A LONGITUDINAL STUDY OF GLOBALLY DISTRIBUTED DESIGN TEAMS: THE IMPACTS ON PRODUCT DEVELOPMENT.

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Abstract

Globally distributing design teams during Product Development is increasingly common across a wide range of industries. Factors impacting the success such as communication, documentation and maintaining a common vision are intensified in comparison to when design teams are co-located. Much of the research towards the impacts on the Product Development process in distributed design teams consists of interviews and observations of short design sessions, with few observational studies focusing on the whole process of Product Development. With the results from a longitudinal observational study and interviews with key members of a project team, this paper investigates the factors impacting the success of Product Development when teams are distributed globally, from the early planning and development phase through to the final testing and refinement. The results indicate an increased requirement for project control strategies during the early phases of Product development to ensure a common vision is maintained throughout the phases of Product Development.

Keywords: Distributed design teams, Project management, Longitudinal study

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1 INTRODUCTION

Factors impacting the success of Product Development (PD) projects are intensified when teams are distributed globally, making it a challenging task for project management to deal with effects on time, cost and quality. It is important for project management to understand when challenges, such as communication difficulties, a lack of common vision between team members or issues related to documentation, may occur during PD projects, enabling them to take the necessary preventative action (Edmondson and Nembhard, 2009). When investigating factors impacting the success of PD, the majority of research in the field of distributed design teams consists of studies involving interviews or observations of short design sessions, typically lasting 1-2 hours (Eris et al., 2014; Scrivener et al., 2003; Hansen and Ahmed-Kristensen, 2011). There are few cases reported in literature of longitudinal observational studies of globally distributed design teams in PD projects. This paper aims to contribute to the further understanding of the factors impacting the success of PD projects when teams are distributed globally. With the results from a longitudinal observational study over 8 months, the factors impacting the success of a globally distributed PD project are mapped across the phases of PD, beginning from the early planning phase and development through to the final testing and refinement. Furthermore, the relationship between the impact factors (IF's) and key parameters for performance is described.

2 LITERATURE REVIEW

The section reviews the literature in conventional PD with particular focus on the factors impacting the success. Following this, the literature on distributed design teams in PD is reviewed. Where possible, observational studies of projects that involve all phases of PD are reviewed; in comparison to those that focus on single phases.

2.1 The Conventional PD process

The process of PD is the sequence of steps or activities that an enterprise employs to conceive, design and commercialise a product (Ulrich and Eppinger, 2011). The sequence of steps varies depending on the context at which the organisation operates. The PD process model referred to in this paper is the generic product development model (Figure 1). The model consists of six, iterative phases from the early planning to the final release of the product to market. After each phase in the process, a gate must be passed before moving to the following phase. The process of PD has been described as a method for controlling the activities associated with PD and reducing risks during PD projects (Cooper et al., 2001).

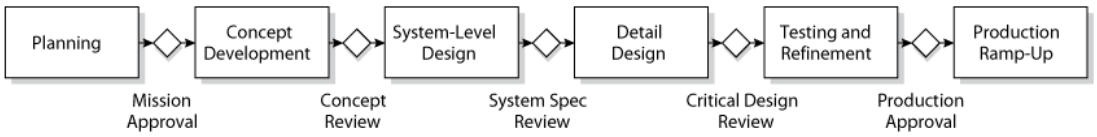

Figure 1.The Generic Product Development Process Model (Ulrich and Eppinger, 2011).

The following key parameters emerge in literature when project managers assess the success of PD projects:

- *Time* - relates to the product development time and is imperative as it allows companies to bring their product to market early.
- *Cost* - relates to both the cost of development and the manufacturing cost of the product and determines profit margins.
- *Quality* – relates to product performance and the extent to which the product meets the demand of the market.

The parameters play a significant role in the eventual success of PD projects and understanding the impacts on these parameters in PD is critical for project management.

2.2 Factors impacting the success: Conventional PD projects

Table 1 lists factors impacting the success of conventional PD at a project level from five independent studies. For each of the longitudinal studies, real time observations were conducted during a project,

enabling an in depth understanding of the IF's across all phases of PD (Hales, 1987; Kleinsmann, 2006; Hoegl et al., 2004). This in depth understanding is lacking for the two remaining studies (Edmondson and Nembhard, 2009; Phillips, 1999) as the studies were retrospective in nature and IF's across all phases of PD are not discussed. Although each of the studies investigates the IF's from different viewpoints, many of the factors are inter-related and vary in importance over the course of PD projects. There is an agreement among the authors in Table 1 that teamwork and shared understanding has an impact on the success of PD at a project level. During the longitudinal observational studies (Hales, 1987; Kleinsmann, 2006; Hoegl et al., 2004), quality in relation to both the product and process was found to be a key IF. Furthermore, project management and commitment to the PD projects were considered important factors.

Table 1. Factors impacting the success of conventional PD projects.

Author	Method	Phases of PD	Factors impacting the success of PD
Hales (1987)	Longitudinal observations	Entire PD process	Expertise, Experience, Commitment, Motivation, Systematic design approach, Team productivity, Work quality.
Kleinsmann (2006)	Longitudinal observations	Entire PD process	Information processing, Project documentation, Division of labour, Project planning, Product quality.
Hoegl et al. (2004)	Longitudinal observations	Entire PD process	Interteam coordination, Project commitment, Teamwork quality.
Edmondson and Nembhard (2009)	Literature review	N/A	Project complexity, Team diversity, Temporary membership, Fluid team boundaries, Organisational infrastructure.
Phillips (1999)	Case studies (Interviews)	N/A	Project management, Communication.

2.3 Globally distributed design teams in PD

Since its introduction, the environment where PD takes place has changed and become less predictable (Cooper, 2014). The motivation to reduce development costs, shorten development time and reduce proximity to global customers has seen companies looking to globally distribute their design teams during PD projects. When considering the generic product development model (Figure 1), Hansen and Ahmed-Kristensen (2011) observed that companies look to globalise the later phases of the PD process, with low value adding activities being outsourced and higher value adding activities, such as those in the early phases of PD being offshored. It is well documented that the coordination of design teams, which are globally distributed are not coordinated as easily as those in conventional PD where teams are co-located (Littler et al., 1995; Anderson and Parker, 2012; Emden et al., 2006; Hansen and Ahmed-Kristensen, 2011). Factors impacting the success, such as those in conventional PD (Table 1), are intensified in this global context. Despite this, many companies adopt a learn by doing approach to globally distributed PD projects without clearly understanding the impacts on the key parameters for PD: time, cost and quality (Dabhilkar and Bengtsson, 2008; Kitcher et al., 2013; Hansen and Ahmed-Kristensen, 2011).

2.4 Factors impacting the success: Globally distributed PD projects

Table 2 lists factors impacting the success of globally distributed PD at a project level from four independent studies. Based on the research method, it was difficult to identify factors impacting the success relative to the phases of PD for three of the studies listed in Table 2 (Hansen and Ahmed-Kristensen, 2011; Littler et al., 1995; McDonough et al., 2001). As a result of a longitudinal observational study of an international distributed design project, Scrivener et al. (2003) concluded that although many of the IF's observed were also present in conventional PD projects, the factors were exacerbated during PD projects with globally distributed teams and the need for preventative strategies was evident. However when identifying the IF's, Scrivener et al. (2003) do not highlight where during the PD process the IF's occur. Hansen and Ahmed-Kristensen (2011) found that the challenges experienced during Global PD projects impacted the success; causing time delays, rework and increased resource usage. Results from two surveys (Littler et al., 1995; McDonough et al., 2001)

emphasised the need for a higher focus on project management and control during collaborative and global development projects in comparison to conventional PD projects. The common IF's emerging from the studies are communication, cultural differences, project management and technological barriers.

Table 2. Factors impacting the success of PD projects with globally distributed teams.

Author	Method	Phases of PD	Factors impacting the success of globally distributed PD projects
Scrivener et al (2003)	Longitudinal observations	Design briefing, Design analysis, Concept dev, Concept refinement	Communication, Project management, Participation, Culture, Product quality, Technology.
Hansen and Ahmed-Kristensen (2011)	Case studies (Interviews)	N/A	Culture, Knowledge, Coordination, Communication, Organisational structures, Product features, Process features, Lack of common vision.
Littler et al (1995)	Survey (106 respondents)	N/A	Information leakage, Loss of ownership, Different aims and objectives, Development takes longer, Vendor commitment
McDonough et al (2001)	Survey (103 respondents)	N/A	Project management, Communication, Cultural differences, Technological barriers.

2.5 Summary of literature

Given the lack of longitudinal observational studies in literature of globally distributed design teams in PD, it is difficult to gain an overview of where the IF's occur across the phases of PD. For project management to understand when to set up strategies that reduce effects on time, cost and quality, there is a need to understand how the IF's vary over the phases of PD. This is further supported by Scrivener et al. (2003) and Hoegl et al. (2004). The following section describes the methodology adopted for the empirical study conducted to address this need.

3 METHODOLOGY

The following section describes the research questions formed as a result of the literature review, the research approach adopted to investigate the questions and the method employed to collect the data.

3.1 Research Questions

Based on the conclusions drawn in the literature review, the research sought to answer the following questions:

1. How do the factors impacting the success of PD projects vary during the phases of PD when teams are globally distributed?
2. What is the relationship between the factors impacting the success and the key performance parameters in conventional PD: time, cost and quality?

3.2 Research Approach

To answer the research questions, a deep understanding of the natural context in terms of the product, process and organisation was required. Given this and based on similar studies investigating such phenomenon (Hales, 1987; Scrivener et al., 2003), a case study involving direct longitudinal observations of a PD project was conducted (Yin, 2009; Voss et al., 2002). Firstly; this provided sufficient means at which to map the factors impacting the success along the stages of a PD process in real time, and secondly; provided the context knowledge required to investigate the relationship between the IF's and key performance parameters; time, cost and quality in PD.

3.3 Case study

The case study was conducted at a large Danish manufacturing organisation, which specialise in the production of industrial valves and controls for the refrigeration and air conditioning markets. The motivation for the observed project was to re-design an existing product variant to improve the lifetime of the product. The project was conducted by two engineering departments at the company in both Denmark and India. 10 experienced design engineers from both Denmark and India were involved in the PD project. All phases of the PD project were observed including, *Pre-approval, Planning, Concept Development, Detail Design and Testing and Refinement.* A total of 27 meetings were attended including 14 key project milestone meetings over a time period of 8 months. During these meetings, direct observations were made of the globally distributed teams in India and Denmark at each phase of a PD project. The researchers observed the meetings but did not actively participate. Each meeting lasted between 1– 2 hours and was held using an online meeting tool and recorded for later analysis. Detailed notes were kept and each meeting was transferred into a coding scheme, which is described in the following section.

3.4 Interviews

In addition to the observations, 10 semi-structured interviews were conducted with design engineers, whom were involved in the project from both Denmark and India. The results from the interviews were used as a secondary data source and contributed towards a broader understanding of the factors impacting the success of the collaboration retrospectively. The interviewees were asked to describe:

- How the collaboration with the team in India had affected the team in Denmark (and vice versa) in terms of:
  - The organisational setup and the Product Development process.

3.5 Data Collection and Analysis

The development of the coding scheme was an iterative process, beginning with a pre coding scheme and adding new categories as more data was acquired in order to avoid the confinement of data. An example of the coding scheme developed for data collection is pictured in Table 3. First; the stage of development according to the generic PD process described in literature (Figure 1) is indicated in relation to the stage of development in the company's PD process. Second; the strategic level impact factors discussed during the meetings were recorded and later coded according to the impact factors described in literature (Table 1and Table 2). Strategic level impact factors that could not be coded within the impact factors in literature were placed under an "Other" category. Third; the operational level impact factors, which were related to the strategic factors discussed, were recorded and categorised. Finally, the country of origin of the team member raising the impact factor was noted and the criticality of the factor was highlighted. Frequency counts of each impact factor indicated key patterns and relationships in the data. It is important to point out that each impact factor, both strategic and operational level, was counted in respects to frequency discussed and not frequency mentioned. Following this, the qualitative analysis of the indicated patterns provided an understanding of the rationale and theory underlying relationships revealed from the frequency counts. In addition to the coding scheme, field notes were kept during meetings and frequently referred to during the qualitative analysis.

Table 3. Extract from the coding scheme developed.

Stage of PD*	Stage of PD**	Strategic impact factor	Operational impact factor	Raised by	Critical
Planning	Prepare for M1	Lack of common vision	Managing vendor expectations	Denmark	☐
		Knowledge sharing	Lack of Product & Process understanding	Denmark & India	

4 FINDINGS

The company case is described in the following section. The factors impacting the success of the observed PD project are then mapped along the stages of the company's PD process. The relationship between the IF's and key performance parameters; time, cost and quality are described.

4.1 Company background

Over the past decade, the company has established offshore manufacturing and research and development functions in multiple locations worldwide. The focus for the study described in this paper was the collaboration between two engineering departments based in Denmark and India. In 2011, the company established an offshore research and development function in India with the following motivations:

1. To reduce costs – by gaining access to low labour costs of skilled engineers in India.
2. To increase flexibility – by using the additional resources provided by the Indian engineers to free up the time of the Danish engineers, enabling them to work on more complex development tasks.

At the beginning of the collaboration, key members of the Indian engineers received training in products and processes at the site in Denmark. Since 2011, less complex engineering tasks with low risks, such as the conversion of old product drawings to CAD systems, had been offshored to India while larger and more complex development tasks were kept local. Despite the motivations for the collaboration, the engineers have experienced difficulties in coordinating tasks and activities between the site in Denmark and India, with a number of the Danish engineers dissatisfied with the results. The Danish engineers felt the Indian team were working towards quantity based Key Performance Indicators with financial rewards, which was effecting the quality of the converted CAD drawings.

4.2 The globally distributed PD project

Based on these difficulties, a lead design engineer in Denmark decided to include the Indian engineers in a more complex PD project, providing the Indian engineers with more responsibility towards the development activities of an existing product range. This project was introduced with the aim of improving the collaboration between the two teams and is the focus of the results reported in this paper. The project was introduced to the Indian engineers as a "PILOT" project with the aim of providing an example of best practice. Furthermore, the objective was to improve the lifetime of an existing product, maintaining focus on quality solutions rather than quantity. The success of the project would be measured in terms of the amount of resources consumed. The lead design engineer in Denmark recommended they followed a standard operating procedure (SOP) within the company for completing such a project, documenting the steps followed to allow for learnings to be passed on in future projects. The steps followed during the PD project, which relate to the company's SOP for PD projects can be seen in Figure 2. Despite the project being more complex than previous tasks, it was considered by the Danish engineering team to be a relatively simple project, with the amount of consumed resources expected to be kept low.

4.3 Mapping the impact factors along the PD process

The PD process followed during the project is illustrated in Figure 2. Each phase contains a number of deliverables and the stakeholders to be involved during the PD process. The process is comparable to that described in Figure 1, with the exception of:

- The Pre-approval phase:
  - Before the project entered the phases of PD, there was a pre-approval phase, where initial project plans and a product problem analysis were presented to an approval board for a go/ no go decision regarding the project.
- The positioning of gates:
  - There were three key milestones during the project. At each milestone, the team presented the project to an approval board, which made the decision of whether the project could move to the next phase of PD.

The red pointers indicate the factors impacting the success of the project at each phase of the PD process. The green pointers indicate the stage along the PD process that the project team requested external feedback towards the project progress.

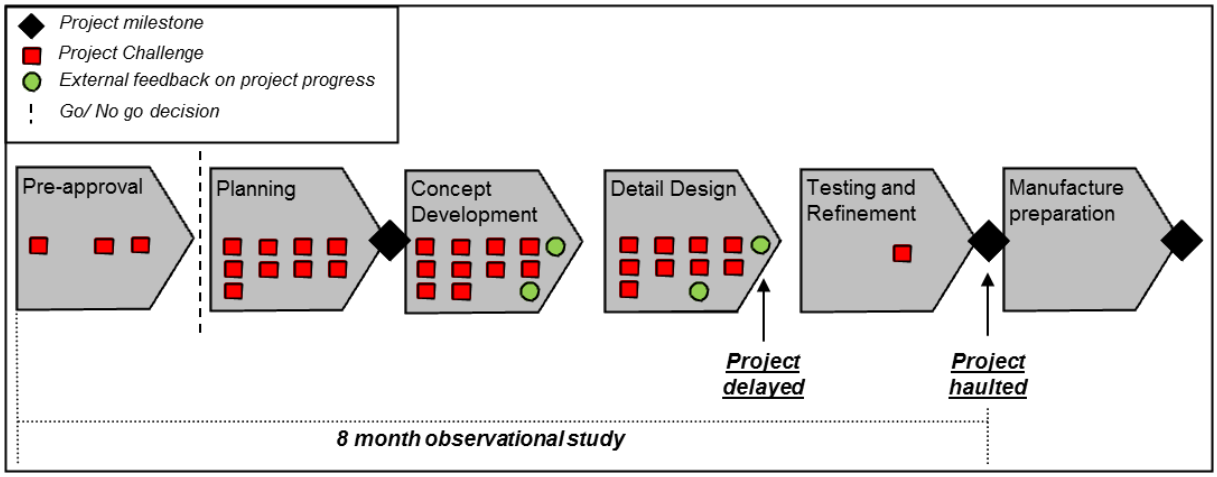

Figure 2. Company PD process, with indication of where impact factors occurred.

After the *Testing and Refinement* phase, the project was halted as other projects at the company took priority, which explains the lack of IF's discussed during the *Manufacture Preparation* phase. Furthermore, the *Testing and Refinement* phase was predominantly conducted at the production site in Denmark, with little involvement from the Indian engineers. The majority of the factors impacting the success were discussed during the *Planning, Concept Development* and *Detail Design* phases. The external feedback was provided at the end of the *Concept Development* and *Detail Design* phases. The feedback was provided by expert design engineers and product technicians who were not involved in the project directly, but were considered knowledgeable toward the product being developed. The final date of the project milestone meeting after the *Testing and Refinement* phase was delayed by two and a half months. The factors impacting the success of the project are illustrated in Figure 3, according to each of the phases of PD pictured in Figure 2. A lack *of common vision* between the Indian and Danish engineers was the factor discussed most frequently during the project with a frequency count of 14. The IF was predominantly discussed during the *Planning, Concept development* and *Detail Design* phase. *Documentation* was the second most discussed IF with a frequency count of 4. Despite only being discussed twice, *standardising tools and procedures* was a factor discussed that the authors considered critical during the project.

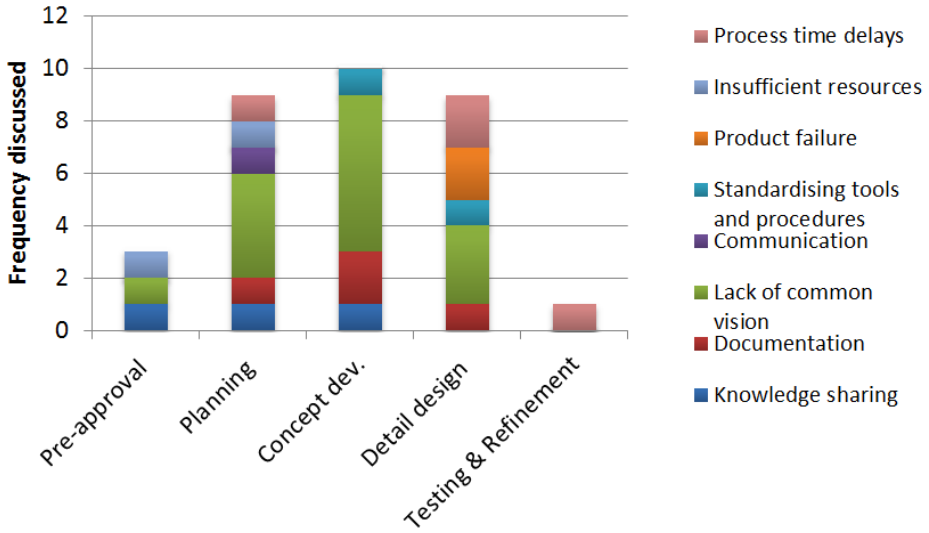

Figure 3. Factors impacting the success of the project at each stage of PD

4.4 Lack of common vision: Managing vendor expectations

During the *Pre-approval* and *Planning* phase, the lead design engineer in Denmark requested the Indian engineers to conduct a root cause analysis, providing 2-3 potential solutions that would improve the product lifetime. This was a deliverable for the first milestone. During the analysis, the

Indian engineer's uncovered additional issues with the product that would have a positive impact on additional product variants, and thereby adding value to the "PILOT" project. A total of 8 potential solutions were presented back to the lead design engineer in Denmark, which the Danish engineer considered being ambitious and outside the main goals and scope of the project, particularly considering the amount of resources required to implement the solutions. The lead design engineer in Denmark reminded the Indian engineers of the expectations for the project and lowered the ambition levels for the project accordingly. The Indian engineers agreed and the project was approved by the approval board at the first milestone meeting. Despite this, during the *Concept Development* and late in the *Detail Design* phase, the Indian engineers continued to push for the solutions, which positively impacted additional product variants. The Indian engineers were interested in increasing the value of the project, while the Danish engineers were interested in working efficiently towards improving the initial problem with the product. Late in the *Concept Development* and *Detail Design* phase, the lead design engineer invited a number of expert design engineers to provide their feedback on the proposed solutions and the progress of the project. The feedback they received was to focus on improving the lifetime of the single product variant by making a small number of design changes and hence, ensuring resource consumption was kept low.

The misalignment of work completed by the Indian engineers with the expectations communicated by the Danish engineers was a key cause for the second project milestone being delayed by two and a half months. The project represents a case where coherence between project goals in Denmark and India was lacking, which is described as a key factor impacting the success of globally distributed PD projects (Table 2). One possible explanation for this was the Indian engineers were aware the project was a "PILOT" project and therefore, applied additional resources than was necessary for the project in order to prove their value. Furthermore, the role of project manager was assigned to a skilled design engineer in Denmark. Project management is a factor impacting the success of conventional PD projects (Table 1) and when managing globally distributed teams, the requirement for project management is increased (Eppinger and Chitkara, 2009). In the case presented, the need for greater project management competencies for the globally distributed PD project was evident. Managing the Indian engineers' expectations was an issue discussed in the early phases of the project. However, the feedback from the expert design engineers was not provided until late in the project, at which time the in depth analysis had already been performed by the Indian engineers. Involving the feedback earlier in the project may have identified the *lack of common vision* in the team, enabling the Danish project manager to take necessary preventative action. Furthermore, as the project progressed, the lack of prioritisation of the project against other more complex PD projects was evident as the project was down-prioritised and halted after the *Testing and Refinement* phase was complete. This was highlighted as a risk for the project in the *Planning* phase of the project.

4.5 Standardising tools and procedures: Alignment of processes

Before the project commenced, the lead design engineer in Denmark suggested the project team follow the SOP developed in the company for the completion of the PD project. The SOP was used during meetings throughout each phase of the PD process by the lead design engineer as an approach to steer the tasks and activities required for the progression of the project. However, from the early *Planning* through to the *Detail Design* phase, the Indian team preferred to plan their activities according to a six sigma process, which the Indian engineers had recently received training in. This caused for further misalignment between the work completed in the project team and the deliverables documented in the SOP. This can be linked to the IF highlighted earlier: *A lack of common vision*. The lead engineer in Denmark attempted to document the project according to the SOP in order for learnings to be carried over to future projects. However, the Indian engineers approached the project as an opportunity to build their competencies in using the six sigma process. This appeared to cause tension between the lead design engineer in India and the lead design engineer in Denmark as the Indian team felt the six sigma process complimented the SOP. Ensuring process modularity during globally distributed PD projects is one of ten, key success factors highlighted by (Eppinger and Chitkara, 2009). The misalignment of processes in the project made it difficult for the lead design engineer in Denmark to monitor tasks and activities between the two teams.

In summary, the case described highlights that *a lack of common vision* between globally distributed teams in PD is a key factor impacting the success of PD projects; causing time delays and increased resource usage. To prevent these issues, it is important to include feedback from stakeholders outside of the project during the early phases of PD projects. This would potentially enable project managers to identify factors impacting the success of a project and take necessary preventative action. The *lack of common vision* was also evident based upon the existing collaboration prior to starting the project observed, where it was felt a number of the Indian engineers were working towards high-level, quantity driven Key Performance Indicators, which had a negative impact on the quality of the work completed. Furthermore, ensuring a project team has the required project management competencies is a factor impacting the success of conventional PD (Table 1). In globally distributed PD development teams, the required competencies are extended and experience working with engineers from culturally different backgrounds is important. Additional controls, especially during the early phases of a project, than those suggested in conventional PD are required when managing globally distributed PD projects. When considering the goals of the project at the outset, it is difficult to label the project a success as the amount of resources consumed, in terms of time, was greater than expected.

4.6 Comparisons with Conventional PD

The process of PD has been described as a method for controlling the activities associated with PD and reducing risks during projects (Cooper et al., 2001). The PD process followed during the completion of the project was comparable to the generic PD process described in literature. Despite following this process, the globally distributed team experienced issues related to a *lack of common vision*, suggesting a need for an increased level of control in the early phases of PD to ensure project level goals are aligned. When considering the key parameters time, cost and quality in conventional PD, Rosenau (1993) described the parameters as being mutually exclusive. However, based on the findings from the case study described, the authors argue that the parameters are highly inter-related and the factors impacting the success in globally distributed PD projects add further complexity. *A lack of common* vision between the two teams at a strategic level led to a misalignment of work completed with the expectations communicated at an operational level. This was evident both in terms of the project described, and the issues with quality versus quantity before the project commenced. These factors impacting the success of the collaborations and caused time delays during the project, and quality issues with work completed. The effects on time and quality led to increased resource usage, which is associated with increased costs.

4.7 Limitations

The single case study approach undertaken is one of very few longitudinal studies conducted of globally dispersed teams, with the strength of real tasks and activities being observed in an industry setting. However, this also means that single factors such as culture or distance cannot be blocked as in experimental studies. Despite this, the benefits of our approach outweigh the limitations.

4.8 Conclusion

The paper investigated factors impacting the success of PD projects when teams are globally distributed. From the literature review, there was a lack of longitudinal observational studies in globally distributed teams, which focussed on all phases of PD; from the early planning and development through to the final testing and refinement phase. To address this, an 8 month longitudinal observational study was conducted, providing an overview of the factors impacting the success across the phases of a PD project. A *lack of common vision* between the teams in Denmark and India, particularly during the *planning, Concept Development* and *Detail Design* phases of the project was a key cause for time delays during the project. Involving feedback from design experts earlier in the process may have allowed the project team to avoid such delays. Difficulties in following a common procedure during the early phases of the project further added to the time delays. By building on previous work in the area and utilising aspects of established methodologies from PD, this paper provides an understanding of the factors impacting the success of PD projects when teams are globally distributed, providing an overview of where along the PD process the impact factors occur. For future research, there is a requirement for additional longitudinal studies in globally distributed teams that map the factors impacting the success across the PD process. This will provide project

managers with an overview of when the factors may occur during PD, enabling them to set up strategies that reduce effects on time, cost and quality.

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