

27th IPMA World Congress

I dentifying and dealing with complexities in new product and process development projects

Bassam A.Hussein*, Giedre Pigagaite, Pedro P. Silva
Norwegian University of Science And Technology, Trondheim. Norway

Abstract

The purpose of this paper is to examine the sources of complexities in new product and process development projects and the approaches used to deal with these complexities. The study also examines the important conditions for implementing these approaches. Information was collected through semi-structured interviews with ten senior project managers from two types of projects; new product development projects and internal process improvement projects. The study shows that in product development projects the major sources of complexity are the interdependency between tasks and the novelty of the project. In process improvement projects, the major sources of complexity are the diversity and multiplicity of end-users and uncertainty. Results show further that addressing complexity in process improvement project is accomplished through robust front-end planning and comprehensive involvement of stakeholder. In product development projects, complexity is addressed through technical means by reducing the number and interdependency between tasks. Conditions for addressing complexities, include holistic understanding of the project, its scope and objectives, understanding the client and its need, having formal project management methods, solid understanding of project team strengths and weaknesses. Understanding the correlation between technical aspects and organizational aspects. Switching leadership styles and skilled project manager.

© 2014 The Authors. Published by Elsevier Ltd.
Selection and peer-review under responsibility of the IPMA.

Keywords—project complexity, internal improvements projects, new product development projects

* Corresponding author. Tel.47 73593804 ; fax: 4773597117
E-mail address: bassam.hussein@ntnu.no

1. Introduction

There is an increasing acceptance that an understanding of complexity is important because of the difficulties which it spawns. According to Geraldi and Adlbrecht (2007) this understanding should help project practitioners to reflect upon circumstance, both holistically and pragmatically, in order to be able to navigate complex situations. Bosch-Rekvelde, Jongkind et al. (2011) argue that aiming to understand complexity does not necessarily contribute to the controllable nature of project complexity; it is merely a way to help project practitioners prepare and ready themselves for dealing with complex or complicated situations. Richardson (2009) believes that understanding complexity should help managers constrain achievement through methods of planning and control (this amounts to reductionist and mechanistic thinking). Others, such as Remington, Zolin et al. (2009), claim that understanding the source of the complexity and the degree of resultant difficulties might help to determine the skills and capabilities needed to deal with a problem.

The term complexity is in common usage and practitioners have a diverse understanding of this term. Syed, Andy et al. (2010) attribute this diversity to the lack of clear distinction between the terms ‘complex’ and ‘complicated’. In project literature, there are at least 31 definitions of complexity (Gul and Khan 2011). In systems theory, the term ‘complex’ refers to a system that is composed of interrelated subsystems, each being, in turn, hierarchic in structure. Common synonyms for the term complex are difficult, complicated, intricate, involved, tangled, and knotty (Whitty and Maylor 2009). The term ‘complex’ is perhaps used because of the lack of a more appropriate expression describing the interrelated features that effect a project’s life cycle, subsequently complicating decision making.

As a result there are many perceptions of the meaning of complexity. Broadly speaking, efforts to understand complexity in the current project management literature can be grouped into three classes. The first class attempts to examine complex dynamic systems in terms of adaptability, non-linearity, emergence, feedback, self-organization and dependency, and to determine how these characteristics can be used to understand single or multiple project environments (Aritua, Smith et al. 2009)

The second class of studies examines single elements, factors, sources or patterns that contribute to project or managerial complexity. A summary of these studies is given in Table I. The third class of studies involves efforts to propose or examine methods, processes or conceptual models which deal with one or several complexity factors. The main thesis of these studies is that current project management methods fail to appropriately deal with complex projects (Thomas and Mengel 2008, Müller and Turner 2010). Some authors believe that complexity does not necessarily require sophisticated and extraordinary control mechanisms. For instance, Whitty and Maylor (2009) argue that just because a project is called ‘complex’ does not mean that complex managerial tools and techniques are required for its control. Hussein (2012) conducted an empirical investigation to document the perception of complexity among project practitioners. Its main purpose was to examine the degree to which practitioners differentiate between sources of complexity and the complicated situations that arise as a result of these singular elements in the course of the project. The complicated situations have therefore to do with the managerial complexities of the efforts conducted to attain project goal and objectives in the presences of the complex elements (Whitty and Maylor 2009).

This research is exploratory in nature and seeks to explore sources of complexities that exist in development projects, outlining the measures used to address these complexities and the necessary contextual conditions for addressing these complexities. Findings of this study are based on interviews that were conducted with 10 project managers from two types of development projects; 1) Internal improvement projects and 2) Product development projects.

Table 1. Elements of project complexities in project management literature

Author	Based on	Complexity definition
Baccarini (1996)	New model	Consisting of many varied interrelated parts and can be operationalized in terms of <i>differentiation</i> and <i>interdependency</i> . Baccarini provides two basic definitions: -Organizational complexity: <i>By differentiation</i> - the greater differentiation the more complex the organization; <i>By interdependency</i> -degree of operational interdependencies between organizational units. -Technological complexity: <i>By differentiation</i> - refers to the variety or diversity of some aspects of a task. <i>By interdependency</i> -between tasks; within a network of tasks, between teams, and different technologies.
Williams (1999)	Baccarini (1996); Turner and Cochrane (1993)	-Structural complexity: number of elements; interdependence of elements (reciprocal interdependence adding the most to complexity). -Uncertainty: uncertainty in goals; uncertainty in methods.
Geraldi and Adlbrecht (2007)	Baccarini (1996) Williams (1999)	The pattern of complexity is formed of 10 characteristics, which belong to three main types of complexity: faith, fact, and interaction. Complexity of faith: Refers to uncertain situations (uncertainty). Complexity of fact: Is related to the structural complexity. Complexity of interaction: Concerns the complexity of the relationship (from intercultural communication to technical interfaces).
Maylor et al. (2008)	Baccarini (1996); Williams (1999)	MODEST model with five different structural complexity parameters: mission, organization, delivery, stakeholders, and team. Two different dimensions have an impact in these factors: Structural Complexity (based on project characteristics), and Dynamic Complexity (based on project interaction).
Remington et al. (2009)	Extensive literature review and Interviews with practitioners	Divides complexity into two factors: <i>dimensions</i> (where the complexity comes from), and <i>severity</i> (the extent to which it will be a problem). A mixture of both gives the degree of complexity. Dimensions: Goals; Means to achieve goals; Number of interdependent elements; Timescale of project; Environment. Severity factors: Non-linearity; Uncertainty; Uniqueness; Communication; Context dependence; Clarity; Trust; Capability.
Vidal, Marle, Bocquet (2010)	Baccarini (1996)	Used the two classical divisions of Baccarini (1996) Technology and Organizational complexity, divided into four families of factors: Project size, Project variety, Project interdependencies, and Project context-dependence. Based on the framework 70 factors adding to complexity were found, but later narrowed down to only 17 (fitting into each category).
Bosch-Rekvelde et al (2010)	Extensive literature review and interviews with practitioners	TOE framework divided into three main groups of complexity: -Technical complexity: focused on content of the Project; -Organizational complexity: Softer aspects of the Project; -Environmental complexity: Influence from the environment on the Project. Identifies 50 factors affecting complexity, grouped into each of these categories.
Gul and Khan (2011)	Baccarini (1996) Williams (1999)	-Structural complexity: Differentiation (number of elements), Interdependencies (between elements). -Uncertainty: Goal uncertainty, Methods uncertainty, Environmental uncertainty. -People uncertainty: Social interactions, Rules of interaction (process of relating)
Geraldi et al. (2011)	Geraldi and Adlbrecht (2007) Maylor et al. (2008)	-Structural complexity: Classical concept, entails size (number of elements), variety, and interdependence -Uncertainty: Also much discussed before, how prone would the Project be to variation. -Dynamics: Changes inside the other dimensions of complexity, closely linked with uncertainty, but more to do with consequences than likelihood of happening. -Pace: Rate (or speed) at which the Project should be delivered. -Socio-political complexity: People relationship in the project, both between themselves and how the environment (political context) affects the Project.

2. Empirical research

This chapter presents the results of 10 interviews with project managers who are dealing with different degrees of complexity in both internal improvement projects and product development projects. The findings are presented in three main sections. The first part presents sources of complexities in these projects and the approaches used to address these complexities. The second part is about the conditions that must be present in order to handle the complex situations.

2.1. Sources of complexities

2.1.1. Internal improvement projects

The purpose of this type of projects is to improve the company's existing working processes and systems. Lager (2002) attributed complexity of this type of projects to two parameters: the level of innovation of the new process (to the world), and how difficult it would be to implement in the company. Difficulties associated with implementing the new processes is attributed to the resistance the stakeholders showed to the new process, which impair the company's capability to implement the new process. Basically, the main complexity of these projects would lie in their stakeholders, and the uncertainty regarding their willingness to adapt to changes. Schrader et al. [1993] described uncertainty as a situation in which a decision maker has a clear understanding of the problem but uncertain of the outcome. What makes it an even bigger challenge is the diversity of stakeholder's expectations.

According to the informants, the main source of complexity is the people that will have to adapt to the new process and routines.

"The main challenge is the people, because we change the way they are going to work."

As matter of fact, it is not the people themselves that are the source of complexity, it is rather the diversity of expectations wishes, needs, willingness to contribute, willingness to adapt, ability to contribute and so forth that complicates this type of projects. In such soft system project, every single unit in the enterprise will be affected and everybody expect therefore to have a say in what the final deliverable should look like and do.

"The complexity lay in finding a common ground that accommodated everybody, each department had a way of doing things and they were not keen to let go."

While some end-users expect to be involved and having their opinions included in the final deliverables, some others and for various reasons that has to do with power, background, and organizational culture will be reluctant to use the new process and this resistance to change creates uncertainty about the real value of the proposed solution.

"Sometimes project managers can come up with the right solution, but it will not be implemented because powerful stakeholders don't like it."

Lack of knowledge about how the end-users will adapt to the new process increase the level of complexity of the project.

"Reaction to outputs can be hard to predict from the beginning, you may only realize the complexity once you are working on it."

Informants have recommend two possible approaches to handle the diversity and the lack of full knowledge about how the final product will be received and employed by the end-users including the possibility of resistance or rejection.

1) Through robust front-end planning, by early identification and assessment of stakeholders profiles, their needs, and expectation. This continuous involvement should help reducing both the impact of both uncertainty and the diversity.

"The best weapon to fight this complexity is to have a very good overview of what stakeholders want from the beginning. If you know what a party is looking for it is easier to sell them the solutions you want."

The main shortcoming of this approach is that it is both time and resource consuming. It is largely dependent on high-level organizational factors, in terms of willingness to free up resources so that they can contribute in the

early phase. It depends also on top-management support to the project. It requires also not only willingness to contribute by the end users but also ability to express what they really want and expect.

“When you start a project, organizational complexity is a given, and there is little to do about it, you have deal with the way your company works.”

Findings by Basu, Hartono et al. (2002) suggest that the involvement of top management in the owner organization is of paramount importance for successful implementation of major information systems projects. Their involvement seems to be more important than the project organizations involvement. Early involvement means a better and more complete understanding of the project's impact on the organization. Hong and Kim (2002) demonstrated that as far as major projects are concerned, it is not always the case that the organization is prepared or adapted, culturally or organizationally for the deliverables of the project will deliver. They have shown that there are few organizations that have an organizational structure that is prepared for the changes that the introduction of large complex projects entails. Therefore, project owner organization should consider the project as a broad introduction of organizational changes, rather than technical software install.

2) There is a less flexible approach taken by some other project managers. This is a top-down approach and consists of trying to freeze the new process design as early as possible and then *force* the different departments to adapt to the results (instead of the other way around). Top management support is a key part of this strategy.

“You should get support from the top management. They should know what you are doing and why you are doing it.”

This might be seen as a speedy but risky business. It is speedy because it requires less up-front planning but contains huge deal of uncertainty about the reaction of the stakeholders to the output. And it requires competent management and higher level of empowerment to the project manager in order to cut through and make decisions:

“The change order system was very rigid, and so not many changes were made. There was not a lot of room for flexibility.”

2.1.2. Product development projects.

In product development projects, we might distinguish between three major sources that contribute to complexity.

a) Technology interdependence

Informants have been unanimous that the main challenge in their type of projects is to handle the interface between a very large number of products, sub-products or components. In addition each requires certain expertise to deliver in the final product.

“The hardest thing is managing and being aware of a lot of elements at the same time, that are usually interacting with each other.”

“The problem with the computer system was that it was divided into 2 job packages: software and hardware, which were dependent on different disciplines.”

b) Technology Novelty

Informants also reported that no matter how much planning you do before hand, when you assemble a final product—or even a part of it—testing will always reveal problems.

“To gain time on the testing we developed a larger testing lab—that allowed us to test for more functionalities than usual—to do most of the testing in-house. This was a big help.”

“Creating a prototype is only half of the job. The other 50% will come in testing, because there is always something that is going to be wrong.”

c) External factors

It was reported that the clients could also influence the development of the final product to make sure that the project delivers what they really need.

“The client has a right to do changes, all kind of changes, even company procedures. For this we need to adapt to changes fast.”

The solution adapted to the problems outlined above contains both a technical and an organization aspect. The technical solution is achieved by reducing the number of autonomous or independent components that need to fit together. Thus reducing the complexity of interface. In order to achieve this technical solution informants indicated that they need to change the way project organization is built, as well as using more time during the planning phase in order to align project team to this approach and getting them to think final product rather than individual disciplines.

“The solution is put all work packages that deliver a single product under one sub-project manager. That is change the focus from discipline approach to final product approach.”

This technical shift requires more planning up-front to achieve better integration and less rework.

“Projects are really large and involve so many competencies and expertise that have to match each other in the final product, that it is important to coordinate for everyone of them at the planning stage of the project.”

Yet again, this approach is time consuming and could be challenging for projects with longer durations. Indeed, some of the projects that were described by our informants were lasting up to nine years, so it can be quite difficult to plan for every possible interaction issue from year one.

Dealing with client interference is still a factor that can have an impact in these projects, and the solutions for this problem requires more involving of the client to ensure their satisfaction..

“We have weekly meetings with the client, looking at the situation, discussing the following week, and future actions of how to solve problems.”

Adopting this approach requires several conditions. These conditions include:

Ability to reduce ambiguity of the work needed to be performed. It is usually the case that the project main goal might be very well defined, however how to get there can be hard to figure out due to the novelty of technology used on.

Nothing comes out of vague work packages that are huge.”

It is also important to have standard and formalized processes to follow during execution.

“Two steps are highly recommended. First, to actually have processes for everything you do: that way you make sure that everybody is working the same way in the company. Second, you should work on making the processes simpler, more effective, and in general easier to do.”

For effective use of available human resources managers should have a very good understanding of the resources they have available and what they can do.

“To do things in a non-standard way you must be very aware of what your resources can and cannot do.”

“If you have a project manager that leads people then he delivers results”

It is therefore important to have at least some connection with their people, this will help lead them better and also identify well the capabilities of the resources, which can be critical in achieving greater flexibility.

The second approach to deal with clients is to depend on guts feeling — is to have a very good understanding of how the client operates and know what they want. This way a manager may be able to actually predict what the client will say to a certain decision or solution, and prepare for it before hand; reducing uncertainty and gaining valuable time.

“We have had to adapt to this situation by learning to take decisions without the time to consult the client sometimes, by watching every aspect of it very well.”

2.2. Conditions for addressing complexities

The above examples, indicates once again that complexities in project are addressed mainly by early planning, through involvement, early identification of tasks, grouping of tasks, reducing the number of independent parts, better integration between disciplines, better alignment of human resources to achieve this integration, better communication with the client. It is the combination of these efforts that are needed to tackle the combined effect of novelty, technology dependency and external factors.

The examples indicate the inter relationship between these efforts. Resolving a technical issue requires better alignment and integration of human resources.

“If the people are going to be involved less than 50%, I do not involve them into the project. It is not useful to me to have somebody who will not put complete attention to the project. It will be easy for them to make excuses if they don’t deliver on time, because they can always blame the other project.”

And at the same time to make sure that the flow of information from and to the client is continues and manageable. The approaches identified by informants in the previous section illustrate also the need of to see most of the consequences their decisions are going to bring. This holistic view requires a certain amount of knowledge about the project purpose, scope and gains.

“It is really important to get in place all the things you have learned at the start of the project: success criteria, rules, client wants, what we expect from the client, and a general understanding of the whole project. Use time to establish necessary things.”

This overall knowledge does not require an expert in every technology the project uses.

“You don’t necessarily have to be an expert, but have a reasonable understanding of everything.”

Another important condition is to understanding the business of the company

This was considered important since it is a precondition so that the project manager will be able to align the project with the business.

“Know very well what the project is trying to accomplish and why it is important to the business of the company.”

Through interviews we have found out that leadership style is usually correlated with the main success criteria of the project. For instance, in internal improvement projects success is the final quality of the product.

“Delivering the right product is the most important thing; the functionality of the final delivery [...] has to be an improvement to the workings of the company.”

In the first case, the leadership style that works best is the flexible one; where discussions are encouraged. This flexibility gives the experts a lot of freedom in order to find the best possible solutions.

“An flexible leadership style is used, in which there is a lot of discussion. The manager usually points the way the project should go, and lets the experts take the best solutions to get there”

And so, this autonomous approach is usually best suited to achieve higher quality results —while taking less consideration of the time and costs of the project.

Whereas in product development projects the emphasis is mostly put on delivering on time.

“Time was the most important. The time has impact on the cost. If you are delivering on schedule usually you are not spending more money than planned.”

In product development projects, (time more important than quality and cost), the leadership style focuses on achieving the deadlines, allowing the team less freedom, and push them for deliverables all the time.

“Sometimes you have to swallow your own pride, you have to move forward.”

At the beginning of the project —when all the deliverables are not yet completely clear— discussion among the team is encouraged, and a flexible style is used. As soon as the deliverables are established, the deadlines are locked and the team begins working in a more vertical way; the manager interested in achieving those deadlines at all costs.

“Normally we start with a lot of discussion amongst everybody. Then the milestones, packages, etc. are identified. We follow then a strict regime to adhere to these targets, and take measures if it is not kept.”

3. Conclusions

In the empirical section, we have tried to distinguish between three main findings;

1) Sources of complexities, this include features that characterize the project or its environment. This may include, diversity of people, uncertainty, technology dependence, technology novelty and client interference with the process.

2) We have looked into how the project organizations have approached the problem to attain project objectives. We have further have shown that there are basically 2 main approaches identified by the informants from both types of projects;

a) an approach that mainly emphasize the importance of early planning, early alignment, identification of tasks and responsibilities, defining robust work packages, reduce the number of tasks. The main shortcoming of this approach is that it is time and resource consuming. It is also largely dependent on high-level organizational factors, in terms of willingness to free up resources so that they can contribute in the early phase. It depends also on access to resources (resource flexibility), it depends on choice of proper organizational structure. It depends also on top-management support to the project. It requires also not only willingness to contribute by the end users but also ability to express what they really want and expect.

b) The second approach is to plan as you go. This approach requires however high level of competence and vast experience by the project manager and the team. Since all decisions are taken based on own perception of the project and its context.

3) Conditions for addressing complexities, this include holistic understanding of the project, its scope and objectives, understanding the client and its need, having formal project management methods, solid understanding of project team strengths and weaknesses. Switching leadership style, skilled project manager. A summary of sources of complexity, approaches used and conditions for addressing complexities is shown in table 2.

Table 2. Summary of sources of complexity, approaches used to deal with the complexities and conditions for addressing complexity

Sources of complexities	Approaches	Conditions for addressing complexity
	Internal improvement projects:	
Diversity	Early alignment of end users to the project	Understanding of whole project picture (stakeholders, Purpose , Scope, Objectives)
Uncertainty	Getting end-users to understand the potential benefits of the project	Top management support
	Balance expectations, needs and wants of stakeholders	Understand the correlation between technical and organizational aspects.
	Design freeze, early on	Understanding the business of the client or the sponsor organization
	Product development projects	Skilled and experienced project manager
Interdependency	Create and maintain a high level of motivation among project members	Formal project management method
Task ambiguity	Reduce ambiguity of the tasks	Understanding the capabilities and strengthes and weaknesses of project team members
	Client approval to manage adjustments, rework and changes	
Novelty	Reduce the number of tasks	Switching leadership style between autnomous and flexibke
	Secure appropriate expertise/resources for the project?	style to more directive and controlling style

References

- Aritua, B., N. J. Smith and D. Bower (2009). "Construction client multi-projects – A complex adaptive systems perspective." *International Journal of Project Management* 27(1): 72-79.
- Basu, V., E. Hartono, A. L. Lederer and V. Sethi (2002). "The impact of organizational commitment, senior management involvement, and team involvement on strategic information systems planning." *Inf. Manage.* 39(6): 513-524.

- Bosch-Rekvelde, M., Y. Jongkind, H. Mooi, H. Bakker and A. Verbraeck (2011). "Grasping project complexity in large engineering projects: The TOE (Technical, Organizational and Environmental) framework." *International Journal of Project Management* 29(6): 728.
- Geraldi, J. G. and G. Adlbrecht (2007). *Project Management Journal* 38(1): 32.
- Gul, S. and S. Khan (2011). Revisiting Project Complexity: Towards a Comprehensive Model of Project Complexity. 2nd International Conference on Construction and Project Management. Singapore, IACSIT Press. IPEDR vol.15: 148-155.
- Hong, K.-K. and Y.-G. Kim (2002). "The critical success factors for ERP implementation: an organizational fit perspective." *Information & Management* 40(1): 25-40.
- Hussein, B. A. (2012). An Empirical Investigation of Project Complexity from the Perspective of a Project Practitioner. Proceedings of IWAMA 2012 - The Second International Workshop of Advanced Manufacturing and Automation, Tapir Akademisk Forlag: 335-342.
- Müller, R. and R. Turner (2010). "Leadership competency profiles of successful project managers." *International Journal of Project Management* 28(5): 437.
- Remington, K., R. Zolin and R. Turner (2009). A model of project complexity : distinguishing dimensions of complexity from severity. Proceedings of the 9th International Research Network of Project Management Conference, IRNOP.
- Richardson, K. (2009). "Managing complex organizations: complexity thinking and the science and art of management " *Corporate Finance Review* 13(1): 23.
- Syed, A., G. Andy, L.-W. Therese, K. Richard, K. Ali and A. Mehmood (2010). "The importance of soft skills in complex projects." *International Journal of Managing Projects in Business* 3(3): 387.
- Thomas, J. and T. Mengel (2008). "Preparing project managers to deal with complexity – Advanced project management education." *International Journal of Project Management* 26(3): 304-315.
- Whitty and Maylor (2009). "And then came Complex Project Management (revised)." *International Journal of Project Management* 27(3): 304.