ABSTRACT

Title of Dissertation: **VIRTUAL AND COLLOCATED PROJECT TEAMS IMPACT ON PRODUCTIVITY IN MEDICAL DEVICE RESEARCH AND DEVELOPMENT**

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Master of Science Project Management
Master of Science Technology Management
Master of Business Administration
Bachelor of Business Administration, Minor in Project Management

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Two project management environments, virtual and collocated project teams, were researched and analyzed in this dissertation to determine the impact in productivity in medical device research and development. The relationship between virtual and collocated project teams and project management levers was also explored in this dissertation using four case studies. This case study methodology was performed based on the lack of past research to explore virtual and collocated project teams in four research and development medical device environments. The following project management levers were integrated into the research: environment (virtual and collocated project teams), leadership, meetings, team maturity (knowledge and experience/expertise), continuous process improvement, and information communication technology processes. The research contributes to medical device research and development organizations that utilize virtual and collocated project teams and suggests best practices to improve productivity. This also provides project team members potential ideas into improved productivity.

Both project team environments were viewed as effectively achieving productivity. The results of the four case studies indicated no significant differences between virtual and collocated project teams productivity. Minor differences were found across the project management levers in the case studies.

The following major recommendations are made for improving productivity in future virtual and collocated project team environments: medical device research and development organizations should give additional attention to more up-front planning to determine risks, resources, continued process improvement, information communication technology, and leadership needed to complete the project; leadership and project management training should be provided, they should continue to seek a balance in project team resources and the level of project team maturity (knowledge and experience/expertise); meetings need to be performed efficiently and have an agenda and information communication technology tools need to be fully utilized and integrated across medical device research and development project teams.

Keywords: case study, virtual project team, collocated project team, productivity, research and development

VIRTUAL AND COLLOCATED PROJECT TEAMS IMPACT ON PRODUCTIVITY IN MEDICAL DEVICE RESEARCH AND DEVELOPMENT

By

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Dissertation submitted to the Faculty of the Graduate School of the
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Preface

The researcher’s journey toward his Ph.D. started many years ago with encouragement from one of his Professors, Dr. Ginger Levin. It is not only passion but persistence that has taken the researcher through this journey. Without both of these, he would not have been able to succeed in his Ph.D. journey. He also would have not reached this point in finishing his dissertation without the support of others willing to critique and encourage.

As this researcher started in this journey, he was set to come up with some insight that would ignite the new product development world. He has spent many hours researching project teams and productivity in order to find some knowledge gaps and add to the body of knowledge.

What he found out is that as he read articles, books, papers, and etc., he started to meet and interact with authors, publishers, and colleagues around the world. There were so many topics and ideas that it was hard to stay focused on just one. He has had countless telephone calls, emails, and social media discussion with many experts around the world.

Another interesting topic that the researcher spent a large amount of time exploring is trust in project teams and how it affects overall productivity. He reached out to thought leaders in academia and people that have their own companies in this area. It was joy to know that so many will take time out of their busy day to discuss this topic with him.

One common thread through all of this process was the virtual and collocated project team and how productivity was impacted both positively and negatively on different project teams. It seemed like a logical area to explore further and research to benefit future project teams.

Dedication

Thanks to my wife, Patricia, and my son, Calvin, for their support and dedication during my research. Without their commitment, effort, and support, I could not have made it through this process. I appreciate the ability to focus on my studies into the late evenings and be able to stay with my work. I know how difficult this was for my family and I thank them for their understanding. Dedication also goes to my parents and my in-laws for their patience and support over the past years. I dedicate to them this important professional achievement.

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I would like to express my thanks to many that helped me through this process. There have been many little things and many large things that people have given as support over many years to be able to get me through the different stages of this doctoral program.

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Thanks also goes out to Professor Cable for working with the researcher at the start of this program, during the program, and at the end to have a successful and valuable experience in the doctorate program at the University of Maryland, College Park.

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Thanks to Dr. Gary Jurek, for his many hours of support, discussion and his annual bread, this always puts a smile on my family's faces. He has taught me many small and large lessons over the many years that I have known him. I would also like to thank him for the countless hours of project management training that I have been a part of over the years.

Thanks to the sponsorship from my manager, Joe Klein, and senior manager, Steve Schultz, for support and the case study project teams. And thanks to the legal group for taking the time to review my materials and make sure everything is correct and in order. Also, a major thanks to the pilot and case study participants who took time out of their busy days to participate in the interviews, to validate interviews, and to provide comments. All of the studies participants were professional, timely, and easy to work with as I progressed through the pilot and case studies.

Special acknowledgement goes to Dr. Tracy Ng, for being one of the scientific developers and specialists spearheading case study utilization in this research.

I also appreciate the support of the University of Maryland, College Park students for giving me a means to discuss ideas, ask for information, and for being there when I needed something. David Choy at the University of Maryland, College Park has been a great friend, classmate, and Ph.D. inspiration. I appreciate all of the telephone calls, emails, and visits. I was always pointed in the right direction to get the information I needed.

Thanks also to Kerri Poppler James as she was always helpful and able to get the information I needed quickly. I appreciate her timely and insightful feedback during my time as a student.

Thanks to Jim Miller at the UMD library. He consistently demonstrated support for my work and was able to suggest sources for consideration. His timeliness and insight made the process much smoother.

Thank you to Lynn and Scott for giving me the time to be able to study in peace as I worked on my dissertation.

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Acronyms

AAMI	Association for the Advancement of Medical Instrumentation
ACS	American Chemical Society
AHP	Analytical Hierarchy Process
AlChE	American Institute of Chemical Engineers
ASSE	American Society of Safety Engineers
ASQ	American Society for Quality
AOP	Annual Operating Process
BA	Bachelor of Arts
C	Collocated
CAP	Change Acceleration Process
CBA	Certified Biomedical Auditor
CBAP	Certified Business Analyst Professional
CC1CTL	Case Collocated #1 Core Team Leader
CC1PM	Case Collocated #1 Project Manager
CC1TM	Case Collocated #1 Team Member
CC2CTL	Case Collocated #2 Core Team Leader
CC2PM	Case Collocated #2 Project Manager
CC2TM	Case Collocated #2 Team Member
CEM	Certified Engineering Manager
CEO	Chief Executive Officer
CIP	Continued Improvement Process
CITI	Collaboration Institutional Training Institute

Class I	General Controls
Class II	General Controls with Special Controls
Class III	General Controls and Premarket Approval
CPAS	Comparative Performance Assessment Study
CPM	Certified Product Manager
CQA	Certified Quality Auditor
CQE	Certified Quality Engineer
CQI	Certified Quality Inspector
CQT	Certified Quality Technician
CSSGB	Certified Six Sigma Green Belt
CTL	Core Team Leader
CV1CTL	Case Virtual #1 Core Team Leader
CV1PM	Case Virtual #1 Project Manager
CV1TM	Case Virtual #1 Team Member
CV2CTL	Case Virtual #2 Core Team Leader
CV2PM	Case Virtual #2 Project Manager
CV2TM	Case Virtual #2 Team Member
DFM	Design for Manufacturing
FCC	Federal Communication Commission
FDA	Food and Drug Administration
FMEA	Failure Mode Effects Cause Analysis
ICT	Information Communication Technology
IM	Instant Messaging

IP	Intellectual Property
IPMA	International Project Management Association
IRB	Industrial Review Board
IT	Information Technology
LSS	Lean Six Sigma
MBA	Master of Business Administration
MBTI	Meyer-Briggs Type Indicator
MSPM	Master of Science in Project Management
MS Project	Microsoft Project
MSTM	Master of Science in Technology Management
ND	No Date
NPD	New Product Development
NPDP	New Product Development Professional
NPV	Net Present Value
PC1	Pilot Collocated Team #1
PC1CTL	Pilot Collocated #1 Core Team Leader
PC1PM	Pilot Collocated #1 Project Manager
PC1TM	Pilot Collocated #1 Team Member
PDMA	Product Development and Management Association
Ph.D.	Doctor of Philosophy
PgMP	Program Manager Professional
PM	Project Manager
PMI	Project Management Institute

PMO	Project Management Office
PMP	Project Manager Professional
PV1	Pilot Virtual Team #1
PV1CTL	Pilot Virtual #1 Core Team Leader
PV1PM	Pilot Virtual #1 Project Manager
PV1TM	Pilot Virtual #1 Team Member
R&D	Research and Development
ROI	Return on Investment
SS	Six Sigma
TM	Team Member
TQ	Total Quality
TRIZ	Theory of Inventive Problem Solving
UMD	University of Maryland
USA	United States of America
V	Virtual

Chapter 1: Introduction

Introduction

Chapter one introduces the background of the dissertation, its significance, the researcher's proposition's, and objectives. It also highlights at a high level the research design including methods and summary. The structure of this dissertation is detailed to facilitate readers of this research.

Introduction to the Problem

> *"The origin, history, and evolution of project management, and its academic background, foundations, and underlying theory, have been debated and studied only to a limited extent from the management fields academic perspective, and supporting literature is limited"*(Kwak & Anbari, 2009, p. 435).

Project management today is still in the infant stages of being productive and active among different management fields (Kwak & Anbari, 2009). In a global environment, organizations have more competition, and in order to maintain a leadership position executives need to utilize the practice of project management. As early as the 1950s, project management was recognized by DuPont and in the aerospace industry. In the 1960s and 1970s, project management teams were implemented in organizations as a way to increase performance (Juran & Godfrey, 1999). Project management teams have constant change, which can affect productivity and performance (Tohidi, 2011). A project team is defined as a group of people with a common purpose and approach for which they hold themselves mutually accountable (Katzenbach & Smith, 2003).

Project management is not only about planning, scheduling, and managing, but it is also about bringing the human aspect together to obtain world class quality (Smith, Smith & Niederhoffer, 1998). Businesses have faced a decline in productivity, quality, and effectiveness (Yang, 1996). Productivity can be improved by using Lean-Sigma and Six-Sigma in organizations. Project teams are trying to find ways to shorten product cycle times and improve productivity while quality remains at a high level (Calantone & Di Benedetto, 2000). Project management teams can be virtual project teams or collocated project teams, which could assist a variety of global organizations in increasing productivity depending on where they derive their human resources.

Figure 1.1 is a high-level overview of the research in this dissertation, which provides the context of this research. Overall, the research in this dissertation will focus on the team environment (virtual and collocated) and its impact to productivity. Interviews with open-ended questions are used with individuals or groups to get their perception and ideas (Glatthorn & Joyner, 2005). The project team environment can be directly related to performance and productivity, which leads to the next theme: performance and productivity. Performance and productivity will be discussed in the context of trends in project management via virtual project teams and collocated project teams, as well as other project management levers that can also increase performance and productivity. In this regard, case studies will be analyzed to discuss these trends, levers, and other factors that relate to project management and the efficiency of a global organization. Project management levers will be discussed in more detail in Chapters 2 and 3.

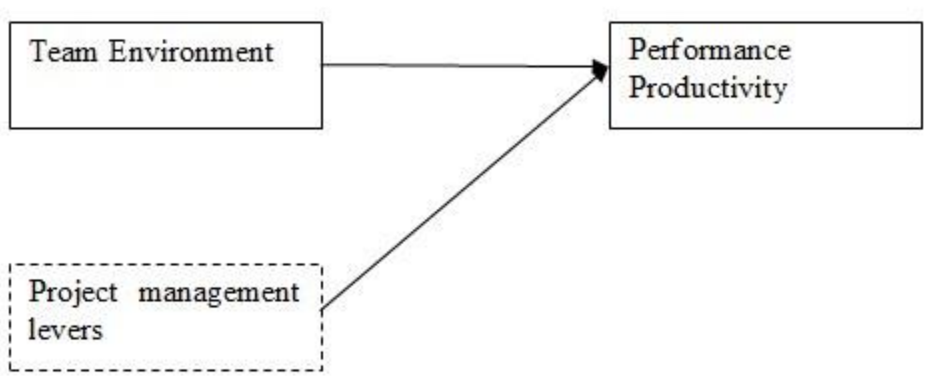


Figure 1.1 Overview of research

Today project teams need to find ways to increase speed to market while not compromising quality. Recent information calls for even more change. Current business developments call for yet another change in leadership toward connectivity and connection. Today’s successful global manager must be capable of optimizing the skills of a diverse workforce, where multiple values, cultures and languages bring the potential for colleagues to disconnect from each other and instead use this diversity to promote collaboration. A key role of today’s and tomorrow's manager is to increase productivity while not compromising quality. Productivity is the dependent variable that brings together a variety of different technology and communication.

To increase the team’s productivity, it is necessary to change the communication and technology (Tohidi & Tarokh, 2006). Relevant and useful knowledge in project management will surface to focus on organizational performance, communication interaction, and collaborative work (Winter, Smith, Morris, & Cicmil, 2006). There was an increased focus on teamwork in the 1970s as a subset of project management (Crawford, Pollack, & England, 2006). Crawford et al. (2006) indicate that teams are still an area of research interest. Project teams are used in the (R&D) medical device industry and can also be complex. R&D utilizes tools and processes that are applied to complex projects (Kwak & Anbari, 2009). The R&D medical device industry provides a suitable context for this case study as virtual project teams and collocated project teams are especially prevalent. Based on the review of the literature there appears to be a gap in the study of virtual project teams and collocated teams as they relate to productivity in an R&D medical device organization.

Project teams can be considered a driver of productivity regardless if they are virtual or collocated. “The empirical evidence regarding team effectiveness is limited and often has the form anecdotes or descriptive case studies” (Tohidi & Tarokh, 2006, p. 610). There are advantages and disadvantages to each of these types of project teams. Some of the most obvious advantages for collocated project teams are interacting face-to-face, and they can also share a common or physical space. Virtual project teams have the advantage to interact 24 hours a day by using technology such as Wiki pages, blogs, and shared sites. Rapid changes in technology have greatly improved the structure of the project teams (Smith et.al., 1998). Some disadvantages of virtual project teams and collocated project teams are poor leadership, poor meeting environments, poor continuous process improvement and poor information communication technology tools. In addition, virtual project teams can have time zone differences. Both virtual project teams and collocated project teams can have cultural differences and a lack of trust during projects

Virtual project teams are dispersed geographically or organizationally. Most virtual project teams work through some type of electronic communication, and team membership is fluid (Cascio, 2000). “Virtual team members are physically separated from each other and rely mainly on technological devices for communication and information exchange” (D’Souza & Colarelli, 2010, pp. 630-631).

Collocated project teams are organized by less distance between project team members and are not challenged by geographical distance and time zones. Collocated project teams are composed of people from cross-functional groups that are working together in the same space (Lipnack & Stamps, 1997). Collocated project teams are “Members in face-to-face teams work in close physical proximity and communicate primarily face-to-face” (D’Souza & Colarelli, 2010, p. 630). Simply stated, collocated is being physically located in the same space (Brake, 2009).

There are project management levers that can influence the productivity of both virtual and collocated project team. Figure 1.2 provides a better understanding of the researcher's overall project management levers to be utilized within this research.

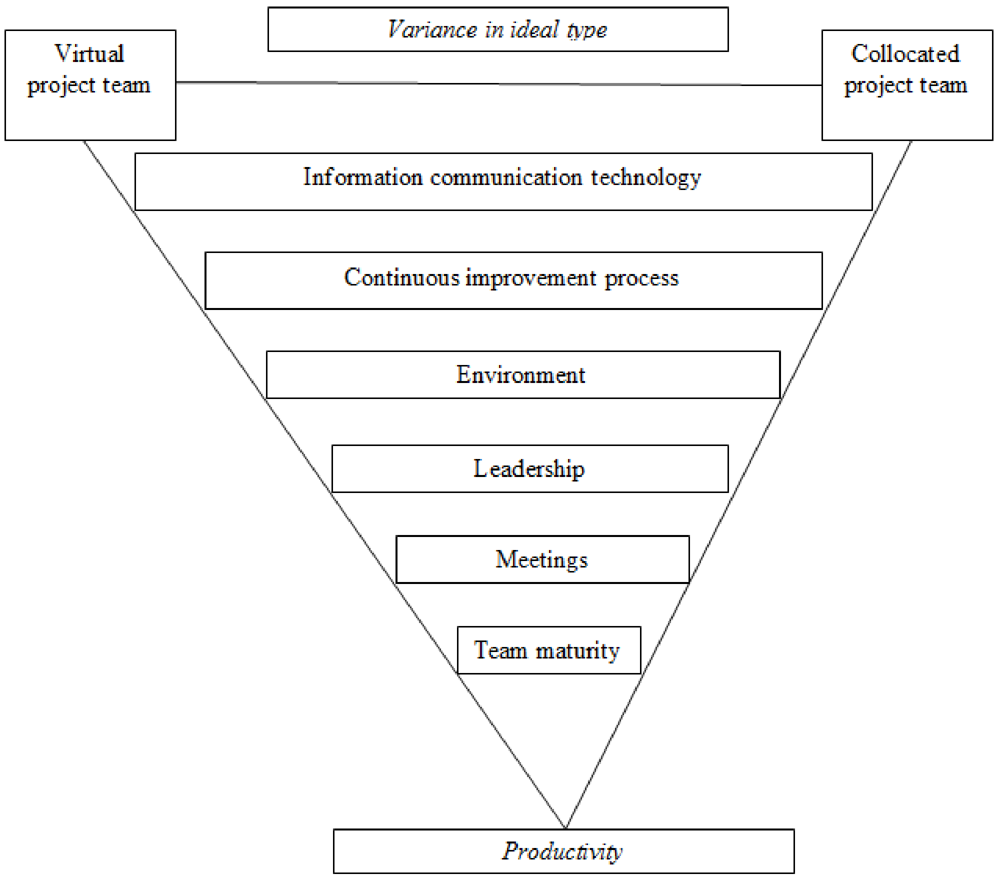


Figure 1.2 Project management levers

Project management levers were determined by the researcher's past experience and from the literature review. He discussed these project management levers with experienced project manages early to brainstorm areas they thought were negatively affecting productivity in project teams. Table 1.1 outlines the general definitions of each project management lever.

Table 1.1 Definitions

Project Management Lever	Definition
Environment	Environment refers to the virtual project team or collocated project team where the project team interacts.
Leadership	Leadership is the project team leadership typically provided in either a core team leader role or project manager role within the R&D medical device organization.
Team maturity	Team maturity is the experience/expertise and knowledge of the project team members on the project teams.
Meetings	Meetings are the typical team meeting that is used for cross-functional information communication and documentation of actions items, risks, etc.
Continuous improvement process	Continuous improvement process is the Lean Sigma or Six-Sigma that teams utilize to improve process.
Information communication technology	Information communication technology is the technology that virtual project teams and collocated project teams are utilizing.

“Communication has always been viewed as a key element in any group, whether collocated or distributed” (Sarker, Ahuja, Sarker, & Kirkeby, 2011, p. 283) and can build a network of people of trust and responsibility (Kähkönen & Leinonen, 1999). Communication is important for successful project management (Kähkönen & Leinonen, 1999). All project team members need to know what the goal of the project is and other items such as schedule, cost and scope. This needs to be communicated to not only the project team members but also to functional management and other stakeholders. Trust and cultural differences are not part of this research but are discussed at times in this dissertation.

Background of the Research

> *"Virtual project teams are more prevalent than ever. It's not hard to see why. Advances in technology have made it easier to organize and manage dispersed groups and people. And competitive pressures and the needs of today's global market workforce have made virtual project teams a necessity for some organizations" (DeRosa & Lepsinger, 2010 p. 3).*

DeRosa & Lepsinger (2010) report that virtual project teams can play an important role in most if not all project teams today. R&D virtual project teams use different types of technology to communicate and complete the research beyond space, time, and organizational boundaries (Ebrahim, Ahmed, Rashid, Taha, 2011b). According to Ebrahim, Ahmed, Rashid, and Taha (2012), the project teams and managers still do not know what type of technology to utilize on virtual R&D teams. This can be true for other virtual project teams. Virtual project teams in general represent a growing need for faster cycle times, lower cost and improved solutions to complex organizational problems. Companies today are investing more in virtual project teams to enhance performance and effectiveness (Ebrahim, Ahmed, & Taha, 2009a).

Project management levers that are utilized in this research are discussed briefly. Both team structures can often have Information Communication Technology issues. Collocated project teams have the option to have face-to face-interactions, and many times this may resolve the problems; being defined as issues or miscommunication between project team members. Many virtual project teams at times take longer to resolve problems discussed earlier. Leadership is an area that can also lead to issues if not performed correctly. The use of effective meetings will add to a successful or unsuccessful project. Project success should have a direct relation to project management processes (Rad & Levin, 2006). Success is also driven from the team maturity of the team and team members, how long have they been with the organization or how long have they been in the industry. Finally, continuous improvement process will help the team run more efficiently through the project life cycle by asking what the customer wants and needs.

This research will use a single organization in a single industry. Using this approach will tend to avoid industry to industry variations (Rochford & Rudelius, 1997). The medical device industry and R&D organization will be the industry for this research. This area is highly technological, innovative, complex, and heavily regulated in a competitive landscape. The medical device industry not only offers clinical applications but also economic value. Most people in this industry are highly educated, skilled, and tend to stay in it for their entire careers. Research from this dissertation could be applied to other high-technology industries by reviewing the positive and negative summaries in Chapter 10 to improve their project management performance.

Each pilot and case study are on a continuum of virtual and collocated team environments as seen below in Table 1.2. A 100% virtual project team would indicate that there was never a face-to-face meeting, and all communication was done with technology. A 100% collocated project team would indicate that the team only used face-to-face communication and very little to no video or other technology. All project teams in the pilot and case studies are between 100% virtual and 100% collocated. None of the pilot or case study teams were 100% virtual or 100% collocated in this research.

Virtual project teams are on a scale from highly virtual to minimally virtual. The same can be said for collocated project teams; they are either highly collocated or minimally collocated (Kirkman, Rosen, Tesluk, & Gibson, 2004; Kratzer, Leenders, & Van Engelen, 2006). Teamwork is shifting from a collocated project team to a more virtual project team (MacDonnell, O'Neill, Kline, & Hambley, 2009). With the improvement in technology and the lower cost of technology more organizations have been able to access project team members. The location of a project team member is not as important now with improved technology.

The virtual project team on one side of the figure over to the collocated project team on the other side depicts the continuum that is in Table 1.2. The distance in between the virtual and collocated is in the overall variance of the virtual project teams and collocated project teams. Within this variance are the researcher’s objectives or project management levers. These areas will be further discussed in Chapters 2 and 3 of this dissertation.

Table 1.2 Virtual and collocated continuum

V 100%	*High*	*Medium*	*Low*	*Low*	*Medium*	*High*	100% **C**
10	7	5	3	3	5	7	10

“Virtuality lies on a continuum ranging from highly to minimally virtual” (Kirkman et al., 2004, p. 178). Collocation can communicate with ICT tools today and virtual can still have face-to-face meetings.

Statement of the Problem

> *“Communication is a tool that directly influences the social dimensions of the team and in addition the performance of the team has a positive impact on satisfaction with the virtual project team”* (Ebrahim et al., 2009a p. 5).

Project management teams have constant change, which can affect productivity and performance (Tohidi, 2011). There is change in project team members, roles, responsibilities, scope, etc. Project management is not only about planning, scheduling, and managing; it is also about bringing the human aspect together to obtain world class quality (Smith et.al., 1998).

R&D in the medical device industry is the context in which this dissertation will perform the research. Songkajorn and Thawesaengskulthai (2012) indicate that the innovation process for R&D medical devices is complex. This increases the need for performance and/or productivity improvement on project teams in the R&D medical device organizations. “Technology is reshaping our world and has influenced our life at a speed unimaginable just a few years ago” (Thamhain, 2005, pp. 12-13). R&D medical device organizations will need to address the speed to market with the speed of information communication technology in the future to be productive. The R&D medical device industry is pushing project teams forward fast in order to have vital devices in the market as quickly as possible (Research and Markets, 2013). All project team members must incorporate quality into all tasks, and they must use principles of project management (Ekins, 2011). Geography and more complex technologies make it more difficult for project teams to meet often (Ekins, 2011). Distance can also be a large factor for project teams. Even being in a different building but at the same company can be as difficult as being in a different country. Once a distance of some short distance is exceeded, the difficulty around the team members focusing on frequent communication can be lower. Early in the project the team needs to agree on what type of technologies will be used for the project communication and how they will be used. Training will also be required in these technologies if project team members do not have experience with the ones selected.

Specifically in the R&D field, virtual project teams and collocated project teams will need to be more productive in order to remain competitive in the global environment (Rognes, 2002). “Future research is needed to assess objective outcomes, including project success and productivity” (Montoya, Massey, Hung, & Crisp, 2009, p. 154). The challenge for many global organizations is to integrate new R&D units so they can improve productivity (Gassmann & Von Zedtwitz, 2003). Little work has been performed to review the success or failure of projects such as medical devices (Lucke, Mickelson, Anderson, 2009). Overall, there is a gap of research in the area of virtual project teams and collocated projects teams in the R&D medical device organizations. It is important to investigate the virtual project teams and collocated project teams in R&D medical device organizations and the impact of productivity. To investigate this topic, the researcher will review the impact of productivity in virtual project teams and collocated project teams and how it effects R&D medical device organizations. This research will provide insight into project management levers (defined in Chapter 2), which in turn can help the reader understand how to improve productivity and ensure medical products approved faster (which is more than critical as additional lives can be saved sooner).

Significance of the Research

This research is centered in a medical device R&D organization. This sector meets the requirements to be suitable for this research. The high rate of growth, intense competition, innovation, and customer sophistication are above average as compared to most other R&D sectors. Medical device R&D organizations need to cooperate with external resources for the R&D of new products (Pullen, De Weerd-Nederhof, Groen, Song, & Fisscher, 2009).

The medical device industry is comprised of a surgical, cardiovascular, home healthcare, general medical and other devices. “The industry is highly fragmented, and North America dominates with 46% of the global market” (Lucintel, 2012, para. 3). An important theme in 2012 was globalization in large markets (Stuart, 2013). Globalization has put more products and services in consumers hands with shorter cycle times (Broeding & Goodwalt, 2012). The global medical device industry has experienced large growth in the past years (Industry Review Press Release, 2012). Increased global competiveness and increased regulation are challenges that this industry faces. China, India, Russia and Brazil are the markets that will be most important in 2012 (Industry Review Press Release, 2012). “Medical device industry norms in 2020 will be radically different that they were in 2012” (Research and Markets, 2013, para. 2). Organization structures will change dramatically in the future, and many medical device companies will not continue to survive or exist (Research and Markets, 2013). “U.S. Medical Devices (In Vitro Diagnostics, Medical Devices, Medical Equipment, and Medical Supplies) is an industry undergoing redefinition and revitalization. Technologies and a myriad of innovations are converging to enable the creation and development of new and/or improved products” (Research and Markets, 2013, para. 2).

The introduction of new medical devices into clinical practice can be delayed in the United States when compared to Europe. A demonstration of both safety and efficacy needs to be demonstrated (Kaplan, Baim, Smith, Feigal, Simons, Jeffreys, Fogarty, Kuntz & Leon, 2004). With increased regulatory approvals and other technology complexity, the process has become more difficult. “Through better understanding of these systems, we will be able to recommend modifications and improvements toward improving speed and efficiency without compromising the basic demonstration of safety and efficacy that remains the USA regulatory mandate” (Kaplan et. al., 2004, p. 3072). The medical device industry is dynamic, fast, and will influence health care cost as much as the pharmaceutical companies. Focused innovation will drive profitability in the long run (Atun, Shah, Banquet, 2002).

Many individuals find it fulfilling to work on medical devices that change people’s lives and save lives. It is a primary factor that drives people to the medical product development industry and keeps them there (Wiklund & Wilcox, 2005). Individuals find themselves on project teams that are cross-functional, virtual, or collocated today. Virtual R&D project teams are temporary teams of geographically, organizationally and time-dispersed knowledge workers who coordinate their work mainly with electronic communication technology to carry out project tasks (Ebrahim et al., 2012). Collocated R&D project teams are temporary teams of knowledge workers who communicate largely face to face to complete projects.

The original research idea developed from the researcher's experience (see Appendix A) and is supported by the gap identified in the literature review in existing knowledge base areas. "We advance our knowledge of globally distributed teams by conducting a field study that compares the collaboration activities between members of a globally distributed team with the collaboration activities between collocated team members performing a similar task" (Gupta, Mattarelli, Seshasai, & Broschak, 2009, p. 148). The significance of this research is to explore virtual project teams and collocated project teams in their environments in regard to R&D medical device team's productivity. Findings from this research may provide insight into how virtual project teams, collocated project teams, and organizations could improve their productivity. Some of the knowledge gaps may be filled, and this may also create future research.

Figure 1.3 presents a framework for the researcher in project management. Element one is used to explain project management, element two is the methodology, and element three is the research, which includes literature review and body of knowledge.

Theoretical Tradition	**Methodology**	**Issue / Area of Study**
Understand and explain world of project management and assumption about and concepts of reality, science, knowledge ethics and values	*Level of inquiry* *View on empirical data* *View on the role of theory in the research process*	*Body of knowledge deemed legitimate* *Previous research* *Extant literature* *Current debates*
Element 1	Element 2	Element 3

Figure 1.3 Practical framework for thinking about project management (Adapted from Winter et al., 2006, p. 647)

Research Proposition

The proposition is that productivity and performance have an impact on project teams, which can be improved by understanding and implementing project management team levers and potentially modify contextual environments in virtual project teams and collocated project teams. All three of the project core themes relate to the project management levers; see Table 1.3 for project management levers. The researcher used this approach to form his ideas and review more detailed level information for this dissertation. By putting the researcher's ideas in a table format, he was able to better understand which ones had a greater chance of impacting productivity versus other levers.

The researcher's dissertation will make important contributions to the virtual project teams and collocated project teams in R&D medical device organization literature. Specifically, he will focus on project teams in the virtual and collocated environment in an R&D medical device organization and their ability to increase or decrease productivity. He will focus on the comparison of virtual project team with collocated project teams in the case studies performed.

Project management is a growing profession and one that has been of interest for many years. In the modern work environment (virtual and collocated teams), the need for organizations and individuals to work on a global level has increased. People can work from anywhere at any time, recruited for their skill sets, and enhance productivity because of less commuting and travel time (Sookman, 2009).

Research Scope and Objectives

The scope of this research is to explore how virtual project teams and collocated project teams impact productivity in an R&D medical device organization. In this research, virtual project teams and collocated project teams will be compared using project management levers such as leadership, environment, meetings, team maturity, and ICT and CIP. The research sample is productivity in a R&D medical device organization.

Productivity in R&D does not come from harder work; it is increased with shorter cycle times, less waste, and improved resource allocation, and having the best talent on the team (McGrath, 1996). “Productivity is an outcome, not an individual or even a team goal; and treating productivity as a goal can have negative unintended consequences” (Starbird & Cavanagh, 2011, p. 121). Project teams that have a goal, proper management, and the resources they need will be a more productive team. A well-designed and well-run process will enhance productivity (Starbird & Cavanagh, 2011). Project team size, though, can negatively affect productivity in R&D (Lee, Kim, & Koh, 2009). Once a project team reaches too many communication channels between team members, it can be difficult to communicate efficiently. Productivity in project teams can be increased with improved relationships and across multiple locations (Wang, 2011). Wang (2011) indicates that virtual project teams are as productive as collocated project teams. A weakness of this study by Wang (2011) is that it only looked at the managers and not the any of the project team members, and the researcher recommends conducting more studies in other organizations.

This dissertation attempts to achieve four research objectives; they are:

1. *To explore the major areas of project management, for example, information communication technology, leadership, meetings, team maturity, and continuous improvement processes on virtual and collocated project teams in R&D medical device teams.*
2. *To identify and explain any productivity issues, positive or negative, in both virtual and collocated project teams in R&D medical device teams.*

3. *To investigate and explain the impacts of project management, for example, information communication technology, leadership, meetings, team maturity, and continuous improvement processes in virtual and collocated project teams in R&D medical device teams.*
4. *To identify and present possible solutions to improve performance or productivity of the virtual and collocated project teams in R&D medical device teams.*

Research Design

The problem is a human research problem in how virtual project teams and collocated project teams are either productive or not productive. The research will explore the project management levers regarding productivity in virtual project teams and collocated project teams in an employment context within an R&D medical device organization. The research "involves emerging questions and procedures; collecting data in the participants setting; analyzing the data inductively, building from particular to general themes; and making interpretations of the meaning of data" (Creswell, 2009, p. 232). The research design of this dissertation was planned and organized following the framework in Creswell (2009) for design (see Figure 4.2). The research design needs to build on a foundation from a philosophical perspective that details the research approach and processes. Creswell (2009) informs researchers to think about "the philosophical worldview assumptions that they bring to the study, the strategy of inquiry that is related to the worldview, and the specific methods or procedures of research that translate the approach into practice" (p. 5). "This information will help explain why the researcher chose qualitative, quantitative, or mixed methods approaches to their research" (Creswell, 2009, p. 5). This research follows the constructivist assumption to claim knowledge. The strategy of inquiry was the case study using the multiple-case, comparative design. The research method relied mainly on open-ended interviews supported by semi-structured interviews and triangulations using documentation and archival records. The research tool was the qualitative approach. Chapter 4 discusses the framework elements and research design. The research process is defined as:

- Phase I – Literature Review
- Phase II – Pilot Case Study
- Phase III – Case Studies
- Phase IV – Comparative Analysis
- Phase V – Validation

Structure of the Dissertation

This dissertation is defined in 11 chapters. *Chapter 1* is the introduction of the dissertation. It contains an overview of the research background and significance, the research proposition and objectives, and a high-level description of the research design. The structure of the dissertation is also part of Chapter 1. *Chapter 2* reviews the literature relevant to the dissertation of virtual project teams, collocated project teams and productivity. The chapter also looks at the virtual project team trends, collocated project team trends and productivity trends. *Chapter 3* is the conceptual development. The conceptual development review details results and findings on medical device, and R&D teams. Definitions of R&D, R&D medical device teams, and models of project success/team performance will be reviewed in this chapter. *Chapter 2 and 3* identifies gaps in the literature and informs the reader. *Chapter 4* describes the research strategy and method for this dissertation. Ontology, epistemology, data collection, and data analysis are explained in this chapter. Reliability, validity, and ethical considerations are explained in this chapter as well. *Chapter 5* describes the outcomes of the “Phase III –Pilot Case Study.” A pilot case study was conducted prior to the case studies to provide initial data to develop the case study interview questions. Analysis and findings were documents from this study. *Chapters 6 to 9* contain the outcomes from each of the four case studies. Each chapter is a single case, and each chapter has the same structure. Section 1 introduces the case study participants. Section 2 describes whether the unit of analysis is a virtual project team or a collocated project team. Section 3 describes the impact of productivity within the case study organization. Section 4 describes team learning and project success. Section 5 details the improvement of productivity within the team and by individual team members. Finally, Section 6 is the conclusion and summary. Findings, where possible, are compared against theoretical frameworks, and ways are suggested to improve the productivity of the virtual project team and collocated project team in the case study organization context. *Chapter 10* is the outcome of “Phase IV – Comparative Analysis” and “Phase V – Validation” part of this research.

Similarities are compared and contrasted within the findings from the four case studies. Practical solutions are provided when possible for practitioners in the industry on how to improve the productivity of virtual project teams and collocated project teams. *Chapter 11* contains the conclusions of the four case studies and the comparative study. Further research is suggested for researchers in similar bodies of knowledge.

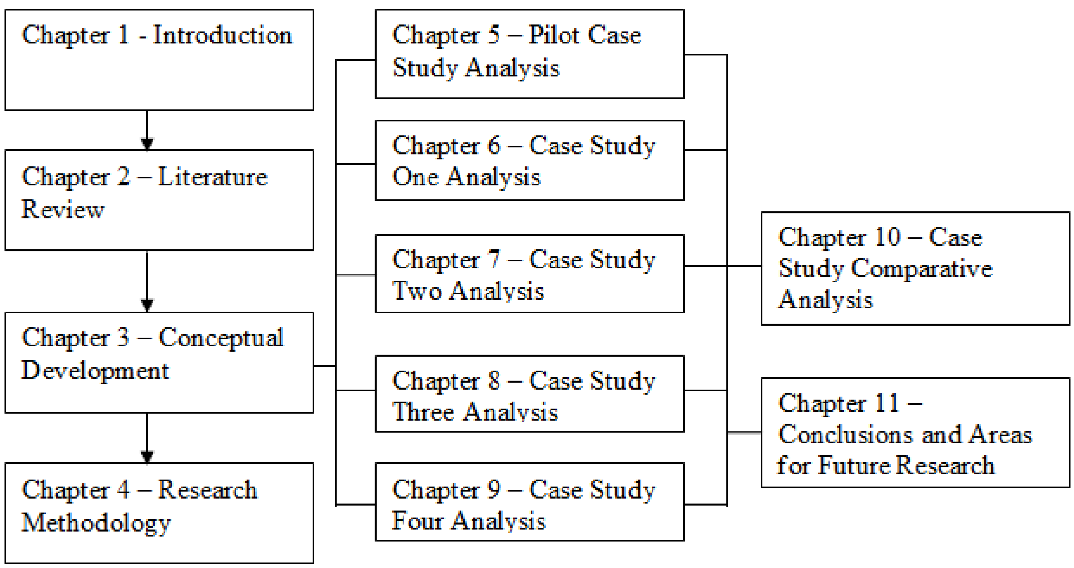


Figure 1.4 Structure of dissertation

Chapter Summary

This chapter has provided the introduction to the entire dissertation. It outlines the purpose and overview of the research and provides background of the research, the research proposition, objectives, questions, and design. This chapter provides a reference for the dissertation. Chapter 2 and Chapter 3 will present the outcomes of the literature review and conceptual development.

Chapter 2: Literature Review

Introduction

The dissertation explores and compares both virtual project teams and collocated project teams in an R&D medical device organization using project management levers introduced in Chapter 1 as it relates to productivity. This chapter provides the literature review for this research, and theories that support the themes of the dissertation. Productivity has been introduced as the dependent variable in this research. This chapter will also provide the trends with virtual project teams, collocated project teams and productivity. Brief project management lever definitions can be found in Chapter 1 (Table 1.1).

The researcher utilized a few online tools to help with his research. A software tool called Publish or Perish (Appendix D4) was one of many used in the literature review to target some of the larger reference materials. Publish or Perish looks up scholarly citations and performs a calculation for citations. The researcher uses the term ‘project management levers’ to refer to his ideas of variables that impact productivity in virtual project teams and collocated project teams. Appendix D3 Google trend is to explain trends in the various areas below, such as, virtual, collocated, project, team, and performance. This is a free, web-based tool that lets the researcher look at the interest on a particular subject matter over time, in the researcher’s case the years between 2004 and 2013. Appendix D2 is a set of keywords to create other themes or ideas under an ad group to see if there are other terms or a series of words to search. Appendix D1 Google and, group ideas uses one key word term or search phrase and then creates a list of similar ideas. The tools are discussed here as the researcher believes they added value to the materials researched.

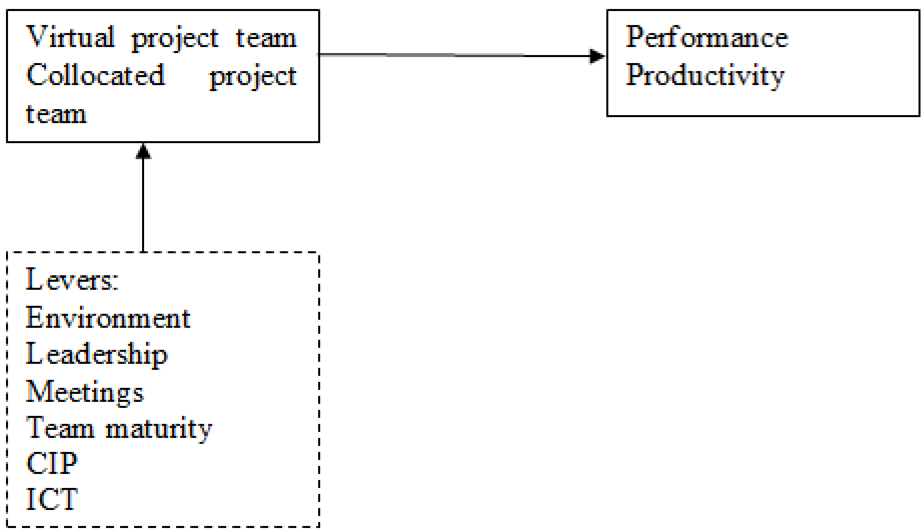


Figure 2.1 Overview of research

The research questions will address both virtual project teams and collocated project teams to review if one type of team is more productive than the other.

> *"As far as efficiency is concerned, preliminary evidence on distributed teams versus collocated teams seems to suggest that collocated teams outperform distributed teams, especially for distributed teams in extreme situations, such as those characterized by a high time and*

> *space separation. Our evidence, instead, shows that both teams attained the same efficiency level"* (Gupta et al., 2009, p. 158).

This study (Gupta et al., 2009) is in the software and information development industry, and this research will review the two types of teams (virtual and collocated) with a different set of criteria. The use of technology in communication for project teams is gradually shifting to a higher level of virtuality (MacDonnell et al., 2009). Gupta et al, 2009 also indicates that future studies could compare virtual project teams and collocated projects teams in other settings. Successful collocated project teams attributes, such as trust, communication, leadership and technology, are a part of virtual project teams (Kuruppuarachchi, 2009). Lee-Kelley & Sankey (2008) indicates that communication, technology, project leadership and project success are important factors in project teams.

Virtual project teams and collocated project teams have been studied from the Product Development and Management Association's (PDMA) 2012 Comparative Performance Assessment Study Research (Markham & Lee, 2013). It is interesting to note that collocated teams are being used more frequently in some cases around the globe than virtual teams (Markham & Lee, 2013). Higher performing teams work in collocated teams (Markham & Lee, 2013). This can also be due to the industry that was sampled and the type of product or service.

Wang (2011) indicates that virtual project teams are as productive as collocated project teams. A weakness of this study by Wang (2011) is that it only looked at the managers and not the any of the project team members, and the researcher recommends conducting more studies in other organizations.

Table 2.1 General attributes of virtual project teams and collocated project teams

Virtual project teams	**Collocated project teams**
Team members are in different locations.	Team members are collocated.
Team members communicate through asynchronous and personal means.	Team members communicate face-to-face.
Team tasks are highly structured.	Team members work on tasks together.

The researcher uses the term ‘project management levers’ to refer to his ideas of variables that impact productivity in virtual project teams and collocated project teams. The literature was divided across multiple independent variables, and the researcher has decided to call these project management levers. Levers come from the researcher’s R&D medical device research orientation.

Table 2.2 Virtual project team and collocated project team levers

Lever	**Virtual project team**	**Collocated project team**
Environment	Ideas may be more difficult to share across time zones and	Interaction outside a collocated project team

	technology.	area may be more difficult. There is less dependency on technology and more emphasis on people interaction.
Leadership	Virtual teams may require more leadership than face-to-face teams. Communication process will be more formalized.	Leadership is traditional and more comfortable for most project managers.
Meetings	A high level of technology is used in a meeting that is due to the lack face-to-face interaction.	A low level of technology is used in meetings, and distractions at a minimum are due to more face-to-face interaction.
Team maturity	Needed for a successful project on virtual teams. Maturity can be assessed by shared experiences, problem solving, integration of tools and the ability to identify issues in the early stages of development.	Related to attitudes and knowledge. Many more shared experience in the organization, direct physical accessibility and immediate problem solving.
Continuous improvement	High level of process when needed improvements are made.	Process driven; when needed improvements are

process (CIP)		made.
Information communication technology (ICT)	Works with technology on a daily basis; trained and comfortable with technology.	Technology is used when needed; not well trained in new technology.

Research indicates high-performing project teams most likely have the following conditions (adapted from Gray & Larson (2005):

- Ten or fewer members
- Team members are on the team from beginning to end
- Team members are assigned full time
- Team members are part of an organization that results in cooperation and trust
- Team members report to the project manager
- All functional areas are represented on the team
- The project has an objective
- Team members are located within conversational distance of each other

The attributes above would be preferred, but in reality they usually do not happen. The project may have part-time employees, some people may not be within close distance, and many teams are larger than 10 team members. The project manager has to be creative and use all of his or her abilities and resources to make each unique project that he or she manages productive. The project manager must operate within cost, time and resources that are given or that the project team planned for and was approved (Kerzner, 2009). Once the project team is assembled, the project manager should work with the team dynamics and determine the project team's strong areas and weak areas to best become a productive project team (Milosevic, 2003). Project managers can be important to achieve high-performance environments, meetings, team maturity, communication, technology, and process. A project manager takes a positive approach to the areas that he or she can control, and for the ones that cannot be controlled, can find a way to make them happen (Kerzner, 2009).

Virtual Project Teams

The word 'virtual' has a Latin meaning that is due to virtues or greatness (Gillam & Oppenheim, 2006). There has been a shift in R&D organizations from face-to-face (or collocated) project teams to the use of more virtual project teams (Ahuja, Galletta, & Carley, 2003). "A project is a temporary endeavor undertaken to create a unique product or service, or result" (Project Management Institute, 2013a, p. 3). "Virtual teams are defined as interdependent groups of individuals that work across time, space, and organizational boundaries with communication links that are heavily dependent upon advanced information technologies" (Hambley et al., 2007, p. 1). In today's world, the need for people on project teams in organizations at a global level is increasing (Kerzner, 2009). Global project management can add to the complexity of project and can have a negative effect to the project (Zeitoun, 1998). This can be due to language barriers, culture barriers and project management methodology. Teamwork in many organizations is occurring across time zones, geography and cultures. In general, a project manager of a virtual team or a collocated team will have authority, accountability and responsibility while managing the project (Smith, Smith, & Niederhoffer 1998). Virtual project teams today have many different technologies at their disposal. The technology has to be the right technology for the team to be successful. In order for the team to succeed the commitment to training, the right set of behaviors also needs to be in place (Smith et al., 1998). To create the most effective project environment that contributes to teamwork, the right behaviors need to be present. An effective set of behaviors can include understanding of ethics, cultural difference, fairness and a common vision (Smith et al., 1998). Virtual project teams will have the same problems that collocated project teams have, but they also have additional areas of concern (Aldea, Popescu, Draghici, & Draghici, 2012). The physical distance in space, time zone challenges, cultural differences and potential languages barriers are a few challenges virtual project teams face. With the new technology come new issues in how to manage and lead virtual project teams.

Team building on virtual project teams requires different behavioral skills. Members on the project team need to be more aware of ethical and cultural differences (Smith et al., 1998). Project teams are operating with fewer staff than ever before, and people are performing more work than before (Wellington, 2012). Virtual project teams need to be aware of limited resources because of tighter budgets and cycle times that need to be improved. Performance needs to be measured and improved where possible.

<u>Virtual project team levers</u>

Environment

"Virtual team members are physically separated from each other and rely mainly on technological devices for communication and information exchange" (D'Souza & Colarelli, 2010, pp. 630-631). Virtual projects team environments have differences in distance, time, and organizational boundaries and depend on communication technology (Smith et al., 1998). Rad & Levin (2003) indicate that a virtual project team can be difficult to define. This is because different researchers view different parts of the virtual team. Virtual project teams are one of the most difficult to support (Fisher, 2000). Due to the dispersed locations of the project team members and the fact that many virtual project teams can work around the clock in different time zones. Members of virtual project teams can be found all over the world. This allows organizations to hire and retain the best talent possible (Pell, 1999) The ability to hire anyone in the world gives a virtual project team a unique advantage to hire the right employees.

Organizational leaders are looking at virtual project teams to reduce costs, improve employee well-being and improve productivity (Sookman, 2009). Virtual projects should make sure that a common set of technologies and effective training on these technologies are agreed upon with the project team (Smith et al., 1998). In virtual project meetings, someone needs to keep people engaged (Sookman, 2009). Meetings are a primary source for the virtual project team's work. Well run and efficient meetings will help with the success of the project and the team (Aranda, Aranda, & Conlon, 1998). The virtual project team needs to perform this with team members located in different locations. Technology has provided a better platform for virtual project teams to have more productive meetings (Sookman, 2009). Project team meetings are needed in order to communicate on virtual project teams. Because of the technology improvements and the lower cost of the technology virtual project teams have become easier to set up and manage.

Even with these improvements, project teams can have problems with sharing information over time zones and distances (Smith, 1998). Warkentin, Sayeed, & Hightower (1997) found that “virtual project teams exchange information less effectively than face-to-face groups” (p. 976). Recent studies did not give sufficient time for groups to develop effective relationship. When this research was surveyed technology was not as common as it is today, which may improve the virtual communication. The main focus of a virtual project team is to promote success in sharing information (Gillam & Oppenheim, 2006). The popularity of virtual teams would appear to be increasing, but a study by Markham & Lee (2013) does not correlate all of this popularity or its connection to performance. Data from 2012 (Markham & Lee, 2013) report indicates that collocation teams are actually performed more than virtual teams in some parts of the globe.

Leadership

Virtual project teams may require even more leadership than collocated project teams. Leadership on virtual teams can be shared, but it needs to be present nearly all of the time Yang, 1996). Rad & Levin (2003) indicate that leadership should be shared on a virtual project team. They take a further step and indicate that shared leadership should be based on task, expertise and location. “There is little current theory to guide researchers on the leadership and management of virtual teams” (Kirkman et al., 2004, p. 179). There currently exists more information today in the area of virtual projects teams and leadership. Purvanova and Bono (2009) indicate that virtual project team members assert that their leaders communicate one way, and it is top down. Since virtual project teams are not always together, or able to communicate at the same time, it would be productive for the project team to share leadership. In other words, different people at different times need to step up into leadership roles depending on where the team is in the cycle of its work. Roles can be split apart, shared and changed as leadership roles can coexist and complement one another (Yang, 1996). Leadership of virtual project teams would justify more research in this area (Gillam & Oppenheim, 2006). Technology and other communications may need to be reviewed and studied. Studies around cultural issues and leadership could add to the literature (Gillam & Oppenheim, 2006).

Team maturity (knowledge and experience/expertise)

Virtual project teams require experience and knowledge in a medical device environment. Team maturity in project management is an important factor because of the fact that it is associated with attitudes, knowledge and actions that contribute to project performance (Chiocchio, Lebel, Therriault, Boucher, & Hass, 2012). Metrics can help the virtual project team in providing the most efficient performance (Rad & Levin, 2003). Project team member maturity is an area that could relate to higher team performance in virtual project teams. Project teams that have more mature team members with experience and knowledge may be able to solve issues and problems quicker. This may influence the environment of a project to be successful. “Project management maturity is an important moderator in project teams because team maturity is grounded in attitudes, knowledge and actions and contributes to project performance” (Chiocchio et al., 2012, p. 47). Rad and Levin (2006) discuss mature organizations and how they can help virtual project teams be more successful and productive. Virtual project teams that can innovate and operate efficiently may be able to gain a competitive edge (Rad & Levin, 2003). Further research should be conducted in the area of project team maturity (Cash-Baskett, 2011). This can drive improved morale while improving profits. Performing established project management processes may also improve efficiency of mature virtual project teams.

Meetings

Virtual meetings require some of the same general requirements as a collocated meeting. Virtual project meetings should be performed on a regular basis for the project team (Rad & Levin, 2003). A meeting is scheduled or unscheduled of two or more individuals with work related topics or information (Longo, 2005). Meetings must be carefully organized and planned in order to be highly valuable and productive (Martin, 2012). Agendas should be provided at all virtual meetings. A facilitator, parking lot, list of actions items and meeting minutes distributed are also good practices for productive and effective virtual meetings. The most effective meetings are ones with ground rules that include not using computers, phones or other technologies to interrupt meetings (Martin, 2012). Distractions during virtual project meetings can be up to 70% when people are doing unrelated work during a virtual project meeting (Sookman, 2009). Meetings are commonplace for virtual teams, therefore, we need to find ways to make these meetings more productive and successful (Longo, 2005). Longo goes on to indicate that there has been little empirical research conducted around meetings (Longo, 2005). Important factors that he points out are meetings should start on time, all key virtual team members are present, refreshments are provided, they are held in a comfortable environment and they use technology. In a virtual project environment, meetings may be an individual or many virtual team members in one location.

Project managers are always trying to complete projects on schedule and within budget (Thomke & Reinertsen, 2012). Communication is a required component of all virtual meetings and team processes. Issue resolution is usually at the front of any virtual meeting, via discussion, email, and video. Meetings should be taken seriously by all virtual project team members, and attendance, accountability and responsibility of each project team member and at each project team meeting should be a priority for project team members (Aranda et al., 1998). People are challenged to find out what works best for different virtual project teams and different work teams.

Currently some project team members are challenged with information or communication overload in virtual project teams.

Continuous improvement process

CIP is the process of performing improvement processes such as Lean Sigma or Six-Sigma that teams utilize to improve process. CIP is also an area that most organizations can work on to improve organizational performance (Calvo-Manzano, Cuevas, Gomez, Mejia, Muñoz, & San Feliu, 2012). Virtual project team performance may be improved when CIP tools are utilized correctly and at the right time during a project. Rad & Levin (2003) indicate that each virtual project team member should be working on improving the processes and procedures. “Members of a mature project team must continuously improve the team’s procedures and policies so that they can meet the challenges of changing project circumstances effectively and efficiently” (Rad & Levin, 2003, p. 54). Zeitoun (1998) also indicates that companies be committed to continuous improvement of systems. Lean Sigma, Total Quality, and Six Sigma, are all methods that drive results (Starbird & Cavanagh, 2011). These methods strive to increase performance in organizations. In this dissertation these methods will come under the heading CIP (continuous improvement process). “A climate of high work importance is associated with higher R&D team productivity” (Lee et al., 2009, p. 3665). To increase a project team’s productivity project teams should update the communication technology that is used and make sure everyone is using the same improvement tools (Tohidi & Tarokh, 2006). Continuous improvement is concerned with increasing performance and improving problem solving (Martin, 2012). Virtual project teams can however take advantage of CIP and make process improvement. “Because most virtual teams are knowledge-based teams that solve customer problems or develop new products, one of the most important performance outcomes is process improvement” (Kirkman et al., 2004, p. 177). This can be through learning or trial and error on the virtual project team.

Information communication technology

ICT allows virtual project team members to communicate globally (Rad & Levin, 2003). Communication is a well-researched area in many dissertations and journals from this researcher’s investigation on virtual project teams. Christenson (2007) speaks to communication is his work and says that communication can have a significant impact on the success of the project. Effective communication can have a positive effect on projects (Christenson, 2007). Development of communication and technology together can support a successful virtual project. Technology forms the conduit in which communication occurs with the virtual project team (Van der Merwe, 1999). There is a commonality among various leadership theorists to the effect of such factors as communication in virtual teams. Communication could be a factor in regard to shared leadership on virtual teams according to Poff. Furthermore communication can ensure a constant flow of information on the virtual project team (Poff, 2008). Hayhurst (2013) states that he believes that using technology such as smart phones and the text messaging at work is creating a more productive environment. ICT is an important factor in R&D teams, which can be explored further (Ebrahim, Ahmed, Rashid, & Taha, 2010). ICT is being performed more today than ever before because of improvements in technology and lower cost. Communication technology can make individuals and virtual teams more productive according to Hayhurst (2013). The ability to use technology on virtual project teams such as text and IM provides the opportunity to gain information quickly and not have to wait for information.

Virtual project teams can have problems with sharing information over time zones and distances (Smith et al., 1998). Warkentin, et al., (1997) "found that virtual project teams exchange information less effectively than face-to-face groups" (p. 976). The main focus of a virtual project team is success in sharing information (Gillam & Oppenheim, 2006).

Virtual project team members have laptops, tablets and smartphones at nearly every meeting, which many try to keep off at meetings. Virtual teams can sometimes be at a dis-advantage as people communicate much more by nonverbal communication, such as tone of voice, body movement, orientation, dress/appearance and expressions (Kerzner, 2009). Communication in virtual project teams has to be used carefully as it could result in a burden of emails and teleconference calls (Lee-Kelley & Sankey, 2008). Technology has increased the level of globalization for most project teams as collocated project team's move toward virtual teams (DeVany, 2009).

Characteristics of virtual project teams

Virtual project teams will play an increasing role in global organizations (Hambley et al., 2007). “Generally, virtual project trams transcend distance, time zones, organizational boundaries, national boarders, and continental entities” (Rad & Levin, 2003, p. 7). Virtual project teams can excel in many areas including idea generation, brainstorming, are due to less interruptions and more equality of project team members (D’Souza & Colarelli, 2010). There has been less research in real settings of virtual project teams, and if these teams increase the effectiveness of the team (Gupta et al., 2009). Technology is also being utilized by virtual project teams to increase effectiveness. Tools such as email, IM and text are examples of technology that may provide virtual project team effectiveness.

The list below outlines the general areas that a virtual team can follow in order to be successful. The requirements of virtual organizations are from two sources (Grenier, & Metes, 1995; Haywood, 1998).

- Existence of performance metrics
- Process definition, maturity, and alignment
- Communication builds trust, which in turn builds communication
- Knowledge sharing
- Commitment to the end project
- The job is not finished until everyone’s work is done

- Recognition and rewards are based on the results that the team produces
- Skill in working with the tools of the trade and virtual operations

This virtual requirement list provides background into areas in which this research will review. A summary of these are performance, maturity, communication, knowledge, team production and virtual operations. These requirements focus on a virtual project team and review potential success factors in virtual project teams. Virtual project teams are accelerated by the availability of technology at their desk or home (Smith et al., 1998). Virtual project teams are more than just technology. Technology enables the virtual project team members to communicate, but it takes more than just technology. Team process, leadership, and communication plans are a few characteristics of virtual project teams (Duarte & Snyder, 2006). These characteristics make the virtual project team more flexible than traditional project teams. Due to this flexibility, virtual team members are able to work at different times of the day. Even though virtual projects teams are more flexible, they are still temporary. In addition the virtual project team can be fragile, due to the independence of project team members and it needs to have leadership and a purpose (Smith et al., 1998).

Figure 2.2 from Lojeski and Reilly (2008), studied a variety of data to review dispersed teams and performance. Project success was correlated with the degree of virtual distance in the project teams. As virtual distance was lower project success increased (Lojeski & Reilly, 2008). This does not tell the whole story on a project, but it is noteworthy to look at this research and virtual distance in regard to project success (Lojeski & Reilly, 2008). Virtual project team members are happy about the increased independence and greater flexibility (Haywood, 1998). By having technology to link project teams that are dispersed it gives team members more flexibility and the ability to work from many different locations.

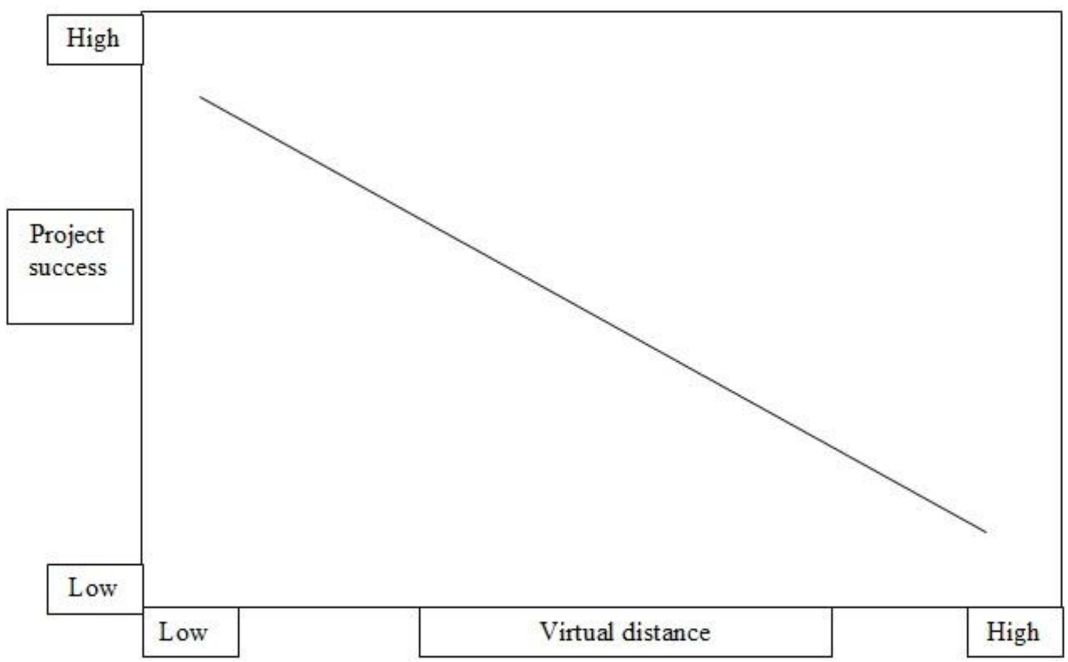


Figure 2.2 Virtual distance and project success (adapted from (Lojeski & Reilly, 2008, p. 52)

Table 2.3 is generic organization of the virtual project team definition. After a detailed review of the literature, this researcher's definition for a virtual team is virtual project teams as a team with the following characteristics: More than 50% of the team is located outside of the main physical area; the main communication mode is by email, phone and other technology; development activities can occur in multiple sites; multiple vendors or internal suppliers may be offsite or development activities may be in a location outside of the main team members location; there is limited, if any, face-to-face interaction; team members located in more than two time zones; and the team shares responsibility.

Virtual project team definition

Table 2.3 Virtual project team definition

Unit of analysis	Common component	Unique (Author specific)	Major resource
People	Distributed, distance	Specific project	Mayer, 2010, (Book)
Employees	Distance	Task driven	Delisle, 2001, (Conf.)
Employees, collaborate	Distance, different locations	Unique skills	Kirkman, 2004, (Journal)
Collaboration	Distance	Work productively	Institute for the Future for Apollo Research Institute, 2011, (Article)
Collaborate	Various locations	Manage goals	Hamilton, 2011, (Article)

Some researchers have said virtual project teams rely mostly on technology for communication (Kirkman et al., 2004). Or put another way virtual project team members rely on electronic technology for the majority of their communications (MacDonnell et al., 2009). One key to improving performance is through solid communication (Smith, 2001). Solid communication can be defined as a project team's plan of how the team will communicate throughout the project lifecycle.

When are you a sender and when are you a responder and how do each of these roles interact with each other would work towards solid communication.

“Virtual team members are physically separated from each other and rely mainly on technological devices for communication and information exchange” (D’Souza & Colarelli, 2010, pp. 630-631). Virtual projects teams have differences in distance, time and organizational boundaries and are dependent on communication technology (Smith et al., 1998). “Virtual teams are defined as interdependent groups of individuals that work across time, space and organizational boundaries with communication links that are heavily dependent upon advanced information technologies” (Hambley et al., 2007, p. 1). Virtual project teams are one of the most difficult to support (Fisher, 2000). This is mainly due to the fact that they are physically dispersed. They rely more on technology in many cases and need to be knowledgeable in phone, computer and video technology in many cases in order to be able to communicate with other project team members. Members of virtual project teams can be found all over the world. This allows an organization to hire and retain the best talent possible (Pell, 1999).

(Fisher & Fisher, 2011) describe virtual project teams as the following if any of the team members:

- Are located in different workplaces
- Work in shifts
- Travel frequently

- Often work from their homes, cars, or in the field
- Are assigned to multiple project teams
- Work part time
- Report to more than one manager

Fisher & Fisher (2011) indicate that there are varying degrees of definitions as virtual project teams are still a fairly new topic. Table 2.3 provides a high-level, virtual project team definition.

Virtual project team capabilities

Virtual projects are about working with geographical distances to create project success and productivity. “Managing virtual distances is a challenging endeavor, but one that results in higher productivity and project success, improved innovation, higher job satisfaction, trust, organizational citizenship, and all of those things that create effective teams and keep them that way” (Lojeski & Reilly, 2008, p. 89). Distance complicates most virtual project teams by less interaction (Duke Corporations Education, 2005). “Research has shown that linking workers together through networks and other communications devices as though they were located in the same office is critical to effectiveness” (Fisher, 2000, p. 301). Virtual project team members will need to network and form relationships to be successful.

Virtual project team members may form relationships with other collocated project team members versus their virtual project team members (Smith et al., 1998). Two major challenges for virtual project teams are trust and communication (Gray & Larson, 2005). Virtual project teams use more high technology solutions that improve communication inside and outside the organization (Barczak et al., 2009). One method to improve trust in virtual project teams is to try and have a face-to-face meeting when possible (Fisher & Fisher, 2011). By reading another person's nonverbal body movement and other nonverbal messages one can start to understand and develop trust. The idea of weekly meetings with a project team promotes trust. Another method or capability that the virtual project team needs to have is the ability to solve conflicts and make decisions (Gray & Larson, 2005) Virtual project teams need to have an upfront agreement on how conflict and issues will be resolved. Since most virtual project team members are physically located a distance from each other this type of agreed-upon guidance will help resolve conflict and issues in a reasonable amount of time. Physical distance can get in the way of problem solving and other attributes in the global environment (Lojeski & Reilly, 2008). Lowering virtual distance can have a positive impact on trust, vision clarity and job satisfaction, which can all drive performance (Lojeski & Reilly, 2008). An area that can be seen as a positive for virtual teams is the lack of interruptions when not in a formal office setting.

Some studies have shown virtual project team productivity gains because of more structure with fewer interruptions (Haywood, 1998). This indicates that project team structure is important as many project team members work at different times of the day. Roles and responsibilities need to be prepared, agreed and signed off to make sure the project team structure is solid and understood. This will help keep roles clear and add structure to the virtual project team. With the increase of virtual project teams, project management is also under a transformation (Rad & Levin, 2003).

Virtual Project Team Trends

> "*Virtual project teams must be especially conscious of their dynamics. Behavioral clues are spread out not only in space but usually over longer timeframes than they are with comparable collocated project teams. Virtual project teams need to design for this supercharged eventuality"* (Brown et al., 2007, p. 5).

The trend of virtual project teams in most organizations is increasing, but there appears to be a lack of systematic research in this area (Wong & Burton, 2000). This may be due to the explosion of technology and the rapid change to many project teams becoming a virtual project team. The rate of change has been fast and academia is still catching up to the rapid level of change. Organizations have long had people who have worked in different locations (Harrell & Daim, 2009). The latest trend is that virtual project teams have increased dramatically in the past years and that the global environment has required organizations to have people closer to vendors, customer, and stakeholders (Fisher & Fisher, 2011). "Traditional face-to-face communication is declining as more and more companies are outsourcing, making use of telecommuters, or creating virtual project teams” (Nemiro, 2004, p. 133). Virtual project management offers new technologies and can bring many locations together at one time. The development of software and the increased use of the internet add a new dimension to project management. Virtual project teams in R&D can provide organizations globally with higher levels of flexibility and improved efficiency (Ebrahim et al., 2010). “A recent study by the American Business Collaborative found that over 80 percent of the project team members surveyed are involved in some way with virtual work teams” (Brown, Huettner, & James-Tanny, 2007, p. 1). Global companies today are relying more on intercultural virtual project teams to focus on projects (Ubell, 2010). Technology is also now inexpensive and effective, which allows people to work regardless of location (Fisher & Fisher, 2011).

However, there is a common criticism in research on virtual project teams that there is a lack of field experiments performed in a commercial environment that compare the behaviors of both types of project teams (virtual and collocated) and how they are related to performance (Gupta et al., 2009). The researcher was not able to locate an abundance of field experiments in the area of virtual project teams and collocated project teams either as a stand-alone or one type of team or with both types of teams. When the researcher adds the R&D medical device organization it appears to be little field experiments available for review.

Wellington (2012) predicts that virtual teams will be more the norm in global organizations especially as global markets continue to grow. Crawford (2002) indicates as virtual projects team gain more experience it will improve the overall performance of these teams. Organizations will need to continue to balance technology and collaborative processes in order to keep performance on track (DeRosa & Lepsinger, 2010). A study conducted in 2008 found that many companies had made large investments into technology and found that 25 percent of the virtual project teams were not performing. This may have been due to the more cumbersome technology seven years ago (DeRosa & Lepsinger, 2010). Google trends or web searches indicate that (Appendix D3) virtual project teams have been searched at a fairly consistent rate. This would indicate that this topic of virtual project teams has been a consistent topic that has been search by other individuals indicating a topic that is being explored to varying levels.

> *"This study thus shows that virtual project team configuration is a topic that merits further exploration. It is therefore hoped that future research on this topic is conducted, resulting in a better comprehension of the optimal assignment of individuals to virtual project teams. This understanding can help organizations improve virtual project team performance, and better utilize offline and online teams, which have become a fundamental component of modern organizations"* (Turel & Zhang, 2010, p. 373).

Collocated Project Teams

In the 1980s and 1990s collocated project teams were thought of as best practices (Bardhan, Krishnan, & Lin, 2012). This is due to the face-to-face interaction and ability to solve problems quickly when needed. Cross-functional project teams collaborate in collocation to improve performance and productivity. Real-time project team interactions/face-to-face make collocated teams attractive to organizations (Poltrock & Engelbeck, 1999). Reducing the space between project team members has long been the way that many organizations operated. “Communication helps a team expose all facets of the problems and formulate approaches to finding solutions” (Poltrock & Engelbeck, 1999, p. 333). Collocation of project teams improves communication with other project team members, creates innovation with ideas and provides cooperation of the cross-functional project team (Griffin & Hauser, 1992).

> *“Higher performing companies also equip teams with skills and resources, engage in more cross-functional training and collocate their teams. Firms in Asia utilize cross-functional team training significantly more than the firms in Europe (43% in Asia vs. 28.8% in Europe) and they are more likely to be collocated than the firms in North America (51% in Asia vs. 34.1% in North America)*” (Markham & Lee, 2013, p. 32).

Markham’s & Lee’s (2013) research points to the use of collocated teams and that Asia has a higher level of collocated teams than the USA. Based on this research of high-performing teams it suggests that collocation is desired for improved performance.

Collocated project team levers

Collocation is still a method for many project teams of today. Research still indicates that face-to-face communication in collocation is useful (Gillam & Oppenheim, 2006). Project teams are designed to research and develop products or services from the efforts of a group of project team members (Press, 2006). Collocated project teams also come in many forms, cross-functional, tiger teams, ad-hoc, etc. Collocated project teams tend to use less use technology or ICT than virtual project teams.

Environment

In face-to-face project teams or collocated project teams, members have a shared location and other items to consider. Organizations are looking at collocated project teams to reduce costs, improve employee well-being and improve productivity (Sookman, 2009). Therefore collocation can be a desired type of project team environment when it is feasible.

Face-to-face interaction is common for collocated project teams and can represent one of the most frequent day-to-day activities for the knowledge worker (Poltrock &

Engelbeck, 1999). Andres (2002) indicates that a rich communication style in a face-to-face or collocated project team resulted in higher productivity than project teams that utilized video conferencing. Companies that are the best use video 15-30% more than the rest of other companies surveyed (Markham & Lee, 2013). This can be important to collocated teams; with cheaper technology they can also use ICT tools. These results indicate that project managers need to find ways to create an improved communication process when using technology such as video conferencing (Andres, 2002). Collocated project teams are able to use email, IM and video since today they are relatively cheap and easy to utilize. This adds flexibility to collocated team members on vacation or at home.

A team structure or collocated project team is a type of project team. This type of project team environment can be collocated with a high degree of autonomy, leadership and dedication (Patanakul, Chen, & Lynn, 2012). Traditional project teams along with high emotions bring a purpose and motivate project team members (Lojeski & Reilly, 2008). Work practices and structures for collocated project teams are the traditional project teams. The collocated team environment is mainly face-to-face communication.

Project teams are collocated and multi tasked within a time pressure environment (Liu & Leitner, 2012). An ideal type of collocated project team would be all in the same time and physical collocated environment. Today, a collocation project team has the ability to extend the normal working day environment and use technology as previously discussed. Collocated project team environments today may work on a short-term project, which is an effective use of this concept (Fisher, 2000). Many companies today still have collocated project teams, such as agile, and they work effectively in many cases. Agile is a type of project team that usually allows for speed and flexibility. However, agile also can be done with virtual teams.

Face-to-face interaction in collocated project teams improves communication, collaboration and meetings (Poltrock & Engelbeck, 1999). Obviously the shift away from collocated project teams is taking place at a rapid pace with globalization and technology improvements. Collocated project teams still have an easier time of sharing information when everyone is located in one space and time zone. People working on collocated project teams can spend from 35% to 75% of their time with face-to-face interactions (Poltrock & Engelbeck, 1999). Some of the most important information may occur at the water cooler, hallway or walking in or out of work. Some organizations will still spend the cost to move all project team members into the same space in order to improve performance and productivity (Fisher, 2000).

Leadership

Managers of collocated project teams, need to focus on the four different models according to Yang and decide which values to focus on at different stages of the cycle (Yang, 1996). Yang's research indicates that there should be shared leadership but perhaps not equal leadership on a team such as a collocated team. A collocated project team that can disperse the leadership role through the project life cycle should be a more productive team, be it virtual or collocated. “Leadership is the process of influencing and facilitating others to accomplish shared objectives” (Sutanto, Tan, Battistini, & Phang, 2011, p. 422). Leadership can also improve the performance of the project team (Hambley et al., 2007). Leadership to improve performance could work well on a more mature collocated project team.

Project team members are empowered to share roles of leadership and managerial roles. This can be accomplished in a collocated project team by discussing roles and responsibilities during the project life cycle. Leadership should be shared by all project team members (Yang, 1996). Leading is about guiding people, listening and influence management. Shared leadership can trace back to the Lewis and Clark expedition in which Lewis and Clark shared leadership of the expedition (Allner & Rygalov, 2008). In face-to-face project teams, or collocated teams, team members typically have a shared location, and visible leadership in which project team members can engage quickly.

Team maturity (knowledge and experience/expertise)

Team maturity in project management and collocation is an important factor since it is associated with attitudes, knowledge and actions that contribute to project performances (Chiocchio, et. al., 2012). Project team members bring a different level of experiences and a unique set of knowledge and team maturity to the project

(Adams & Anantatmula, 2010). Maturity is another area that can have an effect on collocated project team productivity. Maturity of the project team is the experience in the industry, educational background and level of job role understanding. Collocated project team members usually understand which team members have the experience and knowledge or maturity in the project team. Some collocated project teams have a roles and responsibility template that the team fills out to get an in depth understand of the knowledge on the project teak. Collocated team members can see and hear the maturity on their teams which can offer advantages to the collocated teams.

Collocated project team environments will most likely benefit form mature project teams members. This differs from virtual project teams in which collocated project teams can have a better understanding of who the team members are and what their knowledge and experiences are valuable to the collocated team.

Meetings

Meeting environments in collocated project teams should be agreed upon when the project starts by the project team members, and they should remain constant over the life of the project unless there is a legitimate reason to change them. Collocated project team meetings are needed in order to communicate. A collocated meeting is scheduled or unscheduled of two or more individuals with work related topics or information (Longo, 2005). Meetings should include an agenda ahead of time, time management, note taking and notes distributed after the meeting (Starbird &

Cavanagh, 2011). Collocated project team meetings can also include visual aids, face-to-face discussion, and usually meetings in short period of time due to the physical location of the team members. Fundamentally, the meeting environment can be the same for both a virtual and collocated project team with the use of technology on the virtual project team. There could be more structure on a collocated meeting, if the size of the project and project team members is large. Meetings are commonplace for face-to-face meetings, therefore, we need to find ways to make these meetings more productive and successful (Longo, 2005). Meetings in collocation can also be performed to often leaving the project team members in meetings all day and having to work early or late to keep up with their work.

Facilitating at meetings and for the collocated project teams is a process that involves managing relationships of project team members, tasks, technology, as well as structuring the interactions needed in a meeting (Hayne, 1999). An improvement in collocation facilitation skills and tools should increase the level of productivity in teams. Researchers agree that facilitation is a dynamic process that involves many different meeting outcomes (Hayne, 1999). Collocated project teams are typically able to have fewer meetings. As previously discussed, there can be too many meetings when there is a collocation team as there could be too few meetings. The right amount of meeting time by a collocation team will need to prevail with the team members. Collocated project teams can also hold daily, weekly, and monthly but they have the clear ability to have them quicker if needed due to the close physical environment.

Continuous process improvement

The collocation environment offers project teams to be well informed of performance efforts such as CIP (Eccles, 2010). In this dissertation these methods will come under the heading CIP (continuous improvement process). CIP is also an area that most organization can work on to improve organization performance (Calvo-Manzano et al., 2012). Team performance has been of interest for years. LS, TQM, and SS are all methods that drive results (Starbird & Cavanagh, 2011). These methods strive to increase performance in organizations and the collocation project team. In this dissertation these methods will come under the heading CIP (continuous improvement process). “A climate of high work importance is associated with higher R&D team productivity” (Lee et al., 2009, p. 3665). To increase a project team’s productivity they should update the communication technology (Tohidi & Tarokh, 2006). Continuous improvement is increasing performance and improving problem solving. Collocated project teams can utilize CIP in their projects. Collocated teams will have the advantage to be able to have more day to day interaction with the close proximity of the environment.

Information communication technology

Collocated project teams of today may use technology or ICT during projects. Email, IM, phones and video can be used by collocated project teams today. ICT can be a factor in collocated R&D teams which can be explored further (Ebrahim et al., 2010). ICT plays a role in collocated teams and could impact productivity (Fruchter, Bosch-Sijtsema, & Ruohomäki, 2010). Communication technology can make us more productive according to Hayhurst (2013). Technology has given collocated project teams more tools in which they can stay connected with each team member. However technology does not typically play a large role in collocated teams since they have more face-to-face communication. As the efficiency and cost of technology improves each year, the ability for collocated project teams to utilize these tools increases.

Characteristics of collocated project teams

When physical collocation is possible it may not prove effective because of many project team members participating on more than one project at the same time (Poltrock & Engelbeck, 1999). Project team member characteristics differ on collocated project teams and virtual project teams (D'Souza & Colarelli, 2010). Communication and conversation in collocated project teams includes non-verbal, verbal expressions and cues (D'Souza & Colarelli, 2010). Poltrock and Engelbeck (1999) have observed collocated project team members are not always available because of being on travel, at another location or vacation. Some studies have shown that knowledge is reduced with the virtual project team and in the 1980s and 1990s, and this was the case for the popularity of collocated project teams (Gupta et al., 2009). Research has also demonstrated a positive relationship between team empowerment and collocated project team performance (Kirkman et al., 2004). Project team members would like to have meaning around their work and the ability to make decisions.

Collocated project teams tend to have better relationships and team cohesion then virtual project team members (MacDonnell et al., 2009). This is in part to the close proximity of the collocated project team members. Trust can be established quicker and easier typically in collocated project teams. Research has shown that collocated project teams have better communication after being collocated (Van den Bulte & Moenaert, 1998). This tends to be typical when team members are next to each other and interact on an hourly and daily basis. There are many variables that can change the communication flow and success of the collocated project team. The Boeing Corporation, for example, facilitates teamwork by collocating project team members when possible by physically locating project team members in the same location to discuss technical problems (Poltrock & Engelbeck, 1999). If the project is large and complex, collocating project team member may be expensive and not practical (Poltrock & Engelbeck, 1999). However, there is recent research that points out project complexity is not always negative and may not impact performance (Ahmad, Mallick, & Schroeder, 2013). This study points out the possibility of complexity not impacting performance, but it also has limitations such as low reliability, how performance was measured and the multiple interactions to be considered in the study.

Collocated project team definition

Table 2.4 are collocated definitions from a few different authors placed into units of analysis, common components, unique or author specific (if any) and the resource.

Table 2.4 Collocated project team definition

Unit of analysis	**Common component**	**Unique (Author specific)**	**Major resource**
Gathering, people skills	Communication partners	Protocols	Kahn, 2005, (Book)
Close proximity, information flow	Communication, integration	Increase team cohesion	D'Souza & Colarelli, 2010, (Article)
Team area, face-to- face contact	Shorten cycle times, conference room	Lack of space	Smith, & Reinertsen, 1998, (Book)
Team members	Physical location, team room	Ability to perform	PMBOK,PMI Institute, 2013, (Standard)
Face-to-face	Communication, Physical proximity	Nonverbal expression	D'Souza, 2010, (Journal)

This researcher's definition of collocated project is as follows: Most if not all of the project team is in one place and physically next to each other, more than 75% of the team is collocated together, the main development activity and leadership is in the collocation site, the main internal manufacturing may be onsite or offsite, there are suppliers offsite, the team can have face-to-face interaction during the day, the core team works in one time zone, and face-to-face interaction is the norm not the exception. The core team definition is a team of individuals that represent the project.

McGrath (1996) defines a core team as “a small cross-functional project team that has authority to develop a specific product” (p. 21). Core team members direct the team and sub project teams to work with the functional areas in order to drive responsibility and decisions.

“Members in face-to-face teams work in close physical proximity and communicate primarily face-to-face” (D’Souza & Colarelli, 2010, p. 630). Smith & Reinertsen (1998) indicate that face-to-face teams may be able to shorten cycle times. Kahn (2005) indicates to add collocated project teams whenever possible. This allows the project team to not have to depend on technology to interact among the team members.

> *“A team can be defined as (a) two or more individuals who (b) socially interact (face-to-face, or increasingly, virtually); (c) possess on or more common goals; (d) are brought together to perform organizationally relevant tasks; (e) exhibit interdependencies; and (g) are together embedded in an encompassing organizational system, with boundaries and linkages to the broader system context and task environment”* (Chiocchio et al., 2012, p. 8).

Simply stated, collocated project teams are being physically located in the same space (Brake, 2009). Some project teams that are collocated communicate electronically between face-to-face meetings (Kirkman et al., 2004). Technology has increased in ease of utilization for collocated teams and decreased in cost. This provides the collocated project team a set of tools to stay connected. However, these tools need to be managed so that a passive environment will not prevail and team members will only look to leadership for decisions.

Collocated project team capabilities

Best practices in many organizations use low technology or face-to-face meetings and collocation of project teams (Barczak et al., 2009). Collocated project teams can facilitate more interaction and create many ideas (Gupta et al., 2009). Collocated project teams most often use face-to-face interaction throughout the work day and communicate in formal and informal ways. Collocated project teams also can see and hear each other and see each other non-verbal actions as they are in the same physical location (Driskell, Radtke, & Salas, 2003). Researchers indicate that cohesion is important to performance (Gully, Devine, & Whitney, 2012). Collocated project teams will tend to have the same backgrounds in education and cultural since they are in the same location and organization (Pawar & Sharifi, 1997). “Teams can be used in a variety of applications, including problem solving, product development, quality control, project management, decision making, planning and negotiation” (D’Souza & Colarelli, 2010, p. 630). Knowledge sharing is another communication area that collocated project teams use in a real-time environment.

Purvanova and Bono (2009) indicate researchers see that face-to-face communication is superior to computer communication. Face-to-face in this context are collocated project teams. Face-to-face communication minimizes information loss, non-verbal communications are present, and social presence, context and physically (collocated) are not as challenging in distance of each team member (Purvanova & Bono, 2009). The absence of non-verbal gestures and body language can effect communication in a negative form (Walther, Loh, & Granka, 2005). By not being able to see another team members body posture or non-verbal actins you lose a great deal of the communication. Communication skills are key when selecting project team members for a project (Chen & Lin, 2004). Collocated team members need to have good face-to-face communication skills on order to be productive. Organizations are also placing project teams in war rooms (all project team members in one room) to increase their performance and productivity (Teasley, Covi, Krishnan, & Olson, 2000). Collocation offers more project team interactions and communication (Pawar & Sharifi, 1997). With the correct systems in place and information communication technology collocation can offer improved results for project teams (Pawar & Sharifi, 1997). There can be other factors for collocated teams that may impact performance.

The length of time collocated project team members have worked together could affect project team performance (Sivasubramaniam, Liebowitz, & Lackman, 2012). This can be the experience and knowledge of each team member and the length of time that they have worked together. Project team members leaving the collocated project team and new members coming on the team will be disruptive and could affect performance of the project team. Eccles, Smith, Tanner, Van Belle, & Van der Watt, (2010) describe a set of team effectiveness factors "feedback, goal, communication, team identity, performance target, role, individuality, resources, morale, trust/mutual accountability, conflict management and work approach" (p. 3). This research will not review all of these factors, but it will touch on a few of these factors such as team effectiveness, communication, and performance. Team building on collocated teams can be a part of the performance equation and leaders need to have a basic understanding in order to drive project success.

Team building is a typical team methodology that indicates how the collocated teams progress through the various team stages. Project teams will be in different stages for different lengths of time depending on many factors. Project managers and leaders should understand this five-stage team process in order to bring project team members through the different stages (Verma, 1997). The performing stage is when the project team is running productively, with high quality, resources are present and interactions are fluid on the project team (Robbins & Finley, 1995). The performing stage is one that the project team works out the conflicts, and it is healthy and positive (Robbins & Finley, 1995). Many collocated project teams are not able to move quickly from on stage to another. Leadership, team size, interaction and other variables all play a role in what stage and how quickly a project team will from one to another (Verma, 1997). Collocated project teams need to be aware of the different stages and how they can work to their advantage.

Collocated Project Team Trends

Collocated project teams are a traditional type of team. Collocated project teams need to have in depth expertise and knowledge in today's competitive marketplace (Kratzer et al., 2006). Collocated project teams are composed of people from cross-functional groups that are working together in the same place (Lipnack & Stamps, 1997). A recent study looking at collocated people environments with an open plan are likely to have more stress, less satisfaction and less productivity (Codrea-Rado, 2013). Factors contributing to this can be lack of personal space, communication is in the open, and possible unwanted interaction by other team members. Teams and human beings have worked and socialized in face-to-face or collocated project teams (Lipnack & Stamps, 2000). "Face-to-face interactions among people from the same organization typify old models of teamwork" (Lipnack & Stamps, 2000, p. 18). Location and physical space is less important today as technology gives teams the tools to interact in a different way (Lipnack & Stamps, 2000). It is clear that today organizations have more options than just a face-to-face or collocated project team. One other option for project teams is a virtual project team. Face-to-face is still an effective option even in the beginning of a virtual project team. A face-to-face meeting early in the project can foster trust between both parties and help as one prepares and works on. Face-to-face teams or collocated project teams can now be compared to virtual project teams for performance (Gibson & Cohen, 2003).

Google trends or web search interest (Appendix D3) for collocated project team did not have enough search volume to produce any trends. When the researcher used the term face-to-face teams there were again no web search interest from 2005 through

September 2008, but in October of 2008 to present it has been up and down from roughly 40 to 100.

Productivity in R&D Teams

“Research in organizational theory, strategy, and psychology reinforces the idea that knowledge work, such as product development, can be done most productivity in a single location” (Gupta et al., 2009, p. 147). R&D productivity is an important part of global organizations including R&D medical device organizations (Simons, Gupta, & Buchanan, 2011). R&D is an area that fuels innovation and creativity (Kratzer et al., 2006). In the 1980s and 1990s this was the case for the popularity of collocated project teams (Gupta et al., 2009). Project team members in the medical device industry are part of the knowledge workers of today. Typically it takes many years of on-the-job experience on medical device teams to gain this knowledge. R&D designers are part of these knowledge workers that are key to making decisions and driving the product design (Pawar & Sharifi, 1997). Workers today are challenged in a global market to increase productivity and still maintain quality of the products or services (Fruchter, et al., 2010). Dailey (1978) indicates that R&D project teams have not been studied in depth around team productivity. Research indicates that the environment (virtual or collocated) in the R&D project team is an important factor to consider by organizations (Dailey, 1978).

Productivity in R&D does not usually come from harder work, it is increased with shorter cycle times, less waste and improved resource allocation all with the best talent on the team (McGrath, 1996). “Productivity is an outcome, not an individual or even a team goal, and treating productivity as a goal can have negative unintended consequences” (Starbird & Cavanagh, 2011, p. 121). Individual people that are high performers tended to communicate more often and with people from outside their project team (Brown & Eisenhardt, 1995). Project teams that have a goal, proper management and the resources they need will be a more productive project team (Kerzner, 2009). A well-designed and well-run process will enhance productivity (Starbird & Cavanagh, 2011). Project team size can negatively affect productivity in R&D (Lee et al., 2009). There is no one preferred project team size, each project is unique and has to be scoped and resourced appropriately. Projects can change dramatically with a breakthrough discovers that could change the scope of the project (Verma, 1997). Productivity in project teams can be increased with improved relationships and across multiple locations (Wang, 2011). The R&D literature indicates that communication is important to R&D productivity (Bardhan et al., 2012). Research by Wang (2011) indicated that virtual project teams are as productive as collocated project teams. A weakness of this study is that it only looked at the managers and not at any of the team members, and the researcher recommends to conduct more studies in other organizations (Wang, 2011).

Some explanation of differences over the years in productivity can be from generational differences. Project team members under the age of 30 will typically be more computer savvy, while the older generation thinks in a more linear fashion. These generation differences need to be understood in project teams for overall productivity. The newer generation has fresh ideas and unique skills but lacks some of the business experience (Lipnack, & Stamps, 2000). Technology is changing the way people perform daily tasks and how productive the project team is overall. The new generation of R&D project team members is more experienced typically with new technology but lack basic business experience.

> *"On-boarding of new team members may require some coaching of the existing team, depending on the teams diversity of generations – and a discussion of the various generational characteristics with the team in preparation for negotiating the flow of a new member's integration can be priceless"* (Starbird, & Cavanagh, 2011, p. 150).

A project team manager or leader will need to understand the differences in generations and how they can positively and negatively affect the overall productivity of the R&D project team. Changes in the way the team operates may be needed with the generational differences, and it will differ from project to project and team to team. Positive behaviors need to be enforced as they are different for each generation and each person (Starbird, & Cavanagh, 2011). These differences will again affect the productivity of the project team.

<u>Understanding team productivity</u>

“If you can’t explain it simply, you don’t understand it well enough.” Albert Einstein

“Productivity is important in all teams that are formed to produce a result” (Duarte & Snyder, 2006, p. 188). Project teams have been around for years, and many people in R&D have been on project teams or been a leader of a project team. Katzenbach and Smith (2003) explored the impact of project team’s performance is important and the teams are there to drive the performance. “Performance is the crux of the matter for teams” (Katzenbach & Smith, 2003, p. 12). Today there is more urgency toward project team performance and delivering results. Project teams can perform well and bring experiences and knowledge together. The team performance curve indicates that as performance increases the team maturity moves toward a high-performing team (Katzenbach & Smith, 2003). For example, the USA Olympic basketball team had the best individual players but failed to win a gold medal and finished with the bronze medal because of poor team performance (Starbird & Cavanagh, 2011). As described in the example above, when even the best individuals come together and do not work as a team, performance will suffer.

Team performance has been of interest for years. LSS, TQM, and SS, are all methods that drive results (Starbird & Cavanagh, 2011). Methods, theories and tools such as LSS, TQM and SS strive to increase performance in organizations. In this dissertation these methods will come under the heading CIP (continuous improvement process).

“A climate of high work importance is associated with higher R&D team productivity” (Lee et al., 2009, p. 3665). To increase a project team’s productivity they should update the communication technology (Tohidi & Tarokh, 2006). Continuous improvement is increasing performance and improving problem solving (Martin, 2012). Communication technology is important to increase productivity in project teams (Cash-Baskett, 2011). “The key to productivity is to stop doing nonproductive work” (Pine, 2007, p. 33). It should not always be about the project team member’s increase in work but the decrease in work in order to drive productivity. Observations of project team members play a key role in productivity.

When performing research on project team members, one has to be careful about the observation of humans (Speser, 2006). For example, a study of workers at Western Electric Company’s Hawthorne plant looked at various factors to see if they had an effect on productivity. When changes were made, productivity increased, but over time the increase in productivity decreased. Researchers realized that it was not the various factors that had changed, but the workers that were aware they were being studied, so when the study discontinued, so did any productivity gains (Landsberger, 1958; Roethlisberger, 1964; Speser, 2006). Known as the Hawthorne effect, experiments indicated that people show interest in their work when management shows interest in them (Robbins & Finley, 2000).

Characteristics of productive teams are as follows: (Press, 2006, p. 12).

- Members set, agree and commit to goals

- Team goals outweigh individual goals
- Members understand roles and shift as needed
- Members contribute skills and experiences
- Members are tolerant of mistake of themselves and others
- Members are open to new ideas and take risks
- Decisions are made on facts

There is a great deal of opportunity to improve productivity and performance in organizations (Starbird & Cavanagh, 2011). “To develop a productive team clearly takes plenty of people skills, communication, understanding, negotiating, and patience” (Press, 2006, p. 14).

Methods to plan for a productive team include (Press, 2006, p. 14):

1. Common sense and effective human behavior 50%
2. Shared desire for a positive outcome 20%
3. Clear process 20%
4. Content knowledge 10%

Understanding project team success

Project team success can mean many different things to individuals and teams. Müller and Turner (2007) have researched the area of leadership style, project type and what the combined impact is on project teams. “Project manager’s leadership style influences project success" (Müller & Turner, 2007). They performed an open-ended interview set of questions in which they used 10 success criteria and tracked how many times each of the 10 items were mentioned (Müller & Turner, 2007). The study of project managers and leadership style in complex projects in a qualitative study is appropriate literature for this research. Project teams can be similar to soccer teams in that they are made of individuals that make the sum of the team and the combined talent of the project team and have an impact on overall productivity (Franck & Nüesch, 2010). Research has been performed in the area success and project teams, by an open-ended interview set of questions in which they used 10 success criteria and tracked how many times each of the 10 items were mentioned (Müller & Turner, 2007). This was one mythology to track project success, but most organizations do not take the time or resources to perform these interviews. Organizations have a limited amount of resources, and most successful companies will concentrate resources on key projects (Rosenau, 1998).

Results of this project team success study point to communications in nearly all of the industries interviewed, as one of the key factors of project success (Müller & Turner, 2007). Project managers with improved communication skills can influence productivity improvement (Henderson, 2008). "Prior results show that teamwork and communication matter as well in successful New Product Development" (Barczak et al., 2008, p. 21).

Individual productivity

Individual productivity is about setting goals and achieving results in order to be successful (Pozen, 2012). Individual goals do not always drive performance, and sometimes can play a negative role (Starbird & Cavanagh, 2011). Project teams members can have their own set of goals that are not strategically aligned with the project teams and this can create problems in time, cost and scope. Individual performance is individual behaviors that add to effectiveness (Chiocchio et al., 2012). One policy or mandate for all employees to motivate or make them more productive or perform better will not always work as people are motivated by different factors (Schwartz, 2013). Effective communication in individual performance is through trust (Sarker, Ahuja, Sarker, & Kirkeby, 2011). Trust may be a larger factor on a virtual project team as these team members may be seen as high performers (Sarker et al., 2011).

By only focusing on an individual goal while participating on a project team can result in poor productivity for the project team. The individual goals can solve one problem but may result in more problems overall. “Results are function of effort and effort is a function of reward” (Starbird & Cavanagh, 2011, p. 38). Project team members have to determine how to work individually and collectively to be more productive (Duke Corporate Education, 2005). “Labor statistics say that office automation is leading an upsurge in productivity in every country in the world” (Robbins & Finley, 2000, p. 244). This type of automation can result in productivity improvements but it is also the individual that can create problems. “A recent survey of one hundred high achievers suggests, their single most common trait was discontent, restlessness fuels productivity" (DeRond, 2012, p. 16). Individuals on project teams need to be challenged and rewarded for their success. For example, Toyota's ability to improve productivity was so effective that other competitors could not fully believe that they were really able to produce at such high levels (Martin, 2012). Toyota was able to create an environment and process that individuals believed in and understood. People that are disciplined usually are efficient and productive people (DeRond, 2012).

Decisions by project team members require individuals to commit to and be accountable in order their performance to improve, which will increase the performance of the overall project team (DeRond, 2012). The project team begins and ends with individual team players. Today's top leaders (manager and supervisors) tend to perform at a very high level and are productive (Robbins & Finley, 2000). Productivity is a real issue today with financial losses that are due to anxiety and depression (Chiocchio et al., 2012). Project team members will need to find ways to increase productivity in the future to remain competitive (Drucker, 1999).

Project management levers and productivity

Project management levers (as discussed earlier in the chapter) and productivity as the dependent variable will be utilized in this research. "The difference in productivity between an average team and a turned-on, high performing team is not

10 percent, 20 percent, or 30 percent, but 100 percent, 200 percent even 500 percent", Tom Peters as quoted in (Gray & Larson, 2005, p. 343). Productivity has increased over the last 25 years, and this is a large factor in why we have been able to improve the standard of living (Starbird & Cavanagh, 2011). Project teams increase productivity because they are closer to the activities and see the opportunities (Robbins & Finley, 2000).

In the researcher's dissertation, he will extend the literature on virtual project team and collocated project teams impact on productivity in medical device R&D. Project teams in general need to be productive in order to compete in the global markets. Social support has been used for project teams building to improve productivity (Chiocchio et al., 2012). Project resources are needed to carefully move from project team to project team in the organization to improve productivity.

The project team, in many organizations is a grouping of collocated people working for a common purpose. This is no longer the norm; instead, people find that project teamwork occurs across many time zones, locations and organizations. Nearly all organizational teams are virtual project teams to some extent (Johnson, Hermann, & O'Neill, 2001). Virtual project team communication could be negatively affected with project management communication and project productivity (Henderson, 2008). If there is not effective leadership of a virtual project team communication can be negative and drive lower productivity. If there is not a solid understanding of the project scope, communication and leadership there may be negative outputs in time, budget and quality in both virtual and collocated project teams. R&D project teams are made up of many different backgrounds and experience, which if not managed effectively could result in the project team being unproductive (Nakata & Im, 2010). This is back to the project team environment (virtual and collocated), and the project management levers discussed earlier in this chapter. These examples are needed in order to be successful and productive. If they are weak a project team may not meet its objectives or goals. The productivity issue is not only common on virtual project teams but also is common on collocated project teams. NPD researchers believe that one are that needs improvement is project team communication and support (Barczak et al., 2008). Of course there are many factors within each project team, and not all factors will be reviewed in this research. The project management levers are a framework for areas to be researched by the researcher.

Figure 2.3 provides a visual form of the interactions for virtual project teams and collocated project teams and the impact on productivity. This indicates the structure, people and technology of the project management levers and the relationships between each section.

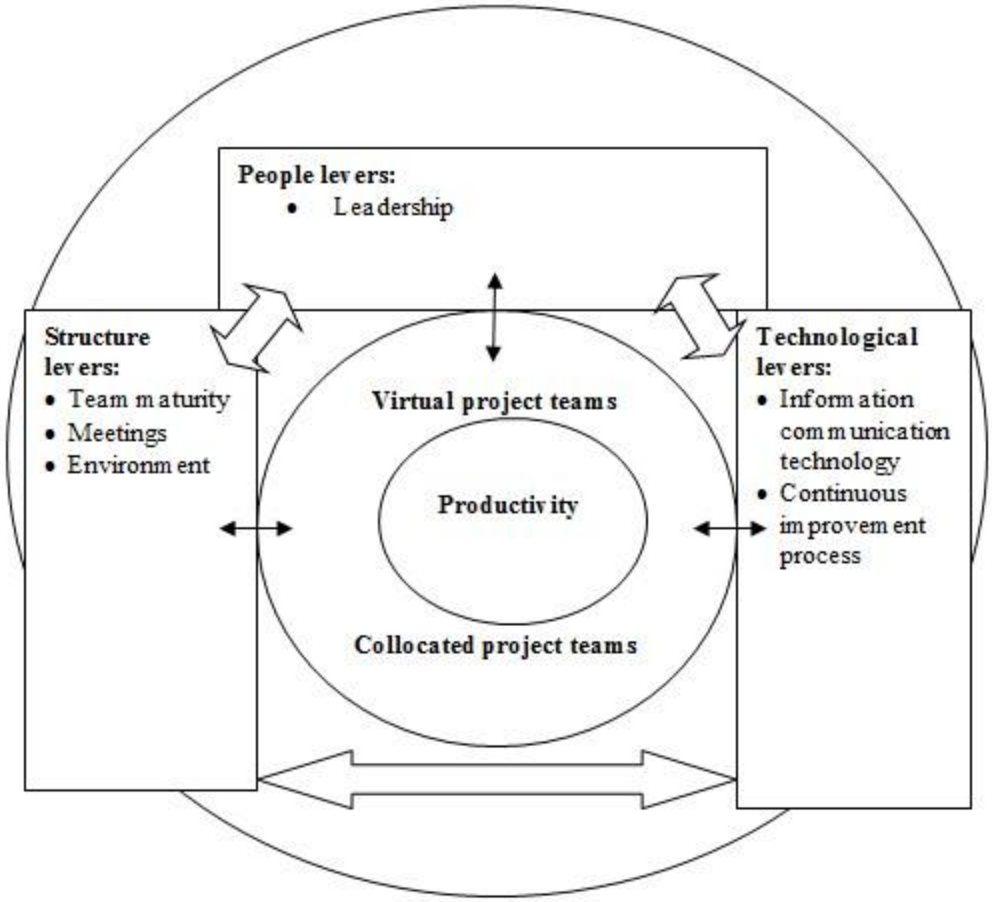


Figure 2.3 Productivity and interrelationships

Performance versus productivity

Performance in a team environment, which is rich in cooperation and knowledge sharing, can improve performance (Markham & Lee, 2013). Teams that perform better than other teams have a higher level of cohesiveness among team members and are from higher performing organizations (Markham & Lee, 2013).

"Research shows that very few organizations make significant progress in their overall business performance" (Martin, 2012, p. xv). Behavior in the organization prevents performance improvements. Productivity and performance are used in academic and organizational groups (Tangen, 2005). Productivity is a term that is multidimensional and can be used in different contexts, and performance is an overall term that can include productivity (Tangen, 2005). Project teams are made up of individuals with different expertise and backgrounds. Competitive and other performance pressures are necessary for organizations today (Okes, 2013). Project teams of today need to perform in order to remain and even improve productivity. Several factors external and internal to the project play a role in the overall performance of the project team (Verma, 1997). Verma (1997) suggests “technical success, performance on schedule and performance on budget” (p. 119). Functional managers and senior managers need to step up in order to have more effective cross-functional project teams and improved performance (Barczak et al., 2008). Leadership by the managers is needed to be more effective and improve performance. A lack of leadership will make it difficult to gain in productivity and performance.

As organizations engage in more teamwork, performance metrics will also need to change (McGregor, 2013). This is based on performance reviews of today and how these performance indicators will need to change into the future. Organizations that are best in class from the 2012 Comparative Performance Assessment Study are 30-50% more likely to use Critical Chain, Program Evaluation and Review Technique, Gantt, Failure Modes Effects Analysis, and Design for Manufacturing, LSS and Theory of Inventive Problem Solving (Markham & Lee, 2013).

Patient safety literature suggests that team performance is critical for patient care (Chiocchio et al., 2012). Team work is a focus in healthcare and medical device teams (Chiocchio et al., 2012). Team performance should connect the organization strategy and vision (Jones & Schilling, 2000). Project teams need to set up the correct metrics to measure performance. Performance measures are used to proactively monitor the project (Milosevic, 2003). Performance measurement is a way to keep project control. When the performance is known we can figure out the difference between the start and the actual performance (Milosevic, 2003). Performance is also a result of cost, time, and scope (Lewis, 1998).

Verma (1997) suggests that trust is a key component to increasing project team performance. A consequence of trust is that is it fosters cooperation (Uslaner, 2002). When the project goals are not being worked on and the project team is handed more goals and objectives, productivity will decrease (Robbins & Finley, 2000). Project performance is the result of a project team reaching its objectives and goals. Performance is the value of what people do (Chiocchio et al., 2012). “Project performance is fundamental to project management” (Chiocchio et al., 2012, p. 55). Project performance can be an element of time and did the project finish within the time in the schedule. Quality and budget also are factors for project performance (Kerzner, 2009). Some of the areas that a project manager needs to consider with high-performing teams are: groupthink, bypassing authority, burnout, and work/life balance or strain on personal relationship (Gray & Larson, 2005). Effective knowledge sharing is needed for performance in either a collocated project team or a virtual project team (Gupta et al., 2009).

In Figure 2.4, the business strategy is the start for the project team to improve its performance. The business strategy is aligned with the project team strategy. Performance is measured in this simple diagram that project teams can use throughout the time they work together. “Project managers must use their skills to get rid of poor performance and increase the productivity of average performers” (Verma, 1997, p. 183). Project managers need to increase their skill level in order to improve development of high-performing project teams (Verma, 1997). Performance metrics should be used to manage process activity in the organization (Broeding & Goodwalt, 2012). Metrics should focus on quality, cost and schedule and have the past and present (Broeding & Goodwalt, 2012). Performance in project management contributes greatly to performance through the use or resources and schedules (McGrath, 1996).

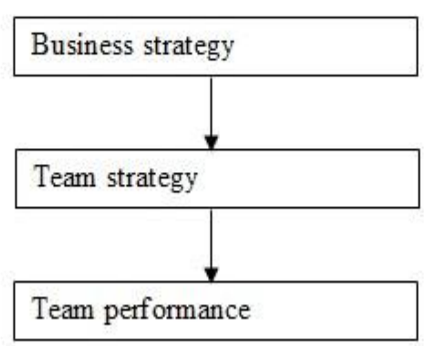


Figure 2.4 Team performance (Jones & Schilling, 2000, p. 79)

"Project success is dependent upon the combined performance and productivity of team members" (Verma, 1997, p. 203). Project team members should work together in order to drive success of the project and the project team. Project performance refers to the extent to which a project is carried out on time, within budget, and satisfying client/customer requirements (Kerzner, 2009). The internet will continue to play a major role in the success of project teams in order for organizations to deliver innovative products (Ozer, 2004).

Productivity Trends

Productivity is an area that can be utilized by organizations to drive improved results. How productivity is measured can be different from project team to project team. A project team that is well designed in an organization can expect to see increased productivity (Lurey & Raisinghani, 2001). Team effectiveness has three main components. The first is productivity, the second is the ability for the team to learn, and third is the extent to which a team is able to satisfy individual members along a number of intrinsic measures (Lurey & Raisinghani, 2001). Productivity can usually only be assessed after the work is completed or through an improved process to measure team productivity midstream or during the work (Okes, 2013). Gains from productivity are not automatic and it is leadership that may lead teams to positive productivity gains (Huang, Kahai, & Jestice, 2010).

Processes would be improved in real time to see how a virtual project team or even a collocated project team is performing (Lurey & Raisinghani, 2001). In other words, project teams would need a process or processes to know what they are currently at in performance, where they want to make improvements, and the extent of their desired improvements. There are many definitions of productivity. Mohanty (1992) has defined 12 definitions at a macro and micro level. At the macro level, they are international viewpoint, national viewpoint, organizational viewpoint, industrial viewpoint, and manufacturing viewpoint. At the micro level, they are resource viewpoint, total productivity measurements, total factor productivity, engineer viewpoint, accountant viewpoint, and management viewpoint (Mohanty, 1992). For purposes of this research, the definition will be that productivity is a measure of team effectiveness as it relates to project success.

Factors that can affect productivity that are project team related include, for example, technology innovations, the economy, and time (Mohanty, 1992). “Being successful at improving productivity may require finding out what is really going on, and making certain that those who will participate know the objectives and ground rules” (Mohanty, 1992, p. 99). This also includes knowing the players and how they perform tasks. For instance, Rubinstein, Meyer and Evans (2001) found that engineers took 25 to 50 percent longer when switching between multiple tasks than if they had done these tasks sequentially.

There are many ways to look at productivity, and different factors one could choose. More research is needed in the area of productivity and project teams to fill the gaps and help both the practitioner and the academic. Cycle times in recent years have also been declining in NPD (Barczak et al., 2008). Thomke and Reinertsen (2012) have spent many years working with different companies including medical device organizations in product development. In some cases, they have found that to complete projects more quickly and efficiently, some organizations would require 50% more resources (Thomke & Reinertsen, 2012).

The researcher reviewed Google trends or web search interest (Appendix D3) and found that at least performance was higher as a search word. Productivity when used on Google trends indicated a peak in 2005 and then was stable from 2007 to present.

As seen in the Table 2.5 below, there are many different resources for the literature search. Table 2.5 is a sample of the literature reviewed in this chapter of the dissertation. The researcher has focused on books, journals, previous dissertations and other research.

Table 2.5 Literature search findings (dissertations not included)

Dependent Variable	**Independent Variable**	**Major Resources**
Productivity	Environment	Daily, 1978, (Journal)
Productivity	Meeting	Boule, 2008, (Journal) Rezgui, 2007 (Journal) Tullar, Kaiser & Balthazard

		1998, (Journal) Longo, 2005, (Thesis)
Productivity	Leadership	Hoch & Dulebohn, 2013, (Journal) Huang, Kahai & Jestice, 2010, (Article) Balthazard, Waldman, Howell & Atwater 2004, (Conf.) Yang, 1996, (Journal)
Productivity	ICT	Nader Ebrahim, Ahmed & Taha, 2009a, (Journal)
Productivity	CIP	(Calvo-Manzano et al., 2012)
Productivity	Facilitation Tools	Clear & MacDonell, 2011, (Journal) Workman, 2007, (Journal) Paulson, 2004, (Conf.) Pauleen & Young, 2001, (book)
Productivity	Team maturity	Thamhain, 2003 (Journal)
Productivity	Leadership	Hoch & Dulebohn, 2013, (Journal) Huang, Kahai & Jestice, 2010, (Article) Balthazard, Waldman, Howell & Atwater 2004, (Conf.) Yang, 1996, (Journal)
Productivity	Interaction	D’Souza & Lepsinger, 2010, (Journal) Gupta, Mattarelli, Seshasai & Broschak, 2009, (Journal) Purvanova & Bono 2009, (Journal)

		Andres, 2002, (Journal)

Figure 2.5 is a model of productivity for this research. Virtual project teams, collocated project teams and productivity are the three main themes in this dissertation. Environment (virtual and collocated), leadership, meetings, team maturity, ICT, and CIP are the project management levers that align to the productivity dependent. As discussed earlier in the chapter, these project management levers are defined for each environment, virtual and collocated. Based on the researchers experience and literature results these were the areas that had impact to the project while being unique enough to be researched in a dissertation.

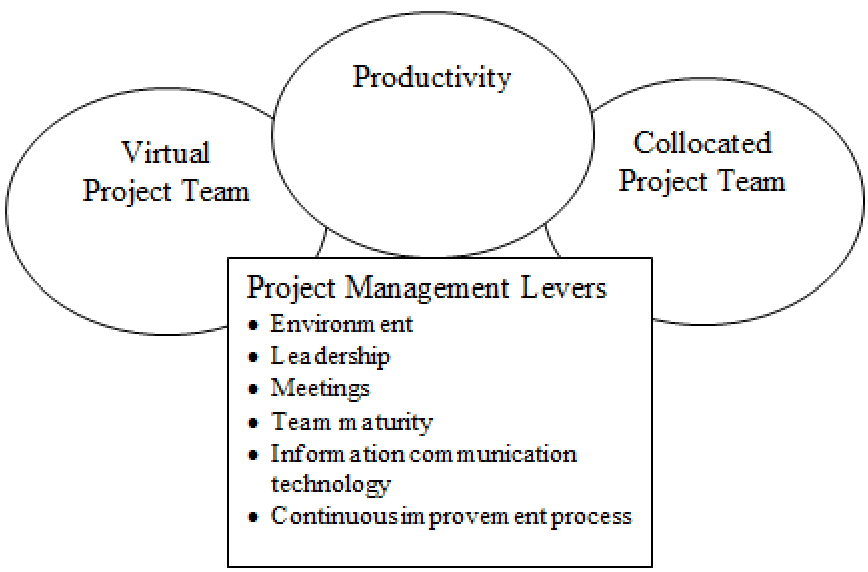


Figure 2.5 Productivity model

The Ringelmann effect (individual average performance) investigated team size and productivity in the late 1800s. Alan Ingham picked up this experiment in the 1970s (DeRond, 2012). The finding was that “team members seemed to be reducing their effort because their individual contributions were no longer easily identifiable” (DeRond, 2012, p. 97). Larger teams can be much more complex and challenging to lead and perform because of the Ringelmann effect.

Statement of objectives

The objectives for this research are below. These are the main drivers in this dissertation and will facilitate the research questions and analysis.

The dissertation attempts to achieve four research objectives; they are:

1. *To explore the major areas of project management, for example, information communication technology, leadership, meetings, team maturity and continuous improvement process on virtual and collocated project teams in R&D medical device teams.*
2. *To identify and explain any productivity issues positive or negative in both virtual and collocated project teams in R&D medical device teams.*
3. *To investigate and explain the impacts of project management, for example, information communication technology, leadership, meetings, team maturity and continuous improvement process in virtual and collocated project teams in R&D medical device teams.*

4. *To identify and present possible solutions to improve performance or productivity of the virtual and collocated project teams in R&D medical device teams.*

Table 2.6 outlines the virtual project team and collocated project teams and the relevance to the dissertation and is a summary of what is covered in Chapter 2.

Table 2.6 Literature review summary

Discussion	**Relevance to dissertation**
Virtual project team levers, characteristics, definition and capabilities	This section describes the first core theme – virtual project teams in the dissertation. It reviews views of scholars that have studied the area of teams with details around virtual teams. Research, theories and models are discussed in a generic general team theme.
Collocated project team levers, characteristics, definition and capabilities	This section describes the second core theme – collocated project teams in the dissertation. It reviews views of scholars that have studied the area of teams with details around collocated teams. Research, theories and models are discussed in a generic general team theme.
Productivity	Productivity is a key output of teams in order to be successful. For the purposes of this research, the definition is that productivity is a measure of team effectiveness as it relates to project success.

Chapter Summary

Virtual project teams and collocated project teams have been around for years. Table 2.6 is a summary of this chapter. Productivity has been introduced as the dependent variable in this research. The role of a successful project team, collocated or virtual, needs to be able to increase productivity in a global environment. This chapter has discussed the literature review for virtual project teams, collocated project teams and productivity for this dissertation and research.

This chapter has also reviewed the virtual project teams and associated project management levers and also the collocated project team and associated project management levers. Productivity was also reviewed in this chapter. Chapter 3 will discuss the conceptual development for medical device, R&D, teams and trends in this dissertation.

Chapter 3: Conceptual Development

Introduction

This conceptual development will introduce the R&D project teams, R&D medical device teams, and trends. This chapter will provide a brief history of the medical device industry and to provide context. Three core themes are presented throughout this dissertation. They are virtual project teams, collocated project teams (for comparison) and productivity.

Medical Device R&D Background

The medical device (or diagnoses and treatment) industry had its first major invention with the thermometer in 1603, by Galileo (Fries, 2005). The next major innovation was the stethoscope in 1819, by Laennec. It was not until 1895 that Roentgen discovered the X-ray. Since the 1900s, many more inventions and innovations have been discovered in the area of medical devices (Fries, 2005). Today there are many more medical devices on the market in the modern age of technology. Medical devices vary in many ways, size, shape, and function, but they all have one thing in common: they all need to be safe and effective for the use for which they are intended (Fries, 2005). “Making devices safe, effective, and reliable begins in the earliest stages of product design and is a continuous process through production and maintenance” (Fries, 2005, p. 119). R&D medical device teams are finding solutions to clinical problems (Kucklick, 2012). R&D success is from inventions (Ebrahim, Ahmed, & Taha, 2008a). The combination of medical devices and innovation fuels new indications and devices. Indications are the disease site or part of the human body that the medical device would be implanted or targeted.

The medical device industry is comprised of a surgical, cardiovascular, home healthcare, general medical and other devices. The industry in North America contains 46% of the global market (Lucintel, 2012). An important theme in 2012 was globalization in large markets (Stuart, 2013). Globalization is creating a more competitive market for medical products and services. The global medical device industry has experienced large growth in the past years (Lucintel, 2012). Increased global competiveness and increased regulations are challenges that this industry faces. China, India, Russia, and Brazil are the markets that will be most important in 2012 (Industry Review Press Release, 2012). The medical device industry will look different in 2020 than it currently is today (Research and Markets, 2013). Project team structures will change dramatically in the future, and many medical device companies will find it difficult to conduct business in this space (Research and Markets, 2013). U.S. Medical Devices (In Vitro Diagnostics, Medical Devices, Medical Equipment, and Medical Supplies) is an industry undergoing changes and trying to redefine the industry’s goals. New devices and technologies are changing and creating new markets and new solutions for patients (Research and Markets, 2013).

The definition of a medical device is *"any instrument, appliance, material or other article, whether used alone or in combination, including the software necessary for its proper application, intended by the manufacture to be used for human beings for the purpose of:*

- *Diagnostic, prevention, monitoring, treatment or alleviation of disease*
- *Diagnosis, monitoring, alleviation of or compensation for an injury or handicap*
- *Investigation, replacement or modification of the anatomy or of a physiological process*
- *Control of conception*

And which does not achieve its principal intended action in or on the human body by pharmological, immulogical, or metabolic means, but which may be assisted in its function by such means" (Fries, 2005, pp. 54-55).

Medical devices are many simple and complex components that are encountered on a daily basis.

The cost to research and develop a medical device product from beginning to end is a long and complex process. The end goal of the product or service is to drive clinical and economic value. "R&D consumes people, and people use time and money" (Teixeira & Bradley, 2002, p. 1). The term R&D is one that relates to innovation commercialization. Research is usually not tied to any development product in the early stages, but it is "vital to ensure knowledge on a subject that is readily available and stimulate new product opportunities" (Cooke & Mayes, 1996, p. 46). "Research indicates that knowledge sharing can improve team performance" (Huang, 2009, p. 788). The R&D process in a medical device organization can be difficult and usually is a complex project or set of projects. Early inventors of medical devices did not have to work in a heavily regulated industry such as in the USA where the Food and Drug Administration (FDA) protects the public from unsafe medical products (Kucklick, 2012). R&D medical device teams of today are highly functional, complex teams that utilize many different communication technologies. A complex team is a cross-functional group of project team members that are focused on a device, therapy, hardware, software, etc. (medical device) that restore life or improves the quality of life. The next section will review at a high level the R&D teams and their technology use.

R&D Teams and Technology

"R&D is the core activity that sustains organizational innovation. However, we still know little about the critical success factors for R&D teams" (Huang, 2009, p. 786). The challenge for many global organizations is to integrate new R&D teams so they can improve productivity (Gassmann & Von Zedtwitz, 2003). Many studies have been performed to better understand success factors in R&D projects (Balachandra & Friar, 1997). It is difficult to establish a set of success factors. Studies should attempt to review the settings and approaches. Research has shown that R&D is improved in a collocation environment (Henderson & Stackman, 2010). This study indicates that location, technology, cost and their interrelationships all play an important role in project management (Henderson & Stackman, 2010). Technology improvements have changed how we work as an R&D team (Duke Corporation Education, 2005). Characteristics of R&D project teams can be communication, project time, leadership and research experience (Lee, et al., 2009). R&D teams are complex and can drive team performance (Huang, 2009). Many R&D teams use the internet and organization's web site to share project information (Ebrahim, Ahmed, Rashid, & Taha, 2011a). Virtual teams in R&D may be able to reduce cycle times and be more efficient (Ebrahim, Ahmed, & Taha, 2009b). R&D teams need to be able to get information from many different sources quickly in order to be effective (Ebrahim, Ahmed, & Taha, 2008b). The life cycle for a product to get to market is important to organizations today (Parry, Song, De Weerd-Nederhof, & Visscher, 2009).

Team members of a R&D project team, virtual or collocated, use digital communication, videos, electronic whiteboards, audio links, email, instant messaging, websites, and other means to communicate (Ebrahim, et al., 2011a). Collocated R&D project teams may also use visual management to communicate to the rest of the project team. Visual management is a method to show activities, schedules and accomplishments in an easy format that can be used for a short meeting on a weekly or daily basis. Visual management can also address whether a project is meeting the targeted schedule or contract dates, can highlight problems and issues, and also provides management with brief visual overviews. Visual management is an effective tool in communicating upward and downward in a R&D program/project team

(Ebrahim et al., 2010). The ability to have important information in a visual representation makes it easier for others on the R&D project team and outside the project to understand its status. These authors focused on its use in collocated, but it could have comparable value on virtual teams.

There are many important technology factors and new technologies that R&D project teams can use now. “With rapid development of electronic information and communication media in the last decades, distributed work has become much easier, faster and more efficient” (Ebrahim et al., 2009a, p. 2653). Research in the area of ICT is still limited (Vaccaro, Veloso, & Brusoni, 2008). Ebrahim et al., (2011b) states that future research is needed to further examine the ICT environments. Based on the current literature the researcher also indicates that more research would be needed in the area of ICT.

“Even though successful outcomes of a new product or commercial R&D project are hard to predict, the research to date has attempted to derive a comprehensive model of what leads to success or failure” (Balachandra & Friar, 1997, p. 276). There are a large number of factors that drive R&D success. Technology, environment, and leadership constitute the greatest areas for most R&D organizations (Balachandra & Friar, 1997).

The R&D team’s research at 3M’s Optical Systems Division indicated lower project performance because of time and budget reductions (Chandrasekaran & Mishra, 2012). Time and budget are directly correlated with project performance as indicated in the 3M example. Balachandra and Friar (1997) conclude that R&D is a complex process, and more research is needed. R&D project teams need to stay flexible as global competition increasingly changes. R&D leaders will need to continue champion innovation and commercialize successful products (Marion, Dunlap, & Friar, 2012). Innovation is an important factor for organizational success in today's market (Ebrahim, Ahmed, & Taha, 2009b).

Medical Device R&D Teams

R&D teams in the medical device organizations are a complex group of activities and projects in a regulated industry, as already indicated. Uncertainty in the market place has increased risk and cost in the R&D organizations, which can all affect productivity (Blomqvist, Hara, Koivuniemi, & Äijö, 2004). Project teams are used in R&D organizations to develop ideas, innovate, and share knowledge (Ebrahim, Ahmed, & Taha, 2008c). They also can help reduce risk and commercialize products with increased efficiency and productivity. Project teams in the R&D medical device organizations need to plan in sufficient detail. Often, these R&D project teams do not have a clear direction, whether they are virtual or collocated project teams concerning the use of ICT (Ebrahim, et al., 2009a).

R&D project teams need to be aware of time to market as this is a key for successful organizations (Kumar, Deivasigamani, & Omer, 2010). R&D is an organization's competitive advantage from a strategic perspective (Blomqvist et al., 2004). Project teams in R&D medical device organizations need to also understand the clinical applications and the technology of the product or service (Lucke et al., 2009).

R&D medical device project teams follow a process in which they bring the customer requirements, technologies, suppliers and company competencies in which a virtual or collocated project team in an R&D medical device organization would begin to plan the project (Fries, 2005). All project team members must incorporate quality into all tasks, and they must use principles of project management (Babler, 2011). Geography and more complex technologies can make it more difficult for project teams to meet often (Babler, 2011). This can add to the already complex products and work to be done by the project teams.

Commercial success of products is the financial lifeline for most organizations. In the medical device area, end users need to be part of the design process (Brown, Dixon, Eatock, Meenan, & Young, 2008), and more research in this area is warranted.

R&D medical device teams need to also address ethical considerations when choosing projects. R&D teams need to be aware of the projects, the output of these projects and how critical these products can be to the end user. Ethics should remain high on the list for all R&D project team members. Project team managers need to keep ethics a priority in order to improve the culture of the project team (Kerzner, 2003). It is up to the project manager and how he or she handles difficult situations in terms of ethics (Gray & Larson, 2005). Medical device R&D project teams need to remind themselves how important ethical practices are to the product and more importantly to the end user.

In addition, in selecting to pursue projects other factors are unmet needs, technology requirements, and capabilities. Both internal and external, time, risks, and rewards should also be reviewed. Medical devices are products that are engineered (Citron, 2012). The R&D process in medical devices is complex, and its goal is to advance medical devices to better serve patients who need them (Citron, 2012). Figure 3.1 outlines a typical R&D medical device process. “There has been little work done analyzing the effect of experience on the success of a medical device development project” (Lucke et al., 2009, p. 7057). Most medical devices follow a similar flow of product definition. Customer needs are the start of the process, which move into specifications, technology and on to application, platforms or enhancements. Depending on the technology and the level of complexity this process can take many years to complete.

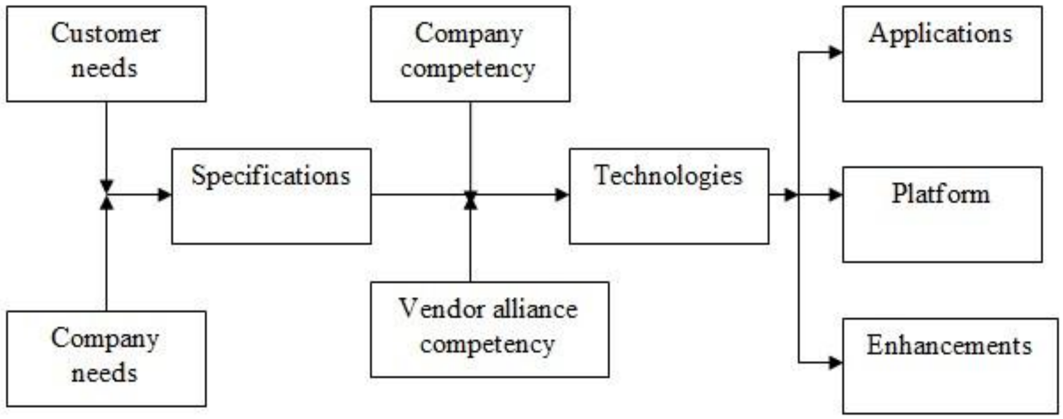


Figure 3.1 The product definition process (Fries, 2005, p. 122)

The researcher points out that there is a lack of research in the R&D medical device teams and project areas from the literature reviewed in this dissertation. In addition, the existing research was minimal, and little information exists with the three cores themes combined: virtual project teams, collocated project teams and productivity.

Medical Device R&D Trends

> *"If the medical device industry is going to survive,"*. . . *"the business model has got to change. It's now a mature, slow-growth industry, he said. It has to make simpler and less costly products "* (Schafer, 2013, para., 1).

Current trends in the R&D medical device industry are rather apparent and clear to most in the industry.

- Health care economics are a global challenge.
- Many medical device products are becoming more complex.

- The regulatory environment is more stringent globally.
- Customers want simplicity in product solutions.
- Medical device companies are shifting from being product focused to owning the disease solution.
- The current medical device sector is experiencing intense competition.
- A customer focus with the ever increasing technological innovation is required to maintain a competitive advantage.

Health care economics are a global challenge. Physicians and providers of healthcare are also feeling the increased pressure. Organizations must choose their strategy and technological innovations carefully to compete on a global level. “The choice of strategy is often reflected in the organization structure and innovation activities of the company” (Janssen, 2012, p. iv). The objectives of the global medical device organizations are to improve treatment for humans and to create innovations accessible to developing countries (Songkajorn & Thawesaengskulthai, 2012). Customers would like simplicity and economic value in medical device product solutions (Chatterji, Fabrizio, Mitchell, & Schulman, 2008). Songkajorn and Thawesaengskulthai (2012) also indicate that the innovation processes for R&D medical devices are complex. “This increases the need for performance and/or productivity improvement on project teams in the R&D medical device organizations” (Thamhain, 2005, pp. 12-13). R&D medical device organizations will need to address the speed to market with the speed of technology in the future to be productive. Medical device companies also need to address how they can improve productivity in their R&D project teams.

Chapter Conclusions

The focus of this chapter was to provide an overview of the conceptual development around medical device, R&D, teams and trends. Medical device R&D organizations utilize project teams in both virtual and collocated project team environments. The information in the previous sections leads to conclusions in Table 3.1 below.

Table 3.1 Background of key areas in this dissertation summary

Background	**Notes**
Medical device R&D background	The medical device project teams of today are highly functional, complex teams that utilize many different communication technologies.
R&D teams and technology	Technology involves many important factors that R&D project teams can use now. The presence of smart phones, tablets, computers, and other technology makes it very easy to communicate today.
Medical device R&D teams	All project team members must incorporate quality into all tasks, and they must use principles of project management. Geography and more complex technology make it difficult for project teams to meet.
Medical device R&D trends	The current medical device sector is experiencing intense competition, reduction in cost, more customer focus, and ever-increasing technological innovation. Physicians and providers of healthcare are also feeling the increased pressure.

Chapter Summary

Chapter 3 has provided a conceptual development of the medical device, R&D, teams and trends. The R&D process in medical devices is complex, and its goal is to advance medical devices to better serve patients who need them. “Peoples contributions to a team should depend on their skills and the quality of their work, rather than on proximity to a work site” (Poltrock & Engelbeck, 1999, p. 339). This chapter provides the conceptual development for this research. Chapter 4 will discuss the research methodology and how research will be conducted in this dissertation.

Chapter 4: Research Methodology

Introduction

This chapter will outline the research strategy and method of this dissertation. The methodology is following a case study approach. Ethical consideration and reliability of the research will also be summarized in this chapter. Thus, the research methodology is organized around: research design, research process, data analysis, research reliability, and ethical considerations. The ontology and epistemology will be reviewed, and the research behind this design will be discussed. The ontology of the research is from the experience and background of the researcher, references to literature and consultations with practitioners in the context of the research.

Bryman and Bell (2007) discuss the epistemology and research design framework and also the detailed processes of the research methodology. This is the framework for the case study of this dissertation. “Epistemology was concerned with the source of validity in our knowledge of the physical world” (Parsons, 1967, p. 443). Epistemology discusses acceptable knowledge as a discipline (Bryman & Bell, 2007). Yin (2003) states that “case studies are the preferred strategy when “how” and “why” questions are being posed, when the investigator has little control over events and when the focus is on contemporary phenomenon within some real-life context” (p. 1). Creswell (2009) defines “a case study as a qualitative strategy in which the researcher explores in depth a program, event, activity, process, or one or more individuals" (p. 227)

The case study methodology allows an opportunity to have meaningful characteristics of real-life events of the organization, and thus this approach is one of the best ways to perform social science research (Yin, 2003). The case study methodology will allow the researcher to witness first-hand information from participants. Heath (2006) indicates that the framework for a case study should incorporate four structures: 1) the flow of events, 2) the element, 3) the clear time sequence, and 4) the disclosure. Case studies are a preferred strategy when asking "how" or "why" questions and when one has little control over the events (Yin, 2003). Cases come in a variety of forms and are used in many ways (Heath, 2006). As a research study, the case study is used to contribute to knowledge of an organization.

Background of the research

The research idea for this dissertation came from the researcher's personal work and academic setting on R&D medical device projects and intellectual curiosity. It has been observed by the researcher that R&D medical device project teams, both virtual and collocated, have unique ways of using project management levers. Project management levers in this dissertation are the environment (virtual and collocated), meetings, team maturity, and continuous improvement process and information technology communication. The researcher has led both virtual project teams and collocated project teams to successful medical device commercialization. Over this period of time the researcher has observed effective and ineffective use of project management levers by virtual project teams and collocated project teams. After each project, the researcher tried to better understand why the overall success of the project was either positive or negative. Figure 4.1 visually depicts the goals of the researcher for this dissertation. A personal goal of the researcher of this dissertation is to assess what is effective and ineffective in virtual project teams and collocated project teams processes and to make recommendations to improve project success and productivity.

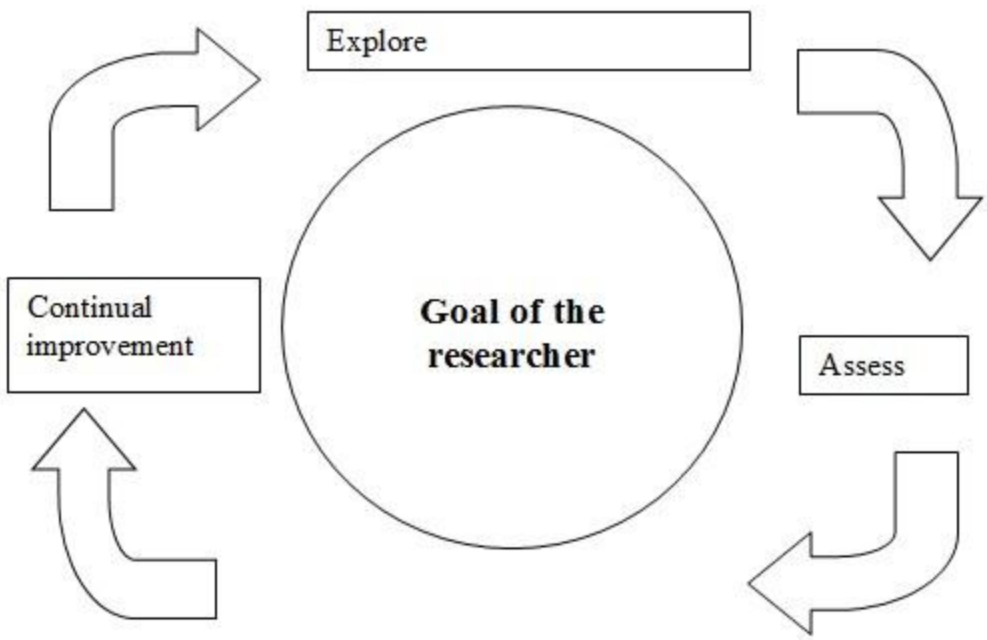


Figure 4.1 Goal of the researcher

Additionally, while technology has improved over the past years to make the job of a project manager easier in theory, technology has also complicated the project manager role and results. Because of the complexity in electronic project management tools and software, some project managers have found it difficult to determine which project management levers would be the most productive to use within a virtual framework. This confusion has caused increased turnover by project managers and project team members, as well as confusion within the project, in some cases. As project teams attempt to understand the decreased retention of employees and decreased overall productivity, they need to understand the impact. In this vein, the researcher hopes to determine the causes of this trend and to determine how to increase the success and productivity of the project teams and thus the organization at large.

The projects must create effective strategies for improving project team processes and productivity by utilizing strong team leaders who foster positive project teams, in which each member's contributions are valued and recognized components to the overall team success. Project team leaders must help the project teams to effectively prioritize and utilize effective project management levers they receive on a daily basis. Accordingly, the researcher hopes to provide strategies and research to help organization, project team leaders, and project teams create a productive and positive environment in which to flourish. Additionally, the researcher will discuss efficiencies and inefficiencies observed in the case studies, pointing out areas in which project team success was hindered because of various obstacles that beset a virtual or collocated team.

To provide more information for this research, the researcher looked to experienced practitioners through pilot cases. "Pilot case studies may be conducted for several reasons unrelated to the criteria for selecting the final cases in the case study design" (Yin, 2009, p. 92). The pilot case study will help refine data with the procedure and data. A pilot case study can be viewed as a laboratory to observe others, different approaches and look at things from different angles (Yin, 2012). There are very few research projects that addressed R&D project teams with regard to virtual project teams and collocated project teams. In the medical device organizations the researcher could not find any research that included all the variables that he is proposing for research in the real world. With limited research references being available, the researcher decided to use research design that supports an exploratory approach (Yin, 2003). "Some of the best and most famous case studies have been both explanatory case studies" (Yin, 2009 p. 3).

Projects need to create positive teams and processes in order to be more productive. It is difficult for project team members to sometimes balance all of the project management levers they can use on a daily basis. This researcher would prefer to see projects have a strategy on improving productivity or performance and perhaps utilize lessons learned from this research. In this researcher's experience project success has been dependent on the project leaders. Many project team members were not given the chance to weigh in on what may work best for them when it comes to the project management levers, and this many times creates a negative impact. The researcher observed over time that many different technologies would evolve over the life of the projects. A great deal of time was spent working on what technology should be utilized: email, video-conferencing, intranet/internet and simple face-to-face interaction, for example.

The researcher observed that over the time of leading projects in the virtual project environment and environment that the virtual project teams were able many times to have solid communication tools that they used since they had to use communication technologies. The researcher also noted that even though the virtual project teams had more consistent communication styles, they still had issues and problems on the project team. Another observation was depending on which generation of people was on the project team as results would vary. Generation X likes communication in many forms and seemed to be more adaptable, generation Y liked more communication by phone or face-to-face. The newer generations of knowledge workers were much more comfortable and willing to try new and improved technology in any form in the researcher's experience.

> *Project management levers have a positive impact on productivity in virtual project teams and collocated projects teams in R&D medical device organizations.*

The researcher has observed people at virtual project team meetings who, when called upon, have to ask what the question was because they were not actively listening, and this researcher believes this will have an impact on productivity. He has seen this on collocated project teams and on virtual project teams. In addition, he sees time wasted in unproductive meetings when they are scheduled for one hour, with no agenda, and yet often they last to fill the allotted time. Most meetings lack an agenda or objectives many times, and there is often a lack of understanding within the project team regarding the purpose of the meeting without this information. During project team meetings, it is hard to always receive full participation and to persuade people to stop using electronic devices. Since most organizations are becoming global they are dealing with some type of virtual project team structure or collocation project team structure. The researcher has been a project manager on many virtual project teams and collocated project teams in the R&D medical device industry, and he has seen similar behavior over and over again. More research is needed to enhance the performance of virtual project teams (Ebrahim, Ahmed, & Taha, 2009a).

The researcher used a few methods to determine validity of the topic. The researcher surveyed ideas on this topic through reviewing many areas of literature in many diverse forms. In addition, he asked the views of many project management and executive leaders. From over 215 literature sources referred to in Chapter 2 and Chapter 3 of this dissertation, not one of them covered all of the core themes (Virtual project teams, collocated project teams, productivity and all in the R&D medical device space). The review of these sources indicated that there is a limited amount of research in virtual project teams and collocated project teams in an R&D medical device environment. Many literature sources have been reviewed and documented in the literature section of this dissertation. This researcher was unable to find research on the specific topic of virtual project teams and collocated project teams in R&D medical device teams.

In the appendix D, the researcher reviewed a few early research type tools to gain a better idea on themes and information for this dissertation. This helped him make sure that these terms were the best descriptions he could use for future searching. This information was used in the literature review to target some of the larger reference materials. Chapters 2 and 3 review these tools.

Research Design

> *"Research designs are plans and the procedures for research that span the decisions from broad assumptions to detailed methods of data collection and analysis. The selection of a research design is also based on the nature of the research problem or issue being addressed, the researcher's personal experiences, and the audiences for study"* (Creswell, 2009, p. 3).

Knowledge claim approach

"The goal of research is to rely on as much as possible on the participants views of the situation being studied" (Creswell, 2009, p.8). Constructivism is the most appropriate knowledge claim approach for this research. People seek understanding of the world in which they live (Creswell, 2009). The research design for this dissertation was organized using Creswell's (2009) framework for design (see Figure 4.2 below). The research design needs to build on a foundation from a philosophical perspective that details the research approach and processes. Creswell (2009) informs researchers to think about:

> *"The philosophical worldview assumptions that they bring to the study, the strategy of inquiry that is related to the worldview, and the specific methods or procedures of research that translate the approach into practice". "This information will help explain why they chose qualitative, quantitative, or mixed methods approaches to their research"* (Creswell, 2009, p. 5).

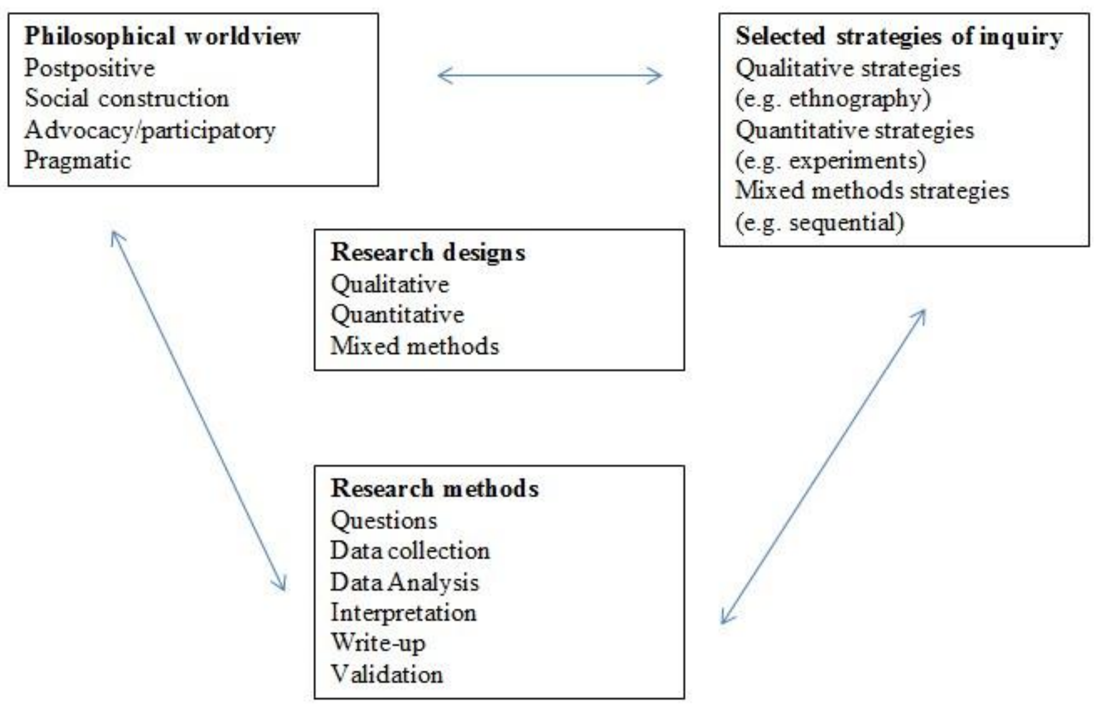


Figure 4.2 Framework for design (Creswell, 2009, Figure 1.1)

Ontology and epistemological of research

Ontology is concerned about the nature of social sciences (Bryman & Bell, 2007). The topic being researched was created and revised by the way the researcher understands the real world or ontology. The way to research the real world has to question if the findings discovered are of quality with validity and reliability (Bryman & Bell, 2007). The term worldwide view means a basic set of beliefs that guide action (Creswell, 2009). To assure the research findings will be valid and reliable, the research has to begin with a design with philosophical foundation that creates research process and data analysis. The framework for design indicates that there are three areas of design that need to be identified. The areas are worldviews, strategies of inquiry and research methods (Creswell, 2009). This research refers to this framework philosophical worldviews, research strategy and research design. There are a few main concepts that are used in addressing this framework. "What are the philosophical assumptions the researcher will bring to the study, what type of research strategy will be used in the overall research and the specific methods in conducting these strategies" (Creswell, 2008, pp. 3-4). Identifying elements of the research will aide in the research process and data analysis of this dissertation.

Creswell (2009) explains that there are four different worldwide views. They are postpositivism, constructivism, advocacy/participatory, and pragmatic (p. 6). "Positivism is an epistemological position that advocates the application of the methods of the natural sciences to the study of social reality and beyond" (Bryman & Bell, 2007, p. 16). Creswell (2009) states that "postpositivism assumptions hold true for quantitative research than qualitative research" (Creswell, 2009, p. 6). The term "postpositivism represent thinking after positivism, challenging the traditional notion of the absolute truth of knowledge" (Creswell, 2009, p. 7). The knowledge area or gaps under research are minimal at best. The term postpositivism that Creswell discusses does not seem to fit with this research since the variables are not all known at the beginning of the research. Because of this issue, it will be difficult to adopt a research method.

> *"The advocacy and participatory approach holds that research needs to be intertwined with politics and a political agenda. The research should contain an action agenda for reform that may change the lives of the participants, the institutions in which individuals work or live and the researcher's life"* (Creswell, 2009, p. 9).

The researcher will not change the lives of any people or organizations during the research and does not have any political agenda. The advocacy and participatory approach is not applicable to be used in this research. The pragmatism approach is another position about claims of knowledge. "Instead of focusing on methods, researchers emphasize the research problem and use all approaches available to understand the problem" (Creswell, 2009, p. 10). At the beginning of this dissertation, it was unclear if issues exist, and the researcher only had an idea that perhaps virtual project teams were more productive and/or successful than collocated project teams. The outcome of this dissertation may not find out what works even if the fourth research objective was set to find possible solutions. Based on this realization, pragmatism is not the best research approach for this dissertation.

Creswell (2009) indicates another knowledge approach called constructivism. “Constructivism hold assumptions that individuals seek understanding of the world in which they live and work” (Creswell, 2009, p. 8). Bryman and Bell (2007) define it as “constructionism is an ontological position (often also referred to as constructivism) that asserts that social phenomena and their meaning are continually being accomplished by social actors” (p. 23). Creswell (2009) defines constructivist researchers as “focus on the specific contexts in which people live and work” and recognize that the researcher’ “own background shapes their interpretation”. . . . “The researchers intent is to make sense of (or interpret) the meanings others have about the world” (p. 8). The research started with an idea around the experience of the researcher and on to a literature search and a pilot study of experienced professional practitioners. The concept of researching virtual project teams and collocated project teams in R&D medical device teams to understand how project management levers plays a role in the success or failure and productivity of the project. The first three research objectives can be accomplished by the researcher determining the meaning of the participants in the specific context. The final research objective is an attempt to identify and present possible solutions to improve productivity of the virtual project teams and collocated project teams in R&D medical device teams. In summary, constructivism was the choice for this research.

Qualitative

In research design there are two main design areas – qualitative and quantitative (Bryman & Bell, 2007; Creswell 2009) are discussed and detailed by the authors. "Qualitative research is the method process of research that involves questions and procedures collecting data in the participants setting. Quantitative research is a means for testing objective theories by examining the relationship among variables" (Creswell, 2009, pp. 232-233). Different research methods or strategies of inquiry classified either under qualitative or quantitative research designs can be mapped against positivism or constructivism epistemologies (Creswell, 2009). Under Creswell's (2009) framework for design, alternative strategies of inquiries are suggested with quantitative, qualitative and mixed methods.

Qualitative research is performed to help better understand the problem "Identifying the purposefully selected sites or individuals for the proposed study. The idea behind qualitative research is to purposefully select participants or sites that will best help the researcher understand the problem and the research questions" (Creswell, 2009, p. 178). This dissertation will perform qualitative research with research questions. All participants will remain anonymous, and each of their identities will be kept confidential. None of the participants are aware of any other participants in this research study from the researcher.

Creswell (2009) states that “qualitative research is a means for exploring and understanding the meaning individuals or groups ascribe to a social or human problem” (p. 232). Coding interviews and personal observations, developing nodes around these topics and writing memos and then showing the links are all parts of the case study (Charmaz, 2006).

> Yin (2003) *“states making the research choice among experiment, survey, archival analysis, history or case study by considering three conditions: (a) the type of research question posed; (b) the extent of control an investigator has over actual behavior events; and (c) the degree of focus on contemporary as opposed to historical events”* (p. 5).

The focus of this dissertation focuses on the project management levers used by virtual project teams and collocated project teams in the R&D medical device teams and its impact on productivity. These are variables (project management levers) and technology that are constantly changing at an ever increasing pace. The actual events and behavior of the participants will not be able to be manipulated. The research objectives review ‘what’ type of questions to explore or contrast the virtual project teams and the collocated project teams. The focus is on the how and why form of research questions such as why virtual and collocated project teams in R&D medical device teams are related to product success or failure; why productivity issues, positive or negative, effect both virtual project teams and collocated project teams in

R&D medical device teams; and how the impact of project management levers in virtual project teams and collocated project teams in R&D medical device can effect productivity. Figure 4.3 outlines the basic qualitative study approach and logic of this approach (Creswell, 2009). The researcher has chosen case studies as the strategy of inquiry under the qualitative research design paradigm (Creswell, 2009, p. 12). The case study in this dissertation is an R&D medical device organization that employs both virtual and collocated project teams.

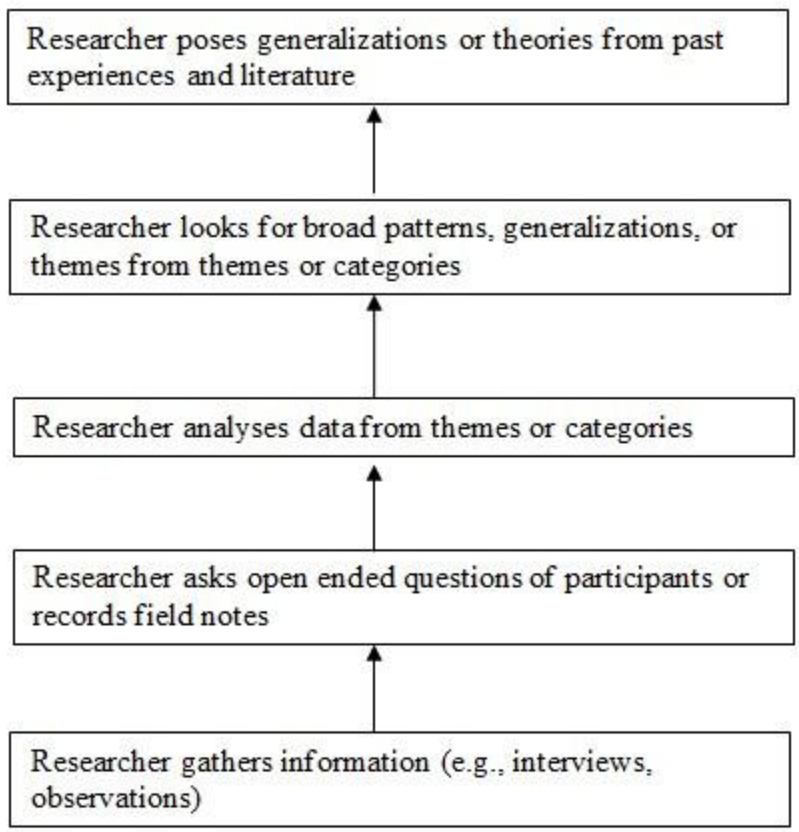


Figure 4.3 Qualitative study approach (Creswell, 2009, p. 63)

Pilot case study

To provide more information for this research the researcher looked to experienced practitioners within the dissertation context through pilot cases. “Pilot case studies may be conducted for several reasons unrelated to the criteria for selecting the final cases in the case study design” (Yin, 2009, p. 92). The pilot study helps refine data with the procedure. There are very few research projects that addressed R&D project teams with regards to virtual project teams and collocated project teams. With limited research references being available, the researcher decided to use research design that supports an exploratory approach (Yin, 2003). “Some of the best and most famous case studies have been both explanatory case studies” (Yin, 2009, p. 3).

All of the pilot cases and the subsequent case study interviews are done with projects that have had new products into commercialization within the last six months. Each interview lasted from 40 minutes to 50 minutes in length. Four of the interviews were completed face-to-face, and two of them were conducted by phone given the geographical distance.

A total of five open-ended questions were designed. The questions were designed to ask “respondents about the facts of matter as well as their opinions about events” (Yin, 2003, p. 90). The questions also “ask the respondent to propose his or her own insights into certain occurrences and may use such propositions as the basis for further inquiry” (Yin, 2003, p. 90). The research questions were respondent oriented depending on their role and experience in the organization. Each question is targeted around the research objectives of this dissertation. After each of the pilot case studies were transcribed, they were sent to each individual participant to have them validated.

Table 4.1 Pilot and case study interview questions supporting research objectives matrix

Research objective	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
To explore the major areas of project management, for example, information communication technology, leadership, meetings, team maturity and continuous improvement process on virtual and collocated project teams in R&D medical device teams.	X	X			
To identify and explain any productivity issues positive or negative in both virtual and collocated project teams in R&D medical device teams.			X	X	
To investigate and explain the impacts of project management, for example, information communication technology, leadership, meetings, team maturity and continuous improvement process in virtual and collocated project teams in R&D medical device teams.		X			
To identify and present possible solutions to improve performance or productivity of the virtual and collocated project teams in R&D medical device teams.	X			X	X

Case study

Case study research includes both single and multiple case study designs (Yin, 2003).

> Yin (2003) states *that "although all designs can lead to successful case studies, when you have the choice (and resources), multiple case designs may be preferred over single case designs . . . your chances of doing an effective case study will be better than using a single case design" (p. 53) and the "evidence from multiple cases is often considered more compelling . . .and more robust" (p. 46).*

This research investigates the phenomena of an R&D medical device organization employing both virtual project teams and collocated project team members that work in the medical device industry and how they impact productivity. The researcher is interested in comparing and contrasting two different types of project teams (virtual and collocated) in one organization all within the R&D area of the medical device organization.

Baxter and Jack (2008) "define six different types of case studies. 'Exploratory' "is used to explore situations in which intervention is being evaluated" (p. 548). 'Descriptive' "is used to describe an intervention or phenomenon and the real life context in which it occurred" (p. 548). 'Multiple-case studies' "enables the researcher to explore difference between cases" (p. 548). 'Intrinsic case study' "is undertaken when one wants better understanding of this particular case" (p. 548). In an 'instrumental case study', "a particular case is examined to provide insight into an issue or refinement of theory. It provides insight into an issue or helps to refine theory" (p. 548). 'Collective case studies' "are similar in nature and description to multiple case studies" (p. 548). The research will be conducted using the 'collective case study' type defined by Baxter and Jack (2008). Four cases studies will be studied in this dissertation. All four cases will be from one company, and one R&D organization in the medical device industry. When multiple cases are studied using similar methods, they are compared and contrasted with each other

Research method

Another major element that goes into research is "the specific research methods that involve forms of data collection, analysis and interpretation that researchers propose for their studies" (Creswell, 2009, p. 15). Literature reviews and conceptual development around the core themes of this research, virtual project teams, collocated project teams, and productivity, have been identified. The inability to link these themes together is the gap prior to starting this dissertation. There is less information on productivity and R&D medical device teams. Based on the lack of information in these areas and a theoretical basis or reference studies for this research with valid information, it was considered to gather data in the case studies through interviews using open-ended questions. Collecting data may involve observing the behavior of individuals without predetermined questions without the use of specific questions (Creswell, 2009). The studies used this approach to collect data from experienced practitioners. The data collected were analyzed were analyzed and coded into an early list of concepts and categories (Creswell, 2009). This will be used to support the organization of the first version of research questions of phase III, case studies. Collection of data used the information from scholars (Bryman & Bell, 2007; Creswell, 2009; Yin, 2003) to collect data from multiple sources. Yin (2003) lists "strengths and weaknesses of six sources of evidence to collect data documentation, archival records, interviews, directs observations, participant observations and physical artifacts" (p. 86). The researcher has taken three of these six areas of evidence: interviews, documentation and reflective journal during the case studies. Interviews are an important opportunity for the researcher to guide the conversation so as not to be a structured conversation (Yin, 2003). Interviews can collect targeted data, "focus directly on the case study topic and provide insightful information" (Yin, 2003, p. 86). This dissertation will use "face-to-face, one on one in person interviews" (Creswell, 2009, p. 179). Open-ended questions were used to collect data from case study participants. Case study participants of this dissertation were individuals who work in the case study organization and are on either a virtual project team or a collocated project team all in the R&D medical device area of the organization under study. These case study participants are the experts in the context of this research. Semi-structured questions are asked about the participant's background. Reflective journal and documentation are two other sources of data in this dissertation. These are taken as the triangulation sources (Bryman & Bell, 2007; Creswell, 2009; Yin, 2003) to support data collected from the interviews. The triangulation process is described later in this section.

Based on Creswell's (2009) framework for design, this dissertation will use a constructivist assumption to claim knowledge validity. The strategy for research is the case study with multiple cases, comparative design and a qualitative approach. Research methods will utilize open-ended interviews with semi-structured interviews and triangulations using a reflective journal and documentation.

Research Process

The researcher "involves emerging questions and procedures; collecting data in the participants setting; analyzing the data inductively, building from particular to general themes; and making interpretations of the meaning of data" (Creswell, 2009, p. 232). The research design will be divided into five phases. Phase I – literature review, Phase II – pilot case study, Phase III – case studies, Phase IV – comparative analysis and Phase V – validation.

<u>Phase I –literature review</u>

The literature review will help identify which data the researcher will need to use to inform the initial research design and provide theoretical foundations to support the research analysis. The researcher's topic "Virtual and Collocated Project Teams Impact on Productivity in Medical Device Research and Development" has three core themes, virtual project teams, collocated project teams (for comparison), and productivity in an R&D medical device organization. Chapters 2 and 3 review the literature and conceptual development for this dissertation.

Phase II –pilot case study

The pilot case study is phase II of this dissertation. This phase will review the rationale that there has been a lack of proven reference studies that cover all themes of the research. While there are more than 215 literature references in this dissertation, not one of them covers all of the three core themes of this research. The literature was surveyed until early 2013 and could not locate all of the elements in this dissertation from a single source. Literature in the area of virtual project teams is abundant and can be found without issue. When adding productivity the number decreases significantly and when adding R&D, it drops further. Based on these findings, the need to perform a case study has merit (Yin, 2003). More data will need to be collected in the research context, informing the researcher about the themes of the research, validating the planned research processes that can be performed in real life, and formulating the interview questions of Phase III, the case studies.

One organization has been selected in this phase, and within this organization one virtual project team and one collocated project team were selected. The organization is a medical device company with global R&D operations. The first pilot study will focus on a virtual project team and members of that project team, specifically the core team leader, project manager and a team member. The second pilot study will be a collocated project team with the same type of people as that on the virtual pilot study. There were no pre-defined questions. Participants were asked for their views on the topic of this research – “Virtual and Collocated Project Teams Impact on Productivity in Medical Device Research and Development”, and the three core themes: virtual project teams, collocated project teams (for comparison), and productivity.

This phase used open-ended questions to allow the information with limited knowledge before the pilot case study to come from the participants (Creswell, 2009; Yin, 2003). A large amount of data, theories and models around the core themes of the research were gathered from phase I. This pilot study formulated the interview questions for the case study. Chapter 5 presents the results from the pilot case studies.

<u>Phase III –case studies</u>

Multiple case study research will be performed in this dissertation. This phase provides the details of case study processes, data collection and data analysis. As case study is an exploration of a ‘bounded system’ (Yin, 2003), and in this research it is the exploration of one case study organization and two different types of teams. Data collection will include triangulation document collection about the case study project teams and interviews of research participants. The participants are people that have worked in the case study organization and are on a virtual project team or collocated project team in an R&D medical device organization.

This is a multiple case study as defined by Yin (2003), and Baxter and Jack (2008) define the case study as a collective case study. There will be a total of four case studies in one R&D medical device organization with two virtual project team case studies and two collocated project team case studies. All case study project teams meet the definitions in Chapter 2 and Chapter 3 of this dissertation. All case studies are different and will be used for comparative analysis, which will be discussed in Phase IV. The first case study is a virtual project team of more than 100 team members and is a class III medical device (life sustaining medical device) and is a device (which can be a stent, pacemaker, defibrillator etc.). The second case study is also a virtual project team of less than 50 team members, and is a class III device, and is hardware. The third case study is a collocated project team of less than 50 members, is a class III device, and is a therapy. The fourth case study is also a collocated project team of less than 50 members, is a class III device, and is software. The researcher worked with the organization's Project Management Office (PMO) to determine the most appropriate project teams for the case study. The researcher did not want to bias the study by choosing project teams for the case study, thus he asked the PMO Director to identify the project teams that would be most appropriate to research. In addition, all project teams will have had their product or service launched within the last six months. The case study participants will be given time to provide feedback to the researcher when the reports are completed. Phase V will discuss the validation in more detail.

The case study team structure is in which there is a group of individuals with different skill sets. They can be from manufacturing, clinical, regulatory and R&D. The core team would be a large circle. Extended project teams are created below this level to work with the various functional levels. The organization under study uses this type of a project structure. We will focus on the core team structure as the project but smaller projects can be under the core team.

Case study details can be found in Chapter 6, 7, 8 and 9 of this dissertation. Each case study contains an invitation letter with an initial interview protocol (see Appendix B) to each participant. The organization's legal department reviewed the case study questions, consent and associated letter to make sure they met its expectations. Participant's names, phone number and email addresses are readily available to the researcher. The approved University of Maryland ethics processes were followed throughout this research. Before starting any interviews the researcher worked with the University of Maryland Industrial Review Board (IRB) committee to get the proper approvals. The IRB approves the reviews research involving human subjects. The researcher also followed the Collaboration Institutional Training Initiative (CITI) and received training (see Appendix B) prior to the IRB approval of the research. Before the interviews potential participants were contacted face-to-face, by phone or email to explain the research and how they could participate. The participants that accepted were sent invitations, an interview protocol and the consent form prior to conducting interviews. Participants signed off the consent form before the beginning of the interview process. All participants were either on a virtual or collocated project team that commercialized their product during or within the last six months from the interview date.

The researcher used experienced individuals to make sure that representative virtual project and collocated projects were utilized for this research. Each case study of project teams had three participants. The researcher conducted the interviews in random order. This research is using exploratory nature research design. If the same conditions exist, what happens once can happen again (Epstein, 2001). This research used two versions of questions (see Appendix B). Interview protocol version 2.0 was the base version in case studies one through four. Version 2.0 had some minor variation from the previous version (1.0) used in the pilot case study. The purpose is to have interviews to validate concepts and themes collected.

The interview protocols were designed to ask five different questions. All participants answered the background set of questions. These questions asked about the interviewees working history in the organization and in the industry, his or her education level, formal project management training and number of team members on the project team. The next set of questions for each participant was the actual research questions. The initial list of questions was the outcome of Phase I and Phase II, the literature review, and the pilot study, respectively. All participants answered the research questions.

The research questions were open-ended, and the interviews were conducted in a face-to-face basis in an enclosed and secure room. After the interviews, summaries were sent back to the participant for validation. During the same time, the interview data were analyzed to look for themes and gaps. This is a way to triangulate (Yin, 2003; Bryman, 2007) the data collected. The research planned to have a total of 12 participants interviewed and achieved this goal. At the end of each interview, participants were asked to voluntarily provide documentation or archival records that could be shared with the researcher as part of the triangulation data. The detailed analysis was performed, and the four case study reports were completed. Each interview lasted from 40 minutes to 50 minutes in length. In order to capture all of the virtual team members the researcher waited for a few of the virtual team members to be on travel to the site location of the researcher and the headquarters for the organization under study. Four case studies were analyzed by using common frameworks or models, and the reports (Chapter 6, 7, 8, and 9) were organized in the same structure. This phase compares and contrasts themes across case studies to identify similarities and differences.

<u>Phase IV – comparative analysis</u>

Comparative analysis or Phase IV began once the Phase III case studies were finished, and the individual case studies were finished. Comparison findings of the two virtual project team’s case studies and two collocated project teams were performed. Chapter 10 provides the comparative research information for this dissertation.

Yin (2003) states, that a multiple case design is more compelling and robust than a single case study. “If you are doing multiple case study research, you are likely to find that you will need come structure in order to ensure cross case compatibility” (Bryman, 2007, p. 480). This will help the researcher look for missing themes in this research case study.

Phase V– validation

Validation or Phase V is the last phase of the research. The purpose is to validate the findings and their implications for the research questions. All research participants in the pilot and case studies validated the written version of the recorded interviews. The researcher presented the corresponding case study report to at least one representative participant in each case study to provide feedback so as to validate what the researcher understood and concluded. As stated before, the initial case study findings were sent to the corresponding case study participants for voluntary feedback. This is the validation part of the feedback loop. This phase is an important step to ensure reliability and validity of this qualitative research (Bryman, 2007). Reliability is “the degree to which a measure of a concept is stable” (Bryman, 2007, p. 731). Validity is “a concern with the integrity of the conclusions that are generated from a piece of research” (Bryman, 2007, p. 733). Basically, this is the part of the research to assure the quality of the research. After this phase is completed, the case study reports and the comparative analysis outcomes are completed; the research findings were analyzed against the research objectives to develop the conclusions of this dissertation.

Data Analysis

Individual case data analysis

After the interview summaries were prepared, they were validated by the individual participants, and the interview data was codified and analyzed using software (NVivo 10). The list of concepts and sub-concepts were derived from interviews using the coding technique (Creswell, 2009). After analysis of the pilot study interviews, if needed, the next set of interview questions for the case study interviews were updated to support information identified and to collect additional data.

Data collection involved a set of open-ended questions for the study and collecting information through unstructured interviews (Creswell, 2009). Effective interviews will use reliable methods to record the information that one collects (Turabian, 2007). This is a useful collection of data when the researcher cannot directly observe participants. The historical perspective can be provided and allows the researcher control over the questions (Creswell, 2009). Figure 4.4 provides an overview of the data analysis process.

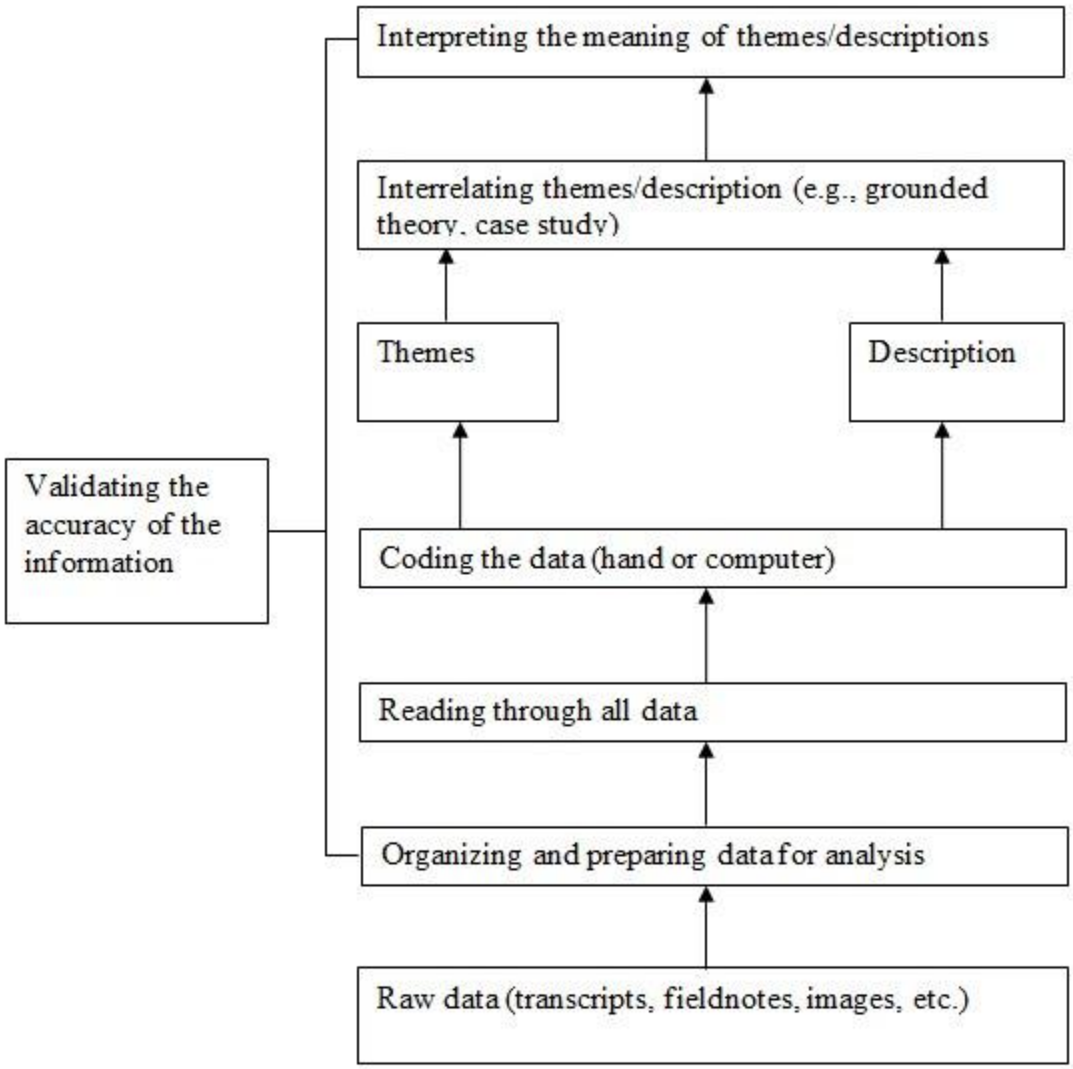


Figure 4.4 Data analysis in qualitative research (Creswell, 2009, p. 185)

Case study research involves data from interviews supporting the concepts. Once the information is collected, it can be developed for coding and how it relates to other concepts. When one interview is completed, new questions may be derived from the information to support new concepts identified and to collect more information. This is repeated until only a few new concepts were generated in each case study. Once the data analysis is completed, data collected from triangulation documents about the particular case study were also analyzed as supplements to the interview information. This information was drafted into a draft version of Chapter 6, 7, 8, and 9 in this dissertation. The case study reports for each case study were documented in the same format and structure. Section 1 introduces the case study participants. Section 2 describes virtual or collocated project teams. Section 3 describes the impact of productivity within the case study organization, R&D medical device. Section 4 describes the team learning and project success. Section 5 details the improvement of productivity with the team and individual. Finally, Section 6 is the conclusion and summary. Findings, where possible, are compared against theoretical frameworks, and ways are suggested to improve virtual project team and collocated project teams productivity in the case study organization context. After comparative analysis and validation, each case study report was further refined with the additional feedback from participants and triangulation documents.

Cross-case comparative analysis

The case-oriented approach using the cross-case synthesis technique is applied in Phase IV comparative analysis (Yin, 2003). Analysis can start looking at patterns or trends if different cases share any similarities, which can lead to further analysis and "raising the possibility of typology of individual cases" (Yin, 2003, p. 135), which may be insightful. In this research, the four cases had a similar context – employer of R&D medical device teams that are in either a virtual project team or collocated project team. Case studies may generate similar or different concepts and themes when executing the case study data analysis in Phase III – case studies. Case study concepts and themes were formatted into nodes and coded to form some uniform framework as suggested by Yin (2003, p. 134). Patterns in the coding table lead to a certain conclusion. Additional coding tables reflecting processes and outcomes of interest were examined in the same way. “The analysis of the collection of tables enables the study to draw cross-case conclusions” Yin (2003, p. 135). Yin (2003) describes this as the ‘cross-case synthesis’ technique. During this stage, triangulation data are collected from the case study teams, and sources are also referenced to support conclusions.

Triangulation

Various scholars recommend triangulation (Bryman & Bell, 2007; Yin, 2003) to make sure that data gathered are valid, reasonably accurate, and sufficient for the purpose intended. Bryman and Bell (2007) define triangulation as it “entails using more than one method or source of data in the study of social phenomena. The triangulation metaphor . . . refers to the process whereby multiple reference points are used to locate an objects exact position” (p. 412). “When you have really triangulated the data, the events or facts of the case study have been supported by more than a single source of evidence” (Yin, 2009, p. 116). The researcher used triangulation data to prepare the interview questions to validate findings from the previous interviews. Triangulation documents were collected prior to conducting interviews of each case study. There is one main category of triangulation documents. These are case-specific documents. They include project tools used, meeting minutes, procedures, reports, and other information provided by the case study participants. All case study project teams have a secure internal intranet portal that they use for team communication, documents, and archives. The researcher used a reflective journal during the interviews to collect his own data to be used in the triangulation process. Keeping a reflective journal is a strategy to examine the researcher's personal assumptions and is a common practice in qualitative research (Ortlipp, 2008).

Data validation

Phase IV – comparative analysis was presented face-to-face or by phone to one participant from each case study to validate its content. Comments were used as appropriate to revise Chapters 6, 7, 8, and 9 of the dissertation. Each participant after the interviews was given a verbal statement if he or she wanted the initial findings through email.

Research Reliability

"The issues of reliability and measure validity are primarily matters relating to the quality of measure that are employed to tap the concepts in which the researcher is interested, rather than matters to do with a research design" (Bryman & Bell, 2007, p. 58).

The terms reliability and validity are commonly referred to when discussing reliability of research.

"Reliability is concerned with the question of whether the results of a study are repeatable. The term is commonly used in relation to the question of whether or not the measures that are devised for concepts in business and management (such as team work, employee motivation, organizational effectiveness) are consistent" (Bryman & Bell, 2007, p.40).

Yin (2003) points out data can be repeated with the same results. There has been discussion among researchers, and a number of viewpoints have been taken by qualitative researchers (Bryman & Bell, 2007). Four tests have been commonly used to establish the quality for social research (Yin, 2009).

"External reliability by which the degree to which a study can be replicated. Internal reliability by which they mean whether or not, when there is more than one observer, members of the research team agree about what they see and hear. Internal validity by which they mean whether or not there is an

> *effective match between researcher's observations and the theoretical ideas they develop. External validity, which refers to the degree to which findings can be generalized across social settings"* (Bryman & Bell, 2007, p. 410).

An effective guideline for researchers performing case studies is to conduct research so an auditor could repeat the case study (Yin, 2003).

> Yin (2003) "*see 'internal validity' as pattern matching, explanation building, addressing rival explanations and using logic models; 'external validity' will use theory in single case studies and use replication logic in multiple case studies; 'construct validity' will use multiple sources, establish chain of evidence, and have key informants review a draft case study report; 'reliability' will use case study protocol and develop a case study database"* (p. 34).

Creswell (2009) refers to validity as the accuracy of findings and reliability as a way to determine whether the researcher's approach is consistent across interview participants. Creswell (2009) sees that techniques are required to operationalize these quality perspectives and identify and discuss one or more strategies. Creswell points out eight verification strategies: 'triangulation, 'use member checking', 'use rich, thick description, 'clarify the bias', 'present negative or discrepant information', 'spend prolonged time', 'use peer debriefing', and 'use external auditor'. These strategies will be utilized where applicable in this dissertation.

The reliability of research in this dissertation was built in the design and executed through the research process. Table 4.2 lists the actions taken in this research according to Creswell's (2009) eight verification procedures and how they delivered 'internal validity', 'external validity' and 'reliability'.

Table 4.2 Actions contributing to reliability of research

Verification procedure	**Action in dissertation**	**Internal validity**	**External validity**	**Reliability**
Triangulate	Multiple data sources used multiple cases and multiple interview participants.	X	X	X
Use member checking	Participants validate interview summary and case study outcomes. At least one participant provided face-to-face feedback or phone conversation on case study outcomes.	X		X
Use rich, thick description	Research process, protocols and data analysis described. Described case study reports of participants.	X	X	X
Clarify the bias	Explained researcher's background, research rationale, used open-ended questions and multiple cases to avoid bias.	X		X
Present negative or discrepant information	Multiple cases used from different backgrounds and projects; four case studies used overall.	X	X	X
Spend	Collected data from	X		X

prolonged time	participants, pilot case then case studies, reviewed literature before and during case study duration.			
Use peer debriefing	One participant reviewed the case study report and provided face-to-face or phone feedback on case study outcomes.	X	X	X
Use external auditor	Committee member of this research provided guidance and a periodic assessment on research process, progress and contents of this dissertation.	X	X	X

Ethical Considerations

All four case study project teams are from a global R&D Medical Device organization. "Researchers need to protect their research participants; develop a trust with them; promote the integrity of research; guard against misconduct and impropriety that might reflect on their organizations or institutions; and cope with new, challenging problems" (Creswell, 2009, p. 87). Minimal to no risk to participants should occur as a result as an output of this research. There were a total of 12 participants interviewed from an overall population of over 1,100 individuals. All research responses were kept confidential at all times. Participant's names were anonymous on all information informal and formal for this dissertation. Identification of participants is only identified with pseudonyms. The name of the case study organization is not disclosed. Interviews are documented in a summary format and do not identify participants. Audio files are coded with non-related legends and are password protected. Participants read and signed a consent form prior to the interview. The protocol and consent form were accessible prior to the interview by the participants. All interviews were voluntary, and the interviewee had the option at any time to not answer a question or stop the interview all together. The written summary of the interview was presented to the interviewee for comments on the accuracy of the interview session.

Chapter Summary

This chapter outlines the research and design selection and the data analysis approach for this dissertation. It also presents the background and justification for this research design. This dissertation topic has limited literature reference research and thus will use the constructivist assumption. The research strategy for this dissertation is the case study; the research method is a qualitative approach with open interviewing, and semi-structured interviews and triangulation techniques. The research processes include five phases: Phase I – literature review, Phase II – pilot case study, Phase III – case studies, Phase IV – comparative analysis and Phase V – validation. The data analysis approach included case study analysis, cross-case comparative analysis, cross referencing to triangulation documents and data validation by participants. Research reliability and ethical considerations are a part of this research and dissertation. The next chapter, Chapter 5 will present the pilot case study.

Chapter 5: Pilot Case Study Analysis

Introduction

Chapter 5 discusses Phase 2: the interview questions for the six total participants in two different project teams: three participants in one virtual project team and three participants in one collocated project team.

Phase 2 – The pilot case study analysis is conducted due to a lack of proven reference studies that tie all of the themes together (virtual project teams, collocated project teams and productivity, all in an R&D medical device organization setting) in this research. Pilot case studies were conducted to finalize the research design for the case studies in this dissertation (Chapters 6-9). The pilot case study helps the researcher in design of the research questions. The pilot case study collected data to validate if the research method for the planned case studies can be used during the interviews and to refine the research questions for the future interviews in Phase 3 – case studies. This chapter will present the information from the pilot studies the six open-ended interviews conducted.

The Two Pilot Case Study Teams

CTL is the core team leader of the overall project. PM is the project manager for the R&D project which feeds into the core team. TM is team member and can be from the core team or the R&D project team.

Table 5.1 Pilot case study introduction

Type of study	**Project team**	**Participant**	**Code**
Pilot case study	Virtual project team Therapy	CTL PM TM	A B C
	Collocated project team Therapy	CTL PM TM	D E F

The first pilot case study virtual project team (referred to as PV1 in this dissertation) in the R&D medical device organization is a Class II medical device product, which is a therapy device. The overall project team size is under 20 people. About half of the team is in the USA, and the other half is in Europe. All members of the project team are full-time employees. In the first pilot case study, the project team had a core team leader, project manager or leader and the rest of the project team members are cross-functional and represent what the project team needs to commercialize the product or service. The second pilot case study involved a collocated project team (referred to as PC1 in this dissertation) in the R&D medical device organization, which is a Class III medical device product and is a therapy device. Class II devices are typically non-life supporting devices, and Class III devices are typically life supporting devices. The overall project team size is under 50 people. The project team is in the USA, and some of the manufacturing is located in different region within the USA with functional leadership centralized in one location. All members of the project team are full-time employees. In practice, the project team will have a core team leader, project manager or leader, and the rest of the project team will be cross-functional and represent what the team needs to commercialize the product or service.

The researcher selected the core team leader as this is the typical overall leader of a project or program in this organization and is responsible for ensuring that milestones and deliverables are achieved. The next title is the project management domain or project manager as this is a typical role on the project teams in this organization and represents the standard project leadership position. The project manager is responsible for a smaller part of the project or program or has an extended project team. He or she will also have some level of responsibility for milestones and deliverables. The last and final role is one of a team member, and this was intended to be anyone else who had a role on the cross-functional virtual or collocated project team. This team member could be from manufacturing, clinical, regulatory, supply chain, test engineering, etc. The concept is to blend the leadership roles and the project team member roles in the interview process and get more of a cross section and less bias if this was just the participants in the leadership role.

Team Interviews Overview

<u>Virtual project team 1, PV1, class II medical device, therapy</u>

Background for pilot virtual team 1, PV1

1. Project team and description, class II medical device, team under 20 people, three year project.
2. Project completed and in final status to commercialization
3. Medical therapy
4. R&D medical device
5. Virtual project team continuum, 7 (Chapter 1, Table 1.2)

Participants are a core team leader, project manager and a team member. Each interview for the virtual pilot study lasted from 40 minutes to 50 minutes. The demographics for PV1 participants are described below in the demographic summary of pilot study participants PV1 (Table 5.2).

Table 5.2 Demographic summary of pilot case study participants PV1

Number of participants	Three
Current position on PV1 project team	One core team leader One project manager One team member
Years of service in current position	Three years to 10 years (average: 6.6 years)
Years of service in medical device industry	Four years to 19 years (average 12.3 years)

Highest education level	Two bachelor degrees One master's degree
Project management training	All internal company project management training

Collocated project team 1, PC1, class III medical device, therapy

Background for pilot collocated team 1, PC1

1. Project team and description, first generation class III device, team under 50 people, five year project.
2. Project completed and in final status to commercialization
3. Medical therapy
4. R&D medical device
5. Collocated project team continuum, 7 (Chapter 1, Table 1.2)

Participants are a core team leader, project manager and a team member. Each interview for the collocated pilot study lasted from 40 minutes to 50 minutes. The demographics for PC1 participants are below in Table 5.3.

Table 5.3 Demographic summary of pilot case study participants PC1

Number of participants	**Three**
Current position on PC1 project team	One core team leader One project manager One team member
Years of service in current position	Three years (average: 3 years)
Years of service in medical device industry	13 years to 25 years (average 18.6 years)

Highest education level	Two master's degrees One bachelor degree
Project management training	All internal company project management training

Participants A and D are core team leaders, participants B and E are project managers and Participants C and F are team members. Participants A, B, and C are from the PV1 virtual project team, and participants D, E, and F are from the PC1 collocated project team. All participants in the pilot study have been in the R&D medical device industry for many years and would be called experienced employees by most standards in the industry.

Virtual Project Team Interviews

Table 5.4 Pilot case study PV1

Type of study	**Project team**	**Participant**	**Code**
Pilot case study	Virtual project team Therapy	CTL PM TM	A B C
	Collocated project team Therapy	CTL PM TM	D E F

The following tables will numerically describe scores each of these project management levers and where they are on a continuum (from 0 equally weak to 10 equally strong). The project management levers are rated by the researcher from the information given in the interviews with the participants.

Table 5.5 PV1 project management levers summary

The researcher's qualitative interviews and the researcher's points of view form the information provided in the interviews.

Individual summary: identified by level Project management levers (0-10) 0 weak, 10 strong	**CTL Virtual project team 1**	**PM Virtual project team 1**	**TM Virtual project team 1**
Lever 1, Environment	6	6	6
Lever 2, Leadership	5	5	3
Lever 3, Team maturity	5	7	5
Lever 4, Meetings	3	5	5
Lever 5, CIP	3	5	3
Lever 6, ICT	7	8	5

The following information is in response to the dissertation topic and title, which the researcher asked as a part of the pilot study. This helped him with making sure that the title made sense to others and had enough substance and context to get the information across to the reader and potentially other future researchers. Each participant had a different view on what the title meant to each of them. Participant A reflected on how virtual project teams were much different 10 years ago and that it was much less productive then it is now. This participant said today's technology has improved how we are able to communicate and lead project teams. Participant B changed the title slightly to have the word “improving” in the body of the title. This participant also indicated that virtual project teams will only increase in popularity as organizations become more global in the future, and stated that this is a popular topic. Participant C thought that the title was worded in a way that was very systematic. This participant agreed with the current title but also described decisions, trust, knowledge and experience as other important factors to be considered.

> *“We didn’t have the official ways to share information or to project information, so it was terrifying, and I would say that it was far less productive then it is today”* Participant A.

> *“You’re going to have more and more virtual teams, because of so many different locations”* Participant B.

> *“However there does become stages where decisions need to be made and that’s where it becomes a case of experience and trust and you know, the knowledge as well”* Participant C.

Figure 5.1 is a visual word frequency virtual pilot case study table that takes all of the words from the combined PV1 virtual project team pilot case. The larger the word the more frequently it was used in the interview. Some of the most frequent words used for PV1 are team, project, think, virtual, and productivity.

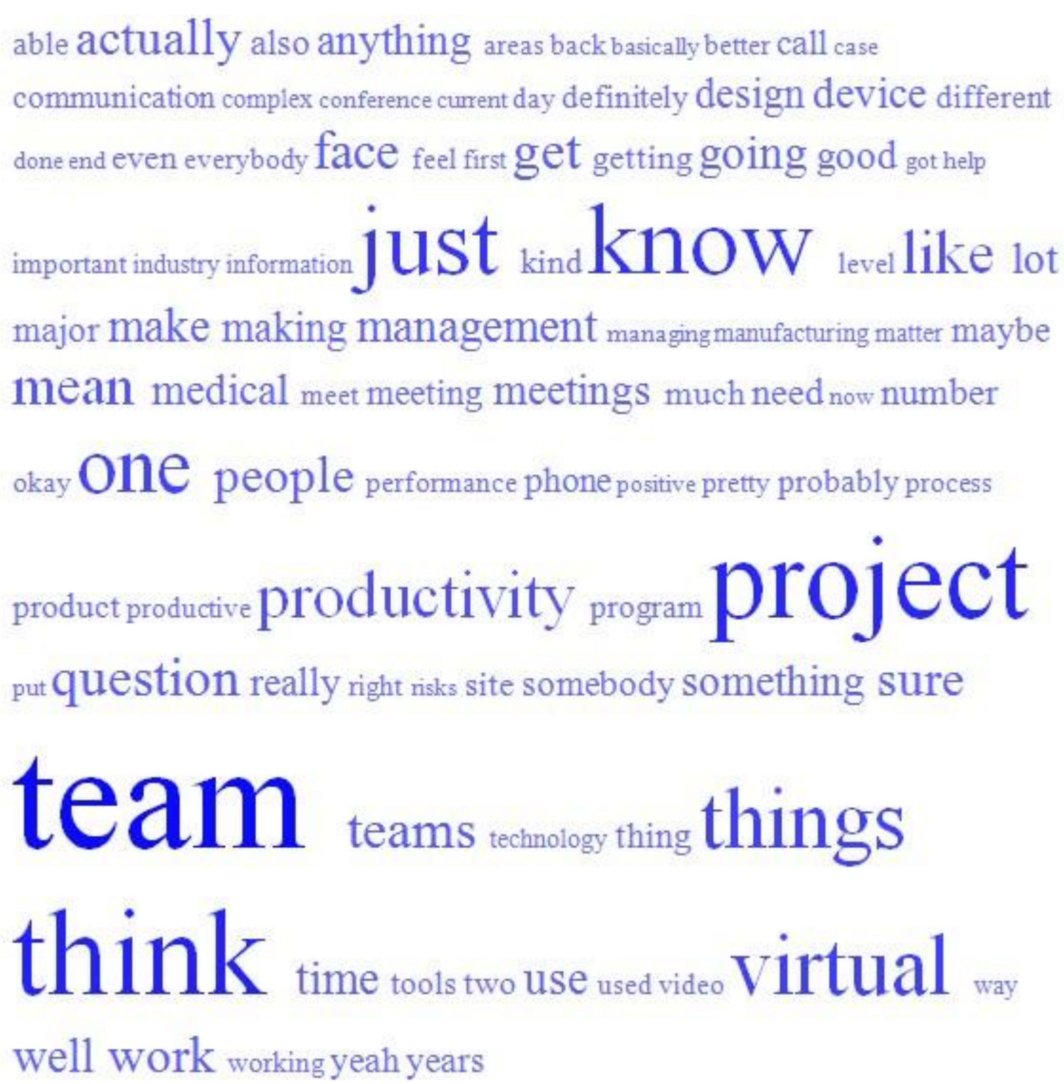


Figure 5.1 Word frequency virtual pilot case study

Collocated Project Team Interviews

Table 5.6 Pilot case study PC1

Type of study	**Project team**	**Participant**	**Code**
Pilot case study	Collocated project team	CTL PM	D E

		TM	F

The following tables will describe numerically by scoring each of these project management levers and where they are on a continuum (from 0 equally weak to 10 equally strong). The project management levers are rated by the researcher from the information given in the interviews with the participants.

Table 5.7 PC1 project management levers summary

The researcher's qualitative interviews and the researcher's points of view form the information provided in the interviews.

Individual summary: identified by level Project management levers (0-10) 0 weak, 10 strong	**CTL Collocated project team 1**	**PM Collocated project team 1**	**TM Collocated project team 1**
Lever 1, Environment	8	6	7
Lever 2, Leadership	8	5	5
Lever 3, Team maturity	3	4	3
Lever 4, Meetings	3	6	7
Lever 5, CIP	3	3	3
Lever 6, ICT	5	5	3

The following information is again in response to the dissertation topic and title, which the researcher asked as a part of the pilot study. This helped him with making sure that the title made sense to others and had enough substance and context to get the information across to the reader and potentially other future researchers. Each participant had a different view on what the title meant to each of them. Participant D talked about the word “virtual” and the fact that these are dotted-line relationships. This participant indicates that it should be positive and fun, and tools are also important and should be used to get information quickly to the project team. And lastly, the participant commented on the areas outside of the organization that the team could leverage to create innovation to move things along faster in the product cycle. Participant E was questioning what the focus of the dissertation is, virtual project teams, poor productivity or productivity of virtual project teams. This participant was not clear on the title and needed an explanation of what the title meant to the research. Participant F liked the title and understood how important virtual project teams are now and in the future. This participant thought it would be an effective idea to take the benefits of a collocated project team and apply them to a virtual project team. In addition the collocated project teams could use the ICT tools to help enhance their communication.

> *“When I think of virtual, I think of the dotted lined relationships. I think of communication channels, where it may not be able to be face-to-face”* Participant D.

> *“Is the focus on virtual teams? Is the focus on poor activity or the productivity of virtual teams”* Participant E.

"I like the title and actually I could see as we get to be a more and more global business, we're going to have more and more virtual teams, so I guess my thought would be like how do you take some of the benefits of a collocated team with the communications and the same work hours" Participant F.

All participants in the collocated pilot study have validated the transcripts that were translated from the recorded interview into summary document. The written transcribed version is a duplicate of the electronic version.

All participants in the collocated pilot study have validated the transcripts that were translated from the recorded interview into a transcribed printed summary document. The written transcribed version is a duplicate of the electronic version. The following sections will outline the three participants views from the virtual project team and collocated project team regarding areas of project management (per the interview questions and research objectives), positive or negative productivity issues, impacts of project management, and possible solutions to performance or productivity.

The participant's views and answers to the open-ended questions are analyzed regarding these areas described above. The following sections will outline what the three participants views from the virtual project teams and collocated project teams are regarding major areas of project management (per the interview questions and research objectives), positive or negative productivity issues, impacts of project management, and possible solutions to performance or productivity. The participant views and answers to the open-ended questions are analyzed regarding the areas described above.

Based on the input from the pilot study analysis and individual interviews the researcher updated the title from “Virtual Project Teams and Productivity in R&D Medical Device Teams” to the current title of this dissertation “Virtual and Collocated Project Teams Impact on Productivity in Medical Device Research and Development.” The current title is a better representation of the actual research within this dissertation and gives the reader a better idea of the contents within the dissertation.

Figure 5.2 is a visual word frequency collocated pilot case study table that takes all of the words from the combined PV1 virtual project team pilot cases. The larger the word the more frequently it was used in the interview. Some of the most frequent words used for PC1 are team, think, project, people, and things. Productivity, management, and location are also used. It is also interesting that the word virtual is in the collocated word frequency figure. This provides ideas of the themes in the interviews.

Figure 5.2 Word frequency collocated pilot case study

Project Management Levers

Pilot study information from the participants regarding the project management levers are summarized by each participant and shown collectively in Table 5.8.

Table 5.8 Summary of phase 2 – pilot information project management levers

Individual summary: identified by level Project management levers (0-10) 0 weak, 10 strong						
Participant	A	B	C	D	E	F
Project Management Levers	CTL PV1	PM PV1	TM PV1	CTL PC1	PM PC1	TM PC1
Lever 1, Environment	6	6	6	8	6	7
Lever 2, Leadership	5	5	3	8	5	3
Lever 3, Team maturity	5	7	5	3	4	3
Lever 4, Meetings	3	5	5	3	6	7
Lever 5, CIP	3	5	5	3	3	5
Lever 6, ICT	7	8	5	5	5	3

"One is like I said a core team meeting where the focus is strictly on making decisions and understanding if there are any specific challenges to the schedule and understanding if there are any major roadblocks to the team functioning in order to be successful" Participant B.

"Quite a lot of information would end up to be too big for email, so it was good to have a site builder location, and also we could keep a history of the project on there as well before it got formally approved" Participant C.

"So I obviously think leadership plays a huge role in both the setting of expectations, as well as overcoming hurdles" Participant D.

Environment

For environment, the views of both CTL's (Participants A and D) felt that their own virtual project team or collocated project team leadership was important to the success of the project team. CTL's like to have a flexible project team and one that communicates effectively. The virtual CTL indicates in one person's experience there are usually more hurdles in a virtual project team to overcome. Experience helps in both environments, but if one lacks the experience then mentors are useful to help the less experienced project team members. Both participants A and D agree that having at least some face-to-face interaction is positive for the project teams. Participant D thinks collocated teams are the most productive. The views of the project managers (Participants B and E) look at the environment of virtual and collocated teams as neither one which is a 100% virtual or collocated environment. A virtual project team would like to have a face-to-face discussion when possible. Virtual project teams in the case of participant B understand that working in more than one culture, time zone and work styles is typical. Participant D also think that by being collocated, project team members can use a dedicated project or war room to have meetings whenever project team members need to use it for a meeting room.

"One thing that comes to my mind right now is when you define virtual team in this case; my case at least, you're talking about teams in two different countries, two different cultures, two different work styles" Participant B.

The views of the project team members (Participants D and F) are that communication is important. All scoring in the summary table, Table 5.8 indicates that environment is scored higher than the middle and may play an important role. Participant F stated that when team members are all collocated they work as a project team and help each other. They also agree on the importance of face-to-face meetings in both environments when possible.

Leadership

Leadership with the CTL's (Participants A and D) are clearly a major topic. Leadership is discussed in terms of the project leadership and upper management leadership. Both participants A and D agree that effective leadership will communicate more consistently to the rest of the project team. Both CTL's agree that leadership should include broad knowledge and experience before one would be in a leadership role. Participant D takes it a step further and indicates that technical competence is an important factor along with leadership, to support the project team.

"So I obviously think leadership plays a huge role in both the setting of expectations, as well as overcoming hurdles" Participant D.

Senior leadership also needs to support the project team in their decisions and get back to the project team in a timely manner about schedule, cost and scope. From the project manager perspective, both project managers (Participants B and E) in the pilot study agreed that project leadership will remove roadblocks and get support from senior leadership. Participant E sees that having a leader in remote areas is important to getting things done correctly, on time, and with consistent communication.

The most surprising finding in the leadership area of this pilot study is that both team members (Participant C and F) had limited comments about leadership. In review of Table 5.8, there is a low score for each TM under leadership.

<u>Team maturity (knowledge and experience/expertise)</u>

In the pilot study case, team maturity was discussed in all of the interviews, but it was not a line item on the open-ended questions. Since the researcher did not get much response to this part of the question in the pilot study, it was included as a part of a question. For the actual case studies and the results in the case studies (see Chapters 6-9). The case studies include more insights and suggestions for improvements.

Only participant A commented and said broad knowledge and experience was necessary to keep the team productive. The rest of the participants discussed this area within other areas but not in this particular question/answer. This subject is an area of improvement from the pilot study to the case study in Chapters 6-9 of this dissertation.

Meetings

The participant's in PC1 had meetings often, and participant F indicated that this was part of the project team's success. The ability to be able to have meetings ad hoc in a project room or hallway was a big plus for the team. The project team was able to solve problems and issues more quickly and in less time. The PC1 project team also used daily stand-up meetings to review roadblocks and align with communication to the core team. Face-to-face meetings were a large part of their daily work stream. PC1 participant A indicated that meetings would happen often in his office and be informal but productive. Close proximity was an advantage in the opinion of participant A. Drawings, prints and other paper documents could be reviewed quickly and in real time. For example, having the ability to review the project schedule, action items, and meeting agendas quickly and in front of other team members was positive for PC1. The participant A on this project team stated having a project room was another way to communicate quickly and productively.

The participants in PV1 indicated that they used weekly virtual team meetings with the core team and also a weekly meeting with the extended project team. The extended project team is typically another level of a project that feeds into the higher level core team. Participant D indicates that the purpose of these meetings is to make decisions and make sure there is understanding about project related matters with the rest of the project team members. All PV1 project team members indicated that they use a tool that enables them to share anyone's desktop with other project team members during the virtual meeting. Participant E indicates that the use of 1:1 meetings by phone is a common way to communicate and hold smaller meetings. Participant F indicates that the use of a pre-meeting or a phone call before going online is sometimes an effective idea to get alignment and understanding before the larger group meets.

Continuous improvement process

The two case study teams were not focused on continuous improvement in their processes but were focused on working toward commercialization of their products.

> *"It doesn't matter if you're dealing with a super high technical electrical device or you're dealing with some simple catheter; that they're extremely complex*" Participant C.

Participant F indicates that verification and validation activities need to be avoided to not be performed over. The verification and validation activities can be rejected many times and have to be run over and over. This causes delays and extra cost to the project team. This can be a large loss of time and productivity. Participant C indicates this is an area that is called out in the product development process and could be improved with a more effective process. Participant B indicates that the house of quality tool adds clarity and engagement to the project. The house of quality tool is a tool that gathers customer feedback and represents it with a scoring summary. The house of quality tool provides a format to gather customer requirements and business requirements for example to score and identify the most important to least important. This helps the project team design to what the customer needs are, can save time and improve productivity.

Information communication technology

All participants indicated that they use ICT to some degree on their project teams. Phone calls, conference calls, shared sites, email, IM, video and shared desktops are the technologies employed by these teams. Participant B indicated that phone calls were preferred over email when possible, and online meetings were also used successfully where everyone could see what a person is talking about with their body language. Participant B also indicated that it can be frustrating when a team member only talk to someone on the phone but never meet them in person. Participant C indicates that people will not speak out on a larger online conference call, so this will end up in having a one-on-one call after the original call. Participants E, F, and A all use conference calls, phone calls, IM and shared desktop to communicate with the rest of the project team.

> *"Rather than send an email or a phone call or set up a meeting, you'd have, we called it like common collisions"* Participant E.

Participant E would rather have a hallway conversation many times over an email that can create a miscommunication or a long email thread noting sometimes emails can be read into if they are not carefully worded.

> *"Secondly I can get; I can basically IM them, I can express what I need to express to them and chat with them, but at the same time I can also share on my desktop and show them what I'm talking about and lately we've also started to use the conferencing and voice and the ability to talk through your computer"* Participant B.

Participants D and E indicated that having a shared site was positive as it could be shared at any time 24 hours a day. They also agreed that for all of the information and large files that having this shared site was useful to the project team. "*I think the thing that was probably more important than the tools were the people"* participant E. This participant believes that projects need the people first and the tools second.

Tools in the project management are in a variety of forms with software, systems and technology. Participant D questions some of the tools that its project team is using but also realizes that there are tools that help in communication and decrease the need for face-to-face conversations. Participant E explains that visual management boards have been a positive tool for their project team. Participant A indicates that a useful project management tool would be one that reflects significant milestones and keeps the details to a minimum.

Positive or Negative Productivity Issues

Participant D believes that not all the tools that are used help with productivity. *"I think that positive use of any of the tools is when the team understands it can use it and sees benefit out of it"* Participant D. Participant F had seen some issues if the project team missed key milestones. Participant F added the development process also needs to be improved as currently it is the largest gap in productivity. The complexity of a medical device can be a negative issue. Participant B thinks there can be chaos with too many people. "*Sometimes we tend to go overboard and have so many more people involved and it just can create some chaos"* Participant B. Participant C believes that sometimes relationships get strained noting with too many people it can cause confusion and team members may simply shut down. They shut down in the context that little work gets performed when the relationships are strained.

Participant A indicates that a program manager needs to really know how the milestones are progressing and must inform senior management with up-to-date status information. This participant also believes that there are more advantages with a virtual project team since work is being done nearly 24 hours a day. *"One thing that comes to my mind right now is when you define virtual team in this case; my case at least, you're talking about teams in two different countries, two different cultures, and two different work styles"* Participant B. Participant B thinks it is positive when project team member uses a tool and get tangible benefits from it. Participant C looks to projects that were done in the past for positive lessons learned for current and future projects.

Impacts of Project Management Levers

Table 5.8 outlines the scoring done by the researcher in regard to the project management levers in this dissertation. The project team environment is stronger for the collocated project team versus the virtual project team in this pilot study. Leadership is in the middle for the virtual project team but higher in the collocated project team. It is interesting to note that TM project team members scored low on virtual and collocated compared to CTL and PM. Team maturity from this pilot study indicates that it is a little more important on the virtual project team versus the collocated project team. Meetings are less important in the virtual project teams versus the collocated project teams. CIP is fairly low for both virtual project teams and collocated projects teams. The two project teams interviewed were more focused on commercializing the products versus process improvement at the time because an organizational CIP initiative had not started when these projects had started. It is important to note that this organization places a high value now on CIP with new projects as it is an important business and customer need. Information communication technology was higher on the virtual project team versus the collocated project team. Some of the pilot study findings align with the literature review regarding meetings and ICT.

Possible Solutions to Improve Performance or Productivity

Participant A believes that project managers should have been on development teams for a number of years. Project managers also learn to ask the right questions on past projects that help with the risks in the current project. Broad experience and knowledge will improve productivity as the project team will uncover risks earlier.

> *"I think the productivity piece in this is you're not managing a task; you're managing a major deliverable or milestone, so you get less into the weeds and getting derailed on the tasks that really don't matter and you're managing critical path*" Participant A.

Participant B believes tools such as IM or sharing a desktop are useful for improving productivity. Other team members work off of each other's strengths, which they can leverage and learn from each other. Participant C thinks his team is productive but does not see a difference in the virtual project team versus collocated project teams other than being able to work in different time zones. Time zones can work to one's advantage since it is possible for more activities to be completed in less time.

Participant D believes that productivity is enhanced with improved decision making on a collocated project team. Project team flexibility is another area that this participant believes promotes positive project team environment.

> *"I think it depends on how you define productivity. I don't think that the number of person hours per team, we might not have been the most productive team, because we worked our tails off. I could tell that our team was in the office for a larger number of hours"* Participant D.

Participant E used a project room, which was a productive and positive place to get work completed. According to this participant a detailed project plan is a must for any productive and successful project team. Being collocated with a common purpose and in close proximity creates ownership with the project team. *"So the number one area, the number one improvement I think by far was the fact we put together a detailed project plan"* Participant E. Participant F believes projects can have less meetings and more improved communication by being able to ask questions of team members. This type of communication can reduce mistakes and can increase the communication process. The project team can have more frequent informal communications and less formal communications.

> *"Team members would help each other out if they had a little bit of downtime, because tooling was being made or whatever the case may be so other members could jump in to help the team members that were in the middle of some of their activities and might need a little help"* Participant F.

Team Interviews Comparison

Table 5.8 lists the numeric scores, which were discussed under the impacts of project management levers. The word frequency query discussed earlier in the chapter, yielded some interesting results. Both PV1 and PC1 included project, groupthink and things in the top three most frequent words used. Productivity, virtual and location were also frequent words used in both pilot project teams. Some of the project management levers are used as frequent words in both PV1 and PC1.

The two pilots showed the need to update the interview questions for the case studies. The case studies in Chapters 6-9 will go into more detail and use the updated survey questions from the pilot study. Appendix B2 outlines the pilot case study questions.

Virtual and Collocated Project Teams Shared Characteristics

Both projects indicated that they think some face-to-face communication is positive for the project team. Technology is now improved so that most tools work well enough for most project team members. Both teams share the same belief that medical devices are complex in R&D. A common purpose or goal is needed to be successful and productive. Many of the participants agreed that meetings can be improved to be more productive for the project teams.

Team Interviews Productivity Comparison

Both the virtual project team and the collocated project team indicated that they were both productive in the yes and no interview survey question, and both project teams answered yes to this question. Both teams also had different ways to achieving what they believe to be productive project teams. The shared characteristics section points out some of these areas from the pilot study interviews.

Pilot Case Study Conclusions

Overall, the views from the pilot study analysis support many of the findings in the literature review and conceptual development, Chapters 2 and 3. The findings in this chapter at the project team and individual level indicate that there are challenges in the three themes. In the context of virtual project team, collocated project team and productivity, the interviews indicate project team environment (virtual or collocated) is one of the most important project management levers for the project teams. ICT would be the next lever that the project teams think is important to productivity. Technology has improved in the past years, and this makes it easier for both project team environments to embrace. Leadership and meetings is the next project management lever that rank with the participants. There is an opportunity to improve leadership and meetings with both project teams. Team maturity was not discussed as much as the researcher had anticipated in the pilot study, and research questions will be updated for the case study. CIP was not a focus of either project team, and it will remain to be seen if the project teams in the case study yield the same results.

One participant perceives that the project will need to be able to manage milestones not tasks in order to be productive. Another participant also stated that the project will need to manage the right milestones and not a number of project tasks. Again, all participants on each project team answered yes to whether their team was performing productively.

> *"I think if you're successful those major tasks or milestones or deliverables I should say, increases the productivity, because you're not managing 400 lines of tasks in a program, you're managing major steps or accomplishments to market release, in our case, for product development"* Participant A.

The summaries of key findings from this pilot case study are:

1. The virtual project team or collocated project team environment in an R&D medical device organization, participants agree that some face-to-face interaction is positive for the project team in either environment.
2. Leadership in virtual project teams or collocated project teams in an R&D medical device organization is about effective communication, experience and knowledge.
3. Team maturity did not yield enough information in this pilot study to determine outcomes. An improved questionnaire will need to include team maturity in the written questions for the case study.
4. Collocated project teams liked the idea of meeting at any time and the ability to use a project room that is dedicated to the project team. Virtual project

teams use phone calls and the shared desktop for meetings, which are increasing in popularity.

5. CIP was not a high priority in the two project teams in the pilot study. It is not clear why it is not performed in the R&D teams in this pilot study.
6. ICT is used in both virtual project teams and collocated project teams. The general feedback is that technology is popular on either type of project environment. The challenge is what technology to use and when to use it for the project team.
7. Productivity is positive in both the virtual project team and the collocated project team. Project teams believe that experience and knowledge can create a productive environment. Virtual project team participants think that tools such as IM and shared desktops can improve productivity. Also projects can move across time zones and can make a project team productive as they keep the project moving. Collocated project team participants think that flexibility, communication when needed and a project room are some the necessary ingredients to drive toward a productive project team.

Chapter Summary

The questions from the pilot study were updated for the case studies (Chapters 6-9) based on the feedback from the pilot study. The discussion on the title was not used in the case study as the researcher had enough information for the pilot study to get the necessary feedback. The title was however updated based on the feedback from the pilot participants. Appendix B2 contains protocol one the pilot study questions and protocol two the case study questions.

Question one was updated for the case study to contain the project management levers in a list for the participants to choose from and discuss. This was not in the pilot study, and the researcher added it based on feedback in the pilot study that the first question was too general in nature. Question two also added more detail on the tools that the researcher was interested in discussing. The pilot study question again was too general and needed more detail for the participants to understand. Question three was updated to include the impact of productivity and performance, which was not included in the pilot study. Question four was updated for the case study to include a yes or no to the end of the question. By answering the question yes or no it gave the researcher a clearer picture of to the thoughts of the participants and helped them make a decision on the productivity of their project. Question five remained unchanged from the pilot study. Overall the researcher added more detail around the case study questions which presented the participants with a better overall description of the information in this research.

The goal of Phase 2 – pilot case study has been to identify information and finding s that can refine the researcher's design and case study questions. The conclusions give the researcher inputs to the case studies of this dissertation to further explore the areas in relation to virtual project teams, collocated project teams and their impact on productivity in R&D medical device organizations. Chapters 6-9 will present the outcomes of the four case studies.

Chapter 6: Case Study One Analysis

Case Study Overview (Chapters 6-9)

For Chapters 6 through 9 the same format is used in each chapter. The case study report outlines the structure of each chapter by section. This is also indicated in the visual representation in Figure 6.1 and is consistent with Chapters 6-9. Each case study chapter will also have a table (see Table 6.1) to indicate the type of project team, virtual or collocated, and which of the participants are being discussed in the chapter and what the letter codes are for each chapter.

The case study report

The case study report for each of the four case studies in Chapters 6-9 has six sections, and the structure follows the six section case study report structure discussed in Chapter four of this dissertation.

Section 1 Describes the case study team and participants.

Section 2 Reviews

a: the project team levers in more detail

b: positive and negative feedback

c: R&D medical device feedback.

Section 3 Investigates the impact that section 2 has on productivity from a team and individual perspective.

Section 4 Is about project team learning and project success.

Section 5 Looks at how productivity could be improved from a project team, individual and R&D medical device perspective.

Section 6 Summarizes the findings and information from this case study.

Figure 6.1 lists the table of contents of this chapter for easy reference.

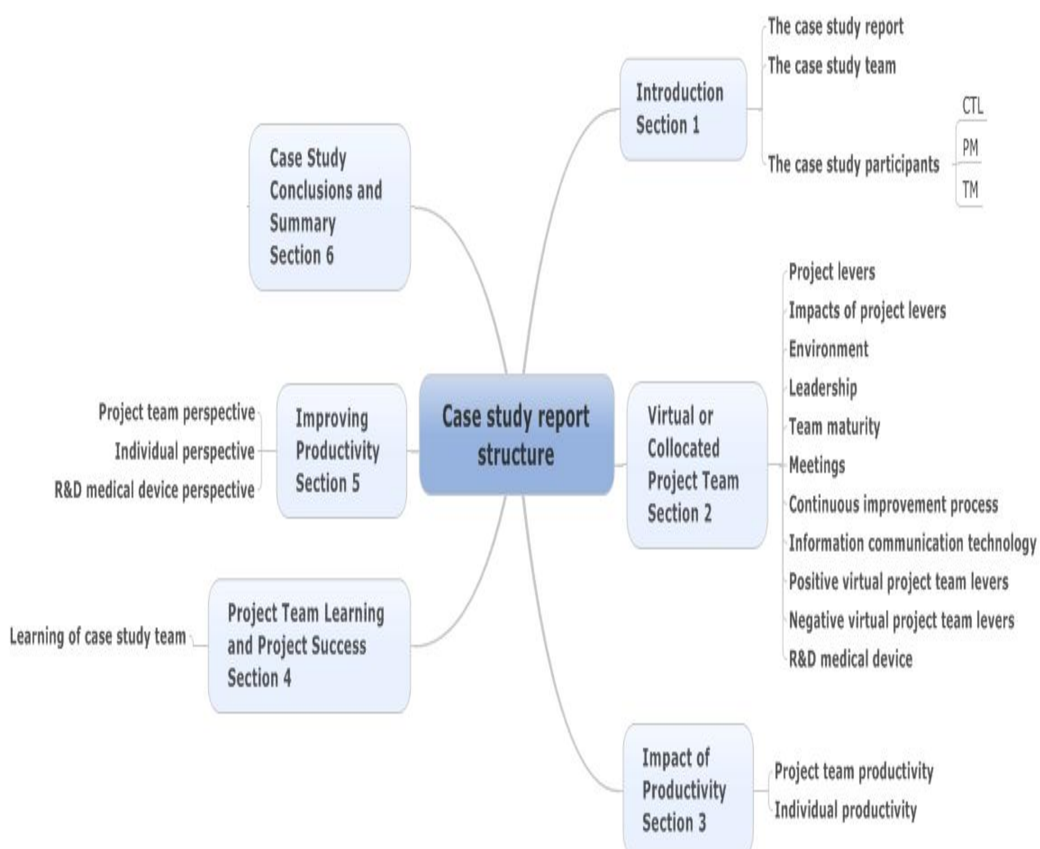


Figure 6.1 Case study one report structure

Table 6.1 Case study introduction

Type of study	**Project team**	**Participant**	**Code**
Virtual	Virtual project team 1 Device	CTL PM TM	G H I
	Virtual project team 2 Hardware	CTL PM TM	J K L
Collocated	Collocated project team 1 Therapy	CTL PM TM	M N O
	Collocated project team 2 Software	CTL PM TM	P Q R

Introduction

These case studies will attempt to further our understanding of the impact on productivity in the virtual project teams and collocated project teams in an R&D

medical device organization. The following will explain the process used to interview the participants and the outcome of the information.

The Table 6.1 outlines the overall framework for this chapter and case study one. Two teams were virtual project teams, and two teams were collocated project teams. Each team consists of three participants that are a core team leader, project manager and a team member. The purpose of this chapter is to present case study analysis of the first case study team. The case study project team consisted of a medical device, which is a class III device. The total project team size consists of over 100 people. The end product is being released or commercialized as the interviews were being conducted. Since the interviews in early 2013, this case study project has entered into commercializing phase of their product life cycle. In addition, a list of triangulation documents (see Appendix C1) was reviewed. The findings in this chapter are from project team CV1, and the three participants are known as G, H, and I.

The researcher developed this format to aid in analysis of development and to add insight about project productivity and the type of project teams.

<u>The case study team</u>

Deliverables for CV1 project team

1. Description: Virtual project team, first generation class III device, large team over 100 people, six year project.
2. Current status: Project near completion and in final status.

3. Type: Device.
4. Project type: R&D medical device.
5. Virtual continuum:8 (see Chapter 1 Table 1.2)

Table 6.2 Case study CV1

Type of study	**Project team**	**Participant**	**Code**
Virtual	Virtual project team 1 Device	CTL PM TM	G H I
	Virtual project team 2 Hardware	CTL PM TM	J K L
Collocated	Collocated project team 1 Therapy	CTL PM TM	M N O
	Collocated project team 2 Software	CTL PM TM	P Q R

<u>The case study participants</u>

Three participants were interviewed for this case study. All project team participants are members of this project. Participants in this study are identified as G, H, and I. The demographics of the three participants are summarized in Table 6.3.

CTL Participant G

Participant G has had key R&D roles as a functional leader, clinical leader, product development leader, and core team leader. This participant also has had internal organization project management training.

PM Participant H

Participant H has had key roles as a development director, team leader, engineering supervisor and individual contributor. This participant also has had internal organization project management training.

TM Participant I

Participant I has had key roles as team manager and project manager. This participant also has had internal organization project management training.

Table 6.3 Demographic summary of case study one participants

Number of participants	**Three**

Current position on CV1 project team	One core team leader One project manager One team member
Years of service in current position	Four years to seven years (average: 5 years)
Years of service in medical device industry	18 years to 28 years (average 22.7 years)
Highest education level	Three bachelor’s degrees
Project management training	All internal company project management training
Size of project team <20, <50, >50, >100	>100

Virtual Project Team One

All three participants had over 18 years of medical device industry working experience. The average medical device industry working experience was 22.7 years. These participants had spent most of their careers in the medical device field; the majority of that time was in the R&D organization. Two of the participants have held more than four different positions within the medical device industry. All three participants have moved at least one level up in the organization. All participants only have a bachelor degree and none of them have acquired a formal project management qualification/certification. All of them did have internal project management training from the organization. The participants are in a functional matrix organizations and do not report into the PMO.

Figure 6.2 is a visual word frequency virtual case study one table that takes all of the words from the combined CV1 virtual project team case study interviews. The larger the word the more frequently it was used in the interview. Some of the most frequent words used for CV1 are project, people, team and think. Productivity and success are also used, but virtual was not used. The project management levers that are indicated here included meeting, leadership, but some areas under ICT, Team maturity and CIP were not used.

Figure 6.1 Word frequency virtual case study one

Project management levers

The researcher uses the term 'project management levers' to refer to his ideas of variables that impact productivity in virtual project teams and collocated project teams. The six project management levers that are used in this dissertation are environment (virtual and collocated), leadership, team maturity, meetings, CIP, and ICT. These project management levers are not new concepts individually, but as the researcher has discussed he believes they play a role in the productivity of project teams in the medical device R&D organization. Details around these project management levers can be found in Chapters 2 and 3 of this dissertation. The following section on the impact of project management levers will summarize and discuss the findings of the case study.

Impacts of project management levers

Each of these project management levers and where they are on a continuum, environment, leadership, team maturity, meetings, CIP, and ICT are summarized in the following three tables.

Table 6.4 CV1 project management levers

The researcher's qualitative interviews and the researcher's points of view form the information provided in the interviews.

Individual summary: identified by level Project management levers (0-10) 0 weak, 10 strong	**CTL Virtual project team 1**	**PM Virtual project team 1**	**TM Virtual project team 1**
Lever 1, Environment	8	9	8
Lever 2, Leadership	8	8	8

Lever 3, Team maturity	7	8	6
Lever 4, Meetings	7	8	6
Lever 5, CIP	4	5	4
Lever 6, ICT	7	6	7

Table 6.5 Analysis summary from case study one of the project management levers

	CV1 case study
Lever 1, Environment	Environment is important, face-to-face when possible is preferred, and technology and improved tools make virtual project teams possible.
Lever 2, Leadership	Leadership is the highest ranked item of the project management levers in this case study. All participants see leadership as important to project success.
Lever 3, Team maturity	Team maturity is ranked high by two of the three participants. This project team was able to select their project team members, which mainly was based on maturity.
Lever 4, Meetings	An effective mix off meetings was used on this project team, and new tactics and technology were implemented.
Lever 5, CIP	CIP was not performed much in this project.
Lever 6, ICT	Emails, IM, phone, teleconference, video, etc. were used on this project team.

Environment

Participant G understands that the team is geographically dispersed, but this person also made a point to travel and visit the different sites to understand the roadblocks and issues. Participants H and I see that the virtual project team environment is important, but they now have the technology and tools to facilitate easier communication. Participant I also agreed that travelling from time to time to visit the different sites was part of the success of the project. Participant H also tried to collocate members when possible in the same building. All three participants agree that when they could get face-to face-time they would surely take that opportunity. A review of the project team's sitebuilder indicated that it was being used, and documents were loaded on to this site.

> *"Actually of all these are very important, but team environment is critical"*. . . "*So we utilized a strong team environment and that's why I believe this project is successful, good relationships"* Participant G.

> *"We used other things to try to create a feeling of team for the people that were remote"* Participant H.

> *"What we did is implement using a team environment or approach"* Participant I.

<u>Leadership</u>

Leadership in this project team was important to all of the participants. All participants discussed this as 'critical' to the success of the project. Participant G sees maturity as a part of the right level of leadership that the project team needs. Project team members report through the functional groups instead of the project team. For this reason participant H thinks that the functional leadership should be better aligned with the project's scope and objectives. Participant H sees that this project did an effective job of selecting leaders and creating leaders within the project. Participant I also believes that there is strong leadership on this project team, and this added to the success of the project. The leaders trust the project team members, and when problems or issues occurred, project team members could rely on the leaders to help them solve them. The issues list was reviewed on this project team's intranet site to determine if actions were being assigned and completed as a part of the virtual project team environment. It appeared the action items were resolved and closed on the dates indicated.

> *"That's why the maturity and their leadership is so important is I've got to be able to you know implicitly trust them and when we had less mature people in certain roles, that is an area where we had some problems both from a cost and schedule perspective"* Participant G.

> *"It's also about creating leaders and so it goes into creating a team, and I tried to design a team that had people that would complement each other"* Participant H.

> *"And again, strong, strong leadership at the vendors' focal points that really helped the team"* Participant I.

Team maturity (knowledge and experience/expertise)

Participant G feels that a certain level of maturity is needed in order to get the right amount of leadership. Project team members need to step up at different points in the project and become leaders. This makes the core team leader's job easier as it would be difficult for this person to provide all of the leadership on the project team. Participant H had recognized that less mature people had more issues than the mature people on the team. This person describes items such as lower trust, which resulted in problems with cost and schedule. Participant G and H were able to select the project team members for this project team, which they felt was positive to team success. Both of these participants also agreed that they had a mature project team, if there was a need to assist less experienced team members; they were able to provide a higher level of guidance and coaching. Participant I agrees that the project was fortunate to have mature project team members. These project team members would perform some different roles and also be able to help to onboard new project team members throughout the project.

> *"Having the right level of maturity is imperative" . . ."If you don't have that correct level of maturity, you don't get the leadership you need to keep the team engaged at the appropriate level, and it becomes a much more difficult task for a core team leader to provide that leadership"* Participant G.

“The project selection was more just the personal knowledge that I had, but after we formed the team we actually did the Myers Briggs analysis, so people were aware of where they were, and they talked a lot about that actually” Participant H.

“Team maturity, we’re very blessed in having a lot of people with a lot of knowledge” Participant I.

Meetings

Participant G believes that having the appropriate project team meetings is important. The meetings were useful to determine project status and progress and to ensure team members recognized their roles and responsibilities. Participant H was trying new technology tools for meetings and also new meeting formats. Some of these techniques worked well, while other did not work effectively. One area that did not work well for this participant was trying to use cameras in meetings that moved to the sounds of the person voice and then directed the camera to that person. People were terrified and horrified at this technology and refused to continue to use it in meetings. One of the techniques that worked well was a ‘study hall’. This was simply a time set aside in which project team members had informal ways of interacting without an agenda. This worked well in this project and was successful. Participant I indicated that the project team weekly meetings, and overall meetings were not excessive. Participant I thinks that there needs to be some level of trust and that a face-to-face meeting when possible is positive for project success. Meeting minutes from this project were reviewed (see Appendix C1) to compare the information in the written minutes to the participant's interview information. All virtual project team participants agreed that have a project team room or war room had a positive influence on the overall project success. In the CV1 virtual project team they attempted to provide dedicated project rooms to team members in different locations. This provided them a meeting place for video and conference calls to have formal and informal meetings.

> *"Also having you know appropriate team meetings is also very important; make sure everybody's working off the same page"* Participant G.

> *"We would do things like have dedicated meetings and then have what we called study halls where you would just try to have informal ways of interacting without an agenda. That was helpful"* Participant H.

> *"We also meet on a daily basis with the production individuals making sure no problems with the builds of the day and scheduling for future builds and ship commitments"* Participant I.

<u>Continuous improvement process</u>

As seen in the pilot study, this area was rarely used in any of the four case studies. This organization has developed new tools for CIP. However, the teams in these case studies were established before strong efforts and qualified people were there to help these project teams manage CIP. Participant G was still trying to figure out what CIP in the organization was when this project began. The idea of doing engineering early is positive to avoid later surprises during the project. Participant H agreed that this was new when the project began and would have been used if the project was being started today. Participant I indicated that it was new to this project team, but it would be used in more in the future on new project teams. The project team intranet site again was reviewed to determine if there was any CIP information or discussions in the documents and found limited CIP information was available.

> *"We don't sell anything else, but product and if you don't have functional excellence, it's very hard to get done, but it's getting the product out that is the primary objective of why any team exists"* Participant G.

> *"There were people within their individual areas that would use you know you'd see an occasional fishbone diagram or something like that for problem solving, because we're a project with a beginning and an end, not a function, we're not; we weren't so much doing continuous improvement stuff right"* Participant H.

"You need to plan continued improvement process into the project schedule at the very beginning of the project and get it in your schedule and not try to force it in at a later date" Participant I.

Information communication technology

Participant G indicated that they have a website and use IM, cell phones, email and video. Video could be improved as the tools the organization has are cumbersome and do not work very well. Individual computer or Skype type of video tools would work more effectively than the expensive systems in meetings rooms around the organization. This participant also thinks that many people do not like to have their face on the video screen. Video is especially difficult with the more mature team members. They do not always work well with new technology. Participant H sees that the use of shared desktop, email, IM, and social networking worked well for the project team. This participant did make the comment that there is a generational gap in the acceptance of the new tools, and that the earlier generations did not like them, and the earlier generations were fine with any of the new technology tools. One tool that the team liked was using Microsoft Word on the shared site with the ability to check out multiple versions, and when they checked them in all of the revisions would be included saving time on emails and multiple versions of the documents. Teleconference calls did work well in this participant's view, and they performed the job of getting everyone together at one time to discuss issues and problems.

"So I very intentional about making sure that I visited, not just doing emails and voicemails and telephone calls and video calls, but actually being in their geography, so I could better understand what the local obstacles were and know that they had support for helping, help work around what those problems were" Participant G.

"I mean there were the people who were using the social networking tools in their personal lives were more interested in doing it and the people that weren't, thought it was the stupidest idea I've ever heard of. It was a fascinating generation gap" Participant H.

"I mean I know the corporation has rooms and things that you can go to, but with an online meeting and a Polycom, you can do an awful lot without actually seeing the person". . . *"There were more communication problems and people weren't tracking issues as closely*" Participant I.

<u>Positive virtual project team levers</u>

Table 6.6 summarizes the positive project management levers discussed by the participants.

Table 6.6 Virtual CV1 positive project management levers from the project team member's perspectives

	Project team member perspectives
Virtual CV1 positive project management levers	1. Team environment, face-to-face time is effective when it can be performed. 2. Meeting and study hall worked well. 3. Strong leadership improves project success. 4. More mature project team members improve project success. 5. Project team room was a plus for the team members in different locations.

Negative virtual project team levers

Table 6.7 summarizes the negative project management levers discussed by the participants.

Table 6.7 Virtual CV1 negative project management levers from the project team member's perspectives

Virtual CV1 negative project	Project team member perspectives

management levers	1. Functional leadership better aligned with the projects. 2. New technology, cameras on individuals at meetings. 3. Lack of maturity can result in lack of engagement. 4. Lack of CIP tools on the project. 5. Video is cumbersome and clumsy.

Medical device R&D

Participant G sees that the medical device industry has increased the amount of documentation needed for a development project in the past few years. This is due to increased pressure from outside regulatory agencies, the new regulations and standards. Participant H would rather see mature and experienced people in this high technology, complex regulated industry on project teams. The medical device industry is increasing in complexity, and it can be difficult sometimes to keep up to date on all of the changes. Participant I does not see the complexity of developing medical device getting any easier in the short term. Being able to identify project team members inside and outside the organization that can contribute to the project are key for project team success. Regulation represents change dates to processes, which can make it more difficult to move projects to commercialization faster. Overall, all participants of CV1 project team agree that this is a complex and regulated area, and methods to improve quality are required while remaining productive as a project team.

> *"It was very much at risk reward tradeoff and so we understood the cost and we understood the risk before we entered into, which is; and we got organization buy-in on taking on that risk"* Participant G.

> *"We walked up and did a standup meeting where we invited all of the directors and VP's and represented to the world what our plan was"* Participant H.

> *"So having identified focal points at the outsource partners end made a significant difference for the project, that is both in the design and the manufacturing"* Participant I.

Impact on Productivity

Project team productivity

This case study, project team participants agreed that the project team was productive and successful. Participants G, H and I all answered 'yes' to the question "Do you feel project productivity is enhanced because you work on a virtual or collocated team"? The impact in productivity can be seen with the new technology available with laptops, tablets and cell phones or smart phones. The CV1 project team stayed connected with the use of cell phones and using email and face time to communicate. This team agreed that they would have started parts of the project earlier to get improved alignment project goals and scope. All participants G, H, and I also agreed that stand-up meetings (using cameras) and the use of virtual project rooms were helpful; for project success and productivity.

> *"I essentially had great access to all my core team members with their cell phones and email, all that was critically important"*. . . *"Yeah, we had people working on this all over the world, so it was very effective actually"* Participant G.

> *"I don't want to learn, yeah, that was the interesting thing that came out of the social networking experiment, is that they just had no interest in learning, and I don't think it was cause they are not learning, but they didn't see that their investment to learn would have enough value for them"* Participant H.

> *"They work with their engineers in finding ways to make sure that we meet the task and the deliverables in a healthy environment, in a healthy way"* Participant I.

<u>Individual productivity</u>

Participant H would like to have each person take a personality test to help the project team in the future be more productive. This team used the Meyer-Briggs Type Indicator personality type tool, which should continue to be used in future project teams. Personalities can be just as important as the technical knowledge, sometimes even more important. Participant G sees that with the scope controlled that the project stayed on track and met the schedule and cost targets. Participant H also made the comment "what is the alternative" meaning what choice did the project team members have but to participate on this virtual project team. It would not have been feasible for this project team to collocate. Participant I brought up an effective point that the project team tried to follow. This is the 24 hour rule, if the project team has a problem or issues, sometimes it is best to give it the 24 hour rule and see if a solution will be found. Participant I thought that it could be a productivity gain for each project team member to follow this approach.

> *"I think maybe our individual one-on-one opportunities for this have improved, and we just have haven't taken advantage of it enough"* Participant G.

> *"I tried to get someone that would complement the other gaps that I may have had in the team, and it's not just knowledge or expertise, sometimes it's personalities"* Participant H.

"He came up with a saying that I now use; when an issue would come up, he'd always say, give it the 24-hour rule, so if a problem comes up, don't go running off and say oh the world's falling and everything else and doing that, a lot of things worked out on their own" Participant I.

Project Team Learning and Project Success

Learning of case study team one

Overall this project team was successful and productive; refer to Table 6.6 Positive virtual project team levers. The team leaders would have started the project earlier and began stand-up meetings and also meetings on the finances earlier. The project could also change to gain more alignment and accountability throughout the project team. A project team room (dedicated project rooms in different locations) worked well and would be highly suggested for future project teams. The leadership team also needs to know the risks, and a risk assessment should be performed early in the project to help mitigate any potential risks. Participant H indicated that team members need to find ways to keep the project team engaged with the project. As participant I indicates, the project team needs to know the goals and understand the tasks in order to be able to make progress. Leadership can be updated with accurate information on a timely basis.

"Yeah, we did add a few, but we; it was very much at risk reward tradeoff and so we understood the cost and we understood the risk before we entered into, which is; and we got organization buy-in on taking on that risk" Participant G.

"Right and if you've ever been on the remote side you know how hard it is to stay engaged, so yeah, I took some efforts. I wouldn't give myself an A right. I mean there were, but I think we did better than most" Participant H.

"So the project team understands what the tasks are and making sure you're communicating results and details to others who have a higher responsibility" Participant I.

Improving Productivity

Project team perspectives

Participant G would improve on the risk and reward trade off with the project. By identifying risks before the project starts, the project team will be in a much better position to be able to analyze and mitigate them. The tools that indicated earlier were important to participant G; this includes scheduling tools as well as communication technology. Project scope needs to remain in control and on task in order to be productive. Participant H sees that the tools they currently have on the project worked well and said a process and reminders on how to conduct one's self during meetings with teleconference and video would be useful. Project members also need to keep the project team engaged and focused during these meetings. It is easy to get distracted and not focus during a teleconference and is not as easy during a video conference. Participant I thinks that the project team needs to agree the requirements early in the project in order to best understand them.

During the case study, the researcher kept a reflective journal as part of the triangulation process.

> "*To manage a program as large as this one, to manage as many functional areas as we had engaged on this one with as many tasks, it would have been impossible to manage without a tool that allows you to show multiple levels of interactions as well as multiple levels of critical paths"*. . . *"I think our productivity, because we controlled the scope was probably better than a lot of programs in the past. We didn't have a lot of scope creep after we started the program"* Participant G.

> *"Yeah, probably the biggest thing would have been an investment in the fidelity of the interaction tools"* Participant H.

> *"Locking down the requirements upfront is key, because if people know what is expected and what we need and we're not going back and forth having oh*

we’re going to put this in, oh you know what, let’s not, let’s have this” Participant I.

Individual perspectives

Participant G sees that the technology tools will continue be important in the medical device R&D projects of the future. It is also important for individuals to manage their time if they are on multiple projects and not support one project only when they are not adding value to that project. Individual commitment was another item that participant G sees as an important factor in project team productivity. Participant H sees the stand-up meetings as important to drive individual accountability. Stand up meetings are usually 15 minute weekly meetings with video in which each person has a minute or so to give an update to the project team members at the meeting. Project team members did not like to be accountable on an action item and not have an effective answer in from of a leadership group. The embarrassment of not being able to answer a question drove the individual accountability up to a much higher level than just email or IM. The use of social media will possibly change this in the future, but this is still fairly new to this organization at the present time. Participant I agrees with the commitment that participant G has discussed. Participant I also see that inefficiencies or wasted time/resources should be taken out of the process where possible. This person sees project team members need to know their tasks, buy into them and make them their commitment. People do not want to fall short of their goals or commitments. Individuals working in a healthy environment want to get tasks and deliverables completed. Project team members need to take ownership so that the tasks get completed. Participant H realizes there are generational gaps and is trying to figure out how to work effectively with people representing different generation types.

> *"And also I think there's some of it that's got to come down to its an individual giving you a commitment that they're going to get something done and being to look across the table and knowing that they're going to do whatever it take or especially to do their best, because that's all you can really ask people"* Participant G.

> *"But I'm working really hard not to be that guy that can't cross the generation gap"* Participant H.

> *"We have to look at what we don't need to do repetitively, but we need to make sure that we get ownership from people so the task will be completed"* Participant I.

<u>Medical device R&D perspectives</u>

All Participants again agree that medical device R&D is complex and only getting more complex as regulations and standards are updated. Projects seem to take longer and have more documentation than years ago. With a project team as large as this project CV1 in the medical device organization team members need to work together in order to be productive. Participant G sees that the project team and organization need to understand the risks before a project of the complexity of one in medical devices begins. Participant H indicates that more investment in social media tools and project management training in the project teams would be useful. Participant I discussed how team members need to be able to decrease ineffective processes that do not add value in order to focus more on the medical device side of the project. The project team needs to be focused to better serve patient's lives and restore health.

> *"We understood the cost and we understood the risk before we entered into, which is, and we got organization buy-in on taking on that risk"* Participant G.

> *"Medical device organizations should invest more in social tools and training for project team members"* Participant H.

> *"From a success; the one thing our outsource partner does is they identify key people also, so we always have a contact/interface person identified to work with the outsourcing partner"* Participant I.

Case Study Conclusions and Summary

In summary, virtual project team CV1 participants viewed this project as being successful. There was variability between participants. This chapter investigates the impacts of productivity in project team CV1 in a medical device R&D organization. This dissertation investigates the impacts of productivity in a medical device R&D organization. The case study CV1 is a project representing a project consisting of a medical device, which is a class III device. The project team size consists of over 100 people. This case study consisted of a product that is within six months of commercializing during the interviews. Since the interviews in early 2013, this case study project has commercialized its product. This project team has both positive and negative impacts around the project management levers. CV1 project team members all see that this project was successful and productive. The views of the three participants of this case study on impacts of productivity in medical device R&D have been discussed in this chapter for case study one.

Based on the participant's feedback in the interviews both positive and negative perspectives were discussed. These are individual perspectives form the project team that either had strong views or were a consistent theme from the project team.

CV1 has a larger project team in this organization that the other case study projects studied in this dissertation. There are many more communication channels and potential problems when projects have so many project team members. The positive and negative tables outline the highlights from this case study. The demographics also provide a snapshot of the participants and their maturity and educational backgrounds. Participants in this case study rely heavily on technology for meetings communication and individual communication. The project team in CV1 has strong virtual project team environment, strong leadership, and strong team maturity, effective meeting practices, lower CIP and a strong ICT. The project team members are in a functional organization reporting through the matrix function and not to the project teams.

The CV1 project team compares well in environment, leadership, meetings, and ICT when compared to the conceptual development and literature in Chapters 2 and 3 of this dissertation. The project team has been able to deliver a project to commercialization while improving on technology tools, positive team environment and strong leadership. This contributes to success and productivity of this project in the medical device R&D organization.

There are, however, areas for improvement. The CV1 project is not different than many project teams in that it can find areas to advance the productivity of its project. One example is a potential change from people reporting into functional management to people reporting into the project management office. The proper use of video with individuals and a project team setting could enhance the overall project team productivity. This would also include the correct video cameras and software. The CV1 project team utilized both the individual cameras and the video rooms with minor success. A program that has a training element and the proper equipment would gain project team trust and respect for this technology. CV1 had a few minor instances of project team members that were not mature or experienced. The low use of CIP for CV1 is an indication of the relative low maturity of this area from the organizational management. The CV1 case study project was started several years before a formal CIP process was in place. CV1 as a project team was able to use many new technologies and communicate virtually with the project team.

Chapter 7: Case Study Two Analysis

Introduction

Case study two will attempt to further our understanding of the impact on productivity in the virtual project teams and collocated project teams in an R&D medical device organization. The following will explain the process used to interview the participants and the outcome of the information.

Table 7.1 outlines the overall framework for this chapter and case study two. The case study project team consisted of a medical device, hardware, which is a class III device. The total project team size consists of less than 50 people. The end product is being released or is commercialized as the interviews were being conducted. This case study consisted of a product that was commercializing within six months of the interviews, and since the interviews in early 2013; it has entered into commercializing phase of its product life cycle. In addition, a list of triangulation documents (see Appendix C2) was reviewed. The findings in this chapter are from project team CV2 and the three participants J, K and L.

<u>The case study team</u>

Deliverables for CV2 project team

1. Description: Virtual project team, first generation class III device, medium team of less than 50 people, five year project.
2. Current status: Project near completion and in final status.
3. Type: Hardware.
4. Project type: R&D medical device.
5. Virtual continuum:7 (see Chapter 1 Table 1.2)

Table 7.1 Case study CV2

Type of study	**Project team**	**Participant**	**Code**
Virtual	Virtual project team 2 Hardware	CTL PM TM	J K L
Collocated	Collocated project team 1 Therapy	CTL PM TM	M N O
	Collocated project team 2 Software	CTL PM TM	P Q R

The case study participants

Three participants were interviewed for this case study. All project team participants are members of this project. Participants in this study are identified as J, K and L. The demographics of the three participants are summarized in Table 7.2.

CTL Participant J

Participant J has had key roles as a functional manager, project manager, and core team leader. Participant J also has had internal organization project management training.

PM Participant K

Participant K has had key roles as a program development and software development. Participant K also has had internal organization project management training.

TM Participant L

Participant L has had key roles reliability engineer, program manager and functional manager. Participant L also has taken college courses on project management.

Table 7.2 Demographic summary of case study two participants

Number of participants	**Three**
Current position on CV2 project team	One core team leader One project manager One team member
Years of service in current position	One year to four years (average: 3

	years)
Years of service in medical device industry	Eight years to 23 years (average 15 years)
Highest education level	Masters of science Masters in engineering Bachelor degree
Project management training	Internal company project management training and college courses
Size of project team <20, <50, >50, >100	<50

Virtual Project Team Two

All three participants had over eight years of medical device industry working experience. The overall average was 15 years. The participants had spent most of their careers in the medical device field, and the majority of that time for most participants was in the R&D organization. Two of the participants have had more than three different positions within the medical device industry. Two participants have moved at least one level up in the organization since their start date. Two participants have a master's degree and one has a bachelor's degree. None of them have acquired a formal project management qualification/certification. Two of them did have internal project management training from the organization, and the other has taken various project management courses in college.

Figure 7.2 is a visual word frequency virtual case study two table that takes all of the words from the combined CV2 virtual project team case study interviews. The larger the word the more frequently it was used in the interview. Some of the most frequent words used for CV2 are project, team, things and think. Productivity and success are also used and virtual does show up here. The project management levers that are indicated here included meeting, leadership, but some areas under ICT. Team maturity and CIP do not show up on this word frequency figure.

Figure 7.1 Word frequency virtual case study two

Project management levers

The researcher uses the term ‘project management levers’ to refer to his ideas of variables that impact productivity in virtual project teams and collocated project teams. The six project management levers that are used in this dissertation are environment (virtual and collocated), leadership, team maturity, meetings, CIP and ICT. These project management levers are not new concepts individually but as the researcher has discussed he believes they play a role in the productivity of project teams in the medical device R&D organization. Details around these project management levers can be found in Chapters 2 and 3 of this dissertation. The following section on impact of project management levers will summarize and discuss the findings from the case study.

Impacts of project management levers

Each of these project levers and where they are on a continuum, environment, leadership, team maturity, meetings, CIP, and ICT are summarized in the following three tables.

Table 7.3 CV2 project management levers

The researcher's qualitative interviews and the researcher's points of view form the information provided in the interviews.

Individual summary: identified by level Project management levers (0-10) 0 weak, 10 strong	**CTL Virtual project team 2**	**PM Virtual project team 2**	**TM Virtual project team 2**
Lever 1, Environment	6	6	7
Lever 2, Leadership	8	7	6
Lever 3, Team maturity	8	7	6

Lever 4, Meetings	6	6	5
Lever 5, CIP	4	3	5
Lever 6, ICT	7	8	7

Table 7.4 Analysis summary from case study two of the project management levers

	CV2 case study
Lever 1, Environment	Different time zones present some issues, but virtual project teams add more flexibility.
Lever 2, Leadership	Leaders need to get things done and be technically competent.
Lever 3, Team maturity	Project team had positive experience, but outside development partners did not always have the experience needed.
Lever 4, Meetings	Cross-functional meetings were used; if more meetings were needed the project team held them.
Lever 5, CIP	CIP was not performed or visible at the CTL and PM level but was used at the TM level.
Lever 6, ICT	Shared desktop was used across the project team; other ICT tools were also used with positive results.

<u>Environment</u>

Participant J sees that from a virtual project team perspective the different locations and time zones are difficult to work with on a project team. One area that worked well was identification of key people so everyone on the project teams knew roles and responsibilities are for the project. Participant J also likes the idea of at least one initial face- to-face-meeting before working virtually with outside partners. The use of a shared website for this virtual project team is also a positive. Participant J indicates that sending information and having to wait because of time zones or holidays of other people in different countries is a loss in productivity. But this can also work for your project team if the technical skill sets are the same. A project team member can be working 24 hours a day in different time zones. Participant K also acknowledges that the different time zones made some things difficult on this project team. The use of the internet was effective in most locations except for one outside of the USA which caused some problems and delays for the project team. Participant K also thought the project team had a 'productivity penalty', which is due to the lack of experience with some of the outside partners. To improve this in the future participant K suggested that projects should start earlier in the process with the outside partners. Participant L also liked the idea of working 24 hours a day and moving the project team forward all of the time. This participant sees the virtual project team environment as being more flexible as a project team member could work in different locations. Participant L does admit that at times it could be difficult to get questions answered right away. All participants see this virtual project environment as positive with flexibility of the project team.

> *"And those functions are two separate locations and with fairly significant time zone differences like Malaysia versus here and then also we had a European vendor for part of the hardware" "Then we were trying to coordinate three different locations, three different time zones"* Participant J.

"Kind of their ability to access those was also very important and actually; so for the team in Prague, they had pretty good access to the common tool set" . . .*"The team in the Ukraine, due to the way some of the network connections worked and all didn't have such good access, so it was more of a challenge"* Participant K.

"I think for product success it gave us the ability of working all day long; 24 hours" . . . *"There were people in India, and there were people in other countries that were working at all times and that allows us to be more flexible in terms of getting things done"* Participant L.

Leadership

Participant J sees that strong leadership is needed for the project team. Leaders need to be committed and be able to implement the design with the project teams. Leadership on this project CV2 has changed a few times during the course of the project life cycle. Participant J estimated that this occurred at least once a year. Commitment as a leader means that things will get done, and CV2 was able to get things done. Participant K also agrees strong leadership is positive, but this participant also sees that leaders in this industry need to be strong technically. This type of leadership will add to the success and productivity of the project team. Participant L looks at leadership from the technical side, and the needed technical knowledge with the rest of the project team was important for CV2. Participant L indicated that the project team CV2 could have used just a little more leadership in terms of timing with tasks or stopping unnecessary email threads. All participants agree leadership is important to the project team as scoring is fairly high in the numerical portion of the project management levers.

> *"So first leadership below, from the core team down to the people who were doing the designs and doing the implementation and working on the project; very committed, I attribute that to the leadership"* . . . *"And because we lost some of that focus from higher management, I think the team felt like they'd been abandoned a little bit"* Participant J.

> *"I was definitely dependent on having some strong technical leaders on the team, both on the USA side and on the outsourcing team, and we had some really solid people that were really able to fill those rolls and that were critical to the success"* . . . *"Project would have completely collapsed if I hadn't had some really good strong kind of technical leads in a bunch of areas"* Participant K.

> *"For the leadership from basically from myself and up, I think it actually in many ways it was a difficult project, because the scope of the project changed quite a bit over the last three years since we started the project, and it kind of dwindled into something that wasn't entirely what we started with, and therefore, it created a lot of unnecessary churn that if we would have known*

that three years before, we would have probably made decisions a little differently. We probably could have been done with the project much quicker" Participant L.

Team maturity (knowledge and experience/expertise)

Participant J sees that this project had very effective knowledge and experience. Projects of this type have been done before at this organization. Outside partners also had medical device experience, which was a plus for the project team. Keeping the same people on the team was difficult and did not work very well on this project team. Participant J indicated that priorities were changing and different projects would be the number one priority on month and then it would change the next months and resources would get shifted impacting CV2 projects sometimes. When people left the organization they replaced them with less experienced people, which created problems. When people leave the project team so does the knowledge there should be a way to capture this knowledge. There was not an efficient method to capture the knowledge before project team members left the project. Participant K indicates that one of the outside partners was new to the medical device industry unlike the outsource partner that was discussed by participant J, which adds other issues to the project and creates a challenge for the project team. Participant K agrees with participant J in that this person agrees that the project team had effective experience and knowledge. Many on the project team had worked on similar projects as the one on CV2. One area for improvement was better understanding of the standards and regulations.

> *"That was hard and then in my position there were actually only three people in my position that were continuous over the lifetime of the project and that's hard on a team too, continually changing management" . . ."We had very good knowledge and experience; I should say the project had very good knowledge and experience early on*" Participant J.

> *"I had a pretty seasoned team here and that kind of gets back to my issue around having some really good technical leads, and so I had some experienced people, strong technical knowledge and yeah, that was an important success factor in my mind"* Participant K.

> *"A lot of people who were, who have done medical device and who have worked in medical devices quite a long time, so we're very, very knowledgeable in terms of how to do it and in terms of the regular pitfalls that we tend to see in instruments" . . ."I think where team maturity wasn't really good enough was related to the standards and the things that we had in some of the regulations that we have to comply"* Participant L.

<u>Meetings</u>

Participant J indicates that they had frequent team meetings with the cross-functional project team and weekly meeting with the outside partners. Because of time zone differences the meeting had to be held at different times. More meetings for CV2 would be held only if they were needed. When possible the project team would meet the outside partners face-to-face. The organization is responsible for the design and needs to make sure that everyone on the project team understood the design and details. Participant K agrees with participant J in the value and necessity of weekly meeting and cross-functional meetings. In addition a stand-up meeting or short daily type project meeting was performed via a camera for all participants to attend. This would occur once a week early in the morning and last an hour or less. This is not the typical stand-up or agile meeting, but CV2 liked to keep this more informal and open for discussion. If a meeting was not needed it was canceled, and one CV2 participant said that would occur maybe half the time. Participant L also agrees with participant J and K with the weekly cross-functional meetings. Participant L indicated meetings on CV2 were not prepared and planned as well as could have been performed. This participant did not see an agenda and would have like to have an agenda for future meetings. With an agenda the project team can come prepared and ready to discuss the issues and deliverables. Participant L indicates that without this communication a great deal of time can be taken debating about what the project team will discuss. Meetings generally are called by sending a meeting invites by email, and team members usually do not get much if any background and that leaves project team members making up their own minds on what the topics or issues are. Meeting minutes from this project were reviewed (see Appendix C2) to compare the information in the written minutes to the participant's interview information.

> *"And then we would hold more meetings if there was a crisis then you do the everyday thing or every couple of days". . . "The reason to have face-to-face reviews was driven by to the need to ensure that the organization's processes and quality systems were in order regardless of who does the design or how you actually accomplish that work, this organization is ultimately responsible for the design and product*" Participant J.

> *"I mean there was typically enough every week, and sometimes we had to do meetings beyond that. But there was typically enough activity going on, things that needed discussing, decisions that needed to be made where we used that"* Participant K.

> *"We did not; one of the things that I didn't see, at least not on a continuous basis was an agenda to what exactly were the topics for that week. It was kind of like hey, we're having a meeting this week or not we're not having a meeting this week"* Participant L.

<u>Continued improvement process</u>

Participant J did not see much use of CIP on the CV2 project team. Early in the CV2 project team they had some design improvements. Participant K simply indicated that they did not do much with CIP. Requirements were performed upfront and as a part of the CIP process. Testing was also incorporated into a CIP process earlier in the CV2 project. Participant K did indicate that the CV2 project team did get some value out of these tools. This participant did question the value and the goal of the CIP. All three participants agreed that CIP was not used much on this project CV2. This is similar to CV1 in the lower use of CIP. This organization has more tools and training for CIP now as indicated by all of the participants in CV2 and CV1. Participant L said that CV2 used CIP tools, which are different from participant J and K. Participant L did use CIP in this participant's day-to-day work, but it was performed by participants J and K. Participant L is one of the project team members and much closer to the day-to-day work than the CTL and PM. CV2 project team did CIP to reduce risk of the project. This was accomplished by using SS methods to reduce cycle times in the process. It does get back to some of the project requirements that were discussed by participant K. In this case some different terminology is being used, but it is mainly the same information. One of the CV2 project goals was cost of ownership. This refers to the cost over the life of the device to the owner. This can include trips to the doctor, device change outs, and other associated costs. It was a delicate balance of reliability, cost and survivability per participants in CV2.

I do believe that early on they had done some design continuous improvements that they wanted to try and so actually you should ask the development person" Participant J.

"We did some of that upfront, so we did a different method for requirement documentation, kind of use cases as opposed to these textual detail requirements" Participant K.

"One of the big things that we did for this project was definitely apply a lot of CIP tools and a lot of CIP skills to the project itself" Participant L.

<u>Information communication technology</u>

Participant J indicates that language was a barrier to communication. The CV2 project team had three native languages to work with the project. In this case study all of the participants indicated that email was much easier to communicate. CV2 used the share desktop feature, which participant J, K, and L all felt was positive. CV2 also utilized a shared sitebuilder with the internal organization project team and the outside partner project teams. This proved to be difficult for some time with firewalls and permissions. Video conferencing was hardly used at all with CV2 virtual project team. All participants agree that video conferencing in this organization is hard to use, clumsy and just too much work to set up correctly. While interviewing the participants for this case study it was brought to the researcher's attention that most if not all of the video equipment at this organization was being removed. New video systems would be installed at some time after removal. Participant J also commented that many of the project team members were experimenting with webcams on their computers. Participant K indicated that they used email, IM, intranet, internet, Skype, phone calls and teleconferences. This participant indicated that the organization's IT department was not supporting some of these tools early in the project making use of them more difficult. Participant L indicates that they used Skype more than most of the ICT tools. Phone and email are also used heavily in CV2 project team form participant J and K's point of view. Participant J sees that project teams need to know when and how to use email and when to simply pick up the phone. IM was also used frequently as participant L was comfortable with all of the ICT technology. Cell phones were not used too efficiently on this team as this organization does not give everyone a company cell phone; it is limited for higher pay grades and executives.

> *"We do use online meetings, which definitely helps, because than you can talk to something everyone can see and that helps break down that barrier"* . . .*"But again, if you let that lapse or you don't use it for three months and all of sudden you want to start using it again, then there's a big learning curve again and that's both for email and the online meetings"* Participant J.

> *"Yeah, I would say we leveraged all of those. In fact I know we leveraged all of those. We did a lot of Skype, especially with our offshore teams"* Participant K.

"I think that's probably the biggest problem that we have at times is that when it's urgent sometimes we send an email when in fact we should be making a phone call, and I think that's a pitfall sometimes that some teams seem to have, cause they get used to sending an email, and you know thinking that things are done" Participant L.

<u>Positive virtual project team levers</u>

Table 7.5 summarizes the positive project management levers discussed by the participants.

Table 7.5 Virtual CV2 positive project management levers from the project team member's perspectives

	Project team member perspectives
Virtual CV2 positive project management levers	1. Past project experience with same product. 2. Collocated project team members in different time zones when possible. 3. Shared desktop worked well. 4. Positive ICT performance on this project team.

	5. Cross-functional weekly meetings.

Negative virtual project team levers

Table 7.6 summarizes the negative project management levers discussed by the participants

Table 7.6 Virtual CV2 negative project management levers from the project team member's perspectives

	Project team member perspectives
Virtual CV2 negative project management levers	1. Coordination of time zones. 2. Changing project team members. 3. Project team maturity gap with outside partners. 4. No agenda at team meetings. 5. Improved understanding of standards and regulations.

Medical device R&D

From the perspective of CV2 project regulations and standards were discussed by all three of the participants. Over the duration of this project outside regulations had changed, it was difficult to keep up to date and the project team did not have an effective mechanism to keep up with the changes. One of the issues with this CV2 project is that due to the changing regulatory environment the product specification grew from a few lines to over five pages. Participant J explained that in addition to the FDA, the team now has to also comply with different versions of regulations within the Federal Communications Commission. Participant K indicated that keeping track of regulations in an Excel-based format was one way to stay up to date on the changing regulatory environment. Participant L sees that when these regulatory changes are being changed, the labeling or even the product itself may require changes. The standards in general will need to be managed in a way that will assure organizational success in the future.

> *"When we initially started our spec, we had five lines of standards that we had to meet. They were the eight; the medical standards for Europe and the FDA. That was our first product spec. When I took over; so I went back and I looked at that. That's when they went to commitment review with for the product specification. When I took over, it now has five pages"* Participant J.

“I mean the concepts are kind of industry concepts, but yeah, we actually got a set of Excel macros there were kind of home cooked that are being used” Participant K.

“I definitely agree that the regulations are getting a lot more complex. And particularly on my project team, we deal a lot with medical device standards” Participant L.

Impact on Productivity

Project team productivity

This case study project team CV2 agreed that the project team was productive and successful. Participants J, K and L all answered ‘yes’ to the question “Do you feel project productivity is enhanced because you work on a virtual or collocated team”?

Participant J looks at the productivity issue of not how we can increase productivity but how so we as a project team work to find all of the areas that are simply decreasing productivity. What is meant by this is that we are making our process and products more complex. Some of these processes are design, and some are regulations and standards. Other areas that participant J would change in the future are agreeing on a set of technology communication tools and then having training on these tools. Another area would be to keep the team and knowledge together when possible.

Project team members leaving the team can really damage productivity by the loss of momentum, knowledge and continuity. Participant K would like to see collocation when possible with the project teams as this could help project team communication and innovation. Participant L would like to see project and program management tools that would be useful to all project team members. This can include templates, software, and a list of project management experts that project team members could go to with questions or issues on the project.

> *"So virtual teams looking at the same website outside of this organization altogether, so that was maybe unique to the project, because we used some off the shelf products/components" . . ."It's like hey, this is a lot of stuff, so you want to increase productivity, well a lot of things are decreasing productivity and I don't know how you get out of that when you have so many requirements in here"* Participant J.

> *"Yeah, so I mean in my mind; if I could have 100% local collocated team, to me, that would be the most productive thing; might not be the most cost effective thing"* Participant K.

> *"Actually one of the other things that I think we could improve and enhance was, this is more of an organizational thing and again better tools for program management"* Participant L.

Individual productivity

Participant J sees that technology impacts the overall success of the project team in a positive fashion. It is possible to have a meeting at work, home or on the road with laptop and cell phone technology improvements. Participant K thought that risk burn down (method for determining risk level and priority) for the project and product was effective to help individuals better understand their deliverables and schedule. Participant L sees that the use of individual cell phones would be a improve way to communicate and be more productive.

> *"When you're sitting at home doing an online meeting, we did do that. It does help. Also, the fact that we have screens all over now in the conference rooms, those are productivity tools for everybody, right"* Participant J.

> *"The piece that had the most value to me was our backlogs and managing and kind of; we have a burn down chart that really shows here's how much work we thought we had and here's where we're at and here's a projection based on productivity where we're going to end up"* Participant K.

> *"I mean I guess cell phones will be probably on an individual case basis, but I personally did use them a few times to do teleconferences and to log into the calls and things like that"* Participant L.

Project Team Learning and Project Success

Learning of case study team

Overall this project team was successful and productive. One of the lessons learned from participant J was to keep the number of changes in personnel to a minimum. Not all project changes can be avoided, but some of them can, and the leaders need to find ways to keep the impact to a minimum to the project team. It is not only disruptive to the project team, but as seen in CV2 it is the knowledge that is gone when project team members leave the team and that it is difficult to gain the knowledge back on the project team. Participant K goes on to further discuss that the project team had to adapt to the changing personnel and people leaving. This is where the maturity part plays a factor and having people that are experienced in to other areas and can help when the works shifts will improve the project team success. Participant L takes it to an even higher level and does not think the organization has done enough to improve and promote project and program management tools. This participant does not see an investment by this organization's leadership team into project management. Moreover, this participant sees that with a project management effort by the organization one could improve the productivity of the project teams, R&D and the organization.

> *"The one thing that really hurts the productivity of a team and I think* hurt this *project, including my coming onto it is the number of changes in personnel"*
> Participant J.

"We did a fair amount of moving people around to try to kind of manage where the work was happening and rates of getting certain pieces done. So that was, I would say, critically important too" Participant K.

"I mean other than that; I'll say this organization at times, is not really big into program management, for the most part" Participant L.

Improving Productivity

<u>Project team perspectives</u>

CV2 is a virtual project team and has an internal project team and also works with outside partners. Holidays, vacation and other days that people do not work should be communicated up early and kept up to date. Participant J indicated the use of a shared calendar or other tool to keep project team members updated of time off changes for the project would be productive. As discussed earlier in this chapter, the project team needs to keep the number of changes in personnel to a minimum. CV2 was successful from the perspective of participant K in keeping the project organized and effective. Participant K indicated that this may have been improved with a 100% collocated project team. Of course this is not cost effective, and the reasons why many project teams are using virtual project teams. Participant L would like to see that there is an agreed-upon process in how to use the ICT tools that nearly everyone has access to. A process on use of the ICT tools by the project teams needs to be in place at the beginning of any virtual project team.

> *"So you sometimes feel like you lose productivity, because you're waiting till Monday or you're waiting for the European holidays to be over in August or the Chinese New Year in January, so you're not always on the same calendar with virtual teams, certainly geographical virtual teams"* . . .*"The one thing that really hurts the productivity of a team and I think hurt this project, including my coming onto it is the number of changes in personnel"* Participant J.

> *"I think we were able to organize the project in a way that still made that effective"* Participant K.

> *"I mean I've seen projects stall for days and sometimes even weeks, because the wrong piece of information is conveyed or is misunderstood, and I think the fact we now have different tools like email, phone, video and many other things that we can do and we can see right off the bat actually help the projects quite a bit"* Participant L.

<u>Individual perspectives</u>

Participant J would like to see individual transition plans for project team members or even perhaps a process or template to gain consistency. There needs to be a process of how people come on to the project team and off of the project team. As indicated by participant J this had a negative effect on the productivity of CV2 project. Too often people are moved on and off projects without realizing the positive and negative implications these changes have on the project. Or leadership simply asks for a change in resources without consulting project leaders or other functional leaders. Participant K sees that they were hurt on CV2 project because of their virtual project team structure. Participant K indicated that the virtual project team structure could have been improved by grouping virtual team members in the different time zones. This participant indicated that the organization needs to be more diligent in making sure that outside partner's individual shave the medical device experience, and they can start contributing to the project immediately. It was discussed already by participant L that an agenda would be a productive project team tool. Team members need to know what the meeting is about and what will be discussed so they can be prepared.

> *"I've had people since then on my team who've just left for other things and that really hurts the productivity of a project"* Participant J.

> *"So I would say we had a productivity penalty that we paid, because we were virtual, and because we were outsourcing, and we were bringing on people that didn't have a much experience"* Participant K.

"I think an agenda helps quite a bit. It helps you identify whether you need to come prepared, or you don't need to need to come prepared or whether you need to do something different or whether the topic doesn't even; it's not even of your topic, and you may not be needed to attend that particular meeting, so an agenda definitely helps quite a bit" Participant L.

Medical device R&D perspectives

Regulations, standards and complexity in CV2 make this even more difficult to move a project forward and meet the schedule. The project team needs to find a way to stay current and organize regulations and standards. Participant K does not see that it is always an effective idea to have outsourced partners, which may save costs but may be at the expense of lost productivity in the long run. Medical devices are complex on to themselves but when the project adds in new regulations and standards it can become overwhelming. Organizations and project teams such as CV2 need to develop better ways to handle the ever changing and speed of changes with standards and regulations as pointed out by participant L.

"I don't know if the project from beginning to end was four years and that it's just unreasonable to think that a team of eight people, plus even the vendors, that these people are going to stay on for four years" Participant J.

"I mean I do think we saved the company money by virtue of the fact that we outsource, because whatever productivity hit we got was compensated or more than compensated for by the fact that's it's just cheaper labor" Participant K.

"I think one of the basic problem that we have sometimes right now, it's not even knowing what the standards are at, but even knowing whether the standards sometimes applies or not, and I think that's too basic for us to spend you know weeks or months just to try to figure that one out" Participant L.

Case Study Conclusions and Summary

In summary, virtual project team CV2 participants viewed this project as being successful. There was variability between participants. This chapter investigates the impacts of productivity in project team CV2 in a medical device R&D organization. The case study CV2 is a project team representing a project consisting of a medical device, hardware, which is a class III device. The project team size consists of less than 50 people. This case study consisted of a product that is within six months of commercializing during the interviews. Since the interviews in early 2013, this case study project has commercialized its product. This project team has both positive and negative impacts around the project management levers. CV2 project team members all see that this project was successful and productive. The views of the three participants of this case study on impacts of productivity in medical device R&D have been discussed in this chapter for case study two.

Based on the participants feedback in the interviews both positive and negative perspectives were discussed. These are individual perspectives from the project team that either had strong views or a consistent theme from the project team.

CV2 is a medium-size project team in this organization when compared to other projects in the organization R&D area. There are many more communication channels and potential problems when projects have so many project team members. The positive and negative tables outline the highlights from this case study. The demographics also give a snapshot of the participants, their maturity and educational backgrounds. The project team in CV2 has an effective virtual project team environment, effective leadership, effective team maturity, adequate meeting practices, lower CIP and a strong ICT. The project team members are in a functional organization reporting through the function and not to the PMO. CV2 project team compares well in environment, leadership, meetings, and ICT when compared to conceptual development and literature in Chapters 2 and 3 of this dissertation. The project team has been able to deliver a project to commercialization while improving technology tools, positive team environment and effective leadership. This contributes to success and productivity of this project in the medical device R&D organization.

As observed, in most project teams there are items that can be improved in the future. CV2 project team did lack some maturity with the outside partners. The potential change of project team members and the loss of knowledge management and disruption in schedules could be improved in the future. This is potentially an organizational change in policy to have transition plans or a process for project teams to follow. Participant L felt an agenda at meetings would have a positive impact on productivity. CV2 project team members need to be present at meetings and know what the topics of discussions will be presented. A project team may spend most or all of the meeting debating those agenda items. The shared desktop technology under ICT was viewed positively with all CV2 participants. Overall ICT was an effective source of communication for the CV2 project team. CV2 had some issues with time zones and the management of communication. The low use of CIP for CV2 is an indication of the relative low maturity of this area from the organizational management. The CV2 case study project was started many years before a formal CIP process was in place. CV2 as a project team was able to work across multiple time zones and with outside partners in order to achieve productivity and project success.

Chapter 8: Case Study Three Analysis

Introduction

Case study three will attempt to further our understanding of the impact on productivity in the virtual project teams and collocated project teams in an R&D medical device organization. The following will explain the process used to interview the participants and the outcome of the information.

Table 8.1 outlines the overall framework for this chapter and case study three. The case study project team consisted of a medical device, therapy, which is a class III device. The total project team size consists of less than 50 people. The end product is being released or is commercialized as the interviews were being conducted. This case study consisted of a product that is commercializing within six months of the interviews. Since the interviews in early 2013, this case study project has entered into commercializing phase of its product life cycle. In addition, a list of triangulation documents (see Appendix C3) was reviewed. The findings in this chapter are from project team CC1 and the three participants M, N and O.

<u>The case study team</u>

Deliverables for CC1 project team

1. Description: Collocated project team, first generation class III device, medium-sized team of less than 50 people, four year project.
2. Current status: Project near completion and in final status.
3. Type: Therapy.
4. Project type: R&D medical device.
5. Collocated continuum: 7 (see Chapter 1 Table 1.2)

Table 8.1 Case study CC1

Type of study	**Project team**	**Participant**	**Code**
Collocated	Collocated project team 1	CTL	M
	Therapy	PM	N
		TM	O
	Collocated project team 2	CTL	P
	Software	PM	Q
		TM	R

The case study participants

Three participants were interviewed for this case study, and all project team participants are members of this project. Participants in this study are identified as M, N and O. The demographics of the three participants are summarized in Table 8.2.

CTL Participant M

Participant M has had key R&D roles as a manufacturing engineer, engineering manager, project manager, program manager and core team leader. Participant M also has had internal organization project management training.

PM Participant N

Participant N has had key roles as a development technician, development engineer, manufacturing engineer, manufacturing manager, development manager and project manager. Participant N also has had internal organization project management training.

TM Participant O

Participant O has had key roles as core team member and project manager. Participant O also has had internal organization project management training.

Table 8.2 Demographic summary of case study three participants

Number of participants	**Three**
Current position on CC1 project team	One core team leader One project manager One team member
Years of service in current position	Two years to 11 years (average: 5.3 years)

Years of service in medical device industry	Nine years to 37 years (average 22 years)
Highest education level	Two bachelor degrees One master's degree
Project management training	All internal company project management training
Size of project team <20, <50, >50, >100	<50

Collocated Project Team One

All three participants had over nine years of medical device working experience. The average was 22 years. The participants had spent most of their careers in the medical device field, and the majority of that time for most participants in the R&D organization. One participant has more than seven different positions within the medical device industry. Another participant has had over five positions within the medical device industry. All three participants have moved at least one level up in the organization. Two participants have a bachelor degree, and one with a master's degree. None of them have acquired a formal project management qualification/certification. All of them had internal project management training from the organization.

Figure 8.2 is a visual word frequency collocated cases study three table that takes all of the words from the combined CC1 virtual project team case study interviews. The larger the word the more frequently it was used in the interview. Some of the most frequent words used for CC1 are team, project, things and think. Productivity and success are also used and show up here. The project management levers that are indicated here included environment, maturity, meeting, leadership, but some areas under ICT. CIP does not show up on this word frequency figure.

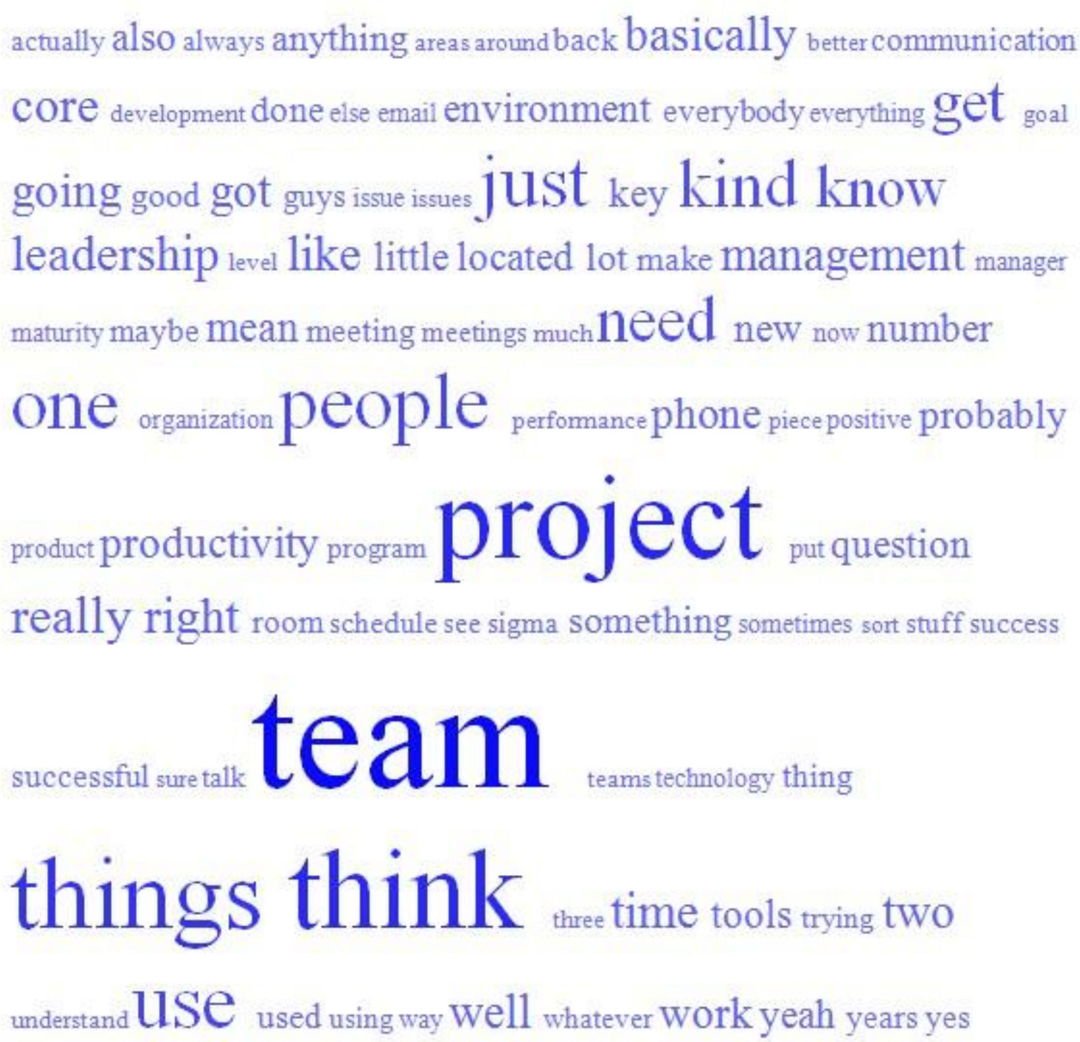


Figure 8.1 Word frequency collocated case study three

Project management levers

The researcher uses the term ‘project management levers’ to refer to his ideas of variables that impact productivity in virtual project teams and collocated project teams. The six project management levers that are used in this dissertation are environment, leadership, team maturity, meetings, CIP and ICT. These project management levers are not new concepts individually, but as the researcher has discussed he believes they play a role in the productivity of project teams in the medical device R&D organization. Details around these project management levers can be found in Chapters 2 and 3 of this dissertation. The following section on impact of project management levers will summarize and discuss the findings of the case study.

Impacts of project management levers

Each of these project levers and where they are on a continuum: environment, leadership, team maturity, meetings, CIP, and ICT are summarized in the following three tables.

Table 8.3 CC1 project management levers

The researcher’s qualitative interviews and the researcher’s points of view form the information provided in the interviews.

Individual summary:	**CTL Collocated**	**PM**	**TM**

identified by level Project management levers (0-10) 0 weak, 10 strong	project team 1	Collocated project team 1	Collocated project team 1
Lever 1, Environment	8	7	6
Lever 2, Leadership	8	8	7
Lever 3, Team maturity	7	7	6
Lever 4, Meetings	7	6	5
Lever 5, CIP	4	4	5
Lever 6, ICT	7	5	5

Table 8.4 Analysis summary from case study three of the project management levers

	CC1 case study
Lever 1, Environment	Collocation facilitates real-time meetings, which can solve issues and deliverables in a short time.
Lever 2, Leadership	Leadership is all about the helping the project team to be successful.
Lever 3, Team maturity	Maturity is positive on CC1 project teams, but project team members need the correct balance of experience.
Lever 4, Meetings	Weekly meetings and efficient use of an agenda.
Lever 5, CIP	Low CIP overall project team use and few CIP tools performed.
Lever 6, ICT	Effective use of ICT tools with the collocated team environment.

Environment

The collocated project team environment is one that has been used heavily in the past. With new technology for communications it has changed how project teams interface. With the popularity of virtual project teams, collocated project teams can also take advantage of these new and improved technologies. Participant M sees that team members can get information and answers quicker when they are collocated. Because of this ease of access to information (data, technical files, face-to-face discussion), the team can be more efficient and productive. It is a first line of communication if team members are in the same area, and the technology can be used as a backup to the face-to-face contact. One other area is that project team members that are collocated should remain on the project team full time. It is difficult to work with project team members that are part time or on other projects. Participant N agrees with participant M that collocation supports a quick conversation about most items that are needed to discuss with the project team. This participant discussed the use of a project room or war room, which is dedicated to only this project team. The war room facilitated conversations, meetings and a place to get the project team together for just about any project-related item. Participant O sees that by being near each other project team members can engage in hallway conversations or have random meetings when working in the same physical area. Issues are addressed promptly and efficiently. When this participant is hearing an issue or conversation and it is related to this person’s knowledge or specific area, a mini meeting can take place, and decisions can get completed real time with the team members. Body language is also important, and meeting face to face team members can see this part of the communication equation.

> *"The key, the whole philosophy our team says is are we setting up our people up for success so they can execute in the right environment to the point where I refuse to start a project before I was given the resources, and I was given the resources and that project ended up being successful"* Participant M.

> *"That helps and supports; it supports quick short conversations almost always about issues, occasionally about accomplishments, but because you're sitting there you can call somebody into a conversation if you're having one on the phone"* Participant N.

> *"In person you can see what people are really thinking, which you can't do over the phone necessarily"* Participant O.

Leadership

Participant M sees leadership as an important part of the collocated project team. Leaders should be somewhat predictable and know the objectives of the project so that the entire project team is working with most important information. In addition leaders should set clear expectations of the project team members and set examples for the project team. Leadership is also about project team members taking ownership of the tasks and deliverables that they are accountable for in the project. If the project team had to choose only down to one item, leadership is about clear communication every day, week and year with the project team members. Participant N again agrees with participant M and adds that leadership should be the number one requirement for a project team to be successful. If a leader on the CC1 project team cannot demonstrate strong leadership, the project will most likely have all kinds of issues with leading the team and will have an effect on schedule and cost. Leadership should not be a dictatorship or demanding, but instead it has to be a fine balance of many different leadership characteristics. High expectations need to be placed on a leader, and the leader needs to deliver. All project team members need to exhibit some type of leadership qualities in order for the project to be successful. Leadership is all about aiding the project team to be successful. Participant O agrees with participant M and N. Leadership is a key role in the success of project teams. In this organization's current environment the CTL leadership role is taking on more responsibility. Leadership is about being the cheerleader, removing roadblocks and moving the project team in the right direction as outlined in the project plan. Leadership and team environment go together with positive communication needed in project management and projects. Project team members who can support other team members in different roles is another part of effective leadership. There should be individuals who can step into their leadership role and lead a meeting, function or deliverable.

> *"So I think good leadership is a good communication and clear expectations and setting a positive example and setting a positive environment"* Participant M.

"I think leadership is probably the number one requirement if you're going to be successful" Participant N.

"I think that leadership plays a key role in this, and I'm going to count leadership as the core team leadership, so you're aware I'm defining that and the core team" . . ."I mean you need to; leadership is required to align the troops, get everybody moving in the same direction, be the cheerleader, be the pied piper of the whole thing, remove the roadblocks if we have roadblocks with upper management, that sort of thing" Participant O.

<u>Team maturity (knowledge and experience/expertise)</u>

Participant M indicates that team maturity may equal high performers, which will make the project team more efficient and require less coaching time by others on the project team. Project team members that have performed similar projects will be much easier to lead. We do have some talented less experienced people, but it takes more coaching and time to bring them to an acceptable learning curve and training them about the complex medical device R&D organization. One key project requirement is also the availability of resources; CC1 has had to start and stop because of shortage of resources. Participant N sees that they have both knowledgeable project team members and experienced project team members. The project cannot have just all inexperienced project team members or all experienced project team members, they need a mix in order to be successful. With inexperienced project team members they may have the opportunity for more discussion as on the most effective way to perform a deliverable. With less experienced project team members they would have more of a learning curve and would not most likely question a more senior person, which would also have disadvantages. It can be a delicate line of experience levels, and the CTL and PM should review their project teams to see if they have the overall best balance. Participant O indicates that project teams will always run into problems, and how project team members react is part of the maturity process. The organization needs promote the maturity of the project team to foster the right training and coaching for the people on teams. The mature project team members need to listen to the ideas of the less experienced project team members; it needs to be a balance.

> *"The more mature team you got with high performers, the more efficiency you have and less coaching and time and effort that needs to happen"* Participant M.

> *"Well yeah, you have to have people who have operated and gone through the process of working in the regulatory environment to be successful, so they can help guide you in that and guide the younger individuals in that"* Participant N.

> *"I think are sometimes they are afraid to make a stance, and I think it has to do with maturity in the job, and it's not that they're not good at what they're*

doing, it's just; you got a 20 something year matching up against a 50 something year old" Participant O.

Meetings

Project team meetings need to be efficient and not just because they are one hour or two hours according to Participant M. Weekly core team meetings occur and are two hours in length. The time at the core team meetings is usually filled with activity. This can be due to lack of an agenda, not having all of the functions present or poor facilitation of the meeting as examples. There is also an extended team meeting on schedule once a week, which is important to the project team. This meeting is typically led by one of the core team members and may include team members that are not a part of the core team. Participant N sees that having fewer meetings creates more success for the project team. This project team does use an agenda, which is helpful for getting the meeting done on time or ahead of schedule and keeping the expectations across the project team's members consistent. Leading in team meetings by helping facilitate or assigning roles is also important for CC1 project team. Participant O indicates that they guess what outside regulatory agencies will say to any of their decisions from meetings. This is an effective discussion, but sometimes we have to actually ask the outside regulators the questions. Participant O considers large meetings are not an effective use of time for the most part. This participant is not into formal meetings and presentations. Sometimes in this organization we rely too heavily on this type of meeting for communications. Participant O indicates it is important to get project team members to be present at meetings so that they can be given deliverables and be held accountable. Meeting minutes from this project were reviewed (see Appendix C3) to compare the information in the written minutes to the participants' interview information.

> *"Team meetings, I think the key there is that they are efficient, not just to fill in time"* Participant M.

> *"You know I am most successful having fewer; less instead of more team meetings"* Participant N.

> *"You can have a lot of hallway conversations and address issues promptly, quickly"* Participant O.

<u>Continued improvement process</u>

Overall there was little use of the CIP tools, and it was not the focus of this project team. Participant M indicates that they used some of these CIP tools. Design of experiments and development of requirements were performed by the CC1 project team. There was not a great emphasis early in the project team a few years ago with CIP tools, and there is more of a formal initiative to use the CIP tools and incorporate them into the schedule of development projects starting in the last year from the PMO. This project is being commercialized, and it would not make sense to do this type of work now since it needs to start early in the development project schedule. Participant N agrees with participant M and the project team used a few tools, but it was not the emphasis of the project team. Participant O agrees with M and N in that they used some of the tools. It is a requirement now in the organization to use these tools with projects starting since late 2012.

> *"We did some design of experiments that supported our efforts for that and we also used the house quality for flowing down our requirements to ensure we were meeting the requirements of expectations"* Participant M.

> *"We've used some of those things. We used an adaption of voice of the customer, Analytical Hierarchy Process and risk management"* Participant N.

> *"You're doing it no matter what. I think it's embedded, continuous process improvement is embedded in a lot of the processes and things that we do already, so to call it something different for me is kind of a little whatever"* Participant O.

<u>Information communication technology</u>

Participant M indicates that they used visual management as a tool to be able to present information concerning the schedule, risk, issues, cost, etc. There are many variations of this type of tool, and this CC1 project team used it differently though out the project depending on what the most important topics were in the development cycle. The use of IM and email were performed on CC1 project team. CC1 uses phone, email, internet, intranet, online meetings, shared desktop, IM, and sometime cell phones. Not everyone has a company cell phone; it depends at what job level a team member holds. CC1 found that having a cell phone was critical to the success of our project team. Participant M also said that their documents are on their intranet site and accessible to all of the project team members on the CC1 project. Participant N agrees with participant M in the ICT tools that were used on CC1 project team. IM could be used with many people, and this participant just was informed of this tool at the time of the interview and how to use it correctly. Project teams have different levels of ICT knowledge's and generation gaps. In order to be productive they all need to know and understand the ICT tools that will be used on the project team. Participant O indicated that they need to be careful with email and phone messages as they are archived and used for information at any time after they are sent or recorded. The shared desktop is also another tool that CC1 project team utilized and the participants indicated they had success with this tool. Participant O said video was not really used for CC1 collocated project team. This participant did agree with M and N and with the rest of the ICT tools. The shared site was also utilized a great deal by the CC1 project team. Participant N indicated it is a great place to have project team documents and get easy access to the documents.

> *"We try to prioritize a face-to-face number one, phone number two, email number three is the priority's as far as I consider effective communication"* . .

.*"So we do use the internet/site builder that's dedicated to our projects, so it's a repository for a lot of documents and the communication"* Participant M.

"Been kind of successful using text, cell phone texting back and forth occasionally too in more of an immediate response needed situation" Participant N.

"This organization doesn't pay for my phone, so it's my personal phone. It's for my convenience and not for the organization's convenience, so I don't always answer" Participant O.

Positive collocated project team levers

Table 8.5 summarizes the positive project management levers discussed by the participants.

Table 8.5 Collocated CC1 positive project management levers from the project team member's perspectives

Collocated CC1 positive project	Project team member perspectives

management levers	1. Collocated project team environment. 2. Leadership to be successful. 3. Efficient meeting time use. 4. Visual management boards were effective. 5. Shared desktop was effective.

Negative collocated project team levers

Table 8.6 summarizes the negative project management levers discussed by the participants.

Table 8.6 Collocated CC1 negative project management levers from the project team member's perspectives

	Project team member perspectives
Collocated CC1 negative project management levers	1. Less experienced team members take more time to coach and train. 2. Some experienced team members may not listen to those with less experience. 3. CIP tools are rarely used.

	4. Resources need to be available when needed. 5. Some project team members do not have a cell phone.

Medical device R&D

Participant M sees that the environment that the project teams are in at this organization and in the medical device industry creates a great deal of paperwork that is due to the regulatory and complex nature of the business. There may be opportunities and efficiencies for improving productivity by focusing on the required paperwork and improving the way it is currently performed. CC1 had a solid project scope, which will be useful for future projects in order to gain productivity with documentation. Participant N agrees with participant M in that the industry is complex in this environment. This participant also takes it a step further and discusses that the technology we are working with is cutting edge and changes quickly, which is another challenge for the project teams. Participant O also agrees with participant M and N and sees that recent changes, such as the combination product definition which is a product with two or more regulated components, will add to the current scope of future projects and also add to more documentation for new projects.

"So the bureaucracy in itself and the regulations in itself is probably not conducive productivity, but once you can define the scope then you can basically try to figure out what's the best way" Participant M.

"*I think; if you look at a lot of industries we got to be right up there in complexity of everything, not just the technology, but everything and especially now in the environment we're in"* Participant N.

"This is a compliant medical device, so it's combo product. We're having some concerns related to the test methods that are used to test pharma" Participant O.

Impact on Productivity

Project team productivity

This case study project team agreed that the project team was productive and successful. Participants M, N and O all answered 'yes' to the question "Do you feel project productivity is enhanced because you work on a virtual or collocated team"?

The project team is a complex, and the regulatory environment in the medical device industry is constantly changing. When the project adds the complexity of medical products, such as the medical devices, it increases complexity. Participant M sees that having resources fully dedicated would have a direct impact on productivity. Too many project team members in this participant's current and past project have not been fully devoted making the project team member multitask between projects. This in participant's M opinion has a negative impact on productivity. Participant N agrees with participant M in the project resources and even goes a step further to indicate that a smaller fully dedicated team would impact productivity positively rather than a larger project team that has project team members at different times. Participant N indicates another area is to perform planning earlier in the project life cycle. Identification of the goals and objectives and the steps below or deliverables and then gaining agreement from the project team and leadership would be beneficial to the project team in the short term and long term. Participant O indicates that overall team dynamics are the key to impact on productivity. A mature project team, effective leadership and positive collocated work environment will provide an impact for the project team productivity.

> *"So that probably can't always be possible based on the size and the scope of a project, but if you can have full-time individuals at and of itself is productivity, especially if that person or persons can be a little bit multi-talented and can expand their role a little bit"* Participant M.

"The other thing would be very valuable is to have dedicated teams. I'd rather have smaller teams with people 100%. We don't have that on our teams" Participant N.

"I think the team dynamics, so if you will, the leadership and the team environment and the maturity, those are very positive things in terms of project management" Participant O.

Individual productivity

Project teams consist of individual contributors. Participant M indicates that project team members need buy in from each team member and then the accountability to complete the task or deliverable. The project needs to agree on dates, cost and deliverables. There are key resources that are not needed 100%, but for the resources that are needed 100% this would have a positive impact on productivity. Participant N sees CC1 had more than a few instances where resources were required on the schedule, and when needed they could not get them, or they were not available at 100%, creating delays in the schedule that had to be made up in other ways to stay on the project timeline. Based on these instances participant O indicates that when these resources changes happen, people need to stay focused and not get upset over the changes in scope or project timing. Participant O indicates that one item that can be counted on in any project is that there will be constant change.

"So you got your individual contributors that are contributing, so you get buy-in, and you get real things that are the real dates or links or budgets and the bottom line is how many samples or product do you need" Participant M.

"Project team members should be dedicated to project teams 100% of their time" Participant N.

"I think people need to remain calm, and I think that sometimes we do not remain calm, and we respond emotionally" Participant O.

Project Team Learning and Project Success

Learning of case study team

Overall this project team was successful and productive. The collocated environment offers many advantages over being in a virtual environment as participant M indicates. Project team members are able to get information exchanged quickly without waiting for a meeting or phone call. This participant does not know how to measure it, but would offer that collocated may be more productive than other environments. Participant N as already discussed sees that up front planning and buy in from stakeholders would be in the best interest of the project team and the organization. There can be productivity gains by spending more time earlier in planning to better understand the needs, risk, customer requirements and other variables to ensure project success. Participant O sees that having the CTL, PM and a few other key project team members makes the communication cycle one that is fast with the ability to solve problems quickly. There will not be the need for as many meetings and miss-communication when project team members are so close to each other.

> *"Yes, I don't know if I can measure it, but I can say since your collocated, you basically answer questions quicker and so it's more efficient, because you're right there to ask the question and you're not waiting for a meeting or waiting to be able to talk or communicate with that person"* Participant M.

> *"I think spending more time on the very front end of the project and clearly identifying the goals, identifying the main or end goal and then clearly identifying and buying agreement to sub-goals that meet that end goal"* Participant N.

> *"So you have operations, quality, core team leader and development right there in the same like proximity, and you can have those discussions right outside of the core team leader's cube, and we solve stuff right there"* Participant O.

Improving Productivity

Project team perspectives

Participant M would recommend collocated project teams as a way to improve productivity on a project team. CC1 had a productive team based on the three participants interviewed on the project team and with this environment; they were able to stay clearly focused during their project. Participant M sees that the CC1 project team was able to reduce time to get problems solved and deliverables completed on time. Participant N sees that leadership is the area that project teams need greater focus in order to ensure project success, and spending time up front to plan and organize the project will enhance project team member's productivity. Participant O sees that alignment with the CTL, PM and project team members are key to the overall success of the project. Being able to have the same goals, objectives and know what the deliverables and cost are will potentially improve the productivity of the project team. The collocation piece is also another area that worked well with CC1 as we were able to get things done so quickly by just talking about issues and solving them right away.

> *"So I would say the fact that you're collocated adds to efficiency because it reduces time to address any topics that need to be addressed"* Participant M.

"I guess I have to believe positive leadership is number one key" Participant N.

"When we are not in alignment with our core team leader and our core team, it is not possible to be successful" Participant O.

<u>Individual perspectives</u>

The resources on CC1 were not always there as already discussed in this chapter. Participant M would like to see future projects have dedicated resources where it makes sense but also have the needed resources or what the project was promised in the project plan. These resources would also be multi-talented or would be able to fulfill multiple roles. This approach would enhance productivity without the need for additional project team members. Participant N said email, IM, cell phone and other ICT technology worked well for CC1, and it enhanced productivity and would do so for other future projects. CC1 used the face-to-face contact as the first type of communication but also incorporated ICT technology to offset people that were not able to be on site. Participant O agrees that individuals that are collocated will improve productivity. It is an advantage to actually overhear a conversation about the project with the CTL sitting nearby and then being able to answer or determine a solution immediately.

> *"But if you can have full time individuals at and of itself is productivity, especially if that person or persons can be a little bit multi-talented and can expand their role a little bit"* Participant M.

> *"Email allows for that one person who can contact several individuals with exactly the same information"* Participant N.

> *"I literally sit right next door to the CTL and PM, and so when the PM is talking about an issue, I hear it when I'm at my desk"* Participant O.

<u>Medical device R&D perspectives</u>

Participant M indicated there is a great deal of paperwork when working in a regulated environment. Many project team members would rather not spend so much time on documentation, but it has an important role in the industry and this organization. To be more productive leaders will have to work on ways to streamline the documentation process with projects and the larger organization. This is no small task, and one that is changing with new technology, software, regulations and a complex product environment. Participant M indicates that project team members also need to have the scope approved early in the project to keep changes to a minimum later in the project. With medical device products complexity the project needs to have an effective plan up front and then effective leadership to execute and manage. Participant N really wonders if the organization hides behind the complexity of our projects and products. This can be used as an excuse too many times when the situation may be complex, has cost overruns, or if the schedule is late. The key perhaps is to better understand the strategy and scope early in the project life cycle to reduce complexity. Participant O sees that since we are in a regulated industry and with the ever-changing requirements and complexity project teams need to play a larger role. Many decisions made early in the project need to have regulatory buy in in order to ensure project success and timeliness. Members of the regulatory agencies typically are in the best position to know the current and even future changes to the medical device industry.

> *"I think the key, because you're right, the environment is a lot of paperwork, there's a lot of things that engineers don't like to do, because you have to document everything or whatever. That kind of goes with the turf, so that in itself probably doesn't; not conducive for productivity,, but I think the key is, is ensuring you scope everything properly upfront so you know what has to be done and from knowing what you have to be done, figure out the smartest way to do it"* Participant M.

> *"I wonder, I truly wonder if sometimes we don't hide behind that complexity a little bit"* Participant N.

> *"I mean obviously regulatory is huge on this particular team, because of strategy"* Participant O.

Case Study Conclusions and Summary

In summary collocated project team CC1 participants viewed this project as being successful. There was variability between participants. This chapter investigated the impacts of productivity in project team CC1 in a medical device R&D organization. The case study CC1 is a project representing a project consisting of a medical device, therapy, which is a class III device. The project team size consists of less than 50 people. The end product is being released or is commercialized as the interviews were being conducted. This case study consisted of a product that is within six months of commercializing during the interviews. Since the interviews in early 2013, this case study project has commercialized its product. This project team has both positive and negative impacts around the project management levers. CC1 project team members all see that this project was successful and productive. The views of the three participants of this case study on impacts of productivity in medical device R&D have been discussed in this chapter for case study three.

Based on the participants' feedback in the interviews both positive and negative perspectives were discussed. These are individual perspectives form the project team that either had strong views or a consistent theme from the project team.

CC1 is a medium-sized project team in this organization when compared to other projects in the organization R&D area. There are many more communication channels and potential problems when projects have so many project team members. The positive and negative tables outline the highlights from this case study. The demographics also give a snapshot of the participants and their maturity and educational backgrounds. The project team in CC1 has an effective collocated project team environment, leadership, team maturity, meeting practices, lower use of CIP and effective ICT. CC1 project team is similar in environment, leadership, meetings, and ICT when compared to the conceptual development and literature reviewed in Chapters 2 and 3 of this dissertation. The project team has been able to deliver a project to commercialization while improving on a positive collocated project team environment, effective leadership and the ability to use ICT tools. This contributes to success and productivity of this project in the medical device R&D organization.

As observed in most teams there are areas for improvement. The CC1 project did lack some maturity issues with less experienced project team members, and the ability for these project team members garner needed respect from more experienced project team members. Other opportunities for improvement are the ability to add resources or obtain resources when needed according to the project schedule. The shared desktop technology under ICT was positive with all CC1 participants even though this is a collocated project team. ICT could be improved with all project team members having a cell phone. Project team members with a personal cell phone were reluctant to use it in the office. The low use of CIP for CC1 is an indication of the relative low maturity of this area from the organizational management. The CC1 case study project was started many years before a formal CIP process was in place. CC1 as a project team was able to work as a collocated project team in order to achieve productivity and project success.

Chapter 9: Case Study Four Analysis

Introduction

Case study four will attempt to further our understanding of the impact on productivity in the virtual project teams and collocated project teams in an R&D medical device organization. The following will explain the process used to interview the participants and the outcome of the information.

Table 9.1 outlines the overall framework for this chapter and case study four. Two teams were virtual project teams and two teams were collocated project teams. Each team consists of three participants that are a core team leader, project manager and a team member. The purpose of this chapter is to present case study analysis of the second case study team. The case study project team consisted of a medical device, software, which is a class III device. The total project team size consists of less than 50 people. The end product is being released or is commercialized as the interviews were being conducted. Since the interviews in early 2013, this case study project has entered into commercializing phase of its product life cycle. In addition, a list of triangulation documents (see Appendix C4) was reviewed. The findings in this chapter are from project team CC2 and the three participants P, Q and R.

<u>The case study team</u>

Deliverables for CC2 project team

1. Description: Collocated project team, first generation class III device, medium-sized team less than 50 people, two year project.
2. Current status: Project near completion and in final status.
3. Type: Software.
4. Project type: R&D medical device.
5. Virtual continuum: 8 (see Chapter 1 Table 1.2)

Table 9.1 Case study CC2

Type of study	**Project team**	**Participant**	**Code**
Collocated	Collocated project team 2 Software	CTL PM TM	P Q R

The case study participants

Three participants were interviewed for this case study. All project team participants are members of this project. Participants in this study are identified as P, Q and R. The demographics of the three participants are summarized in Table 9.2.

CTL Participant P

Participant P has held key R&D roles as a manager, CEO and core team leader. Participant P also has had internal organization project management training.

PM Participant Q

Participant Q has had key roles as an engineer and project manager. Participant Q also has had internal organization project management training.

TM Participant R

Participant R has had key roles as product support engineer. Participant R also has had internal organization project management training.

Table 9.2 Demographic summary of case study three participants

Number of participants	**Three**
Current position on CC2 project team	One core team leader One project manager One team member
Years of service in current position	Two years to 11 years (average: 6.3 years)
Years of service in medical device industry	Six years to 22 years (average 13 years)
Highest education level	Two masters degrees

	One Ph.D. degree
Project management training	All internal company project management training
Size of project team <20, <50, >50, >100	<50

Collocated Project Team Two

All three participants had over six years of medical device working experience. The average was 13 years. The participants had spent most of their careers in the medical device field and the majority of that time for most participants was in the R&D organization. One participant had held over four different positions within the medical device industry. All participants have a master's degree, one with two master's degrees and one with a Ph.D. None of them have acquired a formal project management qualification/certification. All of them did have internal project management training from the organization.

Figure 9.2 is a visual word frequency from collocated case study four table that take all of the words from the combined CC2 virtual project team case study interviews. The larger the word the more frequently it was used in the interview. Some of the most frequent words used for CC2 are team, project, think and things. Productivity and success are also used and are shown in the table. The project management levers that are indicated here include environment, meetings, leadership, but some areas under ICT. CIP was not mentioned in this word frequency figure.

Figure 9.1 Word frequency collocated case study four

<u>Project management levers</u>

The researcher uses the term ‘project management levers’ to refer to his ideas of variables that impact productivity in virtual project teams and collocated project teams. The six project management levers that are used in this dissertation are environment, leadership, team maturity, meetings, CIP and ICT. These project management levers are not new concepts individually, but as the researcher has discussed, he believes they play a role in the productivity of project teams in the medical device R&D organization. Details about these project management levers can be found in Chapters 2 and 3 of this dissertation. The following section on the impact of project management levers will summarize and discuss the findings of this case study.

Impacts of project management levers

Each of these project levers and where they are on a continuum, environment, leadership, team maturity, meeting CIP, and ICT are summarized in the following three tables.

Table 9.3 CC2 project management levers

The researcher's qualitative interviews and the researcher's points of view form the information provided in the interviews.

Individual summary: identified by level Project management levers (0-10) 0 weak, 10 strong	**CTL Collocated project team 2**	**PM Collocated project team 2**	**TM Collocated project team 2**
Lever 1, Environment	7	8	8
Lever 2, Leadership	7	8	6

Lever 3, Team maturity	7	6	8
Lever 4, Meetings	6	6	7
Lever 5, CIP	3	4	2
Lever 6, ICT	6	5	6

Table 9.4 Analysis summary from case study four of the project management levers

	CC2 case study
Lever 1, Environment	Focused collocation environment in a project/war room worked well for this project team.
Lever 2, Leadership	CC2 had strong and driven leadership on this project.
Lever 3, Team maturity	CC2 had a mature project team, and they were able to select the team members.
Lever 4, Meeting	Meetings were used only when needed, but CC2 could have improved on meeting efficiency.
Lever 5, CIP	Only a few CIP tools were used.
Lever 6, ICT	CC2 utilized most ICT tools during the project.

<u>Environment</u>

CC2 project team is a collocated project team environment. Participant P sees collocation as a way to resolve problems quickly and enables hallway conversation to move the project forward, which could not be achieved without a collocated project team environment. This project team was collocated in an open team environment or a large room in which each of the core project team members are together. This was a first for many project team members with a focused collocation environment. The output on CC2 was more efficient than the typical process at this organization. The project team requires an effective leader for success in this type of environment. Since the organization has different interests and priorities, with this type of focused collocation environment team members have to adapt quickly. With the same organization's engineers, environment and process participant P said we were able to achieve a higher productivity. The focused collocated environment enabled the project team to connect at all times of the project. Participant Q had a similar view as participant P in that the collocation was a positive part of the project success. Participant P noted being able to see most of your project team in the same room across from each other all day was effective for communication and moving the project forward. The day-to- day work is impacted and sometimes even by the hour. Having project team members sitting right next to other project team members gives the ability to move to a white board and discuss issues to solve a problem and complete deliverables quickly. Participant R agrees with participant P and Q in that collocation is valuable to this project team. It makes it easy to simply talk in depth as required and create actionable items to work toward by the project team. This participant thinks that innovation is encouraged when team members are sitting so close to each other. The interactions are valuable with other people listening and being able to become part of the conversation at a moment's notice. Sometimes, however, project team members have to find space outside of this room to just have quiet and concentrated thinking time.

"Yeah, I mean main thing is you want to get stuff done and you needed to communicate with people, and it's always very helpful when you can walk outside into the hallway and talk to the folks that you need to in order to get problems to discuss and resolve" . . ."So that co-location helps a lot that way" Participant P.

"I mean collocation to me, gives you speed of information transfer" Participant Q.

"Well I think collocation in our case was very valuable" Participant R.

Leadership

Leadership is a large part of any project team in order to be successful. Participant P sees that leaders need to ensure predictable, understanding of objectives; be effective communicators, set positive examples and clear expectations. As the project leader performs more leadership roles a number of times it usually becomes more efficient. You need talented people, but assuming that the project already has them, it is leadership which will move the project team forward. Leadership is about planning and execution, and these are the basics of project management. A leader will set the tone with attention to project scheduling, costs and risks. CC2 had a driven leadership style in the CTL and the project management methodology. Participant Q sees leadership similarly to participant P. Leadership is importation for setting direction and creating communication below and about the project team. Leaders need to set the tone and show examples to project team members of effective leadership. Leaders need to understand the needs from schedule, cost and risk perspectives and share this information with others on the project team. Leading is about helping the project team succeed, however that may be during a project. Participant R indicates agreement with participants P and Q in that leadership plays a key role especially with the CTL. CTLs as leaders are taking on more work and accountability in the organization. CTLs as leaders need to be careful when to include others into discussions as it can be counter-productive to the project team. For example, a CTL could jump to a root cause or conclusion without understanding all of the details of the problem. The CTL can be a really strong leader, and if team members disagree, they may be reassigned. The CTL could use his or her influence to remove team members or block others from becoming a part of the project team.

> *"Leadership is crucial to direction setting, risk management, resourcing, budgeting. I mean this is all stuff that typical leaders do, in addition to the nuts and bolts of pure project management are planning and execution"* Participant P.

> *"I think leadership, very important from setting direction and making sure; the communication part of leadership I think"* Participant Q.

"I don't know what you mean by leadership beyond that, but I think the CTL sets the tone and people fall in line with that or they are not part of the project" Participant R.

Team maturity (knowledge and experience/expertise)

CC2 project team is knowledgeable as a project team. Participant P indicates that there is really effective knowledge in certain areas of the project team. The project team also relied on outside suppliers to gain expertise in other areas that they did not have on the internal project team. Even though CC2 had many mature project team members, this collocated and open environment was new to many on the project team. Knowledgeable resources were needed at different times of the project. It would be an improved process if a project team could bring in knowledgeable resources only when needed as the project schedule would indicate. Participant Q agrees with participant P in that this project team relied on the maturity of the outside suppliers to add competencies lacked by the internal project team. Project team maturity in general was a major asset to the project team. Participant R indicated that CC2 was able to select the project team members, and they had many mature project members. Even with mature project team members this project was complex, and it still was difficult even with the experience and knowledge or maturity of the team.

"It takes a while to create that talent and expertise to kind of do that. For many on my team, this was the first time they had to work in an environment like this, so it had its set of challenges" Participant P.

"They do it sometimes better than we do in cases and so that; it's under a team maturity. That's also a big asset" Participant Q.

"They were able to pick what they considered to be good, knowledgeable, experienced people and that's all fine, but again this is a complex project, and I don't know that all of our experiences, all of our skills, all of our training were up to all of the complexities" Participant R.

Meetings

The CC2 team met on a weekly basis on mostly on the technical side of things during the project. Participant P tends not to hold large scale meetings regularly. Communication needs to happen at the organizational level, but this participant is not a proponent of formal meetings and presentations. When meetings do occur the CTL expects that everyone would be present to discuss plans and deliverables and then holds them accountable. Meetings have their place but if team members can solve something in five minutes why have a formal meeting. Participant Q indicates that CC2 has daily meetings with different groups. There were issue resolution meetings, deep-dive meetings and stand-up meetings. Meetings need to be effective, and sometimes there are too many people in a meeting that do not need to be there, but team members were unsure because of lack of preparation or knowledge of what the meeting topic was for the meeting. Participant R said there was very few meetings and felt it is an effective approach. This participant agrees with participant P, in that if projects can have a quick meeting between people that are near each other why call an actual meeting. It saves time and money and brings more efficiency to the project team. The collocated project room served as a great place to hold discussions in the course of a normal work day and get problems solved quickly. Meeting minutes from this project were reviewed (see Appendix C4) to compare the information in the written minutes to the participants' interview information.

> *"I personally am not a big proponent of large-scale meetings"* . . .*"I like more of a collaborative, ad-hoc, get together the right number of people that need to get together to solve the problem"* Participant P.

> *"The bigger team meetings will be used to set direction understand key issues, communication of barriers, all that kind of classic things"* Participant Q.

> *"By the time the meeting is held and is over, it's irrelevant, because things have changed"*. . ."*We'd be having our own meeting, maybe 15 or 20 seconds to work something out, and that was very effective"* Participant R.

Continued improvement process

Participant P realizes project teams need CIP, but they can use many tools to accomplish CIP. The project does not have to use a specific tool and then continue with that tool. The process is more important than the tool itself. Participant Q indicated that they did use one type of CIP called Failure Mode Effects Analysis (FMEA). But for the most part the project team was not focused on CIP on CC2. Participant R sees that CIP is just effective engineering and that the organization will need to develop it into each project team member's way of doing business in the future.

> *"Not Lean Sigma, Six Sigma, but we did use the other in terms of metrics that we had set ourselves for tracking and measuring performance"* Participant P.

> *"So we use those tools to particularly understand longevity, FMEA type analysis"* Participant Q.

> *"Now people will say we do CIP all the time, because that's good engineering, but that's not what you're asking"* Participant R.

Information communication technology

The CC2 team has an effective understanding and uses most of the ICT tools. Participant P used Skype, IM, email, phone and desktop sharing. CC2 also used the shared website and intranet. Outside development partners could easily work with our site to collaborate with us. Participant Q agrees with participant P with most of the ICT tools except video. Occasionally they used shared desktop and IM. Participant R agrees with participant Q in the video usage. Participant P indicated the use of Skype with vendors was effective, but participant Q indicated that project team video did not work well when they needed to communicate with the outside partners. There are too many issues with setting up the video system and using it. CC2 relied heavily on teleconferences and email documents. Participant R said phone, email and IM were used a great deal as already indicated by participant P and Q. When working with outside partners one also has to be aware of speaking skills versus writing skills for people outside of the organization's country or when English is not their first language. The other ICT systems used are part of the organization's formal documentation system. CC2 had a more open style when it came to cell phones. It did not matter if they had a personal cell phone or work cell phone; they used them when needed.

> *"These days everything; we use everything, right. We use Skype. We use phone. We use email"* Participant P.

> *"We use conference calls all the time, and we will email documents out before our meeting starts and then reference that page through and occasionally use*

the sharing Live Meeting mechanisms, but not video, and then of course use email and IM" Participant Q.

"That kind of thing is necessary as well as patience and a growing understanding of language barriers, terminology, speaking skills versus writing skills. It all came into play, and even some socialization since what's considered polite or impolite is different from place to place" Participant R.

<u>Positive collocated project team levers</u>

Table 9.5 summarizes the positive project management levers discussed by the participants.

Table 9.5 Collocated CC2 positive project management levers from the project team member's perspectives

	Project team member perspectives
Collocated CC2 positive project management levers	1. Focused collocated project team environment. 2. Strong leadership on the project team. 3. Mature project team members. 4. Efficient use of meetings.

	5. Effective use of ICT tools and cell phones.

Negative collocated project team levers

Table 9.6 summarizes the negative project management levers discussed by the participants.

Table 9.6 Collocated CC2 negative project management levers from the project team member's perspectives

	Project team member perspectives
Collocated CC2 negative project management levers	1. Project team members need quiet time outside collocated room. 2. Complexity of the project is too much for some of the project team members. 3. Meeting preparation and the number of people in meetings. 4. CIP tools used very little. 5. Video did not work for this project

	team.

Medical device R&D

Medical device R&D project teams are not unique in that they deal with regulations similar to many other project teams in other industries. There are many companies that also deal with regulations outside of the medical device industry. Participant P sees that it comes down to attitude and problem solving. It is about looking for new ways to solve problems and still comply with the requirements, standards and regulations. When project team members work in a business that saves lives, they are trained to think differently when they are designing and developing products that will extend and save people's lives. Participant Q indicates that modeling is used and will be used more in the future to help predict the reliability of medical devices. This type of tool can save time once it is established and increase productivity and reliability. Participant R agrees that this is of course a regulated medical device industry, and it takes more effort to perform in R&D since it is a medical product and not a commercial product.

“I mean we do, we are in a very, I suppose, lifesaving business, and people are trained to think a certain way and approach product development in a certain way for good reason” Participant P.

“Because it’s Class III medical, we rely on a lot of these tools to model that which can’t be tested and get to levels of predictability in the up-front design work” Participant Q.

“Yes, this is more complex than a general commercial product, because it’s a regulated medical industry” Participant R.

Impact on Productivity

Project team productivity

This case study project team agreed that the project team was productive and successful. Participants P, Q and R all answered ‘yes’ to the question “Do you feel project productivity is enhanced because you work on a virtual or collocated team”?

Participant P sees that productivity was impact by the results of CC2 project. The project team was able to perform this project in a shorter time than any other comparable project. This participant is new to the organization and came to the project team as a CTL with different ideas. With the current organization structure, engineers and project team environment, the overall results were improved productivity of the project. This type of focused collocated project team came with a cost. The execution model used was not a model that could be sustained in this organization. Project team members would be ineffective if the model was used into the future. Many project team members were not able to keep up with the high pace and micro management. The daily pace was too quick for many team members as participant R indicates. Participant P indicates that this approach takes some of the positive parts of the new execution style and molds it with the current organization and process is most likely the best approach to a new project in this organization. Participant Q said they need to have the right people on the project team. Meetings and other communications need to have some planned thought to keep the people and the communication channels to a minimum. Too many people involved in a meeting for the simple fact of including them can be counterproductive. Planning up front with roles and responsibilities would be a productive way to keep the communication crisp and concise. Participant R indicates that deliverables are important to the success of the project. All project team members need to know their deliverables, timing and impact on other deliverables. There also needs to be a sense of urgency and accountability with these deliverables. This has a direct impact and the project team productivity.

> *"Look, in the end of productivity of the group to a large extent is set by the attitude and the drive of the team leader, okay"* Participant P.

> *"You don't always know who you need, so then if you have everyone in a meeting, then you have a couple that aren't productive and so how do you partition that design of the system and then create subunits and how those subunits communicate to each other is one opportunity for improvement"* Participant Q.

> *"I think it would just be the deliverables. To complete a project you need to complete a long list of deliverables. Deliverables to transfer to manufacturing, to transfer to the Design History File, file, to transfer what you know, and those were all delivered"* Participant R.

<u>Individual productivity</u>

Participant P already indicated that the model used for CC2 would not be sustainable. It is partially up to the individuals and a change in attitude and problem solving. This can be facilitated with training and tools for problem solving. This is not an easy task in this organization as there are many initiatives that focus the project team's time. Participant P indicates that there is room for productivity improvements with individuals, but it will also need to have senior management approval for the scope of work. Participant Q sees that an individual can have an impact on productivity with pre-defined roles and responsibilities. This was partially performed on CC2, and it worked effectively and had an impact on the success of the project. Participant R also agrees with participant Q, and said CC2 could have improved on its role and responsibilities. The CC2 project had in some cases project team members that assumed other project team members were performing deliverables when they actually were not. This had a direct impact on the overall project schedule. With the CC2 project team collocated and focused in mostly one room, it was able to overcome most of these types of issues with informal discussion in the collocated project environment.

> *"So the answer is that yes, productivity improvements are in fact possible, but I don't think they are sustainable"* Participant P.

> "*So that comes with good role definition and good definition of the outcomes and responsibilities and what each individual would be held accountable for"* Participant Q.

> *"I was assuming things were being done or other people assumed things were being done that in fact weren't done"* Participant R.

Project Team Learning and Project Success

Learning of case study team

Overall this project team was successful and productive. Participant P sees that if project leaders could find an even more efficient way to bring the right skill sets on the project team at the right time that would improve operational efficiency and productivity. By keeping many internal or external project team members on the project during times that resources are not needed, the project team has to incur all of that cost. This is not the most efficient way to run a project. Knowing what skill sets are needed and when a skill set is required can really improve the project team's productivity. Participant Q indicates that projects need to have up-front planning and a solid strategy before they start the project. The execution after the planning has been completed needs to remain through the project life cycle. The team prepares the plan, has it approved; when there are changes, the team updates the plan. This is a changing target and a complex target in which it takes careful consideration of many pieces through the project. Participant R agrees with participant Q in that an effective plan should be set early in the project and updated and followed during the project. The project team needs to be able to see the goal and the steps needed to get there. This drives accountability and alignment through the project life cycle.

> *"By using you know flexible teams from the outside to augment a core internal team, we basically bring in the skill set that we need at the right time and then when we don't need or we pass that need, we basically let go"* Participant P.

"So it's one thing to get the engineering part right, but then to get all the process steps right as we've laid them out and to bring those teams on board and get them working in fluid step with each other, it really requires you to think through your strategy" Participant Q.

"I think it would be really good to have a good plan at the beginning and a way to update it periodically. We started that way, but it fell by the wayside as I said. I don't know how to establish that plan or maintain that plan better after what we've been through" Participant R.

Improving Productivity

Project team perspectives

Overall, the R&D organization may need to change and improve in order to gain effective improvements in productivity. Beyond the R&D organization the overall organization may need to also adapt to improvement as all of the projects are cross-functional project teams. The quality team, reliability team, R&D team, manufacturing team, etc. may need to operate in a different fashion. Participant P on the CC2 project indicates that this project team had productive results; however, the results for CC2 could have been even more improved if the CTL did not have to compromise. If the R&D process could have been written and invented differently

CC2 would have gained even more with productivity and ROI. It is difficult to try and create a new environment, a new process and new attitudes. Participant P indicates for future projects utilizing outside development partners, a process and simple spreadsheet to outline return on investment, net present value, etc. should be prepared to make sure the project team has the right partner for this project. Project team members would be pulled back into ineffective methods, and it was difficult to improve with new approaches. It is basically moving away from the old paradigm shift and into a new paradigm. Participant P indicates that if the organization as a whole is a matrix organization and changes are made to the R&D organization, we also need to have the other parts of the organization change to get true improvement. Participant Q sees that the ICT tools are effective. There could be more training in the use of ICT tools. Project team members were not all familiar with all of the available tools. Participant Q indicated that the tools could be added to the strategy of the project or in the early planning process to gain the alignment of the project team. Meeting efficiency is another area that CC2 project could have improved. More thought needs to occur on how these meetings can be conducted with the most efficiency for the project team. Participant P also agrees with participant Q in meeting effectiveness. Participant R sees that planning up front is one of the most impactful things that could have been done more effectively on CC2. Without a plan the project team will not know where they need to go and work on the right deliverables for the project. If resources are needed from a different group outside of R&D it is difficult to get them when we cannot show the functional leader a plan.

"So it can't just be one team that's doing things differently, because I depend upon the quality team, the reliability team, the manufacturing team, the sourcing team, the operations team, the regulatory team, the marketing team" . . ."In fact if you think about what we achieved with this project, basically it's the organization's engineers, environment, and process, but they still got higher productivity" Participant P.

"I think having in terms of the location itself and the tool set, I mean I think we've got a good set of tools for what we do. I think some of the organization and the team in terms of how you split that up so your meetings are most effective, so it's difficult" Participant Q.

"*Good communication device too, especially when things are being done at different places, you know that it's going to come together"* Participant R.

<u>Individual perspectives</u>

CC2 participants all feel strongly in the focused project team environment. Participant P feels that people need to be present at work and work efficiently. Seeing people at work interacting and innovating is effective teamwork. This participant trusts his people but also feels that the interactions and communication are valuable part of the project success. Participant P also said key decisions makers need to collaborate and have face-to-face interaction. If the CTL has a choice everyone would be at work every day. There is a place for working at home but typically not on complex medical device project teams. Participant Q agrees with participant P in that the focused collocation created efficiency for the CC2 project team. This brings a sense of urgency and obligation to the other project team members. It drives overall productivity and success for the project team. Again, participant R agrees with P and Q in that the focused collocation project team environment was interactive, and by people hearing other people's conversations it drove many discussions that solved problems quickly and did not have to rely upon new meetings, emails, IM, video or other ICT tools.

> *"So I've kind of looked at what works well and efficiently and I believe in people showing up to work to work"* . . .*"I don't people just being you know, stay at home and work. I just don't like that; I just don't believe that; not that I don't trust them"* Participant P.

> *"So I think there's a ton of efficiencies to be gained from the collocation and I think again, from a sense of obligation and mission to your fellow co-worker"* Participant Q.

> *"There's another thing that comes along with this and I think this has to be noted. That because we're so highly interactive, that people were overhearing each other all the time, everybody was everywhere"* Participant R.

Medical device R&D perspectives

CC2 project team experimented with some different methods that have not been used in this organization in the past. Participant P indicated that the project team was able to take a more aggressive risk management approach for this project. This more aggressive process was a pilot that the CTL and senior management agreed to try as a model for future projects. CC2 is a software project, and it is not directly an implantable device by itself. Participant Q sees that we develop products for the improvement of life and sustaining life or patients and being in this type of a regulated environment, each project team member needs to think through the quality and safety issues. Each member of the project team has an important job to ensure that the products we produce are the best quality and reliability that they can be. This needs to align with the most current standards and regulations in order for overall success in commercialization. Participant R understands that with complex products come with complex interactions. These interactions are not only taking place on the R&D project team but also cross functionally. Participant P indicates that each project team member needs to work toward changing the culture in order to improve business and project effectiveness.

> *"So you can take a little bit more aggressive risk management toward that you might not take when you design an implantable medical device"*
> Participant P.

> *"What's unique about Class III is you really have to think through those things differently in a regulated environment and where you have safety and quality issues at stake"* Participant Q.

> *"Maybe it's the nature of products in general or ours in particular, but there's a lot of cross-functional or inter-functional interactions. And they were complex, they were changing with time and it's hard to put that on paper"* Participant R.

Case Study Conclusions and Summary

In summary, collocated project team CC2 participants viewed this project as being successful. There was variability between participants. This chapter investigates the impacts of productivity in project team CC2 in a medical device R&D organization. The case study CC2 is a project representing a project consisting of a medical device, software, which is a class III device. The project team size consists of less than 50 people. The end product is being released or is commercialized as the interviews were being conducted. Since the interviews in early 2013, this case study project has commercialized their product. This project team has both positive and negative impacts around the project management levers. CC2 project team members all see that this project was successful and productive. The views of the three participants of this case study on impacts of productivity in medical device R&D have been discussed in this chapter for case study four.

Based on the participants' feedback in the interviews both positive and negative perspectives were discussed. These are individual perspectives from the project team that either had strong views or a consistent theme from the project team.

CC2 is a medium-sized team in this organization when compared to other projects in the organization's R&D area. There are many more communication channels and potential problems when projects have so many project team members. The positive and negative tables outline the highlights from this case study. The demographics also give a snapshot of the participants and their maturity and educational backgrounds. The project team in CC2 has a very effective collocation project team environment, effective leadership, effective team maturity, effective meeting practices, lower CIP and adequate ICT. CC2 project team is similar in environment, leadership, meetings, and ICT when compared to the conceptual development and literature in Chapters 2 and 3 of this dissertation. The project team has been able to deliver a project to commercialization while improving on technology tools, a positive team environment and effective leadership. This contributes to success and productivity of this project in the medical device R&D organization.

As observed in most project teams there are areas for improvement. CC2 project team members did need a meeting area outside of the collocated project environment for thinking time. The complexity of this project was at times too much for some of the project team members to handle. This can be a problem if project team members simply stop working because of the overwhelming complexity. Team members at time feel overwhelmed and need to just get away from the high pressure of CC2 project. Meetings should be organized around only the people that need to be there and not include others just for the sake of including them. A large amount of ineffective time and resources will result if these practices persist. The leader of the project team should have a method to deal with productive meetings and share it with the rest of the project team. The low use of CIP for CC2 is an indication of the relative low maturity of this area from the organizational management. The CC2 case study project was started many years before a formal CIP process was in place. Video (with outside suppliers) was utilized at a larger scale with the project team and was not efficient since it was difficult to set up and use. CC2 as a project team was able to work with outside partners in order to achieve productivity and project success. CC2 is another example of project success, and lessons learned from this project team can be shared with future project teams in this organization.

Chapter 10: Case Study Comparative Analysis

Introduction

This chapter is the product of comparing the case studies of two virtual project teams and the two collocated project teams from the same R&D medical device organization. This is performed by reviewing the project management levers and the overall productivity of each of these project teams. “High performing employees result in high performing even outstanding organizations” (Martin, 2012, p. 153).

The four project teams are all medical device R&D project teams. Each project is a different type of medical device product (device, hardware, therapy, and software), and each project team during the interview process was actively getting ready to commercialize the product. All project team members interviewed relied on different levels of project management levers in order to perform as productive project teams. The following sections of this chapter will review the similarities and the differences across the four case studies.

Project Management Levers

Comparing the four case studies, they have some differences in productivity in the medical device R&D organization. The following sections summarize the comparisons and tables and figures to provide highlights about the research. Table 10.1 reviews the overall project team participant demographics, Table 10.2 indicates the various levels of virtual project team and collocated project team on a continuum, and finally Table 10.3 is a summary of the project management levers from each of the four chapters.

Table 10.1, the demographic summary of all case study participants, CTL, PM and TM, indicates that the years of service on the position within the project team and on the project is between three years and 6.3 years with an average of 4.9 years. The years of working in the medical device industry is between 13 years and 22.7 years with an average of 18.2 years. This appears to be a more experienced work force both on the projects and in the industry from the demographics collected in the case studies. The educational background varies from a bachelor's degree to a Ph.D. degree. In all of the 12 interviews, all but one interviewee has taken project management training with the internal organization's project management training courses. The size of the project teams for the four cases vary with over 100 project team members to under 50 project team members. The organization under study is in a matrix organizational system.

Table 10.1 Demographic summary of all case study participants

Demographic	**CV1**	**CV2**	**CC1**	**CC2**
Current positions on each project team	CTL PM TM	CTL PM TM	CTL PM TM	CTL PM TM

Average years of service in current position	5 years	3 years	5.3 years	6.3 years
Average years of service in medical device industry	22.7 years	15 years	22 years	13 years
Highest education level on project team	Bachelor’s degree	Master’s degree	Master’s degree	Ph.D. degree
Project management training	All internal company project management training	All internal company project management training, except one person who had taken college courses	All internal company project management training	All internal company project management training
Size of project team <20, <50, >50, >100	>100	<50	<50	<50
Organizational type	R&D	R&D	R&D	R&D
Organizational structure	Matrix	Matrix	Matrix	Matrix

The degree of either a virtual project team or a collocated project varies from project to project on a continuum and can be found in Chapter 1 (Table 1.2) of this dissertation. The project management levers were used along with the description of the project versus the definition in this dissertation to determine the overall continuum ranking. CV1 is high in the continuum as a virtual project team with its very large size, time zone differences, different manufacturing sites, multiple outside partners and high use of ICT tools. CV2 is medium in the continuum as a virtual project team with its smaller project team size, minimum time zone differences, multiple outside partners and high use of ICT tools. CC1 is high in the continuum as a collocated project team with a smaller project team size, no time zone differences, one manufacturing site, and lower use of ICT tools. CC2 is medium in the continuum as a collocated project team with a smaller project team size, two manufacturing sites, multiple outside development partners and a medium use of ICT tools.

Table 10.2 Summary virtual or collocated continuum

Team	**V 100%**	**High**	**Medium**	**Low**	**Low**	**Medium**	**High**	**C 100%**
	10	7	5	3	3	5	7	10
CV1		**X**						
CV2			**X**					
CC1							**X**	
CC2						**X**		

Table 10.3 is a high-level summary of all of the project management levers.

Table 10.3 Analysis case study project management levers

Project management levers	**CV1**	**CV2**	**CC1**	**CC2**
Lever 1, Environment	Environment is important, face-to-face when possible is preferred,	Different time zones present some issues, but virtual	Collocation facilitates real-time meetings, which can solve issues	Focused collocation environment in one room worked well

	and technology and improved tools make virtual project teams possible.	project teams add more flexibility.	concerning deliverables in a short time.	for this project team.
Lever 2, Leadership	Leadership is the highest ranking item of the project management levers and of the four case studies. All participants see leadership as important to project success.	Leaders need to get things done and be technically competent.	Leadership is all about the helping the project team to be successful.	CC2 had strong and driven leadership on this project.
Lever 3, Team maturity	This project team was able to select their project team members, which mainly was based on experience.	Project team members were experienced, but outside development partners did not always have the experience needed.	Maturity is positive on the CC1 project team, but it needs the correct balance of experience and knowledge.	CC2 had a mature project team, and it was able to able to select the team members.
Lever 4, Meetings	A effective mix of meetings were use on this project team, and new tactics and technology were implemented.	Cross-functional meetings were used. If more meetings were needed, the project team simply had them.	Weekly meetings were efficient and used an agenda.	Meetings used only when needed; CC2 could have improved meeting efficiency.
Lever 5, CIP	CIP was not performed much at all in this project; this organization has a larger	CIP was not performed or visible at the CTL and PM level but was used at the TM level.	Low CIP project team use, but some tools used.	Low CIP project team use, but some tools used.

	presence now with CIP than a few years ago.			
Lever 6, ICT	Email, IM, phone, teleconference, video, etc. was used on this project. There is a potential generational gap for use of new technology.	Shared desktop was used across the project team; other ICT tools were also used with positive results.	Effective use of ICT tools because of the collocated environment.	CC2 utilized most ICT tools during the project.

Environment

Virtual project teams and collocated project and all four of the case study project teams CV1, CV2, CC1 and CC2 all answered the question "Do you feel project productivity is enhanced because you work on a virtual or collocated team? Yes or no and why? All 12 case study participants answered yes to this question. There appears to be no difference when interviewing the project team's members of these four projects in terms of the type of project environment. The fact that all four projects were in the final stage of their project life cycle and commercializing their products may have had something to do with this positive success.

Virtual project teams had the tools and support to be productive in this environment. CV1 did, however, discuss that the team thought an initial face-to-face meeting would be useful if possible to build trust. CV2 virtual project expanded on the difficulty the project team had with different time zones. This project team also discussed how virtual project teams create more flexibility for all of the project team members.

The CC1 collocated project team was able to solve issues and problems quickly by being in close proximity to each other. Meetings were in real time when needed and focused usually on a specific task or problem to solve. The CC2 project team was also collocated but everyone worked in one large room. This approach was considered to be positive for most people on this project team with the majority of meetings contained to this group in one room. The one disadvantage is that when people need quiet time to think they had to find a different location outside of this collocated project room.

Leadership

Leadership was important in all four case studies and ranked strong with all project team participants. Effective leadership was indicated as an important reason for a successful and productive project team. The project team looks to the leader to improve the team’s productivity. This is also true for the communication of the expectations of the project team. There is not a significant difference in the four project team’s leadership perception with the virtual project teams and the collocated project teams. CV1 had the strongest leadership numbers and information of the four project teams interviewed. Project members interviewed on this project team agreed leadership was part of the project team success. CV2 also ranked high in the leadership area, and it was suggested by this project team that leaders of these types of projects need to not only be strong leaders but also technically competent. CC1 project team indicated that leadership will drive project success. CC2 project team indicated they had strong leadership that worked side by side with the project team. The leadership style of CC2 was driven, which was new to some people on this project team.

<u>Team maturity (knowledge and experience/expertise)</u>

Team maturity is about the experience and knowledge of project team members. Team maturity was effective on all four project teams. There is not a significant difference in the four project team's maturity perception with the virtual project teams and the collocated project teams. CV1 project team selected the project team members which were mostly mature team members. CV1 did however use the Myer Briggs Type Indicator (MBTI) to get a full complement and mix of the project team members. CV1 also felt use of the MBTI helped with overall project success. CV1 believed this helped the selection of project team members and they were able to compliment team members but having the advantage of the MBTI tool. CV2 indicates that they had a mature project team internally but would have wanted to see more maturity with outside partners. CC1 had a mature project team, but they needed to have the right mixture of mature and non-mature project team members. Participants of CC1 indicated that they preferred a balance of experienced team ambers and less experienced team members. This gave the project team different perspectives and allowed different views on tasks and issues. The CC2 project team was a mature team, but some of the outside development partners were not as mature. Because of these less mature outside development partners there were some issues noted by the participants of CC2.

Meetings

Meetings were used by all four project teams interviewed. They ranged from formal meetings to informal meetings. There is not a significant difference in the four project team's meeting perception with the virtual project teams and the collocated project teams. There is, however, a difference in how meetings may form informally from virtual to collocated teams. Collocated project teams indicated that they can have meetings anytime during the day as most if not all of the project team members are located in close proximity. Virtual project teams held meetings based on key issues and set up meetings for a future time. CV1 indicated that this project team had an effective mix of meetings and used technology to have the meetings and send the information out after the meetings. CV2 used team meetings with the project team, and if more meetings were needed they would add them. CC1 had weekly meetings and did use a stand-up meeting to review short-term action items. It was also strongly suggested by CC1 to have an agenda for each meeting. CC2 only had formal meetings as required. This project team used the large room for constant mini meetings throughout the day. CC2 could have improved meeting efficiency by communicating more project status Information, which would have been beneficial to the project team members.

Continued improvement process

CIP was not performed extensively by any of the four project teams. This scored as the lowest project management lever for all four of the case study project teams. The organization in the case study has in the last year implemented stronger CIP process for all new projects in R&D. There is not a significant difference in the four project team's CIP perception with the virtual project teams and the collocated project teams. CV1 and CV2 had limited use of the CIP process. However, the TM participant on CV2, participant L, did indicate that a few CIP tools were used. CC1 and CC2 also had low CIP process performance. All participants understood the organizational CIP methodology. This formal CIP methodology was formed well after all four of these projects had started their projects. Future R&D projects would incorporate CIP into the projects right from the beginning.

Information communication technology

There is a difference in the four project team's ICT perception with the virtual project teams and the collocated project teams. ICT was performed much more on the virtual project teams versus the collocated project teams. The numbers in the project management levers indicate the higher use of ICT tools with the virtual project teams over the collocated project teams. CV1 performed ICT a great deal on the project team and used technology when needed. It was noted on CV1 that the younger generations used ICT tools with much more ease. CV2 also performed ICT according to the participants interviewed. CC1 and CC2 project teams both utilized ICT tools but at lower levels than CV1 and CV2. The collocated project teams used the ICT tools as a backup to the collocated environment and face-to-face meetings.

Project team productivity

Project team productivity was consistent across all four project teams when asked the simple question, was your virtual project team or collocated project team productive? The answer in all cases across 12 participants was yes. Many suggestions were discussed in the interviews with the participants. In the context of medical device R&D organization they have all had different experiences over the course of the projects. Some participants have been with the project the entire time, and others have not. All four case study project teams believe that they achieved productivity in the project despite any issues or challenges early in the project life cycle.

Medical device R&D

The organization under study in this dissertation indicated that leadership was strong for the most part across all four teams. There was some information that less experienced project team members and outside partners that were less experienced needed to be mentored or coached in order to be successful and productive. Meetings were performed across all four project teams with varying degrees of formal and informal meetings. Stand-up meetings were popular with CC1 and CC2 project teams. From the organizational and industry perspectives of the medical device R&D, there needs to be more investment to train and encourage ICT tools to be productive. CV1 and CV2 were forced due to the virtual project team environment to use ICT tools more often than CC1 and CC2 collocated project teams. Many participants indicated that they prepared extensive documentation and a method to improve it would be well accepted by the project team members. Risks should also be considered early in the project life cycle to mitigate their occurrence during the project. Risk identification, analysis, and response planning should be a part of the earlier planning cycle that needs to take place on projects.

Positive project management levers

Table 10.4 is an overview of the positive project management levers discussed and gathered during the interviews for this case study. The goal is to provide the reader with an efficient and effective view of the areas considered to be positive. In contrast there is also a negative project management lever Table 10.5 in which the same participants and project management levers may be both positive and negative.

Table 10.4 Summary positive project management lever

Project management levers, positive												
Participant	G	H	I	J	K	L	M	N	O	P	Q	R
Project management levers	CTL CV1	PM CV1	TM CV1	CTL CV2	PM CV2	TM CV2	CTL CC1	PM CC1	TM CC1	CTL CC2	PM CC2	TM CC2
Lever 1, Environment	X	X	X	X	X	X	X	X	X	X	X	X
Lever 2, Leadership	X	X	X				X	X	X	X	X	X
Lever 3, Team maturity	X	X		X		X	X			X		
Lever 4, Meetings		X	X		X	X	X	X	X	X	X	X
Lever 5, CIP												
Lever 6, ICT	X	X	X	X	X	X	X	X		X	X	X

Negative project management levers

Table 10.5 Summary negative project management lever

Project management levers, negative												
Participant	G	H	I	J	K	L	M	N	O	P	Q	R
Project management levers	CTL CV1	PM CV1	TM CV1	CTL CV2	PM CV2	TM CV2	CTL CC1	PM CC1	TM CC1	CTL CC2	PM CC2	TM CC2
Lever 1, Environment			X	X	X	X					X	X
Lever 2, Leadership											X	X
Lever 3, Team maturity		X	X	X	X	X			X		X	X
Lever 4, Meetings			X			X					X	X
Lever 5, CIP	X	X	X	X	X	X	X	X	X	X	X	X
Lever 6, ICT	X	X	X	X	X	X					X	X

Summary of case study information project management levers

Table 10.6 is a summary of the four case study project management levers. The higher the number the more impactful participants believed these project management levers were to the productivity and success of their project. Leadership was the strongest project management lever as indicated by the participants. This was viewed as having a strong relationship to project success and productivity by all four case study participants. The next in order of strongest to weakest is the project team environment. Both the virtual project teams and the collocated project teams indicated that their environment is important to project productivity. Both virtual project teams (CV1 and CV2) did also indicate that an initial face-to-face meeting or at least trying to incorporate face-to-face meeting time if the group or person is not known is preferred. Team maturity was the third highest ranked lever. Participants in all four case studies agreed that in this complex and regulated industry having experienced and knowledgeable project team member's drives productivity. This not always needed or desired as CV1 project team used the MBTI to create a balanced project team. The leader of the team was able to select different project team members based on the MBTI tool. Even with this approach CV1 had a mature project team. ICT is the next project management lever. CV1 and CV2 project teams relied heavily on ICT to perform day-to-day project activities. CC1 and CC2 project teams used ICT, but not as heavily since it was used more as a backup when face-to-face communication could not occur. Meetings are next, and most of the participants in the four case studies indicated that they use some type of meeting format on a weekly basis. CV1 and CV2 used a set meeting time more heavily than CC1 and CC2. All four projects in this research indicated at some point in the interview process that meetings could be improved and be more productive. The final project management lever and the lowest score across the project management lever is CIP. The organization under study has an initiative now to require the use of these tools on each new project. However, since all four of these projects were commercializing their products as the researcher was interviewing the participants, these projects were not required to use CIP. All four projects did however use one or more of the CIP tools in the project management life cycle.

Table 10.6 Summary case study information project management levers

Project management levers (0-10) 0 weak, 10 strong													
Participant	G	H	I	J	K	L	M	N	O	P	Q	R	Avg.
Project management levers	CTL CV1	PM CV1	TM CV1	CTL CV2	PM CV2	TM CV2	CTL CC1	PM CC1	TM CC1	CTL CC2	PM CC2	TMC C2	
Lever 1, Environment	8	9	8	6	6	7	8	7	6	7	8	8	7.3
Lever 2, Leadership	8	8	8	8	7	6	8	8	7	7	8	8	7.6
Lever 3, Team maturity	7	8	6	8	7	6	7	7	6	7	6	6	6.8
Lever 4, Meetings	7	8	6	6	6	5	7	6	5	6	6	6	6.2
Lever 5, CIP	4	5	4	4	3	5	4	4	5	3	4	4	4.1
Lever 6, ICT	7	6	7	7	8	7	7	5	5	6	5	5	6.3

<u>Overall virtual project team and collocated project team maps</u>

Figure 10.1 and Figure 10.2 are summaries of the overall virtual project teams and collocated project team’s framework in this dissertation. The project management levers are listed, positive list, negative list, improving productivity list, and medical device R&D list. This gives the reader a high-level summary for the virtual project teams (CV1 and CV2) and the collocated project teams (CC1 and CC2). The researcher provides this summary for easy access to the overall results of this research and for future researchers looking for a condensed summary of the outcomes of this research. Suggestions for improvements were reviewed with a few experienced project managers from the organization under study to validate the models in this chapter.

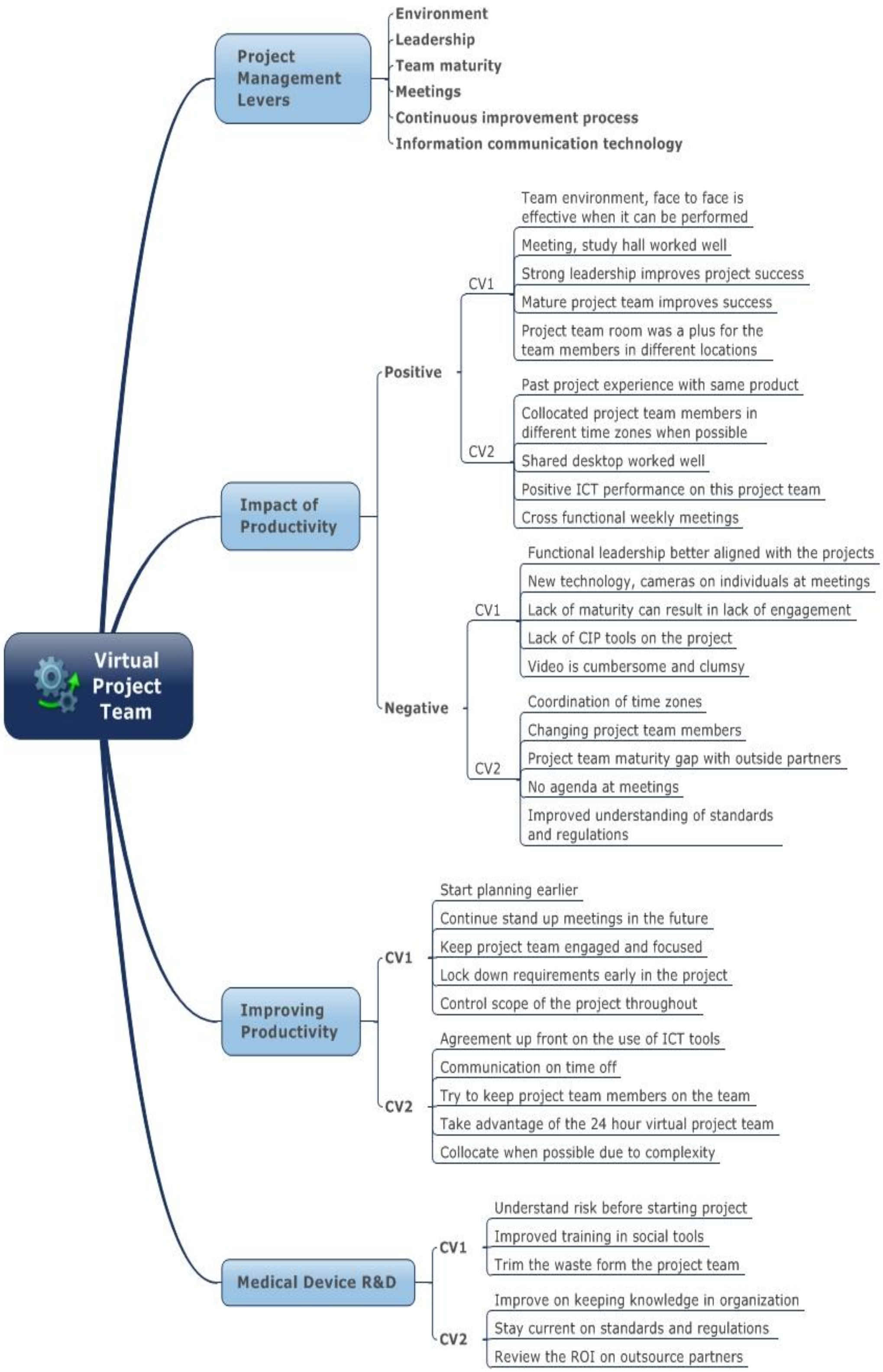


Figure 10.1 Overall virtual project team summary

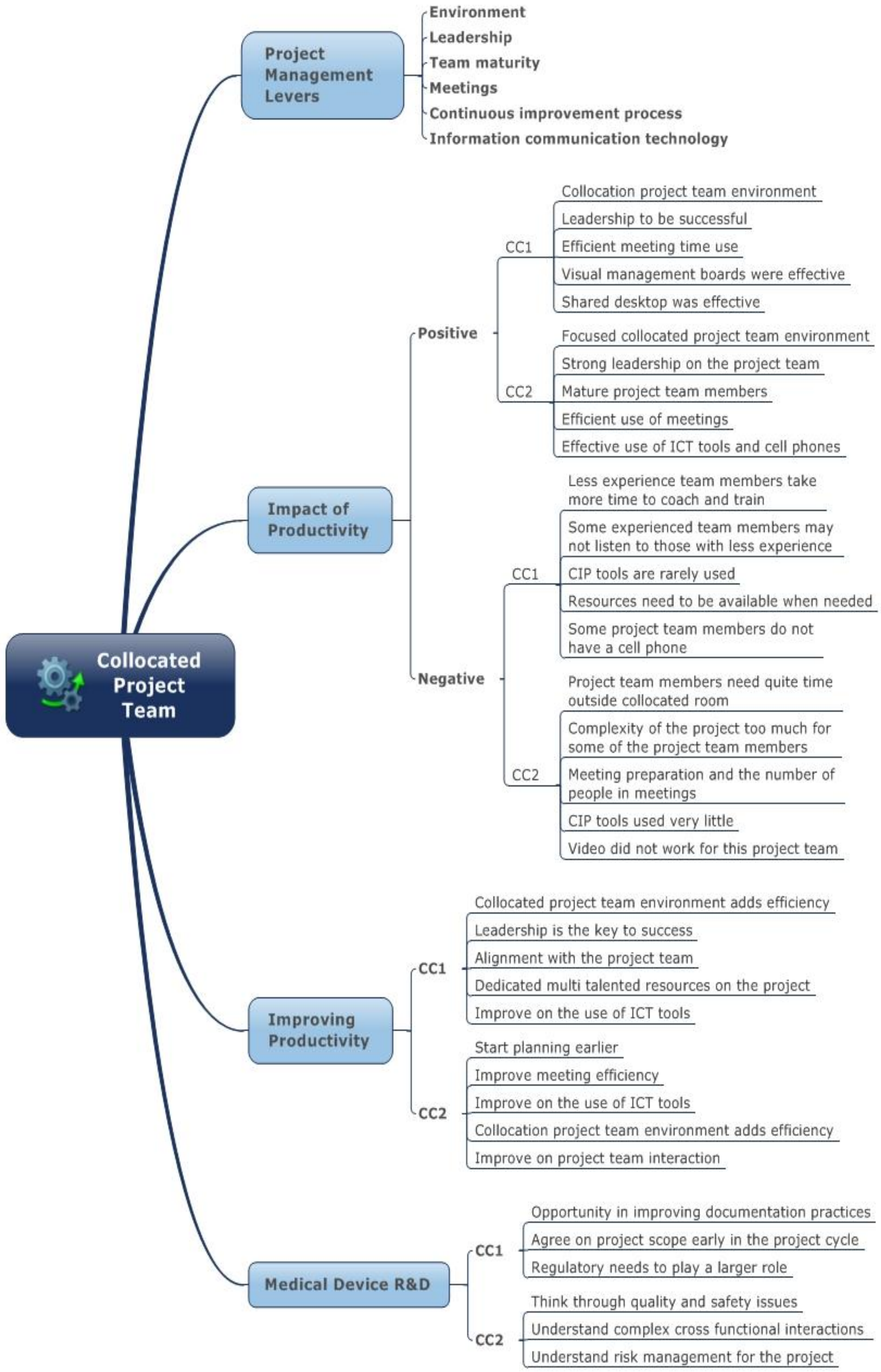


Figure 10.2 Overall collocated project team summary

Improving Productivity

> *"We are what we repeatedly do. Excellence then is not an act, but habit"*
>
> Aristotle

Among the 12 participants from the four case study project teams, all of them have some type of internal project management training. Only one of the participants, participant L on the CV2 virtual project team, indicated that project management courses were taken outside of the organization. It can be concluded that in general terms a formalized project management for the R&D organization may be a simple and effective way to increase productivity. From the PMI 2013 report, PMI's Pulse of the Profession (Project Management Institute, 2013b), it indicates that organizations that are high preforming need to have consistent and continuous training for project managers to improve organizational success. A strong and consistent training program could benefit the overall results. Courses, webinars, certifications, coaches, and mentors could be utilized with professional organizations such as Project Management Institute (PMI) and International Project Management Association (IPMA). Each person on a project team could assess his or her project management skill level and once known work with these groups to improve their knowledge, skills, and competencies. This may be the easiest and most straightforward option for the organization to improve productivity.

Top athletes train most of the time for the small amount of time that they actually perform. People in business spend little time training and expect to perform at top levels (Martin, 2012). By having a training plan or guidelines for individual project team members the organization could move forward in achieving improved performance. Many webinars in PMI and IPMA as well as by others are offered for free and can be found online. It is up to leadership to help formalize this type of a program and help project team members in the organization to achieve higher levels of productivity. Planning and goal setting are important for project teams in the virtual or the collocated environment. An agreed upon and communication goal also can be important for project team and organizational success.

Interviewees in the virtual project environment indicated that planning earlier should be performed on project teams. The virtual project team environment needs to take full advantage when possible of the 24/7 work day. Productivity could be increased with this type of approach when time zones permit this continuous work flow. CV1 and CV2 both had participants that indicated they would prefer collocation of even a few resources in the same building to improve productivity. With the complexity in the medical device R&D the collocation would be desired when possible.

The collocated project team environment contributed to efficiency as indicated by CC1 and CC2 project teams in the case studies. The participants (CC1 and CC2) felt the collocated environment was part of the project team's success. Future project teams should collocate to improve productivity. Collocated project teams could also take note of CC2 and the one large collocated room for future projects.

Leadership on the virtual project teams needs to keep the project team members engaged and focused. Leaders should evaluate team member performance and provide suggestions for improvement on an agreed-upon interval in an individual development plan.

> *"Some team members did not monitor and provide feedback on each other's performance, whereas some were not focused on the tasks, deadlines and deliverables. Poor performance of even one member of a team can affect the overall performance of the entire team"* (Dorairaj, Noble, & Malik, 2012, p. 14).

Leadership also needs to have a plan to keep project team members on the team for its duration or if this approach is not possible have a transition plan ready. Leadership will need to determine an effective way to communicate time off especially on virtual project teams. This is important to ensure improved schedule what and alignment with what by project team members. Leaders also can promote earlier planning. In order to have an effective environment and resources a plan needs to be in place. The project plan is a key component to a successful project. A complete and approved plan that is communicated effectively can be the primary tool for the project team to assure project success. Leadership and other stakeholders need to play an important role in assuring effective project management methodology is in place and followed and feedback on its use and opportunities for improvement are solicited periodically.

Project scope is also a part of the leadership in a project. It is important to have an agreed-upon scope statement and scope management plan and then revise and control the scope when needed with the necessary stakeholders. Collocated project teams indicated that leadership is the key to success. Leaders that are technically competent should be on future project teams to drive success. They should also drive alignment to project goals on the project team to improve performance.

Project team resources in this case study were on the mature side in the case study teams with an average of 18.2 years in the medical device industry. The organization will need to find ways to keep project team members on the team and keep the experience and knowledge they possess within the organization. CV1 used the MBTI, which may be an effective tool to review in other project teams to have a group of team members who work well together and keep people on the project team. Resources on future project teams should be multi-talented, which would most likely indicate that they are more mature project team members. The use of multiple talents of one project team member on the project team would help the efficiency by not having to add other resources or partial resources and minimize the communication channels. The project teams need to also find a way to improve team interactions. Team interaction can play an important role in problem solving to promote innovative ideas and different methods to consider. By having team interaction an important part of a project teams, problems may be solved earlier following a more methodical process.

Virtual project teams see that the use of stand-up meetings should occur. CV1 even used a camera with other participants during the stand-up meetings. These stand-up meetings are effective use of project team member's time to learn about deliverable updates and accountability to planned dates. Project teams that are fully present during meetings will achieve higher productivity while having less meetings and with less time (Martin, 2012). The key to improved meetings is a clear agenda, action items and a focus during the meetings (Martin, 2012). Collocated project teams see that improved meeting efficiency will drive productivity. Meetings need to have a purpose and goal in order to be effective. This can be abused by not providing enough time to set up the meeting before it is held and by not following through after the meeting with actions items, due dates and meeting minutes.

Requirements under the CIP need to be done early in the project life cycle. This drives overall product scope and is important to the success of a product. By doing so, up front with early agreement, productivity can be enhanced. CIP tools should be a process in which project team members simply perform these types of activities. By having a set of tools to refer to and being able to use these tools on a project, it should become an easier process for project team members in the long term. Overall, the use of CIP in the organization under study will increase and the outcome will be different if a future study was to review a new set of projects at a later time.

ICT tools are increasingly important in virtual project teams. Agreed-upon ICT tools with the project team, stakeholders and IT are necessary for future project success. CC1 and CC2 discussed the use of visual management boards. Visual management is one of the more effective tools that are available to project teams. This has moved out of the office and into walls and work areas (Martin, 2012). “Visual management not only provides the baseline for where a department or team is today but also provides the means by which organizations can track improvements over time” (Martin, 2012, p. 58). This process can help project managers balance resources and tasks for a more productive environment. CC1 and CC2 discussed the use of visual management boards. Virtual project teams could also use this format on project team intranet sites as one possibility. Continued use of the project intranet sites will improve performance. “Dedicated project intranet is not only used the most often by all firms but also is the strongest indicator of the Best performing companies” (Markham & Lee, 2013, p. 39). Collocated project teams should take more advantage of ICT on future projects. The technology and ease of use with ICT tools would improve the overall efficiency.

Comparing the four case studies, they all have some differences in how they approach and handle the different project management levers. CV1 and CV2 relied more heavily on ICT tools and held meetings more consistently. CC1 and CC2 relied more on the face-to-face project team environment and the informal meetings.

The visual image in Figure 10.3 below is how the researcher has organized the project management levers discussed in Chapter 2 and Chapter 3 of this dissertation and throughout some of the other chapters. This graphic has project management on a time continuum in the middle of the graphic from the bottom corner to the opposite top corner. In the technical side or top left side it indicates the ICT, CIP and team maturity. In the social side or\lower right hand side of the graphic is indicates that environment, leadership and team meeting are in the social area. Graphic is created by the researcher.

Figure 10.3 Visual of project management levers

Organizations will need to be able to improve on how projects are delivered in the future in order to be successful. It is not enough to just deliver a project on time. A project team will need to deliver on time, cost, and goals. From a PMI 2013 report the best performers create efficiency to drive success, improve talent and their role in project management and have solid practices around project, program and portfolio management as a part of the strategy (Project Management Institute, 2013b). The performers that are best in class standardize project, program and portfolio procedures and mature them. They train project team members in best practices and define career paths for them (Project Management Institute, 2013b).

Project team and organizational structure

Organizations can make productivity gains. The key in the future will be to continue to make these productivity gains and understand in which areas they can be achieved for future success. Leadership will need to ensure the right projects are performed given resource and funding limitations to help improve performance and productivity. Leadership needs to be aware that too many project initiatives may drive decreased productivity in the long run. It may look acceptable to make some short- term changes to the project initiatives but an overall longer-term process is required in terms of impact of the project to the organization's goals. Project management is essential to performance of the business and for organizational success (Project Management Institute, 2013b). By having fewer projects and focusing on project management an organization could be more productive. Project teams need to be aligned around the organization's strategy.

Medical device R&D

The organization under study is a medical device R&D organization. The four case study project teams offered information on how to improve project team success and productivity. The CV1 project team indicated that the team needs to identify risks before starting the project. Risks can be reviewed early in a project with the information available, and a risk plan can be prepared and then updated at specified times through the project. Some level of effort must go into a risk assessment before the project plan is approved, and this risk assessment should be in the project plan. Another area for improvement is the training in the use of social media tools. CV1 sees that there is a generational gap and that younger project team members are for the most part comfortable with social tools, but the older more mature project teams member is not always as comfortable with these set of tools as noted in some of the interviews conducted. If there were training offered by the organization on these tools it may improve the success of future projects. Participant L indicated that most of the issues with the lack of use with these tools were the lack of training. The last suggestion by CV1 was to reduce cycle times on the project team by addressing the requirement for right resources at the right time with the skill set needed by the project team. This area could include cross training to be able to perform different roles, new training or coaching and mentoring.

The CV2 project team indicated that the knowledge, which takes many years of on-the-job work and training, needs to somehow stay within the organization. A plan or program on how to keep the knowledge within the project team and organization should be at least prepared at the project level. This can be a simple process and should not have to be a detailed and cumbersome task. Standards and regulations need to be kept current and communicated to the project team and even to the larger organization. This can be critical to projects in this industry. A plan or process should be outlined by each project team in order to remain current and not be surprised at the end of a project when waiting for a regulatory approval. CV2 performed work with outside development partners in their project. For future projects utilizing outside development partners, a process and simple spreadsheet to outline return on investment, net present value, etc. should be prepared to make sure the project team has the right partner for this project. There can be many options that may need to be reviewed in order to find the right balance of cost, maturity and past success so that the project team will be set up correctly.

The CC1 project team sees that an improved documentation system will provide the team with productivity increases. This is a complex system on its own as processes are required to ensure quality content with ease of access. The key as the participants indicated is finding an agreed-upon way of capturing the correct data needed and keeping it simple. This will ensure that project team members will use the system, but more importantly the information will be there when future project team members or groups outside of the R&D organization need this information. The scope for the project should be approved and provided to the appropriate stakeholders early in the project. This is important to the overall success of not only the project but also the product. A poorly scoped project can create many problems for the project team. A scope that is done correctly will keep the project team aligned to the project goals and engaged throughout the project. CC1 also discussed that the regulatory group needs to have involvement in the project from the beginning. If they wait until after the plan and scope are set and approved, it will have a negative impact on the project productivity since regulatory approvals and wait time can negatively affect the overall project schedule. The regulatory group knows the latest trends in medical device regulations and can bring the focus of potential long lead times to the project team's attention early in the project life cycle.

The CC2 project team indicated that quality and safety issues need to be considered yearly in the project. These two areas cannot be compromised, and metrics for each of them need to be agreed upon early in the project. If the project does not have a solid goal, the team may be working toward a frustrating situation. Interactions among the cross-functional project team members need to be determined in order to have more productive project teams. These interactions can be complex; careful consideration needs to be addressed as to how these types of interactions could be beneficial to the project team. By understanding the complexity of the cross-functional interactions, it may provide insight to how different interactions would give the team an advantage toward ensuring a successful product. Similar to CV1, CC2 also sees that risk management needs to be performed. Risks should be discussed and worked on as a planning activity early in the project. By determining the possible risks early in the project, it gives the project team members an opportunity to form mitigation plans early in the project to improve product success.

Change is happening at a fast rate and is constant for organizations. How project teams in the medical device R&D organizations handle change will most likely impact their productivity.

Section conclusion

> *"Most people spend more time and energy going around problems than trying to solve them"* Henry Ford

By reviewing the background and viewpoints of medical device R&D participants from the case study organization project teams (CV1, CV2, CC1 and CC2) it may be concluded that all participants and project teams agree that their project teams were productive. Future medical device R&D project teams will need to improve productivity in order to remain cost effective and competitive. The project team environment (virtual and collocated) does not have a direct advantage toward improved productivity from this case study research. Project teams of the future may choose to improve on project management levers outlined in this chapter. The positive and negative impacts in productivity outlined also in this chapter offer suggestions to project teams in the medical device R&D organization for future consideration. Overall the future individual worker and project team will likely need to become better problem solvers in order to realize true productivity improvements. Balachandra and Friar (1997) conclude that R&D is a complex process, and more research is needed.

Project Team Characteristics

Virtual project teams are becoming more popular all the time at in most organizations (Lipnack & Stamps, 1997).The research in this dissertation indicates that face-to-face and even collocated project teams are preferred when possible even on a virtual project team. With the right project information virtual project teams and collocated project teams can save time and money for the company. Many of the basic team management rules still apply to a virtual project team. By being more collaborative on a virtual or a collocated project team, team members can use the knowledge of the individuals to improve projects across the organization. Technology supports the project team and should be the focus on either a virtual or a collocated project team. It is about the project teams and how they interact and work together during the project that will get results. The future will encourage project management as a way to embrace virtual project teams following a process that provides organizations with a competitive advantage. It is a matter of degree as to project team methods and processes that drive medical device organization success. Collocated project teams still have their place in the medical device R&D organization. The trend (Appendix D3) indicates that collocated teams are not a major topic of research in the last nine years. CC1 and CC2, however, see that collocated project teams offered an effective solution to the complex projects that they were commercializing. The CV1 and CV2 virtual project teams also agreed that some face-to-face is preferred, and the CV2 project team indicated that if possible it would be preferred to collocate with project team members that are in the same physical area. Project teams of the future will most likely be a mix of virtual project and collocated projects, which will offer an organization the most flexibility, although there are cases in which a virtual project team or collocated project team will be the best alternative to the organization.

Project Management Learning

People are at the heart of all project teams. They can be the winning difference; no product has ever developed by itself. Organizations need to inspire, motivate and reward for the best chance of project success. Cross-functional project teams (virtual and collocated) support a structure that can improve productivity as reviewed in the four case studies. The organization under study researched R&D project teams (virtual and collocated) to assign the correct cross-functional team members to the right projects. Project team leadership of the project or program in this organization under study was devoted 100% of the time. This is in line with best in class companies. Communication to senior leadership should be sought out with each individual project team and provide senior leadership with the information that they need to made effective decisions. More project management training should be offered in the organization under study in leadership and project management general areas. The training in this organization that was offered in project management is no longer offered. To be best in class the training needs to stay current with the changes in the technical and business environments. This includes both virtual and collocated project teams. “High performers have more training in place than low performers, which implies that focusing on talent management improves project success" (Project Management Institute, 2013b, p. 8).

Case Study Conclusions and Summary

The researcher indicates that virtual and collocated project teams are a matter of degree. Research has shown that R&D is improved in a collocated environment (Henderson & Stackman, 2010). The definition of a collocated project team and a virtual project team is a matter of proximity, communication and technology to name a few. The researcher sees productivity is also driven by environment, leadership, team maturity, team meetings, and continuous improvement process and information communication technology. This is not an exhaustive list, but are areas that the researcher has seen poorly performed in his past experiences. Different stages in the R&D process will create variability, which requires different levels of productivity by the team. "We believe that the parallel existence of collocated and virtual teams is the most likely scenario for the immediate future" (Gillam & Oppenheim, 2006, p. 173). The challenge for the future medical device R&D project teams is how to realize productivity increases.

This chapter compares the findings of the four cases studies (chapters 6, 7, 8 and 9). Productivity in medical device R&D organizations is needed to stay cost effective and competitive in the market. Organizations need to determine an effective strategy to gain positive impacts and minimize the negative impacts. The comparative analysis concludes that there is not a significant difference in project teams (virtual or collocated) environment in the R&D medical organization. The degree of leadership, team maturity, meeting, CIP and ICT need to fit the project team's scope and strategy. The comparative analysis indicated that all four project teams viewed environment, leadership, team maturity, meeting and ICT as needed areas for overall project success and productivity. CIP did not have enough information in the four project teams in order to make an effective analysis. A project team with strong team environment, leadership, team maturity, meeting and ICT will likely achieve project success and improved productivity. In order to continue to advance productivity in the medical device R&D organization, more investment will be needed in training of leadership, meeting efficiency, ICT and project management. Project teams also should develop a methodology to capture project knowledge to improve future project productivity.

Medical device R&D project teams should also focus on more up-front planning to identify risks, resources, CIP, ICT and leadership needed to complete the project. The organization under study and the four project teams interviewed are described as mature by the participants. Organizations will need to continue to seek a balance in resources and team maturity in R&D. Project teams (virtual and collocated) interviewed in the organization under study are found to have needed more investment in social tools. Overall the uses of ICT tools are somewhat underdeveloped and can be expanded to improve productivity in the medical device R&D organization.

Chapter 11: Conclusions and Areas for Further Research

Research Findings

Medical device R&D organizations are increasingly moving toward virtual project teams, the latest trend is that virtual project teams have increased dramatically in the past years and that the global environment has required organizations to have people closer to vendors, customers and stakeholders (Fisher & Fisher, 2011). Global companies today are relying more on intercultural virtual project teams to focus on projects (Ubell, 2010). Many different characteristics of both virtual project teams and collocated project teams need to be addressed to realize the benefits of integrating improved productivity into either type of project team. The ability to deliver productive and successful projects is essential to organizational success in the medical device R&D organizations. It is expected that virtual project team popularity will continue to grow. Organizations need to also consider the best of both virtual project teams and collocated projects to have a hybrid project team approach.

Overall, there is a gap of research in the area of virtual project teams and collocated projects teams in the R&D medical device organizations. It is important to investigate the virtual project teams and collocated project teams in R&D medical device organizations and the impact of productivity. To investigate this topic, the researcher has reviewed how the impact of productivity in virtual and collocated project teams can effect R&D medical device organizations as a case study. This research provided insight into project management levers (defined in Chapter 2 and Chapter 3), which in turn can help understand how to improve productivity and could get medical products approved faster (which is more than critical as additional lives can be saved earlier).

From the researcher's literature review of medical device R&D, virtual project teams, collocated project teams, impacts of productivity and of medical device R&D there was limited to no research done with all of these concepts combined. Numerous studies were conducted on each individual core theme by itself. Limited literature could be found on virtual and collocated projects teams when combined with and productivity. There is a gap in the existing knowledge areas. This dissertation is research to aid in filling this knowledge gap and provides insight into virtual project teams, collocated project teams, productivity and in a medical device R&D organization.

Through a case study methodology at one medical device R&D organization, different project management levers were reviewed. Some of these tend to be the same with either a virtual or collocated project, while other project management levers vary in the researcher's analysis. It was found that virtual and collocated projects team participants agree that they were all productive in the interviews. This was a 'yes or no' question with an opportunity to elaborate as to why they thought their project team was productive or not. All four of the projects were in the commercial phase of the projects or the final phase of the project from an R&D perspective. Questions were formulated around the dependent variable of productivity and the independent variables around the project management levers outlined in this dissertation. The researcher acknowledges that there may be many other variables that could be researched and reviewed. The understanding of productivity in virtual project teams and collocated project teams in medical device R&D could be used as a foundation for conducting future studies involving different projects teams working on medical device R&D projects.

Research proposition

At the start of this dissertation (Chapter 1), the proposition of the research has been whether *"productivity and performance have an impact on project teams/individuals which can be improved by understanding and implementing project team levers and potentially modify contextual environments in virtual project teams and collocated project teams"*. All three of the project core themes (virtual project team, collocated project team and productivity) relate to the project management levers, see Chapter 10 (Table 10.3) for project management levers. The researcher used these levers to form his ideas and review more detailed level information for this dissertation. By formulating the researcher's ideas in a table format he was able to better understand which ones had more opportunities to impact productivity versus other project management levers. Table 10.3 only reflects the project management levers through the literature search (Chapter 2 and 3) and the researcher's experience.

Based on the four case studies (Chapter 6 to 9) and the comparative analysis (Chapter 10) of this dissertation, the research proposition is supported. From the project team perspective there are many ways to improve productivity and performance that were suggested by the participants and even performed in the project teams under study. The project teams have performed the project management levers outlined in this dissertation to implement productive projects. The virtual or collocated project environment is understood at the project level, and improvements for productivity are understood at the project and individual levels for future projects. The CV1 and CV2 project teams are successful with strong leadership, strong team maturity, ICT tools and understand that face-to-face contact initially would be preferred for overall project success. The CC1 and CC2 project teams have more informal meetings, are successful with strong leadership, strong team maturity, and ICT tools as a backup to face-to-face communication.

Key success factors for the virtual projects teams in this case study include:

- Face to face interaction when possible
- Strong leadership
- Dedicated meetings times
- Mature project team
- Dedicated space for team members
- Experience in same types of products
- Bundle teams in different time zones in close proximity
- Information communication technology such as shared desktop
- Meetings to include a cross functional group
- Continue strong use of ICT tools

Key success factors for the collocated projects teams in this case study include:

- Collocation project environment
- Leadership for success
- Efficient use of meeting times
- Effective use of ICT tools
- Visual management boards
- Focused collocated environment
- Strong leadership
- Mature project team members
- Shared desktop worked well when needed
- Meetings performed only when needed

Form an individual project perspective the project team was a positive experience. There are many areas for improvement and opportunities for productivity gains. Each of the 12 individuals interviewed in the four case studies all agreed that their project and project team was productive on the day and time interviewed in early 2013.

It may be concluded that medical device R&D project teams (virtual project teams and collocated project teams) have both positive and negative impacts to the organization, project teams and individuals. It may also be concluded that both virtual and collocated project teams were productive in the four case studies in this dissertation. The dissertation concludes that virtual project teams and collocated project teams (Chapters 6 to 9) in a medical device R&D organization are productive. Further analysis in this dissertation indicates areas for improvement in productivity on future projects.

<u>Achieving research objectives</u>

At the beginning of this research, four research objectives have been described. They are:

1. To explore the major areas of project management, for example, information communication technology, leadership, meetings, team maturity and continuous improvement process on virtual and collocated project teams in R&D medical device teams.
2. To identify and explain any productivity issues positive or negative in both virtual and collocated project teams in R&D medical device teams.
3. To investigate and explain the impacts of project management, for example, information communication technology, leadership, meetings, team maturity and continuous improvement process in virtual and collocated project teams in R&D medical device teams.
4. To identify and present possible solutions to improve performance or productivity of the virtual and collocated project teams in R&D medical device teams.

The first three research objectives are achieved through the first three research phases: Phase I – literature review, Phase II – pilot case and review and Phase III – case studies. Findings of the first research objective were documented in Chapters 6 through 9 of this dissertation. It is about the project management levers of each project team. Each project team has its own opinions and experiences -- CV1 and CV2 in the virtual project team environment and CC1 and CC2 in the collocated project environment. There are differences in each project team, but they all seek project success and productivity. Findings of the second research also have been documented in Chapters 6 through 9 of this dissertation. It is about the positive and negative areas in virtual project teams and collocated project teams in medical device R&D teams. The findings indicate that there are areas to build on further and areas for improvement in the medical device R&D organization. Some of the characteristics are project environment and leadership to be successful and mature project teams. Findings of the third research objective additionally were documented in Chapters 6 through 9 of this dissertation. This is the discussion around each of the project management levers and their impact on productivity. Findings of the fourth research objective as well were documented in Chapters 6 through 9 of this dissertation. It is about the project success and productivity of each case study. The summary table is included in Chapter 10 of this dissertation.

The last area to be discussed is achieved through Phase IV – comparative analysis and Phase V – validation (see Chapter 4). Prior to finalizing the comparative analysis and conclusion of this dissertation, participants from each case study project teams voluntarily reviewed the case study report of their project team (Chapter 6 for CV1, Chapter 7 for CV2, Chapter 8 for CC1 and Chapter 9 for CC2). Chapter 10 compares and concludes the findings of the four case studies.

Contribution of the Research

This research has achieved the research objectives defined at the beginning of the research. After researching the relationship of virtual and collocated project teams and impact in productivity in the medical device R&D, the researcher further identifies possible solutions to improve productivity in the medical device R&D organization. The understanding of the current situation and its current impact and suggested solutions are a part of this research.

Contribution to organization

Chapter 10 (see Figure 10.1 and Figure 10.2) provides a map for medical device R&D virtual project teams and collocated project teams that may improve productivity. An organization in the medical device R&D industry can choose different areas under the improving productivity section of the figure. There are also sections in this research on the positive and negative project management areas that may further improve productivity and help organizational leaders understand current project team's practices. Organizational choices may lead to project team success and improved productivity based on the research highlights in these figures. Project teams can utilize this information model to better provide documentation and support for their own success. A review of the individual project teams experience in each of the four case studies will also help future project teams develop a model to improve success and productivity.

In addition to the models in Chapter 10, this research also identifies the project management levers in a scoring model. This is converted from the interviews by the researcher and scored by the researcher. It, however, gives the overall ranking in a numeric format instead of only a narrative format. This can be useful to future researchers and industry. From the numeric ranking it is observed as to what the most important project management levers are by an individual participant ranking to an overall average by project management lever. All four case study project teams can improve productivity in future medical device R&D projects. Suggestions for improving productivity are in Figures 10.1 and 10.2 in Chapter 10. Other medical device R&D organizations and organizations outside of this industry may also take these improvements as suggestions to further their productivity improvement with their project teams.

Contribution to medical device R&D industry

This research provides views from project teams in the medical device R&D organization. CTLs, PMs and TMs were interviewed to get their perspective and experience on both and collocated project teams and the impact on productivity. Chapter 10 provides an overview for project team members and what they may experience in medical device R&D virtual and collocated project teams. It allows other project team members have an overview on productivity in the medical device R&D organization. It also gives them a better understanding of the importance of productivity in these project teams. There is an important impact that the project team can make to productivity, but the individual also needs to understand how he or she can also impact and improve productivity. A sample of the positive impacts in Chapter 10 suggest that leadership is important to success of the projects, and also mature project team members are important for overall success in a regulated environment. A smaple of the negative impacts in Chapter 10 suggest that less experience on a project team takes time to coach and train and should be allocated for in a project plan. It also suggested that CIP tools need to be implemented more efficiently to get productivity gains. Future project team leaders and members may consider taking the information in Chapter 10 (figures 10.1 and 10.2) provided by the participants of the four case studies if they would like to improve future project success and improved productivity. This research helps other future project team members, project teams and medical device R&D organizations better prepare for project success and potential improvements in productivity.

Suggestions of areas for improvement

Chapter 10 concludes the four case studies indicating that medical device R&D project teams can improve their productivity. Medical device R&D organizations will need to find options to improve cycle times and productivity to remain competitive and cost effective. Project environment, leadership, team maturity, meetings, CIP and ICT all play important roles in the medical device R&D organization. Chapter 10 provides areas for improvement for medical device R&D project teams both in the virtual and the collocated project area. Areas for improving productivity are suggested by the four case study participants and should be used by future project team members as guidelines. These are improvements that medical device R&D project teams (virtual and collocated) can implement to advance their productivity and project success. The project levers were not an exhaustive list but an overview of the higher level or more important areas to keep in mind for future researchers or practitioners.

Academic contributions

This research contributes to the body of knowledge in three different areas. The first academic contribution is that it fills as part of the knowledge gaps in the medical device R&D virtual project team and collocated project team. It also achieves the four research objectives stated in Chapter 1. From the dissertation literature review of medical device R&D, virtual, collocated project teams and productivity in Chapter 2 and Chapter 3, it was found that there is limited research on the medical device R&D organizations coupled with virtual and collocated project teams with their impact on productivity. This dissertation achieves the four research objectives stated in Chapter 1. It extends and integrates the bodies of knowledge: virtual project teams, collocated project teams, and the impact of productivity all in a medical device R&D organization. This dissertation performs four case studies (Chapters 6, 7, 8, 9) as examples of medical device R&D virtual project teams and collocated project teams and explores their impact on productivity. The case studies review the project management levers: environment, leadership, team maturity, meeting, CIP and ICT to review overall project success and productivity. The analysis of the four case studies and the comparative analysis have taken the outcomes of conceptual development and literature reviews (see Chapter 2 and Chapter 3) of scholars and practitioners as theoretical frameworks of this research. Chapter 2 is a summary of virtual project teams, collocated project teams, and the project management levers. Chapter 3 is a summary of R&D, medical device and productivity. The researcher developed a framework (see Chapter 1) to capture the project management levers and organize the research questions. The researcher reviewed each case study project team and developed a table to capture the project manager levers and scored the project management levers with a ranking of 0 – 10 (0 equally weak and 10 equally strong).

From the comparative analysis of the four case studies, comparisons have been made between virtual project teams and collocated project teams (see Chapter 10). This is the second academic contribution of this research. Figures 10.1 and Figures 10.2 creates a feasible model for medical device R&D organizations with virtual and collocated project teams to improve their productivity. It links the virtual and collocated project teams output from the four case studies. The virtual and collocated project team analyses provide positive, negative and productivity improvements for medical device R&D organizations and project teams.

The third academic contribution is identifying new knowledge areas that need further study. In the context of ICT tools, project team's members are accessing information and communication at all times of the day and in almost any locations. This is true for both the virtual and collocated project teams. It has been discussed that there appears to be a generational gap in the use of these tools and that further understanding is needed to improve the use of the tools and required training. This is an area in the medical device R&D organizations that could be improved. It is a knowledge area that is needed for further study to identify the possible improvements in ICT, which will drive productivity in the project teams (virtual and collocated). Earlier project planning has been discussed by the CC2 collocated project team. This can have a large impact on the overall productivity of a project team. In the medical device industry this is becoming more important to know the project risks, cost, resources, etc. early enough to make effective strategy and educated decisions. It is another knowledge area that is worth further study. These themes have been discussed by the case study participants. They indicate that the ICT tools have advanced and continue to advance, but there is a lack of training and awareness among the project team members. The lack of up front early planning is evident also with the participants, in that too many unknowns become known later in the project when it is too late to adjust the project schedule. Future research should also review more medical device R&D organizations and look at successful projects and unsuccessful projects to compare the areas in with they had positive and negative success.

This research provides an effective starting point for future research to advance knowledge areas outlined in this dissertation and provides a guideline to those interested in the same knowledge areas.

Limitations of Research

Outcomes of literature reviews of scholars and practitioners have been used as the theoretical frameworks for this research to capture and compare the four case studies. The researcher outlines the framework in Chapter 1 of this dissertation. This provides the project management levers utilized in each of the four case studies. By using this framework the process of identifying improvements may be more effective. This is also a tool for a medical device R&D organization to assess its current situation and identify areas for improvement.

The researcher describes different project management levers in this dissertation that he believes are critical to achieving productivity in medical device R&D project teams. Participants were all on project teams that were in the final months of a commercializing a product. This may have caused a relief of being completed with a project and the researcher may have obtained positive productivity information in this stage of the project when indeed if participants looked at the project from beginning to end or if the research question had been phrased differently the results may have been different. The context of productivity was within the last six months of the project.

The case study methodology was used with specific projects and participants. These projects were the available projects in the organization studied. This limited the participants as the researcher had a specific type of position that was necessary for the interview process. The researcher also wanted to have all projects in the same phase of the project life cycle which in this dissertation was the final phase of the project in the R&D organization. He does not claim that these findings are universal to all virtual project and teams and collocated project teams. The findings do accurately characterize the contexts researched.

The objective of the research is to explore and compare how virtual and collocated project teams impact productivity in an R&D medical device organization. This research then identified possible solutions to satisfy the need to improve productivity of the virtual and collocated project teams in a R&D medical device organization. Suggestions for improvement were validated by experienced case study participants (voluntarily) to validate the proposed solutions. The understanding of the current situation and its current impact and solutions formed the main contribution of this research. It contributed to the organization and team members on virtual and collocated project teams. Other organizations can use this research from this dissertation to review the productivity of their own virtual project teams and collocated project teams. Project management levers consisting of environment, leadership, meetings, team maturity, CIP and ICT levers are explored in open-ended interviews to offer possible solutions in this dissertation. Virtual and collocated project team members can have an impact on productivity and understand the positive and negative areas they are likely to encounter. This will help others with the challenges as virtual and collocated project team members look to potentially improve productivity. Suggestions are given in this dissertation for virtual and collocated project teams to improve and learn outside of the team's boundaries.

This dissertation has investigated knowledge gaps in the virtual and collocated project teams with regard to productivity by linking knowledge areas (virtual project teams, collocated project teams, and productivity). Further study to identify new methods of improving productivity in virtual and collocated project teams may be warranted. Findings in this dissertation can increase awareness and interest for future study on research similar to this dissertation.

This research utilizes a qualitative research approach and has a relatively small number of participants in one R&D medical device organization. The research focuses on virtual and collocated project teams. Participants came from the R&D medical device organization under study. Data collected from the organization were from one department (R&D) within the organization. Some level of bias is most likely even with the efforts that have been performed to minimize bias. Because of the sensitive nature of this industry, it was recognized that only one organization would be studied. The findings cannot be generalized to represent the situation of all R&D medical device organizations. The research has built the research design to maximize the reliability and validity of the research outcomes.

Further Research Suggestions

Further research could be undertaken in comparing successful virtual and collocated project teams with unsuccessful virtual and collocated project teams from multiple medical device R&D organizations. This could also be performed with any organization outside of the medical device R&D organization. The depth and complexity of research and development practices in medical devices is more complicated than four case studies could capture. Evaluating project team members of virtual and collocated teams based on improving productivity will examine how effective they are and will pay close attention to which issues are positive and which issues are negative. Performance metrics could be used to gauge performance of project team members and the project team as a whole. Training is another area to explore with a focus on training to improve productivity. Reaching out to organizations that are world class technology companies and researching their project teams could more effectively understand why they have high performance project teams. Finally, a look into roles and responsibilities and how high performing project teams are more effective than less effective performing project teams may be warranted. Accountability and responsibility could be measured to better understand the positive and negative impacts of each area.

There are many areas that one can study on virtual project teams for future research (Cook, 2011). Future studies could go deeper into the area of productivity with virtual project teams (Cook, 2011). “Future research should study characteristics associated with virtual project team success, productivity and performance” (Booth, 2011, p. 112). More research is needed in which virtual project team members all share the leadership role (Riley, 2011). More research is also needed to determine what procedures and steps should be taken to get past the organizational and environmental effects (Riley, 2011). Where possible, both global and cultural aspects could be taken into account. In other words, it would be advantageous to get a cross-sectional group of survey respondents from across the globe, not just in the USA.

One could examine the virtual and collocated project teams in organizations and assess the levels of well-being, knowledge sharing and trust. Project teams work better in an environment of trust and collaboration. Research on how to know what type of technology the virtual and collocated project team typically uses whether different technologies with which they lack awareness could be conducted. Other activities may also include face-to-face interviews with known virtual and collocated project team members with the leadership roles other than the interview participants. Future studies could also compare productive project teams with less productive projects teams to review the impact of productivity.

The accelerating pace of medical device R&D and new medical device products indicates that future research on productivity must be conducted on a more frequent basis. Future research should examine other important factors not covered in this dissertation. The independent variables were chosen by the researcher and his experience, and this may change with the rapid change of other researcher's viewpoints.

Project management levers have only been assessed in terms of their correlation to other projects and productivity. One of the project management levers (CIP) was not as effective as first thought by the researcher. The participants' beliefs should be researched further in order to understand actual practices. A view of the portfolio in future research could also define why organizations make the decisions to move forward with some projects and not others and what impact the PMO has on productivity.

The case studies should be applied to other medical device R&D organizations around the globe. Once more data are collected there would be a larger sample size in which to draw more conclusions. New data will need to be used carefully in order to not skew the results. The research methodology could move to a survey type tool and get more respondents if the researcher could narrow down the focus of the variables. Efforts to understand any changes to an organization will however need to be done quickly and with a narrow research focus. The researcher was impressed at the speed of many changes while interviewing participants, and any future research will need to take into consideration control measures to be able to recognize, understand and codify. The researcher hopes that further research is conducted as a result of this research and dissertation.

Summary of Chapter

This chapter draws a conclusion to the dissertation by discussing findings from Chapter 6 to Chapter 10 that achieve the research objectives in Chapter 1. The findings are reviewed around the literature review and conceptual development in Chapter 2 and Chapter 3. This chapter has summarized the research findings related to the research proposition and the five research questions in Appendix B2. Virtual and collocated key success factor are reviewed in this chapter. It reviews the contribution to medical device R&D and academic knowledge areas. The research contributes to medical device R&D organizations having virtual and/or collocated project teams by suggesting project management levers to improve productivity and to provide project team members ways to improve productivity in project teams. It further suggests areas for improvement identified in the case studies and as outlined in Chapter 10 of this dissertation. Academically, this research has three contributions including filing part of the knowledge gap, the comparative analysis of the four case studies, and identifying new knowledge areas that need further study. This research does have limitations from limited frameworks and a small number of case studies. Findings cannot be generalized to represent the situation of a typical medical device R&D organization. Future research suggestions are contained in this dissertation for future researchers to add and improve in the related knowledge areas.

R&D medical device organizations will need to address the speed to market with the speed of technology in the future to be productive. Medical device companies should look to outsourcing opportunities to provide R&D flexibility and productivity improvements when possible. Medical device companies, which include R&D, should also look to see how they can ease the burden in order to improve project success and productivity. Project teams (virtual and collocated) that can achieve higher productivity will have a competitive advantage and be able to deliver products quickly to people who need them. The future challenge for medical device R&D

project teams is to achieve solutions that are both productive and improve / save lives of the people that need them.

Appendices

Appendix A. Personal Journey on Project Management Learning

Experience of Researcher Leading to the Research

The researcher is currently a doctoral student of Project Management at the University of Maryland, College Park, A. James Clark School of Engineering, Civil and Environmental Engineering. His research interests include project management in virtual and collocated project teams, new product development, trust, communication, ICT, productivity of teams and general project management themes. The researcher has over 28 years industrial experience in delivery of high technology and complex automotive and medical device projects in the Midwest of the United States of America. During his service in the R&D medical device area of over 23 years, the researcher has held various roles in relation to project management such as R&D engineer, project manager, manufacturing manager, program manager, technology engineering manager, engineering manager, director of product development and senior engineering program manager. In 2003 the researcher became a member of PMI and worked actively with his organization to establish a certification program for fellow project management people.

Academically, in the early 1990s, the researcher graduated from Metropolitan State University with a Bachelor of Business Administration degree (BA). In the early

2000s he obtained his minor in project management from Metropolitan State University, which broadened his outlook on project management.

In 2003, the researcher started back again academically to pursue a Masters in Technology Management from the University of St. Thomas, School of Engineering. He also was awarded the Product Development Certificate of Academic Achievement in 2004 from the University of St. Thomas School of Engineering. Since the researcher was interested in project management, he also enrolled in the Masters of Science in Project Management at the University of Wisconsin- Platteville the summer of 2005. In 2006 he obtained his Masters of Science in Technology Management degree. Later in 2006 he was also awarded a Master's of Science degree in Project Management from the University of Wisconsin-Platteville. The researcher in 2008 then enrolled in a Master of Business Administration program at the University of Phoenix. He obtained his Master of Business Administration in 2009 from the University of Phoenix.

The researcher has obtained many certifications in various areas. In the late 1980s he obtained the Certified Quality Technician, in the early 1990s he obtained the Certified Mechanical Inspector and later the Certified Quality Engineer, Certified Quality Auditor, Certified Biomedical Quality Auditor and finally the Certified Six Sigma Green Belt all from the American Society for Quality Control. The researcher was also named an ASQ Fellow in November 2012.

In the 2000s the researcher focused on the Project Manager Professional (PMP®) credential. Later, the researcher then obtained his Program Manager Professional credential (PgMP®).

Other certifications were also obtained between 2003 and 2012. The researcher obtained the Product Development Management Association New Product Development Professional (NPDP), Society of Manufacturing Engineers Certified Engineering Manager (CEM), Association of International Product Marketing and Product Management Certified Product Manager (CPM), Certified Business Analyst Professional (CBAP), and finally the International Project Management Association (IPMA) Certified Senior Project Manager (IPMA-B). In addition, the researcher is a current member of PMI, IPMA, and American Society for Quality (ASQ, Society of Manufacturing Engineers (SME), Association for the Advancement of Medical Instrumentation (AAMI), Product Development and Management Association (PDMA) and Association of Product Management and Product Marketing (AIPMM). The researcher is also a past member of the American Society of Safety Engineers (ASSE) and American Institute of Chemical Engineers (AlChE).

Over the years, the researcher has led and managed many R&D medical device projects, and some of these projects were in difficult shape (cost, schedule or scope). The projects had poor scope definition, limited cost information, limited schedule information, and thus were behind schedule and over cost in some instances. This was trial by fire for the researcher as a project manager, and a great learning process took place on each and every project. The researcher early in his career learned many project management skills the hard way. He knew that was not the best way to perform projects and wanted to learn about more theoretical ways that the projects could be managed, and people could be trained.

The researcher had been learning project management more academically over the years and also learning project management more on the job, but he wanted to get into even more depth on the academic side and perhaps even research project management. In early 2009, the researcher decided to apply to the University of Maryland, College Park, A. James Clark School of Engineering, Civil and Environmental Engineering, and pursue a Doctor of Civil Engineering with a major in Project Management degree while still working full-time as a senior engineering program manager. The main driver in obtaining this degree was that the researcher found that there had to be many different and better ways to manage, perform, train and approach project management as a whole. The researcher had been observing and listening to industry trends such as increasing productivity and cycle time for projects. The researcher believed that there had to be an improved way to make projects more productive and/or perform at a higher level to create project success.

Since late 2009 the researcher has been looking at many topics on project management that impact an organization. Project teams were high on the list in some way shape or form as impactful to the overall organizational success. The researcher has been looking forward to performing some research on project teams to add to the academic body of knowledge. The researcher has managed both virtual and collocated project teams many times over his career in project management.

Project Management Capability Learning Journey

In the early 1990s, when the researcher graduated with a Bachelor of Arts degree in Business Administration, he knew little about project management. He started working in the 1990s in the medical device field about the time he graduated from college. He continued in this organization through the 1990s and into a different organization in the 2000s. He was basically performing the same role in project management from the mid-1990s to present.

In the beginning of the researcher's career, the projects were less complex and smaller in size. Before 1997 design controls were not regulated by the FDA. After 1997, the FDA put forward guidance in which all medical device manufactures need to follow. Some projects in the mid-1990s could be completed with two to three people on the team. During this time the FDA had not formalized the design control process, which since 1997 has been in place for any medical device organization wishing to commercialize a Class I, II or II medical device in the USA. Before 1997, the R&D engineer would usually serve as the role of the project manager and other roles as needed. The concept of a project was basically a schedule and cost target. Few people in the early 1990s that the researcher worked with knew how to use MS Project or other software at the time. This was somewhat successful before FDA design controls as the formal level of documentation and more detail in the project and design was not so focused. In the mid 1990's the researcher was able to complete an important project in only 11 months with three people on the team and some support functions along the way. The researcher did use design controls and organized and documented the project. The researcher's project was well received, and best of all the end product worked well for the end user or patient. It was commercialized in the late 2000s. In 1997 when FDA design controls were required of all medical device projects, project management started to emerge as a process to plan and document information in the R&D medical device industry from the researcher's perspective. The researcher's first project using the FDA design controls was the most complex project he had led in his career. This project was actually a promotion in title and pay from the previous project mentioned. The technology was cutting edge for this medical device with a short timeline. Quality was also of concern and had to be done with the best people and resources. Technology was from overseas, and the information needed was in a foreign language. Because of IP issues it was necessary to translate the documentation with only a dictionary and the telephone with the overseas group. Many other issues came up on this project, resources leaving the company because of the high stress and miscommunication overseas, long hours, high management expectations and unreasonable milestones. The researcher actually used what is now called agile project management to recover the project and improve project team morale. This meant that every day at 7:00am the project team and operators met to discuss the past day and the current day's work. The researcher used his own ideas in following this approach. In the end the project met its expectations and was commercialized The Company was purchased because of this project’s success, quality and the IP that the organization held. “Very few projects are ever completed without trade-offs or scope changes in time, cost and quality” (Kerzner, 2009 p. 61).

The researcher had now formally recognized that he was a project manager, and many of his co-workers had not viewed this the same way. The researcher worked for the manufacturing department but now was working in the R&D department. The goal was to be the first organization in many areas of medical device technology. The organization relied more on the FDA design control guidance than effective sound project management principles in the late 1990s. The researcher looked to people outside the organization for answers in project management. He was able to find some people for assistance but not really anyone in the medical device profession. Actually the FDA design control process was refined and heavily used as a project management tool. At this time he did not know about PMI or the PMP® certification. Most if not all training had to do with design controls, verification, validation, quality and other topics that were important at the time.

By the late 1990’s, the researcher moved to smaller startup medical device companies in search of an effective combination of new product development and project management skills and knowledge. What the researcher found in three different medical device startups was that they too did not have any formal project management skills or procedures. The researcher used the internet to find some of the information that he was seeking. There was some success with this type of strategy, but it also lacked some fundamental information. He was still able to get projects done mostly on time and budget using simple spreadsheets and day-to-day task focus.

The researcher in the early 2000s finally joined an organization that had some formal project management process. This is when he joined PMI and passed the PMP®. This was refreshing, and he thought that things would change dramatically as they must have the project management recipe for success. He was surprised to learn that many of the product development managers were not PMP® certified nor did they care to take the time to become certified. The organization did, however, have formal basic project management training and advanced project management training. This was due to one individual that was teaching this information at this organization for nearly 15 years and trained most of the people in the organization on general project management. The researcher was thrilled to finally take these classes and meet like-minded people interested in project management.

In the early 2000s the projects were becoming more complex but still manageable. IT groups in the organization proved that project management did indeed work successfully. On-site PMP® review sessions were open to internal and external employees through the local PMI chapter. The researcher had started to try and help the project management wave to get more people involved and trained. He worked with management to show the importance of project management to the new products. During this time he started to work as a project manager on virtual project teams and had to change the way he approached projects and project management.

The researcher was trained in all of the classes the organization offered on project management and continued to learn on the job. He also started to play more of a mentor role to other older and younger project managers.

The medical device industry was still in an effective economic environment, and new markets were presenting medical device organizations with all kinds of opportunities. Competition was present, but profits were effective so the main focus was technology at the time. Training however was there for the people that wanted it. Face-to-face training was the main delivery method, and e-learning or virtual learning was still in the infant stages. Medical device organizations were still unsure about PMOs, and project managers were on their own for templates, software, instruction and other information. The researcher would attend project management functions outside the organization and was surprised to find that most of the people were from the IT industry and not the medical device industry. Other functions began to take on a more important role, such as knowledge management and product development.

The researcher was given even more complex projects with fuzzy scope, schedule and cost. Some of the training that the researcher had gained was helping him in deciding how to manage the projects. The researcher continued to get more accountability but less say in the scope, schedule and cost of the projects. He was able to hire contractors at will, but this did not always improve the situation. In some of the projects he actually had more contractors than full- time employees.

During the 2000s the medical device organizations continued to growth and prosper. Project management at these organizations had grown a little, but not at the overall rate that the organizations were growing. Executives were beginning to realize the importance of project management and the PMO. Technology had also changed and improved for virtual project teams. The real challenge is which technology to use and when. Collocation of project teams was and is still a prime source or first line for new product development to use in order to achieve improved productivity and overall success. The researcher has used both types of project teams and has also seen success and failure of both project teams. What makes a virtual project team performance improve over a collocated project team and what makes a collocated project team performance improve over a virtual project team remained as questions. “The fundamental change is that, with the virtual project team as an option, geographical location is no longer the primary context in which to define and pursue business opportunities in support of strategic goals and competitive objectives” (Rad & Levin, 2003 p. 1). Project managers need to understand the fundamental difference of each type of project teams and have the knowledge and training in order to be successful.

The researcher believes that there will continue to be more virtual project teams and that management will need to better understand the tradeoffs between virtual project teams and collocated teams. Project management levers (as discussed in previous chapters) should be better understood in the R&D medical device teams. The researcher decided to conduct research in this context while obtaining his Doctor of

Philosophy in Civil Engineering with a major in Project Management qualification. The outcome of this research will hopefully contribute to identify ways to improve communication of virtual and collocated project teams in the R&D medical device organizations.

Appendix B. Case Study Interview Documents

Appendix B1 – Initial Interview Protocol

A. JAMES CLARK
SCHOOL OF ENGINEERING

LEARN MORE, GO FURTHER.
It's That Simple!

Design and Social Context Portfolio
A. James Clark School of Engineering, School of Civil Engineering, Project Management.
Department of Civil and Environmental Engineering
1173H Glenn L. Martin Hall
University of Maryland
College Park, MD 20742
Phone: (301) 405-0287

<Employer Letter>

Dear xxxxxx,

My name is **Michael O'Connor.**

I am conducting research as part of my Doctor of Philosophy in Project Management at the University of Maryland, College Park, A. James Clark School of Engineering. The title of my research is "Virtual Project Teams and Productivity in R&D Medical Device Teams".

In an ever increasing area of globalization, R&D medical device teams are having more discussions virtually than ever before. Due to the improvement in technology it is easy for most project teams and team members to communicate with simple and complex tools. The focus of this research is to see what impacts that virtual project teams have as compared to collocated project teams in the area of Information communication technology leadership, meetings, team maturity and continuous process improvement. The conclusions from this research may be used to improve both virtual and collocated project teams in an R&D

medical device environment. Or the research could also be used to help future researchers, including possible publications. This research has no funding from any organization.

I invite your organization to participate in this research. I wish to interview one virtual project team and one collocated project team in the pilot study and then two virtual project teams and two collocated project teams in the actual study. I would like to have a team leader, project manager and one team member to represent each team.

In the process of research, each Participant will attend a 30 to 45 minute interview at a mutually agreed upon location. The draft interview protocol and questions are attached. The interviews will be audio recorded with the consent from Participants. Their particiaptio9n is voluntary and Participants are free to withdraw from the research at any time and to withdraw any unprocessed data previously supplied. After the interview, the individual Participant will receive the corresponding interview summary from researcher. He/She will help to check the accuracy of the summary. Participant may choose to withdraw at this stage. If some organizational documents can be shared with the researcher, the Participant will supply a copy of the document to the researcher. Participants may receive clarification phone calls from researcher on an as needed basis. An initial research finding summary will also be sent to Participants for voluntary feedback. Names of individuals and the organization identity will not be disclosed and will only be referred to by pseudonyms. The research report will document findings from multiple sources including interviews, literature and documentation reviews, in generalized and summarized format. Individual interview records will be kept confidential. Every effort will be made to maintain Participant's anonymity.

Where possible, I would like to have access to some relevant documents of you project team. Such documents may be, but not limited to, project plans, communication notes, meeting minutes, project management methodology, etc. All documents shared will be kept strictly confidential. Electronic files (including audio record files) and paper documents will all be locked in an office cabinet. Electronic files will only be accessed with researchers PC. Electronic files will be deleted after 5 years and hardcopies shredded before disposal after 5 years.

Should you have any further questions, please contact myself Michael O'Connor, oconnm5@umd.edu or my supervisor – Dr. Gregory Baechergbaecher@umd.edu.

Your participation is highly appreciated. Thank you very much for your kind support on the research.

Regards,

Michael O’Connor
Masters of Project Management (MSPM)
Masters of Technology Management (MSTM)
Masters of Business Administration (MBA)
PgMP, PMP, IPMA-B, NPDP
Cell 612-819-6247
Oconnm5@umd.edu
mgoconnor@comcast.net

Any complaints about your participation in the project may be directed to Research Compliance Office, University of Maryland College Park, 1204 Marie Mount Hall, College Park, MD 20742-5121, 301-405-0678 (Office), http://www.umresearch.umd.edu/RCOportal.html

Appendix B2 – Interview Protocols

Interview Protocol (Version 1.0):

Good morning/afternoon/evening.
This research is to be used for my Doctor of Philosophy in Project Management at the University of Maryland College Park, A. James Clark School of Engineering. In accordance with UMD University ethics regulations I would like to confirm that you have read and signed the consent form before we start the interview.
The goal of this study is to explore how virtual project teams and collocated projects teams in R&D medical device team's and productivity. The information generated in this research may be used for improvement of R&D medical device team's productivity in future research projects, including possible related publications.
With your permission, I would like to audio record this interview.

Before we begin, I would like to notify you of the following:

You participation is voluntary. You may halt the interview at any time and/or choose not to answer any of the questions.
Your responses will at all times remain confidential. At no time will your identity be revealed either by the procedures of the study or during reporting of the results.
No negative consequence will result for choosing not to participate.
A copy of the interview summary will be sent to you for validation before use.
An initial research finding will be sent to you for voluntary feedback and a copy of the final research report will be available for your review.
Your identity will at all times be kept anonymous, including in interview summaries and all project documents.

Interviewee Background:

1. What is your current role in your organization?
2. What are your years of service in your current position?
3. What are your years of work in the medical device industry?

4. What key R&D roles have you played in your work history?
5. What is your highest education level?
6. What is formal project management training have you had, if any?

Research Questions:

1. What are the major areas that support project management success and or product commercialization success in your area?
2. What project management tools did your virtual (or collocated) team use on your project?
3. What drives positive use of the project management tools that you described in the previous question, and did that improve productivity or performance on the virtual project team or collocated) project team?
4. Do you feel team productivity is enhanced because you work on a virtual (or collocated) project team and if so why?
5. What do you feel you could do to enhance the productivity of your virtual (or collocated) project team?

Interview Protocol (Version 2.0):

Good morning/afternoon/evening.

This research is to be used for my Doctor of Philosophy in Project Management at the University of Maryland College Park, A. James Clark School of Engineering. In accordance with UMD University ethics regulations I would like to confirm that you have read and signed the consent form before we start the interview.

The goal of this study is to explore how virtual project teams and collocated projects teams in R&D medical device teams are productive. The information generated in this research may be used for improvement of R&D medical device team's productivity in future research projects, including possible related publications.

With your permission, I would like to audio record this interview.

Before we begin, I would like to notify you of the following:

You participation is voluntary. You may halt the interview at any time and/or choose not to answer any of the questions.

Your responses will at all times remain confidential. At no time will your identity be revealed either by the procedures of the study or during reporting of the results.

No negative consequence will result for choosing not to participate.

A copy of the interview summary will be sent to you for validation before use.

An initial research finding will be available to you for voluntary feedback and a copy of the final research report will be available for your review.

Your identity will at all times be kept anonymous, including in interview summaries and all project documents.

Interviewee Background:

1. What is your current role in the organization?
2. What are your years of service in your current position at this organization?
3. What are your years of work in the medical device industry?
4. What key R&D medical device roles have you played in your work history?
5. What is your highest education level?
6. What formal project management training have you had, if any?

7. In total, how many people are on your project team?

Research Questions:

1. What areas from the list below supported project management success and or product commercialization success in your area?
    a. Team environment (virtual and collocation)
    b. Leadership
    c. Team maturity (knowledge and experience/expertise)
    d. Team meetings
    e. Other, please explain
2. What project management tools from the list below did your team (virtual or collocated) team use on your project?
    a. Continuous improvement process (i.e. TQM, lean sigma and six-sigma).
    b. Information communication technology (video, phone, email, IM, intranet, internet, shared site, etc.).
    c. Other, please explain
3. What drives positive use of the project management areas and tools that you described in the previous two questions? How did it impact performance or productivity?
4. Do you feel project productivity is enhanced because you work on a virtual or collocated team? Yes or no and why?
5. What do you feel you could do to enhance or improve the productivity of your project team (virtual or collocated) in the future?

Appendix B3 – Consent Form

Version 1 (Pilot Study)

Project Title	VIRTUAL AND COLLOCATED PROJECT TEAMS IMPACT ON PRODUCTIVITY IN MEDICAL DEVICE RESEARCH AND DEVELOPMENT
Purpose of the Study	*This research is being conducted by Michael O'Connor at the University of Maryland, College Park. We are inviting you to participate in this research project because you are part of a virtual or collocated project team. The purpose of this research project is research on information in virtual and collocated teams in R&D medical device teams and productivity.*
Procedures	*Each Participant will be asked open ended questions in an interview that will last between 20 – 30 minutes. The interview will be a one on one and face-to-face when possible. If not possible the interview will be conducted via the telephone on a secure line. All interviews will be in a secure and closed meeting (in the interviewees general work area) room with the interviewer and interviewee, only. The interview will be audio recorded with the consent of the Participant. All files, audio and discussions will be kept confidential and under password protection on the researchers computer.* *All candidates are eligible and no criteria will be used to recruit under eligibility.* *Participants must be 18 years or older.* ***Sample Questions:*** *What are the major areas that support project management success and or product commercialization success in your area?* *What project management tools did your virtual (or collocated) team use on your project?* *What drives positive use of the project management tools that you described in the previous question, and did that improve productivity or performance on the virtual project team or collocated) project team?* *Do you feel team productivity is enhanced because you work on a virtual (or collocated) project team and if so why?* *What do you feel you could do to enhance the productivity of your virtual (or collocated) project team?*

Potential Risks and Discomforts	*The researcher will keep all interviews and information confidential. No individual indentification or team indentification will be used in this research .Position title will be used and will be the same in all case studies, core team leader, project manager and team member. The researcher does not see any risk of identification in this research.* *The researcher will enroll core team leaders, project manager's s and team members of virtual and collocated projects teams in the researcher's R&D organization. There will be no dual role or any interest of conflict, all teams will be outside any responsibility or authority that the researcher currently conducts in the organization. He will work through the project management office to identify projects and people. The researcher will recruit virtual project teams and collocated project teams through the PMO or Project Management Office which will select teams for the researcher.*
Potential Benefits	*There are no direct benefits to you. However, possible benefits include future research in the area of productivity in the area of virtual and collocated teams in R&D medical device teams.*

Confidentiality	*Any potential loss of confidentiality will be minimized by storing data in a secure location in my home office, locked cabinet, and password protected computer.* *Interviews will be recorded with an audio source and then they will be transcribed and coded to protect the indentification of the Participants. All information collected will remain under lock and key at the researcher's office. All electronic information will also remain under password protection. Information will be kept for 5 years after the research is completed.* . *If a report or article about this research project, your identity will be protected to the maximum extent possible. Your information may be shared with representatives of the University of Maryland, College Park or governmental authorities if you or someone else is in danger or if we are required to do so by law.*
Medical Treatment	*The University of Maryland does not provide any medical, hospitalization or other insurance for Participants in this research study, nor will the University of Maryland provide any medical treatment or compensation for any injury sustained as a result of participation in this research study, except as required by law.*
Right to Withdraw and Questions	*Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if*

	you stop participating at any time, you will not be penalized or lose any benefits to which you otherwise qualify. *If you decide to stop taking part in the study, if you have questions, concerns, or complaints, or if you need to report an injury related to the research, please contact the investigator:* *Michael O'Connor* *6713 Clearwater Creek Drive, Lino Lakes, MN 55038, 612-819-6247, and oconnm5@umd.edu.*
Participant Rights	*If you have questions about your rights as a research* *Participant or wish to report a research-related injury,* *please contact:* **University of Maryland College Park** **Institutional Review Board Office** **1204 Marie Mount Hall** **College Park, Maryland, 20742** **E-mail:** irb@umd.edu **Telephone: 301-405-0678** *This research has been reviewed according to the University of Maryland, College Park IRB procedures for research involving human subjects.*
Statement of Consent	*Your signature indicates that you are at least 18 years of age; you have read this consent form or have had it read to you; your questions have been answered to your satisfaction and you voluntarily agree to participate in this research study. You will receive a copy of this signed consent form.* *If you agree to participate, please sign your name below* .
Signature and Date	**NAME OF PARTICIPANT [Please Print]** |

	SIGNATURE OF PARTICIPANT	
	DATE	

Version 2 (Case Study)

Project Title	VIRTUAL AND COLLOCATED PROJECT TEAMS IMPACT ON PRODUCTIVITY IN MEDICAL DEVICE RESEARCH AND DEVELOPMENT
Purpose of the Study	*This research is being conducted by Michael O'Connor at the University of Maryland, College Park. We are inviting you to participate in this research project because you are part of a virtual or collocated project team. The purpose of this research project is research on information in virtual and collocated teams in R&D medical device teams and productivity*.
Procedures	*Each Participant will be asked open ended questions in an interview that will last between 20 – 30 minutes. The interview will be a one on one and face-to-face when possible. If not possible the interview will be conducted via the telephone on a secure line. All interviews will be in a secure and closed meeting (in the interviewees general work area) room with the interviewer and interviewee, only. The interview will be audio recorded with the consent of the Participant. All files, audio and discussions will be kept confidential and under password protection on the researchers computer.* *All candidates are eligible and no criteria will be used to recruit under eligibility.* *Participants must be 18 years or older*. ***Sample Questions:*** *What areas from the list below supported project management success and or product commercialization success in your area?* *Team environment (virtual and collocation)* *Leadership* *Team maturity (knowledge and experience/expertise)* *Team meetings* *Other, please explain* *What project management tools from the list below did your team (virtual or collocated) team use on your project?* *Continuous improvement process (i.e. TQM, lean sigma and six-sigma).* *Information communication technology (video, phone, email, IM, intranet, internet, shared site, etc.).* *Other, please explain* *What drives positive use of the project management areas*

	and tools that you described in the previous two questions? How did it impact performance or productivity? Do you feel project productivity is enhanced because you work on a virtual or collocated team? Yes or no and why? *What do you feel you could do to enhance or improve the productivity of your project team (virtual or collocated) in the future?*
Potential Risks and Discomforts	*The researcher will keep all interviews and information confidential. No individual indentification or team indentification will be used in this research. Position title will be used and will be the same in all case studies, core team leader, project manager and team member. The researcher does not see any risk of identification in this research.* *The researcher will enroll core team leaders, project manager's s and team members of virtual and* collocated *projects teams in the researcher's R&D organization*. *There will be no dual role or any interest of conflict, all teams will be outside any responsibility or authority that the researcher currently conducts in the organization. He will work through the project management office to identify projects and people. The researcher will recruit virtual project teams and collocated project teams through the PMO or Project Management Office which will select teams for the researcher.*
Potential Benefits	*There are no direct benefits to you. However, possible benefits include future research in the area of productivity in the area of virtual and collocated teams in R&D medical device teams.*

Confidentiality	*Any potential loss of confidentiality will be minimized by storing data in a secure location in my home office, locked cabinet, and password protected computer.* *Interviews will be recorded with an audio source and then they will be transcribed and coded to protect the indentification of the Participants. All information collected will remain under lock and key at the researcher's office. All electronic information will also remain under password protection. Information will be kept for 5 years after the research is completed.* . *If a report or article about this research project, your identity will be protected to the maximum extent possible. Your information may be shared with representatives of the University of Maryland, College Park or governmental authorities if you or someone else is in danger or if we are required to do so by law.*
Medical Treatment	*The University of Maryland does not provide any medical, hospitalization or other insurance for Participants in this research study, nor will the University of Maryland provide any medical treatment or compensation for any injury sustained as a result of participation in this research study, except as required by law.*

Right to Withdraw and Questions	*Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not be penalized or lose any benefits to which you otherwise qualify.* *If you decide to stop taking part in the study, if you have questions, concerns, or complaints, or if you need to report an injury related to the research, please contact the investigator:* *Michael O'Connor* *6713 Clearwater Creek Drive, Lino Lakes, MN 55038, 612-819-6247, and oconnm5@umd.edu.*
Participant Rights	*If you have questions about your rights as a research* *Participant or wish to report a research-related injury,* *please contact:* **University of Maryland College Park** **Institutional Review Board Office** **1204 Marie Mount Hall** **College Park, Maryland, 20742** **E-mail:** irb@umd.edu **Telephone: 301-405-0678** *This research has been reviewed according to the University of Maryland, College Park IRB procedures for research involving human subjects.*
Statement of Consent	*Your signature indicates that you are at least 18 years of age; you have read this consent form or have had it read to you; your questions have been answered to your satisfaction and you voluntarily agree to participate in this research study. You will receive a copy of this signed consent form.* *If you agree to participate, please sign your name below* .

Signature and Date	**NAME OF PARTICIPANT [Please Print]**	
	SIGNATURE OF PARTICIPANT	
	DATE	

Appendix B4 – UMD Application Part 2 IRB

1. Abstract:

Virtual project teams are becoming more of a standard way of business at companies, organizations and higher education institutions. Virtual project teams and collocated project teams are finding themselves using many technologies to communicate during a project. This research will investigate how virtual project teams determine information communication technology (ICT) such as meeting environments, facilitation tools and shared leadership among team members as compared to collocated teams. Project managers and leaders need to use a different set of tools in order to build productivity within the project team.

Which skills and which levers a project team deploys will determine which teams are more successful than others. From the literature review there appears to be a gap in the area of team maturity with the technology chosen as well as the utilization of the technology mainly in virtual teams, especially in R&D medical device teams.

The purpose of this research study is to explore virtual project teams and collocated project teams to determine any differences in information communication technology or ICT. To explore only one type of project team may not explain what possible differences there may be when contrasting two different types of teams. The research will use a case study methodology and

2. Subject Selection:

a.

The researcher will enroll core team leaders, project manager's s and team members of virtual and collocated projects teams in the researcher's R&D organization. There will be no dual role or any interest of conflict, all teams will be outside any responsibility or authority that the researcher currently conducts in the organization. He will work through the organizations project management office to identify projects and people. The researcher will recruit virtual project teams and colocated project teams through the PMO or Project Management Office which will select teams for the researcher.

b.

All candidates are eligible and no criteria will be used to recruit under eligibility. Participants must be 18 years or older.

c.

There are no criteria based on age, sex, race, ethnic origin, religion or any social or economic qualifications.

d.

Pilot Study, one virtual team and one collocated team, 6 team members overall from project two teams

Case study, two virtual teams and two collocated teams, 12 team member total

Grand total is 18 team members

3.

Each participant will be asked open ended questions in an interview that will last between 20 – 30 minutes. The interview will be a one on one and face-to-face when possible. If not possible the interview will be conducted via the telephone on a secure line. All interviews will be in a secure and closed meeting (in the interviewees general work area) room with the interviewer and interviewee, only. The interview will be audio recorded with the consent of the participant. All files, audio and discussions will be kept confidential and under password protection on the researchers computer.

4. Risks:

The researcher will keep all interviews and information confidential. No individual indentification or team indentification will be used in this research. Position title will be used and will be the same in all case studies, core team leader, project manager and team member. The researcher does not see any risk of identification in this research.

5. Benefits:

No direct benefits to the participants.

The benefit will be new knowledge on virtual and collocated teams in the R&D medical device teams using information communication technology.

6. Confidentiality:

Interviews will be recorded with an audio source and then they will be transcribed and coded to protect the indentification of the participants. All information collected will remain under lock and key at the researcher's office. All electronic information will also remain under password protection. Information will be kept for 5 years after the research is completed.

7. Consent Process:

All participants will be presented with a written consent form to be signed.

All participants will receive a copy of the consent form for their records. Measures will be in place to protect participant privacy during the consent process; all interviews will be behind closed doors or a private area.

8. Conflict of Interest:

No conflict of interest

9. HIPAA Compliance:

Not applicable

10. Research Outside of the United States:

a) Has the investigator(s) previously conducted research in the country where the research will take place? No, briefly describe the investigator's knowledge and experience working with the study population. I have worked with Europe on previous projects.
b) Are there any regulations, rules or policies for human subject's research in the country where the research will take place? No, http://www.hhs.gov/ohrp/international/HSPCompilation.pdf
c) Do you anticipate any risks to the research participants in the country where the research will take place, taking into account the population involved, the geographic location, and the culture? No

1

Not applicable

12. <u>SUPPORTING DOCUMENTS</u>

Your Initial Application must include a **completed Initial Application Part 1 (On-Line Document),** the information required in items 1-11 above, and all relevant supporting documents including: consent forms, letters sent to recruit Participants, questionnaires completed by Participants, and any other material that will be presented, viewed or read to human subject Participants.

For funded research, a copy of the Awarded Grant Application (minus the budgetary information) must be uploaded. If the Grant has not been awarded at the time of submission of this Initial Application, a statement must be added to the Abstract Section stating that an Addendum will be submitted to include the Grant Application once it has been awarded.

THE IRB OFFICE WILL NO LONGER STAMP CONSENT FORMS. THE CONSENT FORMS IN YOUR APPROVED IRBNET PACKET MUST BE USED. THESE ARE YOUR APPROVED CONSENT FORMS.

Appendix B5 – IRB Approval Letter

UNIVERSITY OF MARYLAND
INSTITUTIONAL REVIEW BOARD

1204 Marie Mount Hall
College Park, MD 20742-5125
TEL 301.405.4212
FAX 301.314.1475
irb@umd.edu
www.umresearch.umd.edu/IRB

DATE:	February 4, 2013
TO:	Michael O'Connor, MSPM, MSTM, MBA
FROM:	University of Maryland College Park (UMCP) IRB
PROJECT TITLE:	[418958-1] Virtual Project Teams and Productivity in R&D Medical Device Teams
REFERENCE #:	
SUBMISSION TYPE:	New Project
ACTION:	APPROVED
APPROVAL DATE:	February 4, 2013
EXPIRATION DATE:	February 3, 2014
REVIEW TYPE:	Expedited Review
REVIEW CATEGORY:	Expedited review category # 7

Thank you for your submission of New Project materials for this project. The University of Maryland College Park (UMCP) IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document.

Please note that any revision to previously approved materials must be approved by this committee prior to initiation. Please use the appropriate revision forms for this procedure which are found on the IRBNet Forms and Templates Page.

All UNANTICIPATED PROBLEMS involving risks to subjects or others (UPIRSOs) and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office. Please use the appropriate reporting forms for this procedure. All FDA and sponsor reporting requirements should also be followed.

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to this office.

This project has been determined to be a Minimal Risk project. Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the appropriate forms for this procedure. Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date of February 3, 2014.

Please note that all research records must be retained for a minimum of three years after the completion of the project.

If you have any questions, please contact the IRB Office at 301-405-4212 or irb@umd.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within University of Maryland College Park (UMCP) IRB's records.

Appendix B6 – Approval Letter #2

UNIVERSITY OF MARYLAND

INSTITUTIONAL REVIEW BOARD

1204 Marie Mount Hall
College Park, MD 20742-5125
TEL 301.405.4212
FAX 301.314.1475
irb@umd.edu
www.umresearch.umd.edu/IRB

DATE:	February 27, 2013
TO:	Michael O'Connor, MSPM, MSTM, MBA
FROM:	University of Maryland College Park (UMCP) IRB
PROJECT TITLE:	[418958-2] Virtual and Collocated Project Teams Impact on Productivity in Medical Device Research and Development
REFERENCE #:	
SUBMISSION TYPE:	Amendment/Modification
ACTION:	APPROVED
APPROVAL DATE:	February 27, 2013
EXPIRATION DATE:	February 3, 2014
REVIEW TYPE:	Expedited Review
REVIEW CATEGORY:	Expedited review category # 7

Thank you for your submission of Amendment/Modification materials for this project. The University of Maryland College Park (UMCP) IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document.

Please note that any revision to previously approved materials must be approved by this committee prior to initiation. Please use the appropriate revision forms for this procedure which are found on the IRBNet Forms and Templates Page.

All UNANTICIPATED PROBLEMS involving risks to subjects or others (UPIRSOs) and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office. Please use the appropriate reporting forms for this procedure. All FDA and sponsor reporting requirements should also be followed.

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to this office.

This project has been determined to be a Minimal Risk project. Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the appropriate forms for this procedure. Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date of February 3, 2014.

Please note that all research records must be retained for a minimum of three years after the completion of the project.

If you have any questions, please contact the IRB Office at 301-405-4212 or irb@umd.edu. Please include your project title and reference number in all correspondence with this committee.

Appendix B7 – CITI Training

Completion Report

CITI Collaborative Institutional Training Initiative

Social & Behavioral Research - Basic/Refresher Curriculum
Completion Report
Printed on 1/18/2013

Learner: Michael O'Connor (username: oconnm5)
Institution: University of Maryland College Park
Contact Information 6713 Clearwater Creek Drive
Lino Lakes, MN 55038 Anoka
Department: Civil Engineeering
Phone: 612-819-6247
Email: mgoconnor@comcast.net

Social & Behavioral Research - Basic/Refresher: Choose this group to satisfy CITI training requirements for Investigators and staff involved primarily in Social/Behavioral Research with human subjects.

Stage 1. Basic Course Passed on 01/18/13 (Ref # 5935964)

Required Modules	**Date Completed**	**Score**
Belmont Report and CITI Course Introduction	01/18/13	3/3 (100%)
Students in Research	01/18/13	7/10 (70%)
History and Ethical Principles - SBR	01/18/13	5/5 (100%)
Defining Research with Human Subjects - SBR	01/18/13	2/5 (40%)
The Regulations and The Social and Behavioral Sciences - SBR	01/18/13	4/5 (80%)
Assessing Risk in Social and Behavioral Sciences - SBR	01/18/13	3/5 (60%)
Informed Consent - SBR	01/18/13	2/5 (40%)
Privacy and Confidentiality - SBR	01/18/13	5/5 (100%)
Research with Prisoners - SBR	01/18/13	4/4 (100%)
Research with Children - SBR	01/18/13	4/4 (100%)
Research in Public Elementary and Secondary Schools - SBR	01/18/13	4/4 (100%)
International Research - SBR	01/18/13	3/3 (100%)
Internet Research - SBR	01/18/13	5/5 (100%)
Vulnerable Subjects - Research Involving Workers/Employees	01/18/13	4/4 (100%)
University of Maryland College Park	01/18/13	no quiz

For this Completion Report to be valid, the learner listed above must be affiliated with a CITI participating institution. Falsified information and unauthorized use of the CITI course site is unethical, and may be considered scientific misconduct by your institution.

Paul Braunschweiger Ph.D.

Appendix C. Case Triangulation Documents

Appendix C1 – Case Study One References

List of documents referenced in relation to CV1 project team (all various years)

1	CV1 Test documents
2	CV1 Issues list
3	CV1 Shipments
4	CV1 Yield
5	CV1 Root cause analysis
6	CV1 Builds
7	CV1 Topology
8	CV1 Prototypes
9	CV1 Incoming material
10	CV1 Device test
11	CV1 Misc. Test
12	CV1 Meeting minutes
13	CV1 Care forms
14	CV1 Other tests
15	CV1 Launch materials

Appendix C2 – Case Study Two References

List of documents referenced in relation to CV2 project team (all various years)

1	CV2 Shared documents
2	CV2 Agenda and meeting minutes
3	CV2 Desktop items
4	CV2 Subcomponents
5	CV2 Technology library
6	CV2 Issues list
7	CV2 Microsoft vision
8	CV2 Project plans
9	CV2 Project status
10	CV2 Requirements documents
11	CV2 Software technology library
12	CV2 Systems walk thru
13	CV2 Meeting notes
14	CV1 Misc.

Appendix C3 – Case Study Three References

List of documents referenced in relation to CC1 project team (all various years)

1	CC1 Shared documents
2	CC1 Core team documents
3	CC1 Extended team documents
4	CC1 Issues and action log
5	CC1 Meeting minutes
6	CC1 Project plan
7	CC1 Business plan
8	CC1 Schedule
9	CC1 DHF file status
10	CC1 DHF deliverables
11	CC1 Communication meetings
12	CC1 Presentations
13	CC1 AOP
14	CC1 MS project schedule
15	CC1 Misc.

Appendix C4 – Case Study Four References

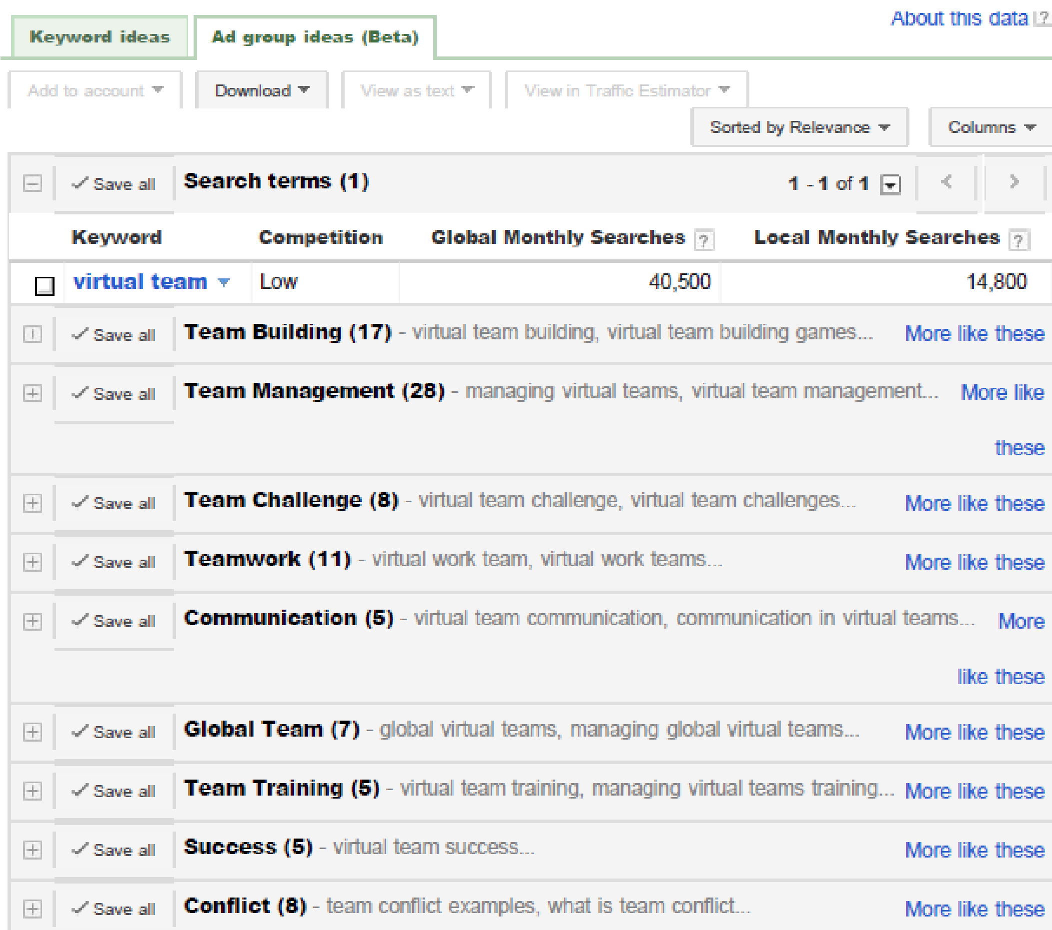
List of documents referenced in relation to CC2 project team (all various years)

1	CC2 Project management
2	CC2 Quality
3	CC2 Regulatory
4	CC2 Systems engineering
5	CC2 Architecture and development
6	CC2 Marketing
7	CC2 Industrial design
8	CC2 Requirements
9	CC2 Operations and manufacturing
10	CC2 Verification and validation
11	CC2 Hardware testing
12	CC2 Meeting minutes

Appendix D. Miscellaneous Documents

Appendix D1 – Google ad group ideas

Google ad group ideas uses one key word term or search phrase and then creates a list of similar ideas. Retrieved from, https://adwords.google.com/o/Targeting/Explorer?__c=8182823203&__u=7052569243&__o=cues&ideaRequestType=KEYWORD_IDEAS



Appendix D2 – Google keyword ideas

Using a set of keywords one can get other themes or ideas under ad group to see if there are other terms to create a series of words to search for. Retrieved from, https://adwords.google.com/o/Targeting/Explorer?__c=8182823203&__u=7052569243&__o=cues&ideaRequestType=KEYWORD_IDEAS

Keyword ideas | Ad group ideas (Beta) | About this data

Add to account | Download | View as text | View in Traffic Estimator

Sorted by Relevance | Columns

Save all **Search terms (1)** 1 - 1 of 1

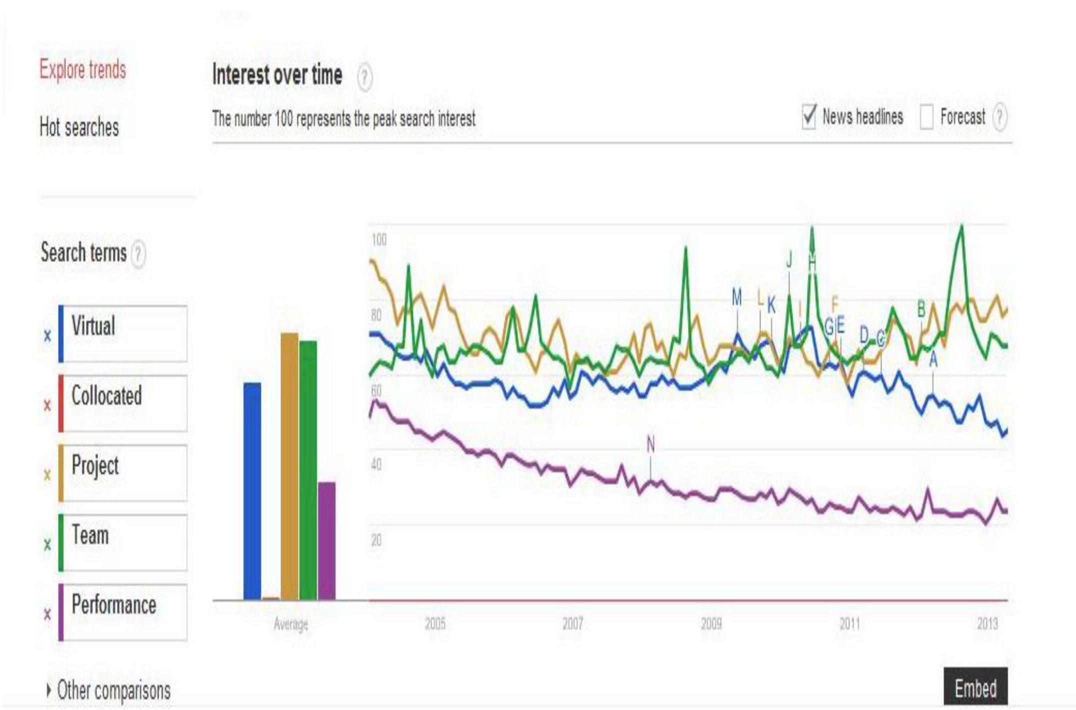
Keyword	Competition	Global Monthly Searches	Local Monthly Searches
virtual team	Low	40,500	14,800

Save all **Keyword ideas (229)** 1 - 50 of 229

Keyword	Competition	Global Monthly Searches	Local Monthly Searches
virtual team building	Medium	1,900	1,300
virtual team challenge	Low	880	590
managing **virtual teams**	Low	1,900	880
virtual teams	Low	33,100	14,800
virtual team management	Medium	1,300	590
virtual work team	Low	1,600	720
virtual team training	Medium	390	210
virtual team challenges	Low	880	480
virtual team definition	Low	590	210
managing a **virtual team**	Low	1,600	880
virtual team building games	Medium	320	210
virtual team building exercises	Medium	720	590
virtual sales team	High	320	110
virtual teaming	Low	1,000	390
virtual work teams	Low	1,300	720
global **virtual teams**	Low	1,300	590
virtual team communication	Low	880	480
virtual team collaboration	Medium	390	210

Appendix D3 – Google trend

Google trend is used in chapter 2 to explain trends in the various areas below, virtual, collocated, project, team and performance. This is a free web-based tool that lets the researcher look at the interest on a particular subject matter over time, in the researcher's case this 2004 to 2013, retrieved from, http://www.google.com/trends/explore#q=Virtual,%20Collocated,%20Project,%20Team,%20Performance,%20Productivity



Appendix D4 – Publish or perish, virtual project teams

This information was used in the literature review to target some of the larger reference materials. Publish or Perish is a software tool looks up scholarly citations and performs a calculation for citations. This is just a partial snapshot of the actual output. The table below is the partial output when the term “virtual project team” is queried.

Cites	Authors	Title	Year	Source
2798	H Kerzner	Project management: a systems approach to planning, scheduling, and controlling	2009	
2308	I Nonaka, R Toyama, N Konno	SECI,< i> Ba</i> and Leadership: a Unified Model of Dynamic Knowledge Creation	2000	Long range planning
2070	SG Cohen, DE Bailey	What makes teams work: Group effectiveness research from the shop floor to the executive suite	1997	Journal of management
1570	D Tapscott	The digital economy: Promise and peril in the age of networked intelligence	1996	
1288	RA Guzzo, MW Dickson	Teams in organizations: Recent research on performance and effectiveness	1996	Annual review of psycholc
1251	GM Olson, JS Olson	Distance matters	2000	Human-computer interact
1035	CD Cramton	The mutual knowledge problem and its consequences for dispersed collaboration	2001	Organization science
1006	J Lipnack, J Stamps	Virtual teams: Reaching across space, time, and organizations with technology	1997	
846	G Hertel, S Niedner, S Herrmann	Motivation of software developers in Open Source projects: an Internet-based survey of contributors to the Linux kernel	2003	Research policy
825	AM Townsend, SM DeMarie...	Virtual teams: Technology and the workplace of the future.	1998	The Academy of ...
815	S Faraj, L Sproull	Coordinating expertise in software development teams	2000	Management science

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