

■ Research Article

Information Management Barriers in Complex Research and Development Projects: an Exploratory Study on the Perceptions of Project Managers

Vitor Ricardo Santos^{1,2*}, António Lucas Soares^{1,3} and João Álvaro Carvalho^{2,4}

¹INESC TEC–Institute for Systems and Computer Engineering of Porto, Porto, Portugal

²Department of Information Systems, School of Engineering, University of Minho, Guimarães, Portugal

³Department of Informatics Engineering, Faculty of Engineering, University of Porto, Porto, Portugal

⁴Algoritmi Center, School of Engineering, University of Minho, Guimarães, Portugal

Many organizations depend on the success of rapidly deployed, limited time frame and multipartner projects as an important element of their business strategies. Information management is regarded as a critical and upmost important issue, especially in projects. Complex projects require additional team collaboration and a consistent information management strategy to support the development of the project. This paper reports the findings of an exploratory study on information management barriers in complex projects, particularly focusing issues and difficulties recognized by project participants and managers. Our study intends to fill the gap in empirical research regarding this subject and to provide new insights for project managers of complex projects to devise more effective information management strategies and tools to set up and run information technology platforms. Copyright © 2012 John Wiley & Sons, Ltd.

INTRODUCTION

In today's economy, enterprises need to achieve shorter innovation cycles. There is also a demand for more and more complex solutions, requiring time-and-place flexible coordination tasks. This can be especially seen in geographically dispersed companies (Klauß, 2008).

The key characteristics of projects are the interdependence of knowledge and skills, the complexity and unpredictability of tasks and problems, and the time line characteristics (Mian *et al.*, 2008). From this perspective, projects can be considered as manifestations of structured, collaborative, and coordinated actions. They involve several participants and organizations that work together to accomplish goals in a determined period. For the

purpose of this study, we will define complex projects as multidisciplinary projects involving research and development activities, carried out by multipartner international teams of different nature (small and medium enterprises, large companies, research centers, etc.) and executed in a geographically distributed environment.

Information management in complex projects poses considerable challenges. These may regard lack of management continuity, absence of standard processes, limited time frame for the execution, and different organizational and technical terminologies. Our study has also identified the following: difficulties in controlling documentation, inadequate information technology (IT) support at disposal, information overload, dispersion of information among different institutions and/or participants, difficulties in updating and adapting information, lack of time for efficient information management, and the codification process of information.

*Correspondence to: Vitor Ricardo Santos, INESC Porto and Universidade do Minho, Rua Dr. Roberto Frias, s/n 4200–465 Porto, Portugal. E-mail: vsantos@inescporto.pt

There are also two critical features that pose a challenge for the design of information architectures: increasing collaborative and distributed practices and the different social contexts (multi and interorganizational) involved. These features introduce one key problem: the effort to set up situational and contextual information management strategies and platforms in a time frame compatible with the duration of the project. Therefore, the study and development of approaches that cuts time and effort to design and implement information architectures and processes for complex projects would be highly advantageous, thus making more effective and efficient the management of complex projects.

Information management improvements in complex projects not only concern developing new IT concepts. They also regard providing a sound guidance to the setup of collaborative processes involving informational content within the project management activities. The development of such methodological guidelines and associated tools needs to be informed by the information behavior of individuals and teams in complex projects and contextualized by the technological and cultural environments. However, current typical project management frameworks and guides, such as the Project Management Body of Knowledge, deal mostly with “document management” as standing for information management and “communication” as standing for collaboration and knowledge sharing.

The research conducted on information management in projects, even more large-scale and/or complex ones, is very scarce and limited. Additionally, the research reported is not directly or entirely dedicated to this subject or even regards empirical research. For instance, Turner (2010) editorial presents the evolution of project management research as evidenced by papers published in the *International Journal of Project Management*. He argues that over the past 20 years, the quality of the project management research has improved. The improvement can be seen in the variety of topics covered by the papers published. In 1987, there was an average of about one and a half topics covered, whereas in 1997 and 2007, an average of two topics was covered; in 2007, many papers covered three topics. However, from 1987 to 2007, according to the table presented, there is only one paper in the topic “Managing information” and it was only published in 2007. This demonstrates the absence of work in this area and the upmost demand for research in the context of information management in complex projects.

This paper is organized as follows. First, a summary of the current issues regarding information management and project activities is presented. Then, the methodology used is addressed. Afterwards, the findings concerning information management

barriers in complex projects are presented. Finally, conclusions and implications for information management in complex projects will be discussed.

INFORMATION MANAGEMENT AND PROJECT ACTIVITIES

In the present time, the major organizations have decentralized and flexible structures, working with information systems that need to handle numerous information sources. These information systems are socioeconomic systems that include software, hardware, and the organizational structure (Ahlemann, 2009).

Consequently, information management is more than just technology because equally important are business processes and practices that support the use of information, as well as the information itself. This includes the structure of information: information architecture, metadata, and content quality (Wilson, 2002). However, information management is not an easy task. There are many systems to integrate, business needs to meet, and complex organizational and cultural issues to address (Robertson, 2005).

According to Detlor (2010), there are three major information management perspectives: organizational, library, and personal. For the purpose of our work, we will follow the organizational perspective, which deals with the management of all information processes involved in the information lifecycle. The goal is to help the organization in reaching its competitive and strategic objectives. Accordingly, we see information management as the management of the processes and systems that create, acquire, organize, store, distribute, and use information to help people and organizations to access, process, and use information (Detlor, 2010).

There are several challenges in managing information in engineering organizations, particularly the increasing volume of information. This is due to modern industries becoming more dynamic in nature and presenting diverse and complex work tasks, trading relationships and environments. Additionally, the temporary and transitory nature of workplaces and workforces has increased (Zhao *et al.*, 2008). As a result, information flow is essential in engineering contexts because difficulties inherent to concurrent engineering regard the completeness, timeliness, and interpretability of the information (Johansson, 2009). For instance, in the construction industry, information flow is mostly manual. Numerous paper documents and drawings are dominant in practice, and the management of loose documents is often very time-consuming, thus reducing the productivity significantly (Wang *et al.*, 2007).

Project management can be considered the appliance of techniques, skills, and tools to project activities to attain certain objectives. It is also accomplished through the application and integration of different tasks of initiating, planning, execution, monitoring and controlling, and closing (Mohammadi & Khalili, 2008). Failure in a project can be regarded as lack of success of the defined mission or drastically exceeding planned costs or schedule (Valerdi & Davidz, 2009).

In addition, complex projects share the characteristics pointed by Eriksson *et al.* (2002). These concerns challenge in language, time zones, organizational and personal cultures, policies, regulations, business processes, political climates, cultural differences, distance problems, communication problems, leadership issues, differences in perception of the world, and team learning. Ireland (2007) confirms the general perception that project complexity has different interpretations according to personal experiences and training. He argues that projects have two primary areas of complexity: technical and management. Technical complexity regards specification difficulties that lead to a design to meet the client's needs, thus providing the product or service. These may include number of pieces, parts, components, or assemblies; technologies involved; number and types of external-to-product interfaces; and innovative or state-of-the-art technology involved. Management complexity regards the business aspects of the project such as financial arrangements, design of the management structure, schedules, staff with proper skills at the right time, and organizational interfaces.

"A question that arises from this discussion is the metric that would apply to a project to put it into the complex category. This has not currently been established and is required to provide some threshold to the inevitable notion that most projects possess some degree of complexity" (Whitty & Maylor, 2009).

We will follow Robertson's (2005) practical approach to information management as encompassing people, process, technology, and content. Therefore, we will consider people as the project managers, project participants, and researchers; process as the management and technical processes that compose and drive a project; technology as the communication tools and platforms used to support team's work; and content as the information that flows in the communication tools and is stored in platforms.

In complex projects, there are several types of information, in different languages and formats, flowing in the communication tools and platforms: structured (specifications, requirements, technical drawings), unstructured (notes from meetings, conversations via instant messaging), multimedia content (demo videos, product photos), documents (manuals,

bibliography), formal (deliverables, authorizations), informal (brainstorm remarks, invitations), administrative (budgets, time cards), and technical (blueprints, software code). Different communication tools and information systems can be used to manage the several types and formats of information, among others are: web content management, document management, records management, digital asset management, learning management systems, video-conference, enterprise search, project management systems, enterprise resources management, instant messaging, and computer-assisted design.

Our research goal was to study the information management behavior and explain the information management barriers that occur in the collaborative processes of complex project development. Ultimately, we intend to help project managers of complex projects to devise more effective information management strategies and tools to set up and run IT platforms.

METHODOLOGY

The main focus of this study is to describe and explain the information management barriers that emerge from the collaborative activities of complex projects. The research question addressed is: what are the information management barriers in the context of complex projects?

The results presented here are the second and last part of a wider study on the topics of information management, knowledge sharing, and project management activities in large-scale/complex projects (Santos, Soares, & Carvalho, 2012). These three categories were used to analyze what subjects perceived about these areas. To achieve the purpose of our study, exploratory semi-structured surveys with individuals from six countries (Portugal, Germany, Spain, United Kingdom, Finland, and France) were conducted.

As seen in the works of Ratcheva (2009) and Ochieng and Price (2010), the data collection involved 24 exploratory interviews (17 face-to-face, 6 via videoconference, and 1 via telephone) over a period of 4 months (November 2009 to February 2010). We also followed Ochieng and Price (2010) approach where a range of organizations in terms of status, size, and projects managed was used. The interviews were conducted with complex project participants, researchers, and managers. These involve persons with solid experience in the area, working in research institutes, universities, IT corporations, and industrial associations. Our intention was to explore a variety of multicultural issues in the context of international project management activities. Therefore, multiple sources of evidence were gathered that would validate general findings and omit possible bias (Ochieng & Price, 2010). The participant's background and experience ranged

from mechanical systems, information systems, multimedia, power systems, industrial management, and construction.

The interviews were conducted using open-ended questions that were derived from the initial research questions and literature review. Before the beginning of the interviews, there was a short conversation with all the interviewed. The context, concepts, and goals were explained to clear any doubts and obtain accurate answers. The questions that guided the interview were the following:

- (i) In your opinion, what are the main challenges in managing information in projects? Why do you think they happen?
- (ii) Can you please describe how your team usually collects and shares information?
- (iii) Do you use information and/or knowledge management software? What are the main deficiencies that you can identify? How would you improve it?
- (iv) How does your team create and organize the information in the information system? Why it is done in that way?
- (v) How do you think information management and knowledge sharing could be improved in a project management context?

Because of the lack of an information management theory in the context of projects, we followed Shachaf's (2008) approach. Consequently, the exploratory interviews were recorded, transcribed, and the interpretation of the text passages was performed using a coding scheme that was developed according to the literature review. This way the coding process allowed additional concepts to emerge from the data, and the subcategories of the coding scheme were developed during the process. "The theory was generated through an inductive method because of the lack of a comprehensive framework for conceptualizing the important elements and their relationships" (Shachaf, 2008). Additionally, the coding scheme was developed using of a concept map. The concept map addressed three major areas: information management, knowledge sharing, and project management activities.

According to Kvale and Brinkmann (2009), typical modes of interview analysis consist of analyses focusing on meaning, analyses focusing on language, and general analysis. The mode chosen for the interview analysis was the analysis focused on meaning. This approach follows the traditional understanding of knowledge as pre-existing elements that can be collected, that is, coding that attempts to bring out what already exists in the texts (Kvale & Brinkmann, 2009). The qualitative analysis software used was NVivo 8 (QSR International, Cambridge, MA, USA). A similar approach can be seen in Hanisch *et al.* (2009), Kvale and Brinkmann (2009), and Ochieng and Price (2010).

Following the findings in each area, the key references and area of work of the participants will be

presented, providing evidences and allowing a better understanding of complex project environment.

INFORMATION MANAGEMENT BARRIERS TO PROJECT MANAGEMENT

This section addresses the findings regarding information management barriers in complex projects. The categories were used to code what subjects perceived as difficulties and problems in the development of the project work. In the succeeding text, the evidences (only some key references) that support the conclusions will be presented, thus enabling a better understanding of the complex project environment. Table 1 shows the seven major barriers to information management that emerged from the content analysis. A total of 83 references to such barriers were identified in the 24 sources.

IMB1: Documentation control

The results demonstrate that *documentation control* is the major information management barrier in complex projects and that it can influence the efficiency of the projects. Participants argue that it is not easy to develop standard templates for the project documentation. However, they are crucial otherwise will lead to inconsistencies in content and structure as well as the development of documents that are not uniform. This issue is impacted by the different organizational cultures because we are dealing with teams that have different methodologies and work practices.

In addition, a project participant is usually assigned to gather and deal with the different contributions to the work package at hand. However, because the document sections were written by different participants, the final document is not coherent. This refers to the absence of work in real time in a document, thus allowing the other partners to monitor the changes immediately. This aspect leads to what the subjects referred to as "document ping-pong", where the documents are constantly exchanged within the project network via email.

Complex projects require a more flexible approach to documentation and multimedia components to facilitate the comprehension and avoid

Table 1 Information management barriers results

IM barriers		References
IMB1	Documentation control	21
IMB2	Inadequate IT support	16
IMB3	Information overload	15
IMB4	Dispersion of information	10
IMB5	Updating and adapting	11
IMB6	Lack of time	6
IMB7	Codification process	4

IM, information management; IT, information technology.

misunderstandings among participants. Additionally, instead of creating and using formal documents (creating a document or chapter and sending it by email or uploading it to a portal), it is necessary to adopt an iterative and real time work approach to documents (for instance, as Google Docs).

In short, documentation control in its various forms (structured and unstructured, administrative and technical, draft and final) is a critical aspect in projects. This barrier refers to such aspects as the following:

- absence of document templates, leading to inconsistent content and formats;
- issues in numbering and versioning documents;
- issues with user hierarchies and permissions in the update and overwrite of documents;
- excessive exchange of documents via email;
- issues in controlling published and updated documentation;
- convergence of approaches and methodologies in a single deliverable or work package;
- need for more iteration of long documents (for instance, requirements or proposals); and
- need for more customer participation in developing documentation.

"It is common not to have a common template, and what happens? Everybody collaborates in the other person's documents, and when we try to merge the documents they do not fit, not only in format but also in structure. Frequently, the result of a determined task is a document that is composed of different parts that are not similar, so the document is not a whole unit as it should be" (x1, Power Systems).

"When we use email several versions of the same document are created, which are all the potential receivers of the document, then someone will have to deal with the individual contributions" (x7, Manufacturing Systems Engineering).

"... I was looking for a document from a project that has been finished. I had 27 versions of that document, and I wasn't sure if the last one was the updated one. Of course I contacted the project manager and he had it, but this is not very reliable" (x15, Power Systems).

IMB2: Inadequate IT support

The second major barrier to information management was *inadequate IT support*. Participants argue that existent platforms do not support project activities properly, and they cannot find tools that adequately facilitate collaborative work. According to them, platforms should be able to deal with individual contributions to the work packages and

provide efficient coordination. Specific issues include difficulties in uploading large documents forcing them to use parallel systems, such as web storage. Consequently, this hampers the information centralization in a unique platform. Additionally, platforms used only provide search and retrieval features in textual documents. However, in complex projects, different types and formats of documents (photos, videos, diagrams, schematics, mathematical files, etc.) are used and exchanged.

It has also been pointed that there is no proper integration between the technical and administrative areas. Teams have to use two or more platforms to control activities, deliverables, budgets, human resources, and schedules. Consequently, information is scattered along different systems. This has also been pointed by Eriksson *et al.* (2002) because they argue that complexity increases when different systems grow together. For instance, control systems merge with administrative business systems, and data is expected to flow between information systems. Therefore, integration of different areas should be considered and the development of a standard interface and interoperability between systems.

In a nutshell, this information management barrier concerns the absence of IT platforms and tools to effectively support complex projects. Limitations include such aspects as the following:

- information system's failure in handling large files or different file formats (forcing participants to use email in exchanging files) and
- inadequate IT platforms to support collaborative work in geographically distributed environment, absence of multiformat search features (text, graphical/visual).

These inadequacies typically fall in these areas:

- Technical: limits of size and types of files (audio, graphical, video) for transfer and upload, multiformat file indexing, inappropriate support for meta-data or semantics, absence of interoperability between systems and interfaces (different systems for different purposes) for the management of administrative (schedules, participants, resources) and technical information (tasks, domain).
- Behavior: not user-friendly information systems interfaces, force teams to change their normal work practices, require too much time to perform the operations (participants stop using them and/or it is necessary constant motivation/persuasion).

"There is an aspect that is very important, existent tools do not facilitate information sharing in different formats, languages from graphic to a more mathematical, to a graphical design, and

even text information" (x11, Mechanical Engineering and Industrial Management).

"... we abandoned that because we cannot centralize in the same solution everything that we need, and that is document management, information sharing, time, schedules and resources management, project management, milestones and activities. We never find a solution that can centralize all of that, so it became very complex" (x20, Manufacturing Systems Engineering).

IMB3: Information overload

The third barrier to information management in complex projects is *information overload*. The findings are consistent with Karim and Hussein's (2008) perception that advances in information and communications technology (ICT) may have imposed immense challenges to managers to handle overly loaded information. This leads to decrease in getting relevant, timely, and accurate information and in managing information flows. Additionally, Robinson (2010) reports an extensive empirical study of information behaviors in engineers. It demonstrates the importance of such behaviors to these technical roles, where 40% to 60% of working time was spent processing, communicating, and disseminating information. Empirical evidences presented by Robinson suggest that moderate levels of communication lead to the most effective performance of engineering teams, as both insufficient and excessive levels lead to performance decline.

Following this drive, subjects point several issues regarding information overload. However, most of them are concern of the use of email because it is the primary tool used for communicating within the project network. This regards, for instance, the excessive use of email and mailing lists for the exchange of technical literature. Consequently, project participants have difficulties in tracking updates and the current state of the domain.

In addition, considerable time and effort are taken to consolidate the vast volume of information dispersed in platforms and required for the development of a deliverable. It is usually necessary to appoint a project participant to deal with the individual project participants' contributions, keep track of exchanged information, and compiling it in a unique document.

In brief, *information overload* regards two main aspects:

- massive number of documents in platforms and repositories and difficulties in retrieving the proper documents; and
- email issues (considered the primary communication tool in projects and used as a central hub for exchanging information with other systems): excessive exchange of emails, not using the subject field correctly, excessive number of mailing

lists, difficulties in keeping participants at the same information level, inadequate use of email leading to misunderstandings, and difficulties in establishing priorities when exchanging information to avoid overloading the other participants.

"We have a repository that is a file server where we have the papers and articles, and then we have Adobe Acrobat, meaning that I can open, insert comments and close, and when someone opens it the comments are there. What are the problems? Suddenly, that has grown and we have thousands and now how to manage that?" (x3, Manufacturing Systems Engineering).

"The main challenge is to pass the requirements through the chain, because maybe there is a big company and there is a costumer, so they are a global company they have costumers all over the world and those costumers give small piece of information, and they should collect this information. There is a huge amount, lot of costumers, huge amount, what is important, what is less important, so, how they could filter this vast information from the information, let's call it must have information or knowledge" (x24, Software Development).

IMB4: Dispersion of information

Dispersion of information was pointed as another information management barrier. This concerns the dispersion of information among different participants, groups, or partners. Additionally, it regards the dispersion of information in different tools and systems (emails, portal, file servers, computer-aided design). For instance, administrative and financial information flows in one system, and technical information flows in a separate system.

Furthermore, there is the challenge of integrating information that is gathered during a project because it is collected by several means: meetings, individually or by teams, from clients, and in different formats and structures. Consequently, content needs to be linked despite the different infrastructures, systems, and technologies used. As an example, project participants may collaborate in Twitter, Facebook, Skype, and MSN. As long as new ICT tools are introduced into society, it is necessary to integrate dispersed information that flows in them.

Because information has different formats, rules, and flows in different applications, time should be estimated and provided to manage the dispersed information. Nevertheless, the effort is only estimated for the development of the technical tasks. Project managers assume that during that time, information (or documentation as participants call it) will be produced and managed. However, in reality, this does not happen, and information is poorly managed, and tasks start to get behind schedule.

In brief, this barrier regards dispersion of information among the following:

- different participants (within the same or different organizations, with different levels of responsibility);
- information systems (administrative, technical);
- collected in different occasions and places (meetings, informal discussions, institutions, countries);
- used in different contexts and purposes (teams, clients);
- in different formats (paper, digital) and types of files (audio, video, graphic); and
- different devices (desktops, notebooks, personal digital assistants).

"The main challenge is essentially the administrative information. There isn't any application for the management of administrative information in project management. There is a financial application, but then there isn't any for the management of the resources of a project. The reporting is done according to European, national, consultancies. It's all done in a dispersed way, ad-hoc, Excel, these things, but there isn't any application for the administrative management of projects. There is only a financial application, costs center, and the only way to follow up a project is with billing and expenses" (x4, Information and Computer Graphic Systems).

"... this information is becoming all over the place as suggested, we have seen something's on mobile phones recently, you could write text messages and you get a response, and these things would be necessarily connected together in an particular thread. You might send a message by text and get a response by email, so also these would be in 2 different places. So increasingly we are seeing mobiles and PCs, which allow conversations in a more generic way so it is looking at the content and not the different infrastructure, systems and different technologies" (x21, Software Development).

"We have weekly or periodic meetings, from 15 to 15 days, depends. And, those are also times to share information. That is good because everybody discusses, but information gets dispersed, right? Everybody takes their notes. Then we don't have anyone that is in charge of collecting information and share it with everybody" (x23, Telecommunications and Multimedia).

IMB5: Updating and adapting

Another barrier that emerged from the content analysis was difficulties in *updating and adapting* information. These regard the challenge of using the appropriate language and/or using different

language levels within the project network. Complex projects encompass different professionals, such as craftsman, engineers, and researchers. Some of them may not have higher formal education levels, but they possess considerable technical expertise. Therefore, it is necessary to adapt the information according to the formal education level of the different participants.

In addition, this barrier also regards providing in a timely manner the relevant information produced in the course of the project to all the participants. This includes using a common structure and the appropriate language level. According to the participants, the effort to share relevant information that each one is producing in a determined moment still poses considerable challenges.

To sum it up, the barrier *updating and adapting* information regards difficulties in:

- adapting and updating information in a language and format that is adequate to the level and context of the other project participants;
- updating (keeping participants at the same information level); and
- syncing (ensure that everybody is working with the same information) in a timing that is useful for the other participants, informing other participants of information updates.

"... use appropriate language with people. Use information with different levels. Some people do not have high education levels, but they are good technically and professionally, so you have to adapt the information for all kinds of levels" (x8, Information Systems Development).

"One of the main is to keep information in sync, so meaning that everyone as the same information at the same time and sometimes people work with outdated information. For example, old deliverables, old templates and those kinds of things and I think that mainly happens because people, for example miss messages and something like that. One of the most challenging parts is to keep people and information in sync" (x22, Software Development).

"Most of the time I am monitoring the latest news of the portal, but we have a huge project, so there are so many contributions it might happen I lost something, I don't notice if someone updated something that I am already waiting" (x24, Software Development).

IMB6: Lack of time

Another barrier referred by participants was *lack of time*. According to subjects, project teams work under a tight schedule, and there is lack of time to conduct information management activities

properly. Consequently, participants argue that platforms and tools need to be more user-friendly and not so time-consuming when performing tasks. Otherwise, even with the proper motivation or persuasion, information management strategies will be destined to fail.

“... if the closing requires much supplementary work people simply won't do it. On the other side, currently what we do is to put everything in a big black bag and close it, and one year later when someone needs to get something, everything is unstructured” (x15, Power Systems).

“... people spend so much time registering adequately what is necessary that eventually give up. We cannot motivate people to do it” (x20, Manufacturing Systems Engineering).

IMB7: Codification process

The last barrier to information management in complex projects was the *codification process*. This concerns the inherent difficulties in:

- presenting information in an appropriate language (different professional and technical terminologies);
- information structure (different rules) and format (different systems); and
- participants tend to formalize (write) strictly the necessary information (because of absence of time and the perception that is leverage over the others).

“... what happens many times is that information has different formats, has different rules, uses different applications to be codified, uses, we use different technical terms that are professional technical dialects, so it is not easy to automate these processes” (x11, Mechanical Engineering and Industrial Management).

“Most of the times things stay in peoples head and are not written, and this brings obvious difficulties. One way to eventually deal with that is, it is not easy, is to calculate and provide time to produce documentation in projects, and sometimes this is not done” (x13, Manufacturing Systems Engineering).

CONCLUSION

Conclusions and implications

The effort to manage information in complex projects is considerable, and project teams do not have good results in this aspect. A consistent information management strategy could significantly influence the overall effectiveness of the project.

Our study derives several implications for the practice and wider disciplines of information management and project management.

Complex project platforms and tools should integrate graphical and multimedia features. It allows moving beyond textual information, thus enhancing collaboration in the several phases of the project. This is supported by Reed and Knight (2010) that argue that electronic media has provided new methods for communication and new models for project team communications. Therefore, the following diversity of tools, platforms, and methods should be included to improve collaboration within project teams: web conferencing, instant messaging, texting, document sharing sites, blogs, wikis, and social networks.

Despite the current limitations of the use of keywords (generic thus not providing accurate retrieval; specific thus turning into time-consuming), project platforms should advance to semantic-enabled systems. Additionally, it is necessary to develop and integrate multiformat handling and search features in project platforms. Otherwise, as some participants mentioned, they will be forced to continue to work with information in the native format and then convert it to standard office formats for exchange and storing.

Reported by a significant number of subjects is the excessive and inadequate use of email. At the end of the day, most projects have a big and complex mailing list consisting of hundreds of emails. In practice, participants are unable to keep an overview of all of them. This aspect is also linked with the issue of information overflow keeping participants at the same information level. Information should be centralized in a platform instead of circulating via email and parallel systems, thus requiring additional effort in consolidating the information.

One aspect that is transversal to this discussion is the fact that the majority of the subjects surveyed works in several projects simultaneously. In reality, they move from one project to another when the deadlines are closing in. The absence of work exclusivity in a single project and the lack of permanent teams add an extra level of difficulty because complex projects integrate large teams, and participants are often replaced causing further instability. As a result, project managers and participants feel that because of the multiplicity of projects and their limited time frame, it is not worth the effort learning how to work with the different collaborative platforms and tools. Some subjects mentioned that project portals have been tested and are easy to adapt to project specific context. On the other hand, some subjects argue that existent platforms and tools do not support efficient collaboration and that this forces them to use email from simple and unstructured to more structured and complex interactions. However, taking into

consideration that participants work in several projects simultaneously, and each project has its own platforms and tools: it is more reasonable to think that they rather prefer to use a “general” communication tool that can be used across projects, thus avoiding a learning curve, time, and extra effort. Consequently, the reason why project collaborative platforms and tools are not usually adopted and/or properly used is due to individual and organizational practices rather than technical limitations.

Work limitations

Our study, as any other work, has important limitations that must be taken into account when considering the results. Our qualitative research approach relies in open-ended interviews as data sources. Despite the use of a significant number of project managers and participants from several organizations with multiple backgrounds, there might have been some bias. All subjects surveyed are from different countries; however, all countries are from the European Union. Consequently, subjects might have presented the European perspective of the information management barriers in the context of complex projects.

Future work

The general goal of this research was to contribute to the understanding of the information management barriers in complex projects. The starting point for future work would be to identify social and technological aspects of information and project organization practices and to study how these influence the quality of the project outcomes. This may include knowledge sharing between project partners. In particular, it would be interesting to know how the project's information processes, architectures, and platforms influence the project's collaboration and knowledge sharing processes and, ultimately, the quality of the project outcomes. These goals could be achieved by conducting in-depth case studies of collaborative research projects with considerable dimension involving multiple partners (multiorganizations and countries).

REFERENCES

- Ahlemann F. 2009. Towards a conceptual reference model for project management information systems. *International Journal of Project Management* 27(1): 19–30. DOI: 10.1016/j.ijproman.2008.01.008
- Detlor B. 2010. Information management. *International Journal of Information Management* 30(2): 103–108. DOI: 10.1016/j.ijinfomgt.2009.12.001
- Eriksson M, Lillieskold J, Jonsson N, Novosel D. 2002. How to manage complex, multinational R&D projects successfully. *Engineering Management Journal* 14(2): 53.
- Hanisch B, Wald A, Lindner F, Mueller A. 2009. Knowledge management in project environments. *Journal of Knowledge Management*. DOI: 10.1108/13673270910971897
- Ireland L. Project Complexity: A Brief Exposure To Difficult Situations. 2007, 10/2007. Retrieved 22/12/09, 2009, Available at: <http://www.asapm.org/asapmag/articles/PrezSez10-07.pdf>
- Johansson E. 2009. Information management for materials supply systems design. *International Journal of Production Research* 47(8): 2217–2229.
- Karim NSA, Hussein R. 2008. Managers perception of information management and the role of information and knowledge managers: The Malaysian perspectives. *International Journal of Information Management* 28(2): 114–127. DOI: 10.1016/j.ijinfomgt.2007.08.003
- Klauff T. 2008. Knowledge management in cross-organizational networks as illustrated by one of the largest European ICT associations: a case study of the “METORA” project of the Federal Ministry of Economics and Technology (BMW). *International Journal of Human and Social Sciences* 3(7).
- Kvale S, Brinkmann S. 2009. Interviews Learning the Craft of Qualitative Research Interviewing (2nd edn). SAGE: Los Angeles [etc.].
- Mian A, Takala J, Kekale T. 2008. Role of Organizational Culture for Knowledge Sharing in Projects. PICMET 2008 Proceedings, 962–968.
- Mohammadi S, Khalili A. 2008. A semantic web service-oriented Model for project management. Paper presented at the Computer and Information Technology Workshops, 2008. CIT Workshops 2008. IEEE 8th International Conference on.
- Ochieng EG, Price ADF. 2010. Managing cross-cultural communication in multicultural construction project teams: The case of Kenya and UK. *International Journal of Project Management* 28(5): 449–460. DOI: 10.1016/j.ijproman.2009.08.001
- Ratcheva V. 2009. Integrating diverse knowledge through boundary spanning processes - The case of multidisciplinary project teams. *International Journal of Project Management* 27(3): 206–215.
- Reed AH, Knight LV. 2010. Effect of a virtual project team environment on communication-related project risk. *International Journal of Project Management* 28(5): 422–427. DOI: 10.1016/j.ijproman.2009.08.002
- Robertson J. Ten principles of effective information management. KM Column. 2005. Available at: http://www.steptwo.com.au/papers/kmc_effectiveim/index.html
- Robinson MA. 2010. An empirical analysis of engineers' information behaviors. *Journal of the American Society for Information Science and Technology* 61(4): 640–658.
- Santos VR, Soares AL, Carvalho JÁ. 2012. Knowledge sharing barriers in complex research and development projects: an exploratory study on the perceptions of project managers. *Knowledge and Process Management* 19(1): 27–38.
- Shachaf P. 2008. Cultural diversity and information and communication technology impacts on global virtual teams: an exploratory study. *Information Management*. DOI: 10.1016/j.im.2007.12.003
- Turner JR. 2010. Evolution of project management research as evidenced by papers published in the International Journal of Project Management. *International Journal of Project Management* (1): 1. DOI: 10.1016/j.ijproman.2005.10.001

- Valerdi R, Davidz HL. 2009. Empirical research in systems engineering: challenges and opportunities of a new frontier. *Systems Engineering* **12**(2): 169–181.
- Wang Y, Yang J, Shen Q. 2007. The application of electronic commerce and information integration in the construction industry. *International Journal of Project Management* (2): 158.
- Whitty SJ, Maylor H. 2009. And then came complex project management (revised). *International Journal of Project Management* **27**(3): 304–310.
- Wilson TD. 2002. Information management. In *International Encyclopedia of Information and Library Science* (2nd edn), Feather J, Sturges P (eds). Routledge: London
- Zhao Y, Austin SA, Tang LCM, Culley SJ, Darlington MJ. 2008. High value information in engineering organisations. *International Journal of Information Management*. DOI: 10.1016/j.ijinfomgt.2007.09.007