

Experiences From Global E-Collaboration: Contextual Influences on Technology Adoption and Use

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Abstract—The article presents a cross-case comparison of experiences from organizational adoption and use of e-collaboration technologies in two large global companies. Challenges in the global implementation process were found to increase with the organizational and geographical scope of the implementation, level of autonomy in the adoption process, cultural diversity, technological heterogeneity, and level of work process support embedded in the system. Alignment with existing collaborative work practices resulted in faster adoption of the technological solution. Highly competitive conditions restricted the resources available for training and experience transfer between projects. Clients' preferences for co-located project operations served as a potential barrier to the very concept of global e-collaboration. The study increases our understanding of the adoption and use of permanent e-collaboration infrastructures at the organizational level, thus expanding the focus of global e-collaboration research beyond the level of ad hoc, virtual teams.

Index Terms—Collaboration technology, cultural diversity, e-collaboration, groupware, infrastructure, information technology (IT) implementation, virtual projects.

To meet the opportunities and challenges from increasing globalization of markets and industries, companies restructure their operations according to new business models [1]. Virtual organizations [2], supply chain management [3], and collaborative commerce (c-commerce) [4] are all examples of such business models, often implying tight collaboration among organizations in different parts of the world. The enabling infrastructure for these forms of distributed collaboration is E-COLLABORATION TECHNOLOGIES, denoting all types of information and communication technologies (ICT) supporting communication, information sharing, and coordination between individuals and organizations. Examples of e-collaboration technologies include web-based team/project rooms (integrating email, instant messaging, group calendars, document management, discussion forums, etc.), desktop conferencing systems (integrating audio, video, and data conferencing), knowledge repositories, and workflow management systems.

The term GLOBAL E-COLLABORATION is defined here as the use of e-collaboration technologies for supporting collaboration among organizational members in two or more countries. In line with the general focus on globalization, the research on applied e-collaboration increasingly takes on an international or global perspective [5]. So far, most of this research has been centered on the global virtual team (GVT) as the most common way of structuring global e-collaboration [6].

However, most of the reported research on GVTs is still based on experiments with virtual student teams, and several studies indicate that this experimental research is not necessarily representative of real GVTs regarding team size, team members' experience, project duration, technology use, etc. [7], [8].

In general, we are still in the early stages of gaining experience on how to effectively implement and use e-collaboration technology for supporting various forms of global work. There are frequent reports of problems and challenges related to the use of these technologies in nonglobal contexts [9]–[11]. When expanding the scope of the collaboration to a global context, involving several countries with potential cultural diversity, language differences, and varying IT proficiency, this entails additional challenges for successful utilization of e-collaboration technologies [6].

To enhance our understanding of the potential challenges involved in applying e-collaboration technologies on a global scale, we need accounts of practical experiences from global projects of this nature. We contribute by presenting experiences and lessons learned from the implementation and use of e-collaboration technology in two large global organizations. Based on interviews with key personnel responsible for the implementation and use of e-collaboration technologies in these organizations, we highlight several potential challenges to global e-collaboration involving technical, organizational, and cultural issues, and discuss how these issues are related to different characteristics of global implementation contexts.

The next section presents a brief overview of research related to global e-collaboration, followed by a

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description of the two case studies. Experiences from the cases are then compared and discussed related to dimensions of the global implementation contexts. The concluding section discusses implications for practice and further research.

OVERVIEW OF RELATED RESEARCH

Information systems research has largely been dominated by the industrialized part of the western world (i.e., North America and Western Europe), both with respect to research institutions and organizations studied. Several researchers caution against transferring knowledge from this western context to other world regions without adaptation to these societies and cultures [5], [12].

A good illustration of the potential challenges of cross-cultural transfer of ICT is the case study of the implementation of an automated accounting system in two Latin American subsidiaries of a multinational airline company [13]. The system design and implementation was run by the US corporate headquarters. Chile was selected as the location for pilot implementation. This first implementation experienced major problems due to the lack of involvement of the subsidiary, language barriers (e.g., lack of Spanish-language training manuals), and other cultural problems related to managerial power, role assignment, and user resistance due to perceived negative effects on job security. Learning from these mistakes, the second implementation in the Panama subsidiary was organized differently, with stronger local involvement (including local management) and a selection of bilingual implementation team members. In addition, Chilean personnel participated in the training sessions, assisting the staff in Panama in solving problems and by supplying real life examples.

In response to the type of cross-cultural challenges outlined above, there is currently an increasing interest in and sensitivity to cultural aspects related to ICT adoption and diffusion in global settings [14], [15]. The research on global ICT can be broadly classified into two streams. The first focuses on ICT applications in different countries and world regions, studying how national culture and other contextual factors related to these parts of the world may influence the implementation and use of the technology [16]. The other stream of research focuses on the use of different forms of ICT on a global scale, that is, applications spanning several countries in different areas of the world.

Related to e-collaboration, there is also an increasing body of research documenting the global proliferation of these technologies. Some examples of studies from diverse countries and regions include:

(1) Alanis and Diaz-Padilla report the increasing use of e-collaboration technologies in Latin America (Mexico) [17].

- (2) Bajwa et al. conducted a comparative survey of task-oriented collaboration in the US and Australia, finding similar patterns regarding diffusion of the various e-collaboration services, although at a somewhat lower level in Australia than in the US [18].
- (3) Vreede et al. studied the application of electronic meeting support systems in three African countries, finding technology acceptance and use to be influenced by cultural factors such as computer literacy, oral communication preference, and language barriers [19].
- (4) Kock conducted an action-research study of the effects of asynchronous group support systems on process improvement groups in Brazil and New Zealand [20].

However, there are as yet few reported field studies of e-collaboration in global organizations. Most e-collaboration research in global settings so far has taken the form of virtual student team experiments, where ad hoc teams of students from different universities are formed for conducting virtual projects specified by the instructors as part of the coursework [21], [22]. These studies show that the students are able to adapt to this new form of work and accomplish meaningful global collaboration through ongoing electronic socializing and structuring of work interactions [23].

With GVTs becoming increasingly widespread in different industries, the GVT research is also expanding beyond these experimental academic settings to include field studies of GVTs in industrial settings. These studies illustrate how GVTs face additional challenges compared to more localized virtual teams. These challenges are both related to people issues (cultural diversity, language barriers, and discrepancies in technological proficiency) and technology issues (hardware and software accessibility, reliability, and compatibility) [6]. In general, the studies of GVTs emphasize the importance of training team members upfront in all aspects related to the teamwork, including cultural training, teambuilding, communication and language skills, and use of different technologies [6], [24]. Norms for accepted team behavior and interaction need to be developed and communicated to the different members [24], for example, in the form of a team contract [25]. This should also focus on the temporal rhythm of the teamwork, including frequency and balance between face-to-face meetings (when possible) and distributed interaction supported by different communication media [26]. It is generally agreed that face-to-face meetings are important in the early stages of a virtual team project for building relations, establishing a basis for trust, and developing shared norms guiding the further work [24]–[26].

The GVT research is characterized by a broad variation in research focus and settings regarding type of industry, tasks, team composition, project duration, and technology support [7]. Dubé and Paré thus argue for a contingency approach in analyzing virtual teams, identifying strategies and lessons that are contingent upon the team configurations [27]. This article expands the research focus beyond the GVT level to focus on the development of more permanent e-collaboration infrastructures in global settings, where adoption and use of the e-collaboration technologies take place at the level of organizational units rather than teams. This is the focus of the two case studies presented in the next section, providing experiences from the implementation of e-collaboration in two large companies operating on a global scale. The discussion of these experiences will focus on identifying characteristics of the global e-collaboration setting that have influenced the implementation processes.

CASE ILLUSTRATIONS

This section briefly outlines the methodological approach for data collection and analysis in the two case studies, followed by case illustrations focusing mainly on key issues and challenges in the two global implementation projects. More in-depth descriptions of the two cases are available in [11] and [28], respectively.

Method A multiple case study design was selected to enable studying variations in the phenomena in focus between different settings [29]. The two cases both included global implementation of e-collaboration practices, although with variation in the scope, contents, and technological platforms for these practices. Thus, the sampling strategy for this study can be characterized as a combination of criterion-based and maximum variation [30].

The main data source for these case studies was interviews with members of the implementation teams responsible for establishing the e-collaboration infrastructure in the two companies. In the first case, ABB Corporate Research, this involved interviews with the following respondents: program manager, process owner, and information system (IS) officer. In the second case, Kvaerner, seven interviews/meetings were conducted over a period of six years, involving five respondents holding the following positions: account manager, project coordinator, design manager, and IT managers of two different Kvaerner companies. In both cases, the interviews were semistructured, focusing on experiences related to the implementation and use of the e-collaboration infrastructure for supporting distributed collaboration. All interviews were taped and transcribed. Document analysis complemented the interview data in both cases. The longitudinal

nature of the Kvaerner case study also gave the possibility for capturing the development in the company's appropriation and use of e-collaboration technologies.

The data analysis involved two steps. First, data from each case study was analyzed for identifying issues related to the adoption and diffusion of global e-collaboration. Second, cross-case comparison was conducted for identifying common and contrasting findings, analyzing the influence of different contextual dimensions on the results in each case. These contextual dimensions are introduced in the section on discussion of case experiences following the case illustrations.

Global E-Collaboration in ABB Corporate

Research This study focused on the development and implementation of a Lotus Notes application in ABB Corporate Research. Asea Brown Boveri (ABB) is a worldwide engineering group with approximately 115,000 employees in over 100 companies, including more than 800 researchers working in eight corporate research centers (six in Europe and two in the US). The research activities are organized in programs spanning all research centers, with reporting conducted by program.

Lotus Notes formed the infrastructure for information sharing and coordination in the ABB group, with corporate research being at the forefront of Lotus Notes deployment. They developed a Notes application supporting the entire workflow in the research process, including idea generation, strategic planning, management, and reporting. The implementation of this system was led by a core team consisting of the IS officer in Norway, the process manager in Sweden, and the project leader from the IT department in Zurich, Switzerland, in close collaboration with the IS officers in each research center. The team experienced several technical challenges. Different time zones led to large global variations in response time, making replication of the Notes databases a complex issue. Performance and stability of the system varied greatly across the different technological platforms in the research centers. The complexity and resources involved in systems administration in this distributed environment created a need for developing meta-processes for automating tasks such as roll-out, upgrades, and access control. According to the process owner, what the users see only constitutes 20% of the entire system.

The system became a major work tool in the daily operations of the research centers, with adoption being fostered by explicit pressure from top management and positive publicity in internal news channels. Strong emphasis was put on providing information and training to the users, also including videos, and CD-ROMs for self-training. Although some successful workshops and training seminars

were arranged, the costs involved (especially for US attendants) limited the use of such forums.

The implementation team also experienced challenges related to cultural diversity among the research centers. The process owner described this as having eight different cultures to relate to, originating from differences in national culture regarding decision making and ways of communicating. This was particularly influential in the design and application of the workflow functionality in the system, with hierarchical vs. nonhierarchical decision structures resulting in the tools being used differently and the roles of the users varying in each center. For example, in some labs the project leader gets to do more, while in others the controllers are doing this. The processes can therefore not be identical. According to the process owner, some of the research centers in central Europe also regarded it as somewhat controversial that the implementation was led from Sweden, with language barriers also imposing a challenge.

The system created a need for changing administrative routines such as production of economic reports. Due to the time lag in the replication process, each client in the system could contain different figures. An economic report was therefore defined as a snapshot of the economic status at the time and place where it was compiled, with trends being made by producing a series of such reports. Global balancing was only done in exceptional cases, as this required shutting down the entire system. This again required new ways of balancing accounts. Further, the transnational flow of information between the research centers also raised new legal issues related to the ownership of this information.

Four months after the installation of the system, the process owner stated that the system had become mission critical to the work process in ABB Corporate Research, and that the workflow would be delayed if the system did not work. According to the program manager, Lotus Notes was now used throughout the whole project process. He estimated that 80% of his work was conducted through Lotus Notes, characterizing the tool as extremely effective.

Establishing a Global E-Collaboration

Infrastructure in Kvaerner This case studied the implementation of a global area network in Kvaerner, a Norwegian-registered engineering group with over 35,000 permanent staff located in almost 35 countries throughout Europe, Asia, Australia, and the Americas. The main business areas of Kvaerner are engineering and construction, oil and gas, and shipbuilding.

In 1995, Kvaerner signed a contract with Telenor in Norway for developing KINET, a global area network based on frame relay, supporting voice, email, and

data communications worldwide in the Kvaerner group. In addition to saving communication costs, the strategic goal of the KINET implementation was to increase collaboration and coordination among the Kvaerner companies by establishing Centers of Competence that could be accessed through KINET. The network was built around four regional hubs, in Oslo, Atlanta, London, and Singapore.

The implementation of KINET was run by a small operation based in Oslo. Although initiated by central management, adoption of the technology was discretionary for each company in the group. This decentralized adoption process turned out to be slower than expected and involved a lot of friction, with the implementation team spending much time and many resources on marketing KINET in the different companies. Several companies did not see a need for this technology, as their level of collaboration with other Kvaerner companies so far had been low. The more political concerns of maintaining existing relations with local suppliers and vendors were given higher priority than initiating collaboration with remote companies within the group.

Cultural differences also added to the complexity in the decentralized adoption of KINET, with formality and structure of decision processes varying among the companies. Generally, developing a common culture in a distributed organization like Kvaerner was regarded as extremely difficult, if not impossible. This was also due to the fact that the majority of the Kvaerner companies had been acquired through takeovers and mergers, often without even changing the management. Still, the potential for KINET to contribute to the development of a more common culture in Kvaerner was used to some extent in the marketing of the network.

In general, the implementation team experienced a clear need for adapting their presentation and marketing of the technology to the local culture and needs of each company, thus requiring assistance from local IT coordinators. Several companies also complained about the costs involved. To establish a critical mass of users, Kvaerner had to sponsor the initial connection costs by providing regional access nodes.

The heterogeneity in size and technical infrastructure of the Kvaerner companies imposed technical challenges in the implementation. The technology chosen for KINET was inflexible for supporting the needs of the small operations far away, and additional solutions had to be developed for these offices to be able to access the network. Further delays were created by the protective policies enacted by national telecommunications companies in China, Singapore, and Indonesia, posing strict regulations for British Telecom as the subcontractor in this region.

Despite the problems outlined here, after two years the entire Kvaerner group was linked to KINET, with traffic increasing steadily and its importance referred to as mission critical. In addition to email, Kvaerner applies a suite of proprietary systems for supporting their distributed project operations, including a document management system, engineering databases, and a project management tool. These systems enable Kvaerner to move their operations between several locations worldwide during different stages of a project. As an example, a major design project in the oil and gas division involved collaboration among engineers in Oslo, Monaco, Abu Dhabi, Korea, Singapore, Perth, and Freemantle.

An important problem related to the effective use of these services is training of the temporary workforce. A large number of agency engineers are hired to work on the projects, and these need to be trained in Kvaerner's proprietary systems. However, this is often restricted by time and budget constraints. As part of Kvaerner's B2B strategy, external parties such as clients and vendors are increasingly given access to the electronic project archives, creating new legal challenges related to ownership of the documentation as this develops throughout a project.

With the reorganization of Kvaerner, a number of regional offices with specific competence areas have been established, such as metals in Stockton, UK; oil and gas in Perth, Australia; etc. Projects in these areas tend to be channeled to these offices, and thus the Centers of Competence vision has been partly realized. However, although KINET and the document management services support distributed operations, there are several examples of how the client's preference for co-located project operations may constitute a barrier to applying a best practice approach based on distributed engineering. As expressed by the IT manager at Kvaerner Australia:

The idea was to have these centers of excellence and use the network to tie them together. The problem has been, though, that the clients typically don't want to have remote processing. They like to have the project and project task force in their city. So we do have a lot of client resistance to that vision.

Further, disciplinary boundaries between the different divisions as well as tight project deadlines restrict the use of KINET for experience transfer between these centers. Thus, despite the gradually successful diffusion of KINET, and its perceived status as being mission critical for the Kvaerner operations, the vision of using KINET for transforming Kvaerner into a virtual engineering company based on Centers of Competence has not yet been fully realized.

DISCUSSION OF CASE EXPERIENCES

Several potential challenges to global e-collaboration are contained in these brief case illustrations. Table I

TABLE I
Challenges to global e-collaboration

		Challenges Identified	Case	
Organizational adoption	O1	Decentralized adoption process	A	K
	O2	Establishing a critical mass of companies/users		K
	O3	Lack of incentives for adoption by individual companies		K
	O4	External relations to local suppliers and vendors		K
	O5	Adaptation to local culture and needs	A	K
	O6	Cultural diversity related to decision-making and communication	A	K
Deployment	D1	Heterogeneous technical environments	A	K
	D2	Hardware and software accessibility, reliability and compatibility	A	K
	D3	Systems administration in global environments	A	
	D4	Synchronization of databases across time zones	A	
	D5	Protective policies enacted by national telecommunications providers		K
	D6	Logistics and costs for arranging training seminars and workshops	A	
Utilization	U1	Training of temporary workforce		K
	U2	Establishing new administrative routines (e.g. economic reporting)	A	
	U3	Legal issues in transnational information flows and B2B collaboration	A	K
	U4	Cultural diversity, e.g. related to definition and execution of roles in workflows	A	K
	U5	Disciplinary boundaries		K
	U6	Clients' preferences for co-located project operations		K

¹Challenges were identified in one or both of the two cases: A = ABB Corporate Research and K = Kvaerner

groups these challenges according to the three major stages in the process of establishing a global e-collaboration infrastructure: ORGANIZATIONAL ADOPTION, involving buy in from the organizational units participating in the global collaboration; DEPLOYMENT of the technology involving roll-out, establishing procedures for systems management and user training; and UTILIZATION, where the technology is incorporated into the daily work routines. These stages represent a simplified version of the implementation process model developed by Kwon and Zmud [31], and serve the purpose of illustrating

how different challenges were identified during the entire process of adoption and diffusion of these technologies in each case.

By comparing the two cases, we may identify potential influences from the implementation context on the appropriation and use of the e-collaboration technologies. Here the term IMPLEMENTATION CONTEXT refers to the combination of the organizational, cultural, project-related, and technological contexts framing the implementation process [11]. Based on the challenges identified in Table I, Table II presents a set of dimensions in which the characteristics of the global e-collaboration context in each case are compared and discussed, as are their effects on e-collaboration adoption and use. For each dimension, the numbering in parentheses indicates the related challenges in Table I.

Overall, the implementation project in ABB Corporate Research may appear to be more successful than in Kvaerner, in terms of faster adoption of the system and fewer reported problems during the implementation process. However, Kvaerner also finally reached the targeted goals regarding diffusion and adoption of the technology. These findings also need to be related to the varying scope and complexity of the two cases. While more challenges were identified related to the organizational adoption process in Kvaerner, the technological complexity of the Lotus Notes system in ABB Corporate Research resulted in other challenges related to systems performance and management. In the following we discuss the experiences from the two cases related to each of the contextual dimensions in Table II.

In general, the experiences from the two cases reflect the difference in organizational and geographical

TABLE II
Influences of global e-collaboration contexts in the cases studied

Contextual dimensions (see Table I)	Characteristics of global e-collaboration contexts		Effects on e-collaboration adoption and use
	ABB Corporate Research	Kvaerner	
Organizational and geographical scope (O1, O2, O5, O6, D1, D3, D4, D5, D6, U3, U4, U5)	Eight research labs in six European countries and the US.	Entire Kvaerner group, >100 companies in Americas, Asia, Australia and Europe.	The organizational and geographical scope of the global e-collaboration contexts implied challenges related to organizational adoption, technological deployment, systems administration, training, and cultural diversity. Overall, the greater global distribution in Kvaerner was found to result in more challenges than in ABB Corporate Research.
Level of autonomy in the decentralized adoption process (O1, O2, O3)	Top management decision to use Lotus Notes as infrastructure. Some level of autonomy related to adoption and adaptation of the solution in each lab.	KINET solution originally a top management initiative, but lack of explicit top management backing during implementation process.	A higher level of autonomy in the adoption decision process combined with limited top management backing resulted in a slower adoption process in Kvaerner.
Alignment with existing work practices (O2, O3, O4, O5, U6)	Lotus Notes application tightly integrated with reorganized work process for distributed research projects.	KINET solution intended to foster new collaborative work practices among Kvaerner companies.	More intuitive benefits from the ABB solution, anchored in the need for support for reorganized work process. Slower process of building critical mass in Kvaerner, due to initial perceived lack of adoption incentives among Kvaerner companies.
Cultural diversity (O5, O6, D5, U4)	Some manifestations of cultural diversity in the form of organization and decision-making processes in different research labs.	High degree of cultural diversity, both at the level of national and organizational culture.	Need for cultural sensitivity was an issue for the implementation teams in both cases, but reported challenges were greater in Kvaerner due to more heterogeneous company structure.
Solution scope (D3, U1, U2)	Lotus Notes application providing detailed support and structuring for core work processes in research centres.	Technological solution supporting basic network infrastructure, with disciplinary engineering applications implemented for different Kvaerner divisions.	Higher degree of work process structuring embedded in the ABB solution resulted in more explicit focus on systems administration, routines, and training needs than for the more general network solution in Kvaerner.
Technological heterogeneity (D1, D2)	Some problems with varying performance of Lotus Notes application on the different technological platforms in the research centers.	Large degree of heterogeneity in technological platforms, reflecting the variation in company size from small regional offices to construction companies with thousands of employees.	Technological heterogeneity was an issue in both cases, affecting stability and performance of the technological solution. Challenges were experienced at a more overall level of network topology in the Kvaerner case.
External relations (O4, U6)	Mostly serving internal customers in the ABB group.	Mainly conducting projects for external customers in highly competitive markets. Strong relations to local suppliers and vendors.	Stronger influence from external relations identified in the Kvaerner case. Existing relations to local suppliers were a barrier in the adoption process. Competitive climate limiting resources for training, knowledge sharing among divisions, and imposing requirements for project organization.

scope between these two global implementation projects. While the implementation in ABB Corporate Research included a relatively small subset of the entire ABB group, located in the US and Europe, the KINET implementation targeted the entire Kvaerner group involving over 100 companies in four continents. In both companies the adoption process was of a decentralized nature, with decisions related to the adoption made by each unit. However, the level of autonomy in these decision processes varied between the cases. In ABB Corporate Research there was a strong management backing for implementing the new solution, as this was closely related to the core working process of the research center. The autonomy in this case was thus related more to local adaptation of the solution in each unit rather than whether to adopt. In Kvaerner, the top management backing was less explicit, and the Kvaerner companies were actually in the position to reject adoption.

A related aspect is the alignment of the technological solution with the existing work processes in the companies. In ABB Corporate Research, the implementation of the Lotus Notes application was an important element in the reorganization toward cross-national research programs. Thus, the rationale for implementing the technology and the potential benefits for project efficiency were clear to the adopting units, and the adoption decision did not imply particular problems for the implementation team. In contrast, although the KINET implementation in Kvaerner was also linked to the vision of establishing Centers of Competence, this was at a more strategic level and not explicitly linked to the perceived needs of the Kvaerner companies. As a result, these companies lacked explicit incentives for adopting the technology, representing a barrier in the process of establishing a critical mass of adopting units. Another barrier was the relation to local suppliers and vendors, raising political concerns about entering new collaborative arrangements with other, remote Kvaerner companies.

The truly global scope of the KINET implementation also resulted in cultural diversity being more of an issue in this case, requiring learning and adaptation in the cross-cultural marketing and transfer of the technology solution. The problems experienced by the KINET implementation team in their first attempt at transferring the technology to companies in the group are similar to the problems of cultural adaptation reported in the Latin American case study referenced earlier in this article [13]. Similar to that case, Kvaerner found it important to use local ICT coordinators in implementation in the different offices. Influences at the regional level manifested in the form of varying restrictions imposed by several national telecommunications providers in Asia. Cultural differences were also identified in the ABB case but were more related

to the challenge of incorporating local variations in decision making hierarchies and roles in the design and implementation of workflow support. This finding again is related to the different scope of the technological solutions implemented. While KINET served as the basic network infrastructure on which the different Kvaerner companies established their various e-collaboration services (engineering data repositories, enterprise document management, desktop conferencing, etc.), the Lotus Notes application in ABB Corporate Research comprised detailed workflow process support. The latter thus implied extensive requirements and challenges related to specifying routines and roles, providing adequate training material, and implementing advanced solutions for global systems administration. The technological challenges experienced in Kvaerner were mainly related to the extensive heterogeneity of the technical environments to be connected through KINET, and to solving incompatibility problems with existing email systems and other applications. In comparison, technological compatibility was not a major issue in ABB Corporate Research, as the different units were already using Lotus Notes as their main work tool. Here, the problems were more related to improving system performance on the different platforms in each research center, etc.

The influence from external relations with customers and suppliers was most evident in the Kvaerner case. In contrast to the research centers in ABB, the engineering companies in Kvaerner are fully dependent on winning contracts for external projects. This highly competitive situation often results in limited training budgets, although Kvaerner tries to convince the customers of the importance of including this for establishing effective project operations. The frequent use of temporary engineers in Kvaerner makes this a particular challenge, as they need to be trained on Kvaerner's proprietary engineering systems.

The tight budgets and time constraints were also found to limit the possibility for systematic capture and transfer of project experience, as the budgets simply did not include time for extensive project write-ups. Further, both companies experienced new and unforeseen challenges related to legal aspects of information ownership and transfer in their international cross-organizational operations. In Kvaerner, disciplinary boundaries between the different divisions also constituted a barrier to the vision of Centers of Competence. Finally, customer preferences for co-located project operations sometimes made it impossible for Kvaerner to run projects according to their perceived best practice of distributed engineering.

The challenges listed in Tables I and II are explicitly related to the global e-collaboration setting of the two

case studies. In addition, several challenges were identified related to the general use of e-collaboration technologies in the two case companies, such as creating incentives for sharing information and knowledge, and inducing personnel to populate the engineering databases with data that were only of use for later stages in the project. Many of these challenges are instances of generic challenges of groupware development and adoption [32], such as critical mass problems (encountered at the company level in the Kvaerner group), disruption of social processes (as related to the workflow design in ABB Corporate Research), the need for unobtrusive accessibility of the collaborative tools (as experienced by Kvaerner in their training of temporary workforce in the use of proprietary systems), and disparity in work and benefits (as perceived by the Kvaerner engineers required to enter data for future use). This illustrates how studies of global e-collaboration necessarily need to build upon existing research on e-collaboration adoption and use in nonglobal settings.

CONCLUSION AND IMPLICATIONS

Previous research has reported many pitfalls in the deployment and use of e-collaboration technologies. Applying these technologies in a global context introduces even more challenges in the form of larger diversity in organizational practices, culture, and technical infrastructure. The case studies discussed in this article identified a range of challenges related to the implementation of global e-collaboration, and showed how these challenges were related to different characteristics of the global implementation context. These findings expand our knowledge of global e-collaboration beyond the level of GVTs.

It is important to note that the case organizations have been able to gradually overcome many of these challenges through a process of learning and experience building backed by the resources available in these large organizations for ongoing support of the implementation process. Organizations pursuing this type of work arrangement should thus not expect a quick route to success, but rather prepare for a gradual learning process that may span several years. Adaptation to local cultures and needs,

creation of incentives for technology adoption in each global node, and development of norms for effective teamwork and related use of various e-collaboration technologies are all instrumental for succeeding in this process. This again requires adequate training in both team and technology skills. E-collaboration technology can also play an important role in this, as collaborative tools for communication and information sharing constitute important elements of the rapidly growing market of e-learning products [25]. Use of internet-based e-learning services can make training programs more accessible for participants from different world regions, and may support the transfer of experiences and best practice related to global e-collaboration.

Further research should identify and disseminate best practices by conducting more field studies of global e-collaboration in different settings. This study has illustrated the importance of contextual influences on the nature of global e-collaboration implementation and use. Further studies could explore in more detail the relationships between different contextual dimensions and e-collaboration success in global settings. There is still a need for developing knowledge on how different e-collaboration tools can be best combined and applied in a coherent way for performing global collaborative tasks. Establishing more guidelines for this would enable teams and organizations inexperienced in global e-collaboration to more quickly reach an effective mode of operations, and thus reduce the time needed for building hard-earned experience through trial and error.

The findings from the Kvaerner case also highlight an important question for further research on the potential limitations of global e-collaboration: How can companies operating in highly competitive climates such as Kvaerner facilitate effective experience transfer and cross-functional learning of the nature increasingly being advocated in the literature on communities of practice [33]? The clients' resistance toward a virtual project organization is also a useful reminder that global e-collaboration is still at a relatively early diffusion stage and has yet to become a universally accepted practice in all industries.

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