also talk about personal matters...we share photos of each other's kids and so on."DK-Operation1

The strategy of arranging physical visits of offshore team members has also provided an opportunity for them to meet face-to-face with internal and external customers of the systems that they develop. These meetings have helped both sides to build trust and develop an increased understanding of customers' needs and business processes to be supported through the software systems developed and/or enhanced with strong contributions of the visitors and their team members. Hence, they learn about the importance of continuous process improvement and how to align the software development processes with the needs and concerns of customers about the quality and delivery dates as stated by one of the visitors.

"How the actual user is using the system and what problems he or she is facing, is of great importance and this direct communication can give us a lot of input regarding how we can improve with usability and how we can improve the processes in our application."PK-Developer2

An improved understanding of customers' needs and business processes enable visitors from offshore teams to gain a broader perspective of the technical and contextual requirements that can be quite useful for effective and efficient performance of their work in different projects. Moreover, first hand observation of the daily processes and activities of the onshore colleagues have enabled offshore team members share their challenges and concerns with their onshore colleagues during social interactions and gatherings that provide much more friendly environment compared with work environment to present and listen each other's perspective and views. These visits have also open up different channels of social interactions and behavioral improvements aimed at sharing relevant information that may only be resided at one but critical for supporting the development processes of teams located another site. We found that these visits have spearheaded many initiatives for improved cooperation and interactions for sharing knowledge between offshore development team and the functional teams consisted of staff located onshore (e.g. helpdesk and usability).

"[It brings] better quality...better information for the customers. Because, often, help-desk doesn't know much about the problem and the solution. But, they're getting a lot more information now from the developers than they used to get. [...] Because now, the developers see the reason for informing the customer. I actually see more trust from our customers to developers in Pakistan. Now we provide information directly from the developers to customers, of course, translated, they [customers] see that they [offshore] actually know about their business processes." DK-Operation1

The strategy of frequent remote visits has also been utilized to informally communicate organizational goals and expectations and why certain processes and activities are important to the visitors for developing shared identity and process knowing. The gained knowledge during the visits is expected to be transferred to the all members of other teams located offshore. The frequent visits of onshore company manager to offshore site provide a dedicated amount of time to have informal and frequent conversations with individuals working on different projects, share the organizational vision, culture, and expectations; this opportunity is also used to motivate offshore members of the teams to learn about organizational goals and customers' expectations and think of process and product solutions to meet rather exceed the goals and expectations.

"My objective is to add a lot of pride into each team, to ensure them that they have the possibility of reaching their goals [...] I need to position myself in a situation where I can say [our goals and expectations] in a way everybody understands without anybody being offended or feeling threatened or anybody disliking me afterwards [laugh]" DK-IT Manager

The informal approach to communicate organizational expectations to the team is to promote a safe and trusting environment for all involved to increase the understanding of the expectations to be satisfied and processes followed. The remote visits are followed by having the visitors to make informal presentations and hold pep talks for their offshore colleagues to brief them about their observations and experiences of people and processes from the onshore side. These kinds of briefings

have helped improve a general understanding of the offshore team members' about the social life and personalities of Danish colleagues and increase social interactions across the sites. The increased trust and social interactions as a result of remote visits have enabled the distributed team members to get to know each other better and develop personal relationships that are being leveraged for sharing domain and process knowledge. The frequent and intense social interactions have been instrumental in improving the awareness on flow of information through different stakeholders and artifacts, and the knowing of processes to be followed for communication, collaboration, and coordination in different projects.

5. LIMITATONS

The potential construct validity threats [18] were minimized by using different sources of data as well as having both researchers participating in data collection activities. We used different data sources including interviews from both perspectives of onshore and offshore sites, observational study of joint workshop and related artifacts (i.e. presentation slides of workshop) to ensure triangulation of data. Furthermore, both researchers conducted most of the interviews and provided complementary explanations to clarify the questions for interviewee whenever required. The semi-structured interviews also enabled us to seek detailed answers through discussions with the interviewees.

We tried to ensure reliability [18] by audio recording and verbatim transcribing all interviews and workshop session. While the findings mainly result from researchers' interpretation of the data [21], we maintained our ongoing internal discussion to verify the findings and decrease risk of misunderstandings.

Our findings are based on a single case study in a particular context that threats external validity of findings.

Internal validity is a concern for causal or explanatory case studies in which researcher specifically investigates relationships between different variables [22]. Our research is based on exploratory case study and the proposed model (i.e. figure 2) aims to present researchers' findings and interpretations in structured manner. Thus it is not characterized as causal case.

6. DISCUSSION AND CONCLUSION

Our research has been motivated by the increasing importance of building an evidence-based body of knowledge for supporting successful GSE by identifying and understand the mechanisms of human-centric approaches to capturing and sharing knowledge about technical and process related issues. We discuss some of the main findings from the reported case study with respect to our research goal of identifying and understanding the strategies that can help GSD teams to form a common understanding of processes, activities, roles, and responsibilities for developing software, called ***process knowledge***. We decided to use the lens of organizational knowing, a theoretical concept that treats knowledge as construct of people's actions that can be supported through social interactions and behavioral changes.

We have explained that the concept of *Knowing* refers to knowledgeability of actions [9]. Hsieh argues that knowing is not only about understanding the knowledge (e.g., knowledge of process) but also continuously reflecting, adjusting, and acting upon the knowledge. She discusses that distributed team members are required to develop *collective knowing* from work and environment of each other for successful collaboration.

However, teams' capabilities for enacting shared knowledge are negatively impacted by distance factors (e.g., geographical, temporal, linguistic, and cultural) [10]. Our findings about the problems caused by lack of process knowledge (such as of low predictability of upcoming tasks and context switching, communication breakdowns, and interpersonal conflicts) are aligned with previously reported research about the negative impact of lack of process knowledge among geographically distributed staff. For example, process conflicts [3, 15] and unawareness [2, 12] are known GSD challenges. In the context of Requirements Engineering (RE), Bhat et al [11] showed that lack of shared process between client and vendor caused conflicts in collaboration on specifications. Damian enlists supporting inter-organizational structure and processes as strategies to facilitate knowledge sharing and acquisition of stakeholders in GSE [23]. Clarification of roles and responsibilities, building communication links, utilizing cultural liaisons as well as synchronization of inter-organizational processes are enumerated as practices to support interaction of distributed stakeholders [23]. While GSD literature usually discuss problem of lacking common process in the context of client-vendor relationships and larger organizations, our study revealed that it could be an issue in SMEs as well. In our study we observed that even though collaboration model of distributed sites represented more integration beyond client-vendor relationship, the distributed teams have been suffering from low visibility into organizational processes. The dynamicity of work and team structures, agility preferences and relying on ad-hoc collaboration of distributed teams caused missing a common vision of development processes (e.g. project initiation process).

Orlikowsky [9] identifies different strategies in large distributed organizations which could enable collective organizational knowing. Those strategies are developing shared identity, enabling face-to-face interactions, learning by doing, aligning efforts, and supporting participation. She argued that these practices can help distributed teams to know the organization, people, coordination mechanisms, and how to grow their capabilities for functioning in a team [9]. Our findings have revealed that many of strategies (such as Meta-level process improvement, virtual community of practice, and virtual joint workshops) implemented in the studied case have helped them to achieve the similar outcomes that are expected to be achieved by implementing the Orlikowsky's strategies for improving organizational knowing in a large distributed organization. Our findings complement to the previously reported strategies for organizational knowing, however, our findings are relevant to software developing process knowing in an SME setting.

We argue that achieving collective knowing in distributed organization is tightly coupled with enabling effective knowledge sharing within teams [8]. Thus, not only provision of knowledge to team members is important, but also the team should be empowered to interact, engage in discussions, provide constructive critique of the discussed ideas, and contribute to collective knowing of their team. Our findings show how knowing organizational process could be enabled in distributed SMEs with virtual integrated teams. Introducing process improvements and extensive elaboration during virtual workshop helped the participants to effectively share knowledge of *process knowledge* [24]. Sharing knowledge about whom we are, what we are accounted for and whom we should communicate with during the process helped distributed teams to develop shared understanding of roles, responsibilities, organizational goals and flow of information. Furthermore, we

can also conclude that enabling cross-functional communication links improved *access* [24] of distributed team members to sources of knowledge and increased awareness of individuals from ongoing tasks/ decisions during the process. Forming virtual communities (e.g., *WhatTeam*) has been helpful in formally bounding different functional teams and enforcing/ facilitating their interactions. On the other hand, remote visits and socialization activities informally shaped communication links between individuals.

The empirical evidence found through our analysis of the data gathered from multiple sources (i.e., interviews, observations, and artifacts) for this study has enabled us to conclude that the adopted practices have been helpful to get distributed teams *engaged* [24] in process and problem-solving activities. Introduced process improvements and forming virtual communities, e.g., *WhatTeam* enabled early involvement of different functional teams in the process and increases their contribution to problem-solving activities. The actions to clarify responsibilities of teams and aligning commitments with organizational goals (e.g., KPIs) have promoted increased interaction of team members for proactively seeking inputs and critically assessing proposed process changes and technical solutions. We can also conclude that regular two-ways visits of remote sites have helped in promoting continuous engagements and increased interactions that are facilitating both sides to keep the processes aligned through ad-hoc and informal communication and ease of reachability of the knowledge sources.

Our findings also show that developing social ties across distributed sites create *safety* [24] that is required for effective knowledge sharing. Building trust and shared identity has helped in the studied case to alleviate defensive attitudes of individuals and increase potentials to accept mistakes/misunderstandings. Social interactions also have eased initiation of contact and eliminated hesitations in seeking inputs from remote colleagues.

7. ACKNOWLEDGEMENTS

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