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PROJECT COLLABORATION IN A DISTRIBUTED ENVIRONMENT

by

SHRIROOPA PRABHAKAR DESHPANDE

A THESIS

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ABSTRACT

This thesis investigates methods of managing projects in an environment where project team members are in different locations. Today, large scale projects undertaken by firms that have a global presence are successfully developed across time, distance, and geographic boundaries. In order to survive in this environment, firms face many project challenges, including diverse employees, various work practices, and communication issues. Many communication issues can be minimized by the proper use of collaborative tools as well as by sharing expertise, coordinating activities, and managing relationships. Web-enabled project management tools have enhanced efforts to increase the quality, competitiveness, and profitability of these types of projects.

The present work investigates project management practices at firms in a wide range of industries, including software, construction, and architecture. Further, it evaluates a research project undertaken by the students of Missouri University of Science and Technology and Prairie View Agricultural and Mechanical University to design a solar roof. This analysis provides a better understanding of the actual problems faced while managing a project where team members are not co-located. Two surveys have also been used to analyze specific issues related to team management in these types of collaborative projects. Effective communication, training, and an appropriate project management approach helps increase the success of projects whose team members are located in various locations.

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1. INTRODUCTION

Project management is the study pertaining to planning, organizing, and managing resources for the successful completion of a project. Project management requires the development of technical skills and an appropriate management attitude. The most important aspects in project management are scope, time, and budget. It is also necessary to clarify the roles and responsibilities of all participants and stakeholders. The project development process goes through the phases of initiation, planning or development, production or execution, monitoring and controlling, and closing.

With the world growing closer due to improved communication channels, many companies have offices spread out through different regions of a country as well as abroad. There are scenarios where the client is in multiple locations. In many cases the projects also have team members at locations which are geographically separated. For effective project management it is important to identify potential problem areas in geographically dispersed teams. This thesis attempts to study project collaboration and determine methods for increasing the probability of project success. This thesis covers aspects of distributed projects in various industries including software, manufacturing, and construction. In order to examine an actual collaborative project, a case study is also analyzed. In addition, two project management surveys are analyzed to determine how project management improvements might be accomplished.

2. BACKGROUND

This section briefly describes the nature of multinational corporations (MNCs) and defines the frequently used terms *globalization* and *outsourcing*. The importance of managing the distributed projects that are such a common undertaking of multinational companies is also addressed.

2.1 MULTINATIONAL CORPORATIONS

Public corporations are legal entities or organizations that are detached and distinct from their owners. A corporation is created by shareholders who have ownership of the corporation, through their holding of common stock. By purchasing stock, one becomes part owner of a corporation. Shareholders elect a board of directors who appoint and oversee management of the corporation. Shareholders generally receive one vote per share. Although some corporations are non-profit, the vast majority of corporations seek to provide a return for their shareholders.

An MNC is a business enterprise that manages production establishments or delivers services in more than one country. Generally the operations of MNCs are spread out across many countries and affect both local and global economies. Although these companies have offices or factories in various countries, there is usually a centralized head office from which they coordinate global management.

Many MNCs have significant influence on integration of national economies into the international economy through trade. As a result, their operations are often controversial. Nearly all major multinationals are American, Japanese, or Western European. Examples include Nike, Coca-Cola, Wal-Mart, Infosys, Wipro, AOL, Toshiba, Honda, and BMW. Supporters of multinationals say they create jobs and wealth and improve technology in the developing countries. On the other hand, critics say multinationals can have an undue political influence on governments, exploit nations in need of development, and create job losses in their own home countries¹.

2.2 GLOBALIZATION

Globalization encourages investment funds and businesses to move beyond domestic and national markets to other markets around the world. This leads to increased interconnectedness and interdependency among markets. Globalization produces worldwide markets, and makes available to consumers a wide range of foreign products. Globalization has led to the emergence of worldwide financial markets and broad accessibility of external finance sources. Globalization has affected international trade and cultural exchange.

Globalization also has led to significant debate. The advantages and disadvantages of globalization have been heavily scrutinized in recent years. Proponents of globalization say that it helps poorer nations to industrialize and that it is responsible for faster growth through increased employment and technological advances. Critics of globalization say that it weakens national sovereignty by allowing rich nations to take advantage of cheap foreign labor².

2.3 OUTSOURCING

Outsourcing is the practice of businesses contracting with third parties to perform tasks that would otherwise have been performed by their own employees. It seeks to minimize labor and energy costs by relying on businesses that specialize in specific business functions. Common examples of outsourcing are call center services, e-mail services, and payroll. Such specialized companies are often located overseas. By relying on outside specialists, outsourcing may make more efficient use of land, labor, capital, technology, and resources.

There are many reasons that companies outsource jobs, but the most significant reason is cost savings. A number of companies outsource customer support and call center functions such as telemarketing, CAD drafting, customer service, market research, manufacturing, design, and web development. Many of the companies that provide these services are able to do the work for considerably less money, since they do not have to provide as many benefits to their workers, and since they have fewer overhead expenses.

Outsourcing also allows companies to focus on other business issues while the details of the outsourced area are managed by outside experts. The specialized company that handles the outsourced work is often streamlined, having world-class capabilities and access to new technology that their client company could not afford. Partitioning of intermediate markets occurs as the coordination of production across a value chain is simplified and as information becomes standardized, making it easier to transfer activities across boundaries. If a company seeks to expand its business to other countries, outsourcing is a cost-effective way to build foundations in those countries.

One of the disadvantages of outsourcing is that it often closes down direct communication between a company and its clients. This prevents a company from building solid relationships with their customers, and often leads to dissatisfaction on one or both sides. Also, outsourcing can affect the local labor market. There is some danger of being unable to control some aspects of business due to delayed communications and project implementation. Care must be taken to avoid leaking important information, which can be more vulnerable if some functions are outsourced. A company may become dependent upon outsource providers, which can lead to problems when outsource providers fail to fulfill contractual obligations. While outsourcing may prove highly beneficial for many companies, it also has many disadvantages. Each company must analyze its needs to determine whether outsourcing is a feasible option³.

2.4 COLLABORATIVE PROJECT MANAGEMENT

Today, collaboration projects are an important aspect of business operations. Due to the complexity and broad scope of issues, collaboration is considered an effective approach to increase efficiency, lower initial investment costs, and provide better service to customers. Business collaboration improves a business by providing a unified set of services through increased communication among the various units of the organization.

Project success is affected by the project management methodology used to complete the project. The Internet revolution has facilitated the use of development

teams working in various locations on multiple continents and different time-zones. These teams can be managed by new web-based project management software. Homogeneity has given way to heterogeneity in terms of language, dress, time of work, and culture. The race to reach the market first with a top-notch product or service, coupled with the need to reduce project costs by getting cheaper and yet more productive labor, has increased the trend toward international collaboration and outsourcing.

Project management software such as Microsoft project is frequently used to help manage each stage of a project. Project management software provides an information repository. Brainstorming sessions become very important, with the information gathered during those meetings permanently recorded in a repository. When a client or project manager suggests any changes to the initial agreement, the information from the repository can be easily retrieved. This repository can be made available to all team members through the use of collaborative web-based tools.

During the life of the project, project requirements may be dynamic in nature and highly susceptible to change. Business environments change with changes in inputs, technology, infrastructure, stakeholders, and personnel. Such situations are regularly faced by a manager in charge of a collaborative project and the manager must continuously gauge the impact of such changes on the progress of the project. This makes project tracking a very important dimension. Today, projects often are carried out around the clock. Due to the difference in time-zones of project teams: one team located at Pune, another in Shanghai and yet another in Sydney, for example, an efficient project manager is one that schedules tasks such that the entire project runs twenty-four hours per day. In medieval British lore, it was said that “for the British Empire, the sun never sets.” British colonies were managed all over the globe. The same can be true for collaborative project management⁴.

For the civil and construction industry, the use of Internet-based collaborative project management is most sought after for improving the overall construction delivery process. It can provide improved communication, coordination, and collaboration among project team members. Construction projects are highly complex, fast paced, and

dynamic. Hence, managing information becomes a very important factor. There are various operations such as acquisition, funding, programming, and designing, along with engineering and budget maintenance. In order to complete a project that meets the requirements of the customer, all the operations must be carried out in a way that supports effective development, utilization, and communication. In addition to the increased demands placed on all key parties to the building process (owners, designers, and contractors), the industry is at a critical juncture in addressing project collaboration problems. One way to address this situation is via web-based project management systems (WPMS) and a Project-Specific Web Site (PSWS). WMS and PSWS are web-based applications that make use of the Internet to perform typical project management tasks, such as storing and managing project information. They allow all necessary groups of people involved in the construction projects (contractors, engineers, architects, and clients) to access and control the information. The combination of the Internet with project management systems has opened many new ways of communication. Through the integration of these two systems, tasks can be accomplished better, faster, and cheaper. Better project control, especially during project procurement, can significantly impact savings on construction projects.

On Demand Construction Project Management (also known as web-based construction project management) is the use of web-based technology to manage the construction of capital development projects. This process streamlines construction management processes. Manual processes can be automated and standardized through use of a central location for information. This information then can be made available through the web, saving time and effort. The project delivery time is reduced through faster, automated communications, decreasing the likelihood of delays and budget overruns. Collaborative project management is also useful for risk mitigation through improved communication. All the stakeholders have visibility into the project's critical paths, which makes the project management more open natured. Members of a construction project can access information easily. This capability, in turn, makes the communication and collaboration process more efficient and more transparent to the construction owner⁵.

2.5 DIVERSITY

There are many similarities between global projects and traditional projects. Both contain no routine tasks. In each type, there are high costs associated with fast tracking the work and the tasks must be highly coordinated. Tradeoffs are often necessary between speed and quality. Projects can be joint efforts among many cooperating organizations. Many projects demand that tasks and operations be done simultaneously.

Global projects differ from traditional projects, however, in that their managers must also deal with a wide range of issues including the following:

- Time-zones
- Language
- Emotional Issues
- Cultural Issues
- Regulations

Large, complex global projects to develop industrial, residential and commercial facilities or infrastructure face the same coordination and integration challenges of scale, complexity, and human resources as projects assigned to a team in a single location. In addition, they must successfully confront the challenges posed by physical distance and conflicts over values, cultural norms, and work practices. They must also adapt to the requirements of various economic, legal, and political institutions. The challenge of global projects lies in identifying and developing approaches, strategies, and tools to shrink the physical distance and develop governance systems that harmoniously integrate participants with different languages, conventions, and regulatory systems. Global projects provide opportunity for researchers to quantify the economic impact of the dimensions of distance and to improve the outcomes of multinational projects for the sponsors, investors, regulators, designers, builders, and host communities involved. The impact of distance gives rise to significant coordination and transaction costs. Physical

distance causes potential problems in communication, travel, and resource shipments among globally-distributed participants. Physical distance may result in misjudgment, misunderstanding, and conflict among participants. When these issues are not properly addressed, the success of the project is also in doubt⁶.

2.6 COLLABORATIVE PROJECT MANAGEMENT TOOLS

Collaborative project management tools address the project management problems created by geographical distances and different time zones. They are expected to provide the following features.

- The tools must have the capacity for separate management of multiple projects or project types from a single location. There must be an option to create project templates.
- The tools must accommodate multiple users of a single account. Users may be onsite employees, subcontractors, clients, telecommuters, or staff working at other branches. These must be able to access the account simultaneously from different locations.
- The tools must accommodate task dependencies in order to manage a large task structure. In most projects, certain tasks cannot begin until others end.
- The project manager must be able to assign appropriate access rights on an individual basis. The CEO might require an overview of all projects and all user activity, whereas technicians might only need to view their assigned tasks.
- The tools must facilitate communication. An e-mail feature allows a quick communication of messages to users in the same account. Video conferencing and online meetings are also important methods of communication⁷.

3. PROJECT MANAGEMENT SCENARIOS IN INDUSTRIAL SECTORS

This section briefly describes three kinds of projects that often occur in a distributed environment. Although each type of project has some unique characteristics, there are also a number of similarities, such as the need for assigning tasks and maintaining communication.

3.1 SOFTWARE

Most software development efforts are undertaken as projects. Their development takes place in a dynamic environment in which business conditions and technologies change over the project lifetime. Customers and users are often unsure of their needs and frequently change their requirements midway through the project. The result is that the software industry often faces cost overruns, late deliveries, poor reliability, and customer dissatisfaction.

Reasons why managing software projects is so difficult

Software is intangible. The progress and quality of software projects are relative and difficult to measure. Software products often are complex, involving many interrelated components. Managing such projects is challenging. Further, the requirements for software projects are often volatile. Customers tend to change their requirements as business requirements change and their expectations are often vague. It is important, therefore, to track these changes and ensure that they are reflected in the product.

The most common difficulties in software project management are:

- Poorly defined goals
- Lack of project plan
- Unrealistic deadlines and budgets

The key dimensions of software project management require continual management attention. These include time, cost, performance, and client relations. Collaborative project management software is often expected to aid in keeping these aspects under control. Today, many project management software packages are available on the commercial market. Some project management software packages offer specialized features to meet the need of specific industries. Project management software is essential for effective planning and tracking of detailed activities. In addition, software often provides top level visibility of progress. These software tools are not a replacement for experienced project managers; they are just intelligent tools to do the tracking work faster. They relieve project managers of detailed clerical tasks and allow them to focus on more important aspects of the job. Project management packages range from simple schedulers to enterprise-wide solutions with varied features.

The fundamental features in most project management software packages include the following:

Front-end planning and modeling: These contain the features for creating and refining project plans. Most programs include PERT networks, critical path analysis, and resource tracking.

Cost and schedule tracking: Collecting cost and status data and tracking status against the plan.

Reporting: Preparing various reports, including exceptions, Gantt charts resource usage, earned value, and trend reports. Most packages let users create templates and customize reports.

Communications: Assigning tasks and receiving status updates via e-mail and publishing reports on the company intranet site.

Collaborative project management has become an important concern of the software industry. Since most software companies have offices around the world, distribution of projects among these offices is based on resource availability, client location, regulatory and tax considerations, and communication costs, along with infrastructure⁸.

3.2 CIVIL ENGINEERING AND CONSTRUCTION

Civil Engineering industries projects have grown complicated as capital investments have grown significantly. Participants in construction projects are often widely dispersed. These projects have strict schedules and stringent quality standards. A schedule slip in these projects leads to much time wastage and mismanagement of resources. Construction projects are generally intricate. The development of such projects require inputs from a range of areas, including financial organizations, governmental agencies, engineers, architects, lawyers, insurance and surety companies, contractors, material manufacturers, and building tradesmen. As a result of this complexity and the development of information technology, communication techniques have received much attention in project management methodology. The construction of even a moderate structure involves various skills, many materials, and hundreds of operations⁹.

Factors responsible for change

The following are some factors responsible for change in the construction environment:

- Foreign investment and liberal trade have changed the international economy. Globalization has made it possible to have mobile labor and competition among foreign and local firms on price, quality, and delivery.
- Participants working from multiple locations must collaborate to use the same set of data.
- Time constraints demand faster results with no increase in resources.

- Rapid changes in project scope and requirements are sometimes needed to meet client expectations.
- Client sophistication has become a major driver of productivity improvements in construction. Clients demand higher quality end products and services at a lower price. This has created a buyer's market in which firms compete for projects at lower margins and demand better project management practices to enforce tighter control on project activities.
- New procurement practices have changed the relationships among team members. For example, procurement schemes such as the Private Finance Initiative (PFI) and partnering have impacted construction project management. PFI imposes high quality standards and stringent schedules on large scale infrastructure projects.

Project Management Communication:

The rapid evolution of communication technologies is making distributed projects increasingly feasible. With the emergence of the Internet, project participants can be widely dispersed yet coordinated by sophisticated tools. The Internet provides rapid information transfer, allowing messages to reach the recipients more quickly and accurately, as well as making them traceable. The Internet is also cost efficient, allowing construction companies to communicate easily with their overseas sites, instead of relying on courier and IDD (International Direct Dialing) telephone usage. It is time and cost efficient to provide an Internet link between the sites for the transfer of high volume information. In order to meet a project's objectives, fast data transfer is necessary, with minimal data re-entry and duplication. For example, during the design stage, drawings must be exchanged among designers. If drawings are exchanged in hard copy, modifications require redrawing. If they are exchanged electronically, however, the use of compatible applications or standard data formats makes update much simpler.

Web-enabled project management software is used in various stages of the project life cycle. During the bid process, the main function of the software is to advertise and distribute tender documents, select successful bidders, and award contracts.

Software is used in this stage to:

- Reduce time in the distribution of documentation and bidder's communications
- Register the bidders online and download tenders/work packages electronically
- Evaluate the bidders' responses through standard templates
- Communicate the changes to the tender documents quickly and easily

In the design and construction stage, web-enabled software essentially ensures that each team member receives the right documents at the right time, such as the latest version of drawings, specifications, and requirements through the web-enabled software.

Software is used in this stage to:

- Circulate the most current drawings and other important documents to reduce errors
- Maintain all the current and past versions in one central location accessible by the team members
- Provide for tracking of all the communication in the team (Audit Trail)
- Provide a fast query process (request for information, RFI) and approval process, by allowing the design team to mark up and comment on drawings online
- Speed up the procurement of materials by automating document distribution and communications (E-procurement)
- Reduce the administrative costs of document handling and distribution to multiple parties
- Ensure ease of analysis, comparison, and evaluation of bids

In the material acquisition stage, web-enabled software is used to ease the complex process of purchasing materials, which requires the identification of considerable resources and potential suppliers as well as the evaluation of quotes, which are normally received in different formats¹⁰.

4. PROJECT CASE STUDY

4.1 BACKGROUND

In a project sponsored by Partners for the Advancement of Collaborative Engineering Education (PACE), 36 students of Missouri University of Science and Technology (Missouri S&T) and Prairie View Agricultural and Mechanical University (Prairie View A&M) collaborated to design a solar thermal roof system. Participants were divided into four teams, each made up of students from both schools, with varying educational levels. Each team was assigned an element to design, document, build, and present. Each team had a mixture of students from both the universities. A competition held at each university campus evaluated the results of each team's work.

The PACE program is a partnership among GM, EDS, Sun Microsystems, and UGS PLM Solutions. The program encourages students to develop new products. Students on the PACE team interact with industry advisors and often collaborate with other PACE institutions in different countries. They use PACE donated software and present their final project to a team of industry judges. The PACE program supports strategically selected academic institutions worldwide to develop future product designers, manufacturing engineers, and managers who understand and apply parametric-based applications in the automotive life cycle management process. PACE supplies the hardware, software, training, and automotive parts to the PACE Institutions around the world. It is assisted by many companies, including Altair Engineering, AutoWeb Communications, Fluent, Hewlett Packard, LSTC, and MSC Software. PACE also finances industry projects that allow students to gain real world experience designing products that could be adopted by GM or other companies. PACE aims to familiarize students with the use of digital communications in the product development and analysis processes so critical to modern engineering practices. PACE sponsors many student design competitions in courses at PACE institutions¹¹.

Since Fall 2006, Prairie View A & M University and Missouri University of Science and Technology (formerly University of Missouri-Rolla) have jointly undertaken

instructional collaborative engineering design projects. They have used the Teamcenter Community and NX3 to implement these projects in association with CAD courses at the two universities. CAE was used for designing the various components of the roof system¹².

It was observed that the collaborative work carried out prior to this project encountered difficulties related to varying skill sets among participants, communication gaps, and imprecise use of computer-aided engineering (CAE) tools. Additionally, problems arose because undergraduate freshmen at Prairie View A&M had difficulties interacting with senior and graduate students at Missouri S&T. There was little formal communication or organized project management. Further, the objectives of using the CAE tools were unclear and there was confusion over use of such tools.

This project was undertaken to address problems encountered in previous PACE program competitions. The objective of the proposed project was to integrate various aspects of managing a collaborative project. Organization of managerial and technical features is fundamental to the success of such projects. This project uses engineering design and design methodology through rapid prototyping. It is aimed at integrating project management into collaborative engineering design projects implemented at Prairie View A&M and Missouri S&T.

The project lifecycle management tools used for this project included

- Teamcenter Community
- NX5
- Microsoft Project
- Tandberg video conferencing

The extended objective was to implement these collaborative design projects in the teaching of two junior/senior level design courses and one project management course. The project was implemented in association with two design courses, *Machine Design II* at Prairie View A&M and *Junior Design Project* at Missouri S&T, and one

project management course, *Global Project Management* at Missouri S&T. In addition, a prototype of the system was to be developed with the machine available in the IDE laboratory at Missouri S&T. Product life cycle management was used for collaboration while designing the system¹³. Tandberg video telephony was used during the STEP project for meetings¹⁴.

Teamcenter software was used for sharing files and project data. Teamcenter provided a single, organized, and secure source of product engineering. It allowed the different development groups to work together as a single entity despite their location at two different sites¹⁵.

4.2 TASKS, TEAM STRUCTURE, AND RESPONSIBILITIES

The project participants were split into four groups, with each group assigned to design and build a component of the solar roof system. Each group was made up of students from Mechanical Engineering departments at both Missouri S&T and Prairie View A&M. Each group also included Engineering Management students from Missouri S&T to manage the collaboration among the groups and group members. Each team started with a proof of concept and a beta prototype of the component, later producing an alpha prototype. The team composition and their tasks are outlined in the following section.

Teams:

Team 1: Photovoltaic System

The objective of the photovoltaic system team was to select and test a photovoltaic panel that would meet the electrical demands of the solar house while absorbing and transferring sufficient heat. The criteria for the choice of panels included ease of procurement, panel efficiency, and type of materials that make up the frame, PV panel, backing, and covering.

Team 2: Thermal System

The thermal system team sought to extract the maximum heat from the high efficiency photovoltaic panel. It aimed to convert the excess radiant energy into heat to boil water. The criteria for evaluation of the thermal system is dependent on pipe configuration, PV panel size, optimal operating temperatures, pipe materials, constructability, and ease of installation for the homeowner.

Team 3: Insulator System

This team's objective was to ensure that the insulator system would prevent heat loss, protect against the weather, and structurally support the internal components of the module.

Team 4: Couplers

The objective of the couplers team was to design and create the specific connections to link the individual modular thermal electric panels. The attachment system would hold together the connections that fasten the modules to the building. The couplers team was responsible for correctly attaching water pipes and electrical connections between modules as well as for fastening modules to the building.

4.3 TECHNIQUES AND METHODS OF COLLABORATION

The teams and responsibilities were assigned initially with more or less equal numbers of students per team. Meetings were held to review progress and plan the next stages of the project. Initially there was some confusion among the teams; however after some meetings and video conferences, participants became better organized and the project went smoothly. Once the entire project was scheduled, every team understood its goals and deadlines. The project management students were responsible for making presentations, which included objectives, technical details, and team member tasks. These students were also responsible for scheduling team meetings.

4.4 RESULTS

A number of project weaknesses were observed by the author, during the project:

- Project managers had little appropriate technical background with the technology being used in the project; therefore the presentation slides were not very effective.
- Project managers were not included at the beginning of the project; therefore they were not immediately able to function effectively.
- The varying educational levels among team participants created communication problems.
- There was insufficient information available about the raw material used for building the roof.
- Work was distributed unevenly among the teams, so some teams had little material to present at the project's conclusion.

At the same time, several positive outcomes were also observed:

- Video conferencing made it easy to have face-to-face meetings. Teamcenter was helpful in improving lines of communications between Missouri S&T and Prairie View A&M.
- There was good bonding within teams and good relations among teams.
- The diversity of educational levels reflected real life project scenarios.
- There was good technical infrastructure.
- Automated software such as CAD was used effectively.
- Websites facilitated data transfer and collaboration.

4.5 RECOMMENDATIONS

Several recommendations follow from the observations made by the author:

- Progress meetings should be more formal and each team should present a progress report and plan for future work.
- Each team should be made aware of its responsibilities from the outset through in-depth project briefings.

- Interdependencies should be managed efficiently, with proper planning and scheduling.
- All tasks should be scheduled with a slight schedule buffer in case of emergencies or unexpected delays. Final delivery dates, however, must remain firm.
- All teams should have multiple back-up plans, and all should know where to find help when necessary.
- Coordination between the project managers and technical team members should be strengthened. Meetings should be held early and often to permit faster integration. Schedule conflicts should be resolved through discussion.

The PACE project reflects project management practices that were followed in a non-professional (student) environment. Generally, such research projects pose a great challenge; as the students are generally focused on their own academic performance and their grades. In order to successfully implement such projects, the projects must also be relatively short term, cost effective, and practical. In spite of numerous problems, the PACE project was a good initial effort in successfully implementing a distributed project.

Today, successful group collaboration is an essential skill which is required in many jobs. Collaborative projects like the PACE project also teach students to plan effectively and reach democratic decisions while respecting everyone's approach and ideas. It is a good learning experience for the students to work in a collaborative environment. Collaborative projects should be encouraged in universities as they provide a hands-on experience and encourage students to think beyond theory and use practical skills to solve a problem.

5. SURVEYS

5.1 SURVEY 1 RESULTS

This survey was provided to students who participated in the PACE competition for designing a solar house roof. The purpose of the survey was to obtain information about the interaction and working relationship of the team members from the two universities. The survey focuses on addressing issues like data sharing, quality of the tools for collaboration, feasibility of the schedules, and the quality of the project documentation.

The survey was posted online through a software tool called Survey Monkey. The reason for the online survey was that it was easy for the students to access, was anonymous, and was easy for the author to evaluate. Out of 36 students who participated in the PACE project, only 9 responded to the survey. Since the responses collected could not be separated by university, a combined analysis was performed. The survey results are presented below.

Survey Questions and Analysis:

1. How would you rate the tools used for data sharing and collaboration?

The survey results showed 66.7% of survey responders believed that there could have been better ways for data sharing and collaboration.

The teams primarily used websites and e-mails for data sharing. The e-mails were used for notifications of meetings, while the website had information about the team member responsibilities and designs of the components allotted to the team. The website was also a good technique to provide other teams with all the details of design without the explicit sending of mails. Teamcenter, a tool for product life cycle management, was used by a few teams for designing the components and circulating them across.

Based on the author's observations, the following appeared to be underlying reasons for the survey results:

- The people were not fully trained to use the Teamcenter; it was just introduced to them.
- Urgent messages could not be given through e-mails and cell phones were used at times. These conversations were not always documented, which created problems for other team members not involved in the conversation.
- The websites had to be maintained with the latest information, which was not always possible for the team members. This created a technical communication gap.

2. Did you have the right background to use the tools?

The survey results show that 55.6% of the survey responders believed that the team members had the right knowledge and the facilities to use the tools. E-mails were the most commonly used way for data sharing. Since most of the team members routinely used the Internet, the members could comfortably use the e-mails and the websites.

Based on the author's observations, the following appeared to be underlying reasons for the survey results:

- About half of the responders believed that the situation could be improved by additional training. The team members were not trained to use the Teamcenter.
- A few of the team members had the knowledge to develop websites and the responsibility of data sharing entirely depended on them.

3. How did you rate the feasibility of the schedules?

The survey results showed that 55.6% of the responders believed that there could have been better schedules for the project.

There were interdependencies which hampered the actual completion of the schedules; e.g. one team was waiting for procurement of the material needed for testing the panels. Another team had to wait until the first team determined the size of the pipes to be used and this led to delays.

Based on the author's observations, the following appeared to be underlying reasons for the survey results:

- Schedules were determined taking into consideration the final deadline for the competition. The project did not continue when the students had exams or other submissions. Thus, some of the schedules looked good on paper but were not actually met.
- There was a tendency to work just prior to the actual deadline. This led to uncompleted work or work with some unchecked errors.

4. How good was the team's approach to problem solving in the initial stages?

The survey results showed that 55.6% of the responders believed that there had to be a better problem solving attitude in the initial stages of the project. Team members mostly needed time to get along with other team members and know their responsibilities.

Based on the author's observations, the following appeared to be underlying reasons for the survey results:

- There was one ice breaker meeting prior to the initiation of the work, which helped in getting all teams together on the same page.

5. How would you rate the team's organization structure?

The survey results showed 44.4% the responders believed that there could have been better ways to organize the teams. The teams were randomly selected. The leads were decided based on the member's willingness to work as team leads. Each team had a

project management member who was responsible for non-technical responsibilities and coordination.

Based on the author's observations, the following appeared to be underlying reasons for the survey results:

- Since this was a research project, it was necessary for every team member to be interested in the task he or she was doing
- The project was on a small scale, hence there was no need to have a separate project management member and a team leader. The tasks of both could have been done by a single member. This would have provided better communication within the teams.

6. How good was project documentation?

The survey showed 55.6% of the responders indicated that the final documentation was satisfactory. The documentation included the designs presented during meetings, the final reports, and Power Point presentations. The documentation was fairly brief, since the documents for one team were used extensively by the other teams.

Based on the author's observations, the following appeared to be underlying reasons for the survey results:

- There was no standard format for the documents, which made it difficult for other teams to understand and easily compare the designs.

7. How do you rate the commitment of the team members to contribute to the project?

The survey results showed that 55.6% of responders believed that there should have been improvement in people's attitude to work for the project. There should have been more commitment of the part of the team members.

Based on the author's observations, the following appeared to be underlying reasons for the survey results:

- The students were not sufficiently motivated to work on the project through completion.

8. How would you rate the cooperation of members from one team towards other teams?

The survey showed 77.8% of the responders believed that the inter-team cooperation was satisfactory.

This project was an internal competition between the teams but it also had to be a joint effort. All the teams were a part of the project and were expected to work together.

Based on the author's observations, the following appeared to be underlying reasons for the survey results:

- The team members from each university were students in the same course and had been working together on other projects and helped ensure good cooperation.
- The designs and testing had to be shared or else this would have hampered the progress of every team.

9. How well do you think the members participated in the discussions?

The survey results showed that the 66.7% of responders felt that members participated in the discussions satisfactorily. There were some opinions indicating that the team discussions could have been improved.

Based on the author's observations, the following appeared to be underlying reasons for the survey results:

- The project was a part of the student's course work. There was a high probability of the students being preoccupied by other homework.

- Lack of information beforehand was a reason that many of the members were not able to actively take part in the discussion.

10. How well do you think the team leader knew his or her objectives and responsibilities?

The survey indicated 44.4% of the responders believed that the team leaders knew their responsibilities well. The team leaders were responsible for presenting the designs and taking decisions regarding the selection of materials. They were also a channel through which the other teams interacted.

Based on the author's observations, the following appeared to be underlying reasons for the survey results:

- The team leaders volunteered so the most enthusiastic candidates were made the team leads. This helped to get the most energetic members as the leaders.

11. How will you rate the team leader's motivation and ability to resolve conflicts and issues?

The survey showed 44.4% of the responders believed that the team leaders had the ability to resolve conflicts and issues faced during the project.

Based on the author's observations, the following appeared to be underlying reasons for the survey results:

- The team leaders were not aware of their responsibilities at the initial stage of the project and could not get all the students to work together.
- The team leaders failed to delegate the work to the members equally due to which some of the members had no work while the other working had a lot of work to be completed.

12. How do you rate the team leader's skills and knowledge?

The survey indicated 44.4% of the responders believed that the team leaders were competent enough to handle the project while a similar number indicated there was room for improvement.

Based on the author's observations, the following appeared to be underlying reasons for the survey results:

- The project team leaders needed improved technical skills.
- The PACE project was a research and learning experience. It was not expected that the team leaders would have all of the technical skills needed.

13. How was the team behavior while working and during the meetings?

The survey results showed that the behavior of the team members was mostly informal.

Based on the author's observations, the following appeared to be underlying reasons for the survey results:

- Since this was a project undertaken in a student environment, the behavior tended to be mostly informal. This is the way students normally interact.

14. What methods were used to communicate with the team members?

The survey showed 66.2% of responders indicated the majority of the communication was done through e-mails. Video conferences were used for team meetings between the two universities.

Based on the author's observations, the following appeared to be underlying reasons for the survey results:

- E-mails were not rapid enough for urgent communication. Cell phones were used to contact people at times of emergency and when immediate replies were needed.

- Video conferencing was used during joint meetings with team members participating from both universities.

15. How were the conflicts resolved?

Survey results show that there were no significant conflicts in the team as reported by 77.8% responders. A few students said any conflicts were ignored without being resolved.

Based on the author's observations, the following appeared to be underlying reasons for the survey results:

- This project had a short span. It was always better to look forward rather than going back and trying to resolve conflicts.
- The team members from each university were in the same course and had been working together on other similar projects. This led to reduced conflicts in the first place.

Recommendations:

In the case of student projects, the quality of the work primarily depends on the interests and motivation of the students. Hence, while forming teams there should be a selection system where students have an opportunity to work on a team whose work best matches their interests. Also while forming teams, it should be ensured that students with different skill sets are put together in one team. The time span for the student research project is usually short, so there are few chances to provide explicit training to the students before the start of the project. Teams with students having varied skill sets should provide an opportunity for students to help train each other. Students should be motivated to participate in group projects by allotting a significant portion of their grade to the project result. This would help ensure that the students devote sufficient time for project work.

Project documentation carries a high importance in projects as it creates a reference guide for future projects and for future teams. The documentation should have a standard format for each team. Finally, peer evaluations can be an effective way for each person to know how other team members viewed their contribution to the project.

5.2 SURVEY 2 RESULTS

This survey was intended for the people working in industries such as software, telecommunication, manufacturing, and construction. This survey provides information on the project management in real life scenarios. Again, this anonymous survey was posted and analyzed with the web enabled software tool Survey Monkey. There were a total of 42 responses analyzed. The survey was divided into sections. The questions in each section were on a similar topic. The analyses have been done section wise since the questions in each section are linked to each other. The exact percentage responses are displayed in the Appendix at the end of the document.

Survey Questions and Analysis:

1. Work Assignment/ Distribution:

The survey results gave insight into about the methods of task distribution in teams. 51.2% of responders believed that task assignments were done in combinations while 36.6% of them believed that one person was assigned more than one task at the same time. It was remarkable that 0% of people believed that the tasks were allotted according to the employees preferences. 76.2% of the responders believed that the work distribution was fair and 65.9% of them said that their skills were appropriately being used for the tasks. Also, 42.9% of the responders believed that their work was dependent on another set of people on the same team. 31% of the responders believed that the work distribution affected their motivation towards work, and at the same time, 33.3 % felt that it affected communication with other team members.

The results confirmed that most work is divided and assigned to individual team members. Further, each team member generally has more than one task assigned. A majority of people believed that they had well-defined responsibilities and roles, even though they were expected to multitask. A majority of people involved believed that the work distribution was fair among the team members. They also reported that their skills are appropriately used in the job. The work is primarily dependent on the skills of the team members in individual teams. The results also showed that the work distribution certainly affects the overall approach of people towards work collaboration, communication approach, and job dedication.

2. On the job Training:

The survey provides insights into initial training and the quality of the training. 36.6% responders were not fully satisfied with the quality of the training. According to 43.9% of responders, the training was highly essential. 61.9% of the responders also believed that the best training could be directly working hands-on with the work assignment. 47.6 % of responders believed that they understood the entire project they were working on, while 23.8% believed that they concentrated only on their part of the work.

The majority of the responders believed that the training given at the start of the project requires improvement, especially in its quality. The majority of the participants believed that the training was necessary and that it should be basically hands-on training instead of theoretical classroom training. The training would basically be about the project and the work assignments. The survey indicates that the information and documentation must be made available in an easy to use manner. Most of the responders believed that they understood the overall project, while a few said that they were aware of only their part of the project. The survey results also indicate that the team members should also receive the information concerning the overall business strategy and various processes.

3. Appraisal Process:

The survey looks at how much the appraisal process affects the employee's view towards work. 21.4% of responders feel that the appraisal process is highly important in encouraging them to work hard. 40.5% of responders stress the need to consider the results of internal exams and external certifications during the appraisal process. Most importantly, around 78.6% of the responders stressed that the manager's view affected the appraisals greatly.

Most of the employees believed that the appraisals encouraged the employee to work harder. Although company policies affect the appraisal process in some form, most of the employees believe that decisions about the appraisals fall entirely in the hands of the project manager.

4. Meetings:

These questions were aimed at analyzing the outlook of people towards meetings. 57.1 % of people said that they had weekly meetings and, at the same time, 67.5% believed that weekly meetings were better than bi-weekly or monthly meetings. 69.0% of the responders said that the team meetings are the best way to keep track of everybody's progress in the team, while 4.8% believed that the meetings are a mere waste of time.

The survey results show that most of the responders had weekly meetings discussing their part of the work. The results also indicate that these weekly team meetings are the best way to keep track of project performance. A few responders also believed that they are a good way to learn about the future goals and assignments.

5. Flexibility of work Location:

This question was aimed at determining the effect of working from home on communication within the team and the team performance. 21.4% of responders believed that telecommuting did not affect the work at all. 2.4% of responders felt that telecommuting highly affected communication with the other team members.

There were mixed responses for this question. Hence, it can be concluded that work from home can adversely affect the communication, depending on the type of work. The results can be interpreted industry-wise as well as job-profile-wise. Construction jobs require the employees to be present at the site of the work. However jobs in software can be done at home and the work results can be sent online.

Recommendations

Work distribution was identified as one of the important factors for work collaboration. There should be complete clarity in job responsibility. It is also better not to overlap the task authority. For example, if a risk arises in the project, divide the risk resolution into distinct parts so he or she can give complete control of each part to separate individuals. When working with large number of team members, the communication needs to be effective and everyone needs to be kept informed of key decisions. Diversity of skills is another important factor in team effectiveness. Team members can use their strengths to compensate for another member's weaknesses.

The appraisal process tries to encourage team members to work more effectively. The appraisal process is a performance management process, which can be an opportunity for the employees to strengthen their skills broaden their skills. Employees should take advantage of this process in order to be more successful in the organization. The appraisal process should be considered as an investment of time and commitment from both the employer and employee. This process should target areas of improvement, project goals, and specific learning objective along with the review of an individual's overall performance.

A successful meeting requires an agenda, time span, participants, and future goals. If the meetings are poorly planned or conducted, they consume large amounts of personal and corporate time. To make the meetings successful, everyone should be prepared by being given appropriate material. Also, priorities should be set ahead of time. The person running the meeting should ensure that everyone attending the meeting participates in the discussion.

Many companies are transitioning to a telecommuting workforce to avoid waste of time in traveling. With such jobs, factors like handling meetings and evaluation of work become more important. In order to be productive, it is increasingly important that those working from home learn effective time management skills.

6. SUMMARY OF SURVEYS

The surveys reflect actual project management practices that are followed in a non- professional (student) as well as in a professional (industry) environment. There are some similarities in the project management practices followed in the two environments. In each case, the survey results showed that the team lead or the project manager carries a great responsibility to make the members work effectively to attain a common goal. The project manager must make sure that every team member knows his responsibility and is encouraged to work to the best of his or her ability. It is also necessary that the work distribution among the team members is well defined. Tools used for communication should be selected according to the work demands of the project and be easy enough to be used by everyone in the project.

There are a few notable differences in the two environments. The student projects are generally thought of as good hands-on-experience rather than as a profit making endeavor. Training and performance appraisals are important in industry projects, but these are not generally followed in the student projects. The training given to industry employees cannot be given to the students, since the time span of student projects is generally short. Also, projects in the student environment are usually tied to a specific course work. This means, however, that there may not be need of specific technical training in most of the cases. Since the aim of the appraisal process is to evaluate the employee's work, it can be compared to the feedback system and grades provided at the end of a student project.

7. CONCLUSION

Distributed projects are becoming important in industry with many of the team members working on the same project dispersed at different locations. Distributed projects include the team members working in shifts or located at various different locations separated geographically or telecommuting team members, or distance education classes. In most of the industrial sectors, distributed project management teams employ a variety of methods and technologies to work together effectively. Firms aim to enhance profits by reducing the expenses associated with production costs, travel, relocation, material, infrastructure, and human resources. To minimize the problems arising in connection with these types of projects, effective communication tools and distributed information technology are necessary. According to the survey analysis and the case study recommendations, for any successful distributed project, the key elements include effective use of communication tools for conflict resolution, team building, and keeping the team members well informed.

In this study the PACE project was done throughout the time span of only one semester. Future research might include determining the advantages of the multi-semester collaborative student projects. This would give the students more time to schedule and execute the projects and to develop stronger working relationship. Since the Web enabled tools carry a significant importance in project collaboration, future work in this area might be to compare the most effective web tools for distributed projects and their applications. Compiling a list of best practices while managing the collaborative projects would also be useful.

Multinational corporations are gaining substantial importance in business markets all over the world. Another area of research is to apply the concept of distributed projects to multinational corporations and study their business strategies. Also this thesis has not addressed the communication issues that arise due to the cultural differences. Managing project collaboration in teams located in culturally different regions of the world can be also considered as a good future work to this research.

APPENDIX

SURVEY 1

1. How would you rate the tools used for data sharing and collaboration?
 - unsatisfactory
 - satisfactory
 - there was scope for improvement
 - best

2. Did you have the right background to use the tools?
 - unsatisfactory
 - satisfactory
 - there was scope for improvement
 - best

3. How did you rate the feasibility of the schedules?
 - unsatisfactory
 - satisfactory
 - there was scope for improvement
 - best

4. How good was the team's approach to problem solving in the initial stages?
 - unsatisfactory
 - satisfactory
 - there was scope for improvement
 - best

5. How would you rate the team's organization structure?

- unsatisfactory
- satisfactory
- there was scope for improvement
- best

6. How good was the final project documentation?

- unsatisfactory
- satisfactory
- there was scope for improvement
- best

7. How do you rate the commitment of the team member to contribute to the project?

- unsatisfactory
- satisfactory
- there was scope for improvement
- best

8. How would you rate the cooperation of members from one team towards other teams?

- unsatisfactory
- satisfactory
- there was scope for improvement
- best

9. How well do you think the members participated in the discussions?

- unsatisfactory
- satisfactory
- there was scope for improvement
- best

10. How well do you think the team leader knew his objectives and responsibilities?

- unsatisfactory
- satisfactory
- there was scope for improvement
- best

11. How will you rate the team leader's motivation and ability to resolve conflicts, and issues?

- unsatisfactory
- satisfactory
- there was scope for improvement
- best

12. How do you rate the team leader's skills and knowledge?

- unsatisfactory
- satisfactory
- there was scope for improvement
- best

13. How was the team behavior while working and during the meetings?

- formal

- informal
- formal during meetings and presentations only
- formal during work only

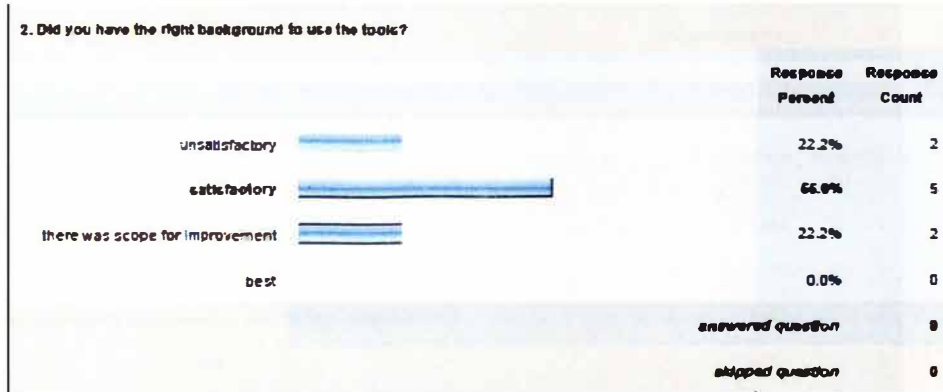
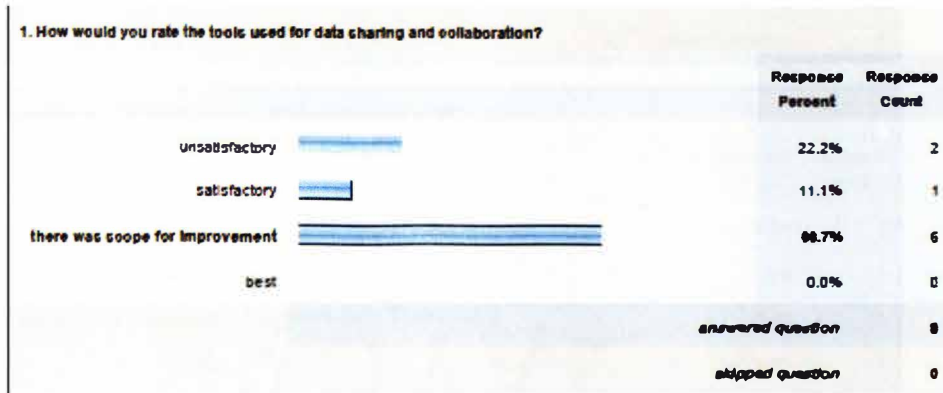
14. What methods were used to communicate with the team members?

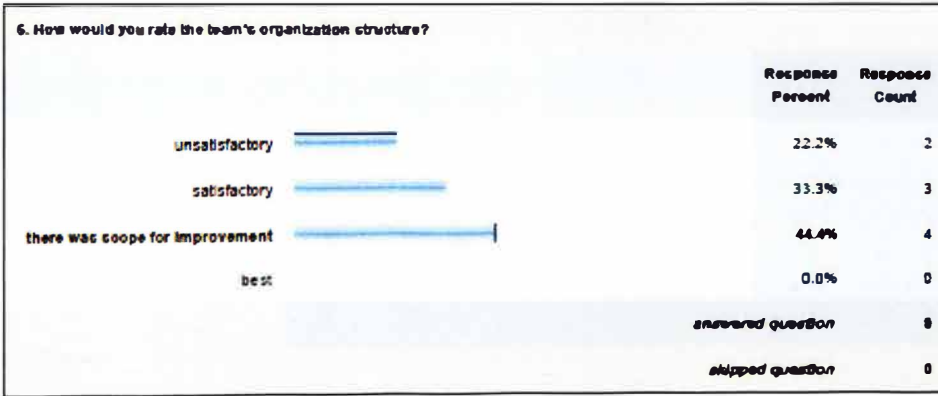
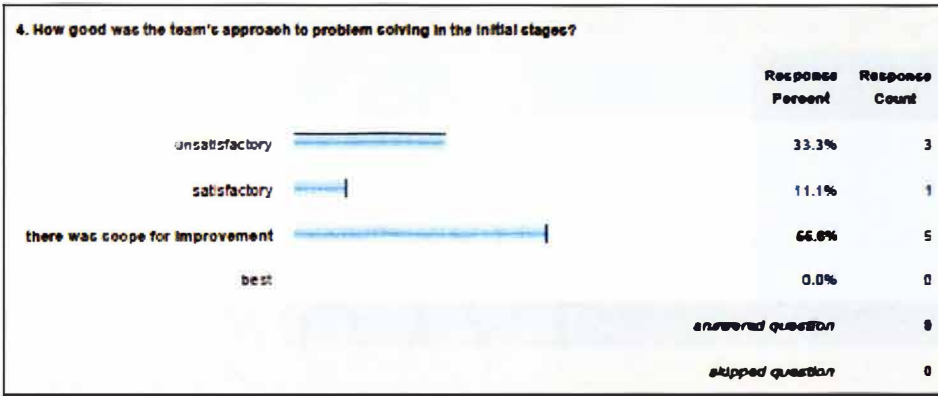
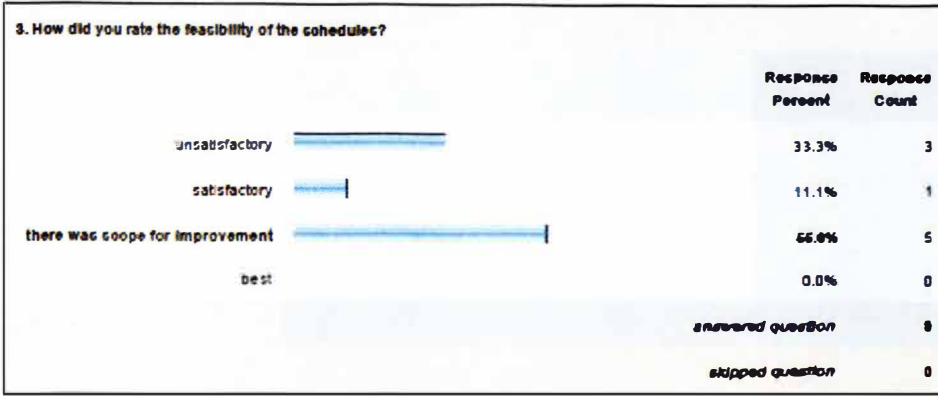
- phone
- mails
- video conferences
- websites
- Other

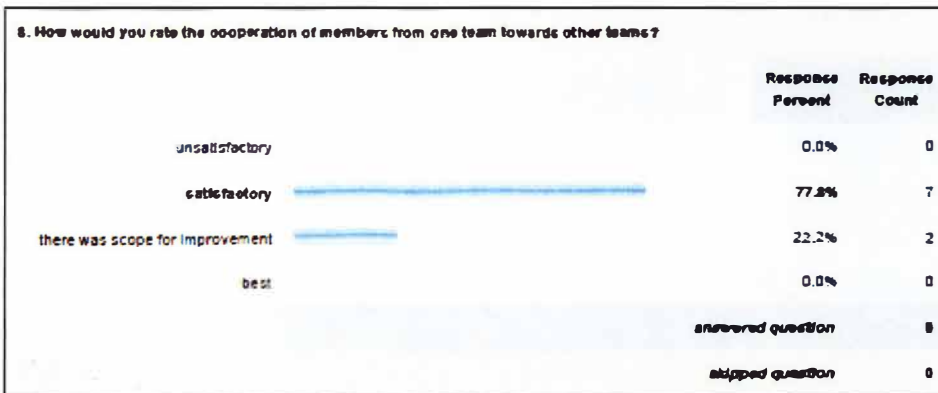
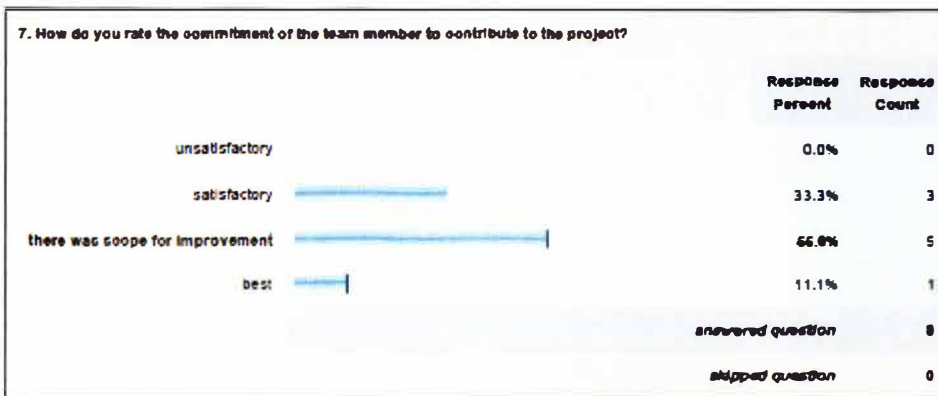
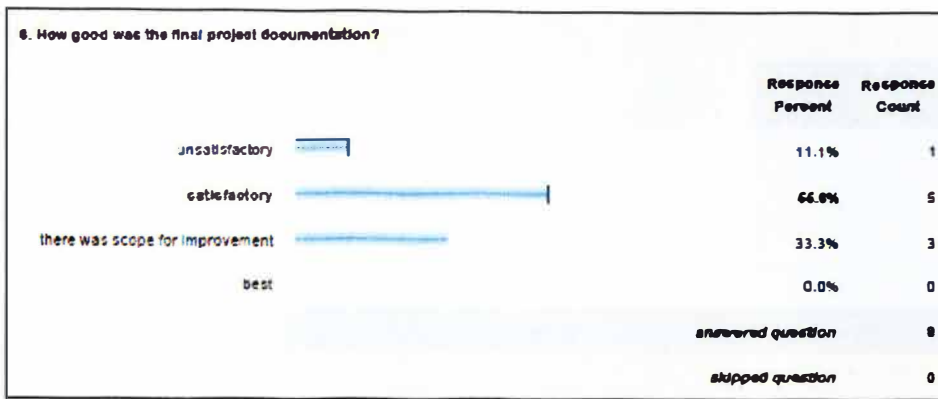
15. How were the conflicts resolved?

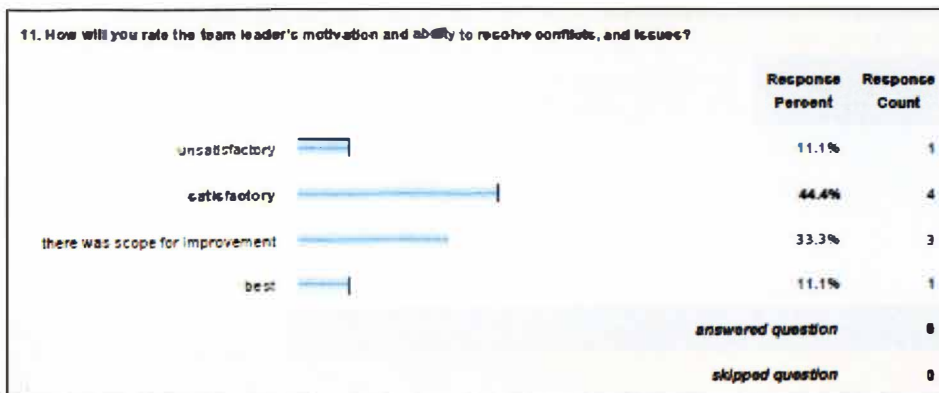
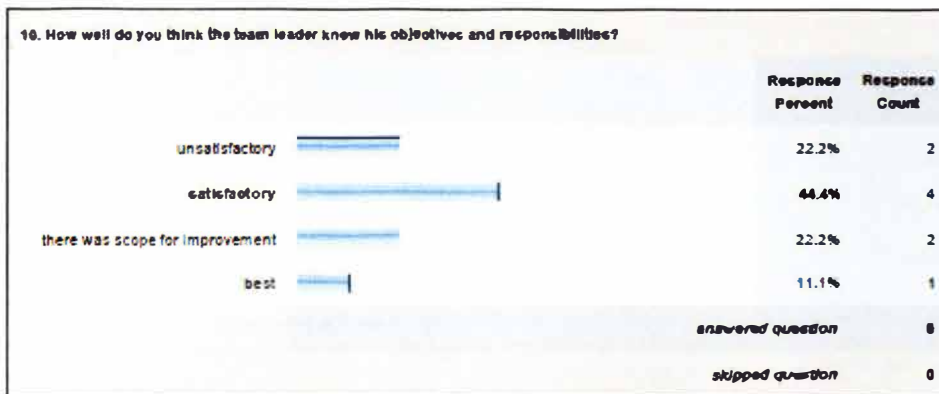
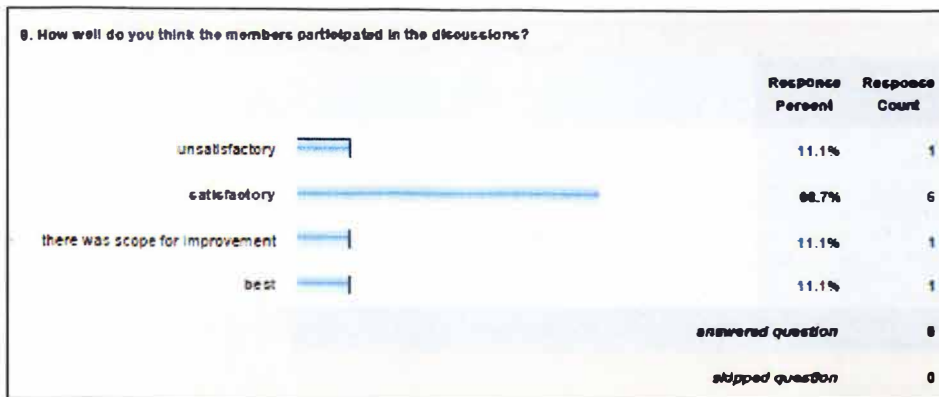
- There were no significant fights , in the first place
- The conflicts were resolve through healthy discussions
- You went ahead by ignoring fights
- You solved the fights and worked together
- Other Way

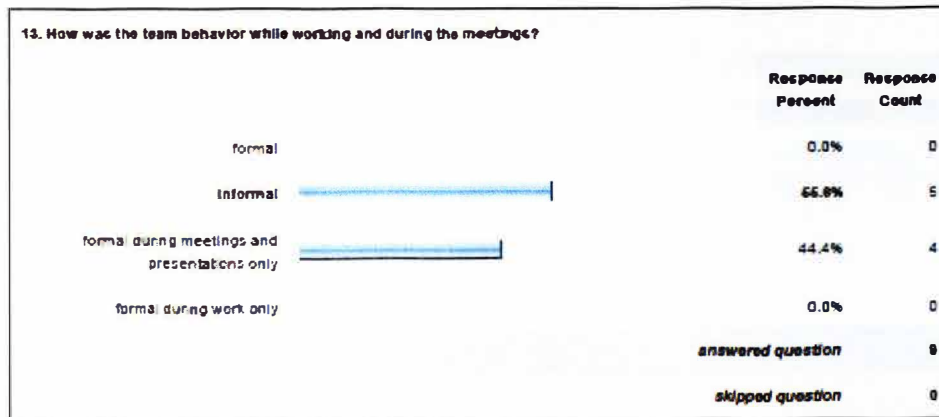
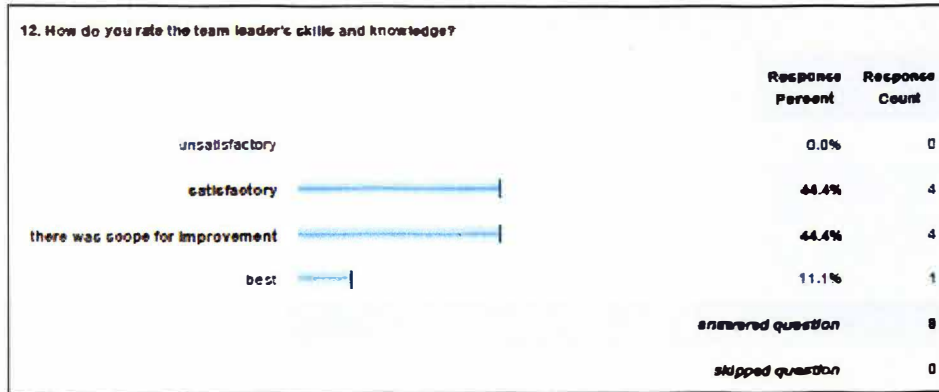
SURVEY 1 RESULT:

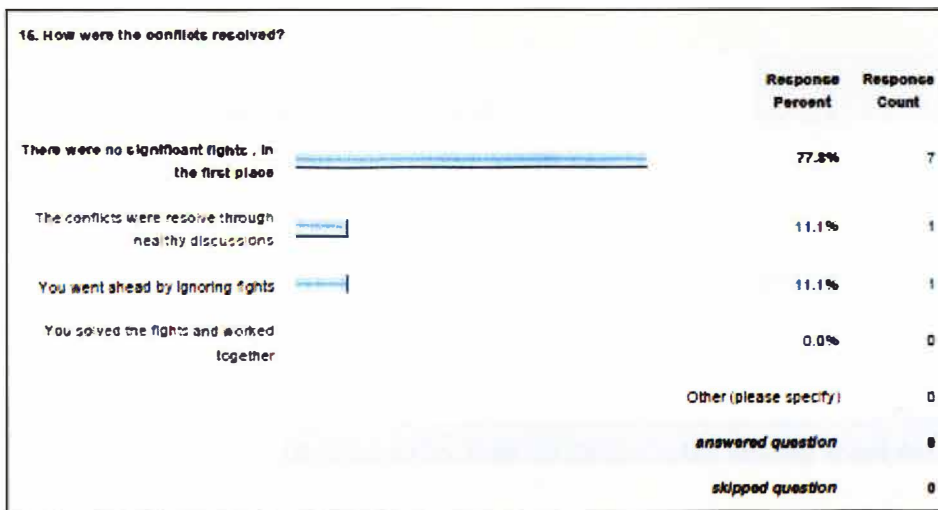
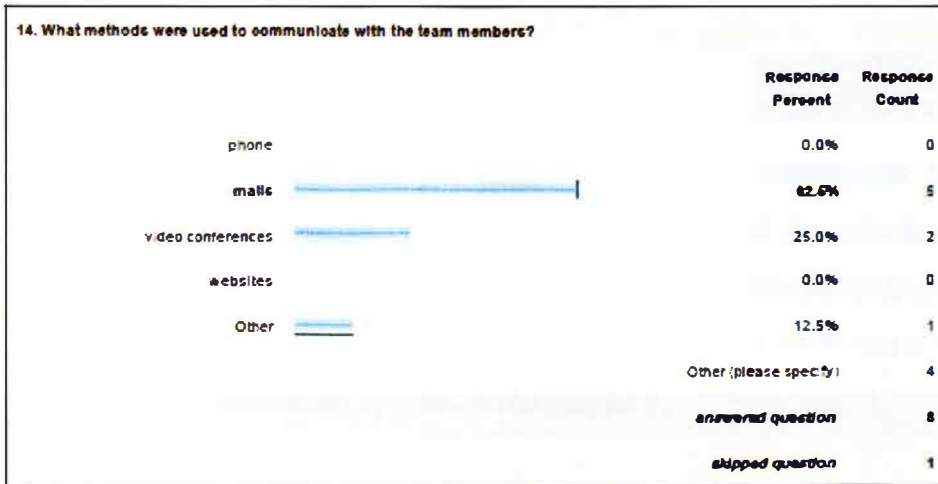












SURVEY 2

Work Assignment/ Distribution:

(Explanation: We have assumed that you have been given an assignment from your manager to meet client requirements. The nature of the work and the schedule may be uncertain .You may also be doing a combination of assignments. The following questions are designed to determine finding the percentage of people who have some degree of uncertainty about their assignments or roles in the project.)

1. How are the tasks assigned in your team?

- Each person is assigned one single task
- Two or more members are assigned to work one task
- One member is assigned more than one task
- Assignments are assigned depending on the member's preference
- A combination of several of the above mentioned methods

2. Which do you feel is the most productive way to assign tasks among team members?

- Each person is assigned one single task
- Two or more members are assigned to work one task
- One member is assigned more than one task
- Assignments are assigned depending on the member's preference
- A combination of several of the above mentioned methods

3. Is your role clearly defined in the team?

- Yes
- No

4. Are you responsible for more than one task?

- Yes
- No

(Explanation: The following two questions determine the percentage of people satisfied with their share, quantity and quality of work.)

5. Do you feel that the work distribution is fair?

- Yes
- No

6. Do you feel that your knowledge and skills are being appropriately used?

- Yes
- No

(Explanation: The following questions determine the percentage of people facing communication problems while doing their work.)

7. Do you feel that you are given assignments that you cannot handle? (Too many expectations from Manager)

- Yes
- No

8. Is your work dependent on another set of people?

- No, not dependent
- Yes, dependent on people on the same team
- Yes, dependent on people another team
- Yes, dependent on people from other companies

- Yes, dependent on the clients

(Explanation: Consider the 'Factors' that have been mentioned in the previous questions. The two questions below are aimed at determining the overall approach of people towards work collaboration.)

9. How much do the factors mentioned earlier affect the dedication towards your job?

1	2	3	4	5
Not At All				Highly

10. How much do these factors affect your communication or approach towards the other team members?

1	2	3	4	5
Not At All				Highly

On job Training: (Knowledge Transfer)

(Explanation: These questions are aimed at analyzing the training methods.)

11. How would you rate your on-the-job training?

1	2	3	4	5
Poor				Excellent

12. How necessary is the training?

1	2	3	4	5
Not At All				Highly

13. What kind of on the job training do you think gives the best results?

- Performance of the rest of your team
- Manager's view
- Company's policies
- Number of years you have been with the company
- Your individual performance

Meetings:

(Explanation: These questions are aimed at analyzing the outlook of people towards meetings.)

19. What is the frequency of team meetings?

- Weekly
- Bi weekly
- Daily
- Monthly
- Infrequently (No set schedule)
- Other

20. What should be the frequency of team meetings, ideally?

- Weekly
- Bi weekly
- Daily
- Monthly
- Infrequently (No set schedule)
- Other

21. What do you think turns out to be the main purpose of meetings?

- Waste of time but just another formality

- Somewhat useful in staying informed
- Good way to keep track of everybody's work and work distribution
- To learn about the future goals and assignments of the team
- Other

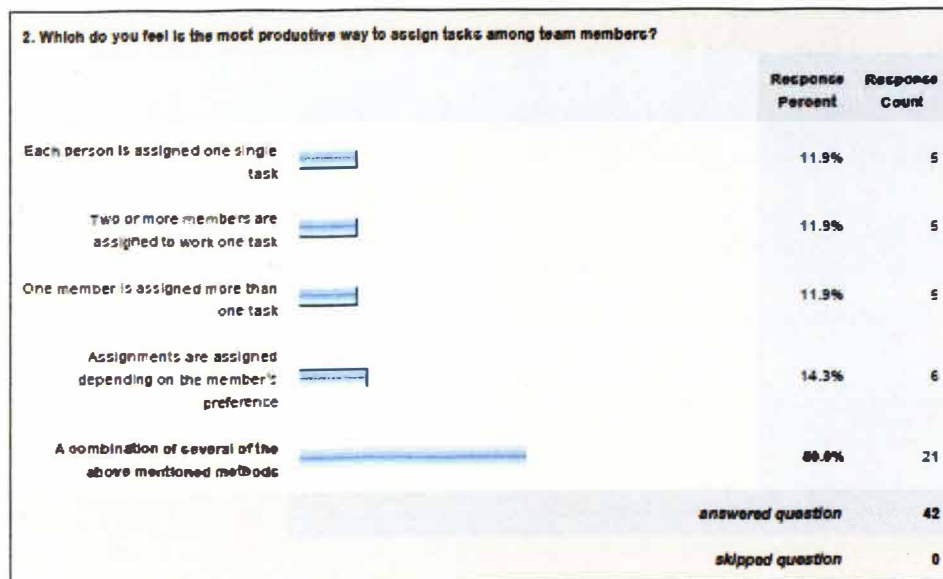
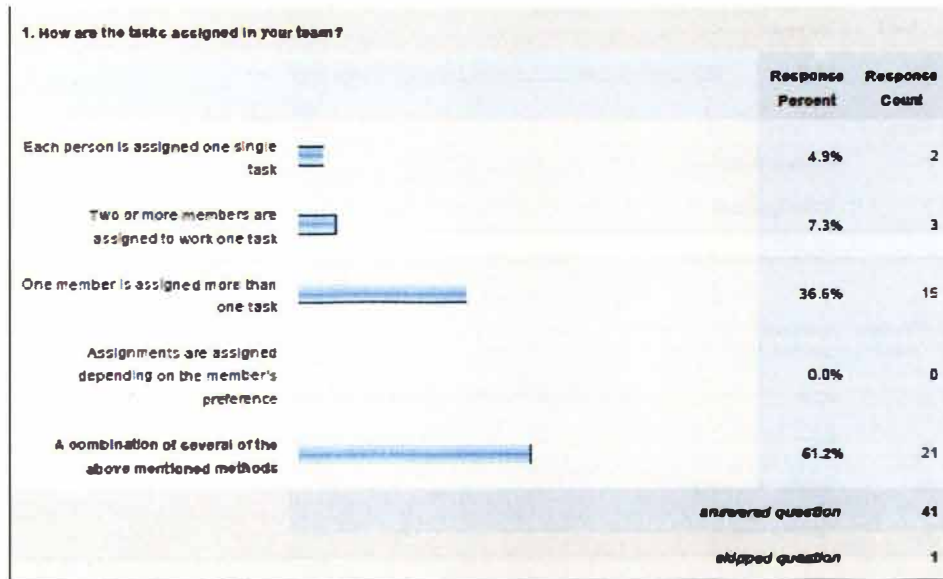
Flexibility of work Location:

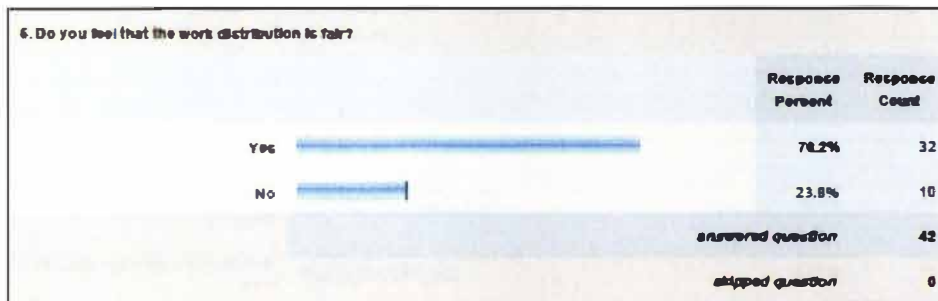
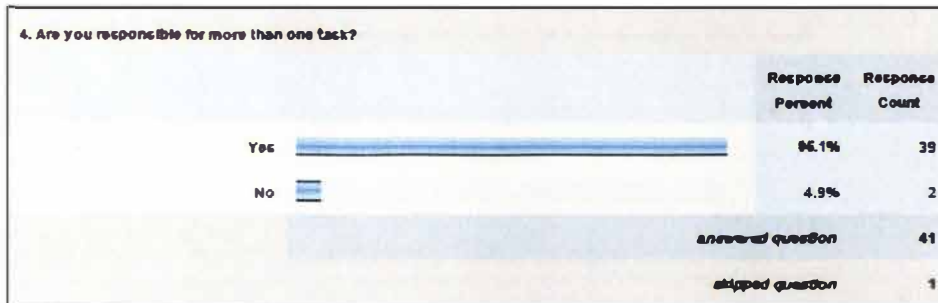
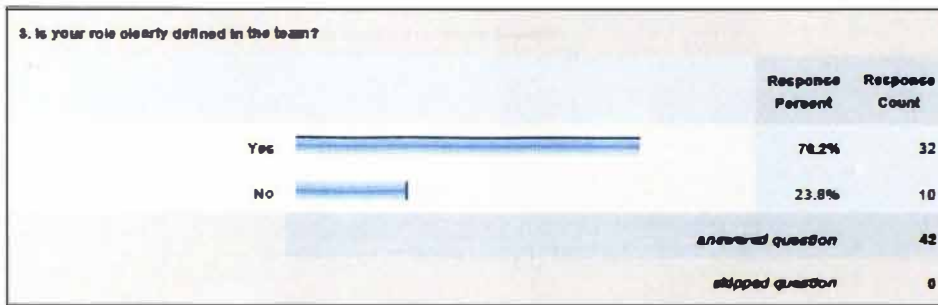
(Explanation: This question is aimed at determining the effect of work from home on communication within the team.)

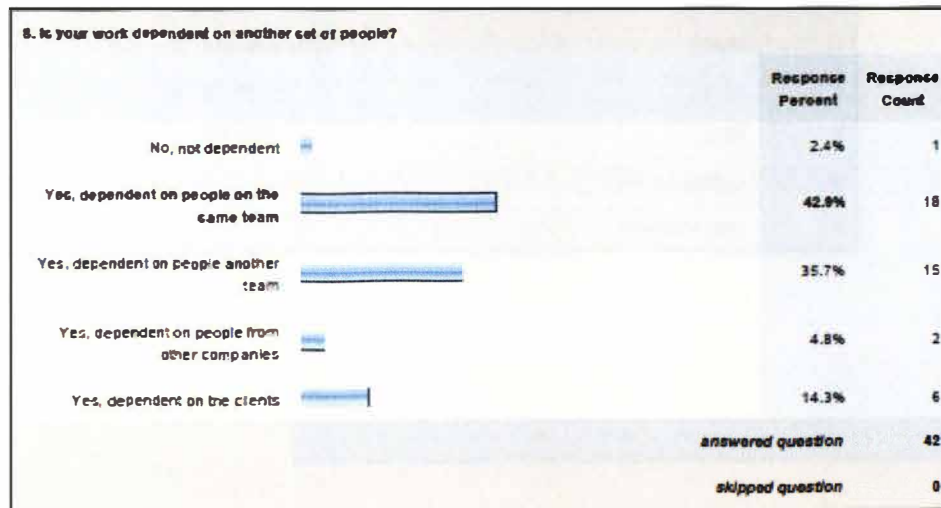
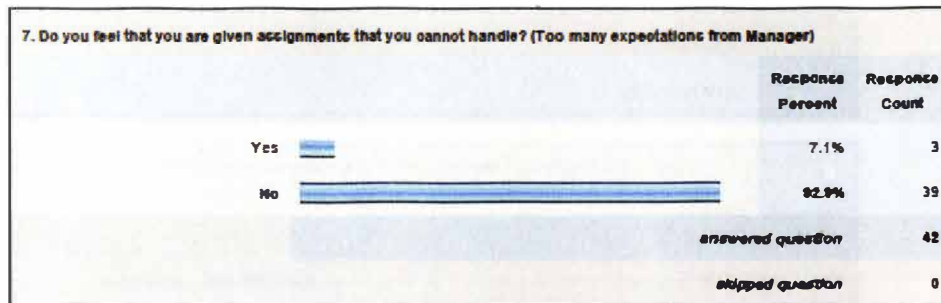
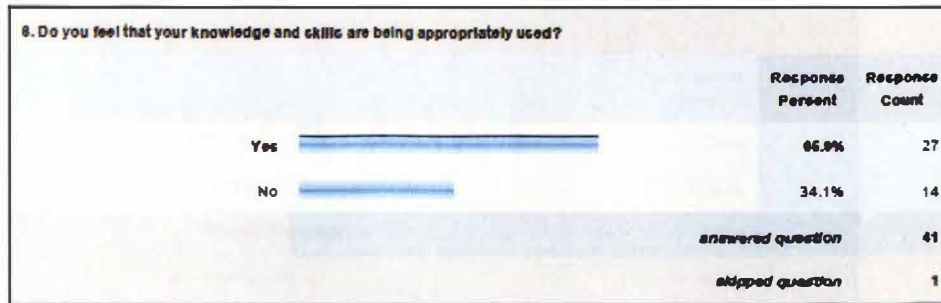
22. How much does working from home negatively affect communication with the team?

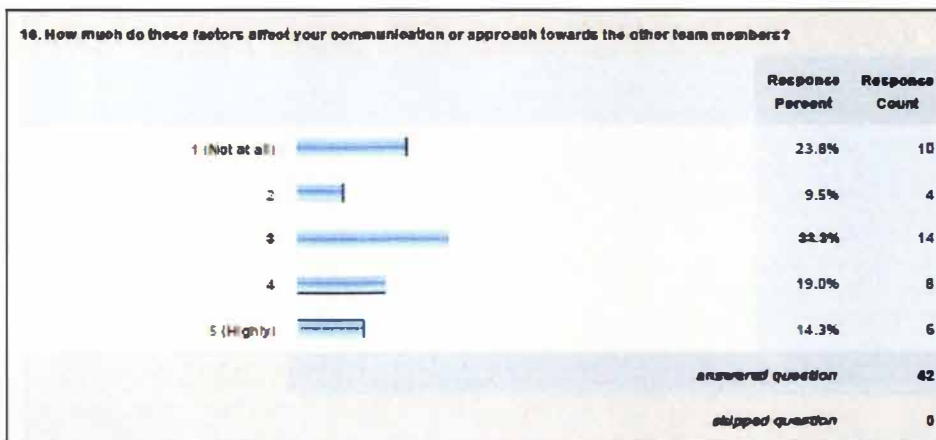
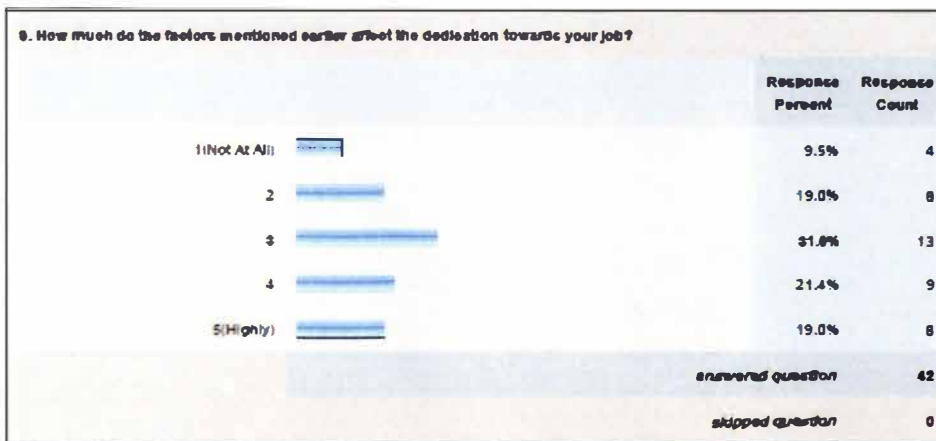
1	2	3	4	5
Not At All				Highly

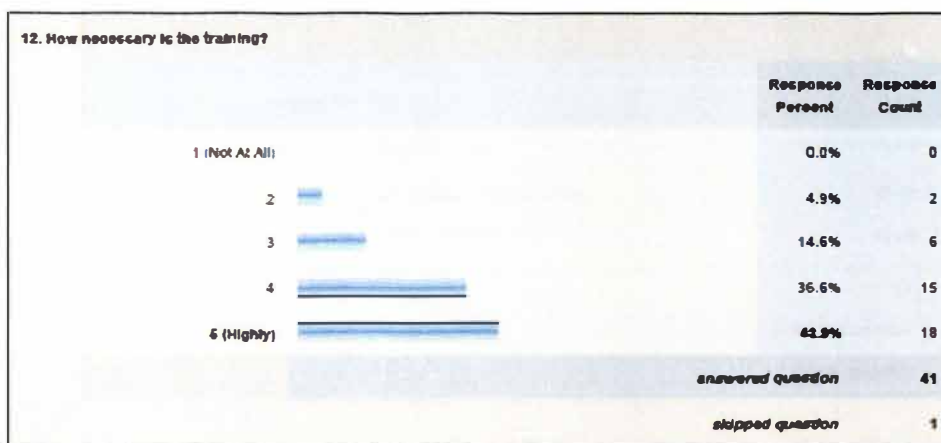
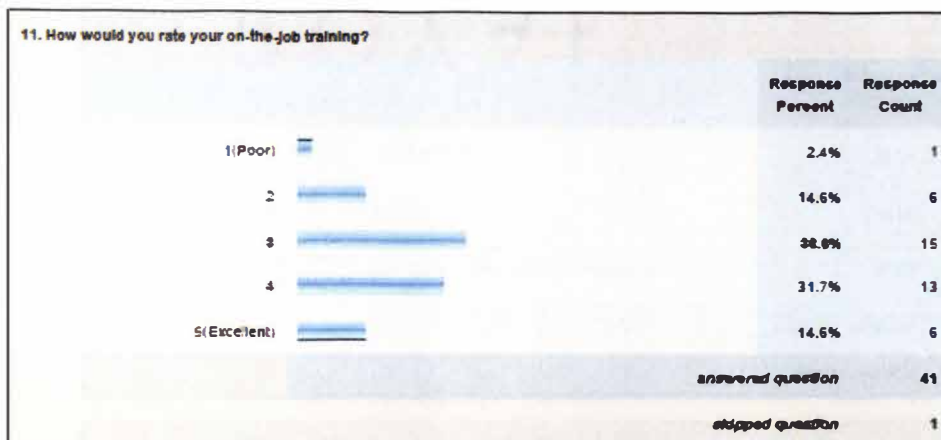
SURVEY 2 RESULTS:

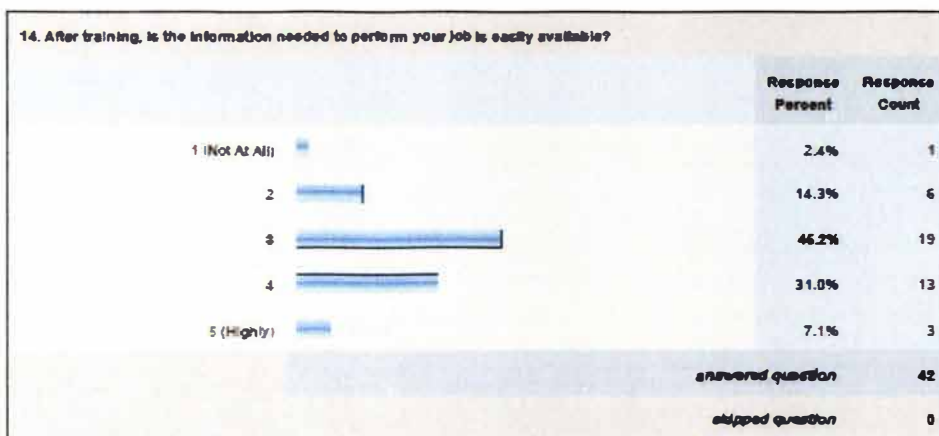
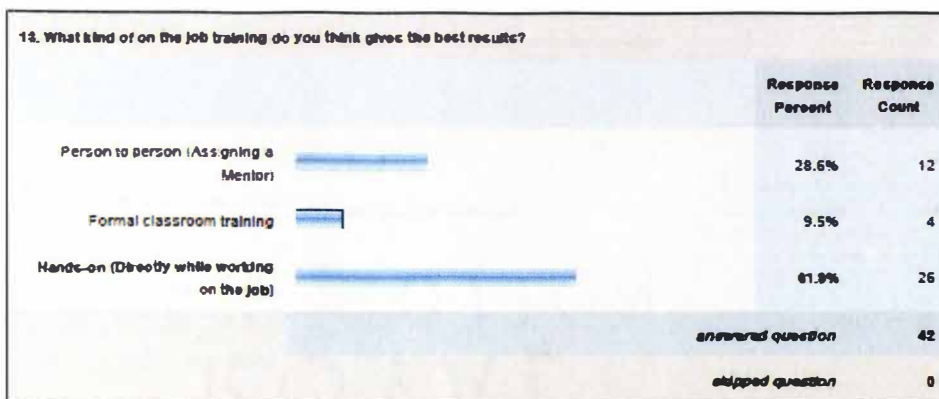


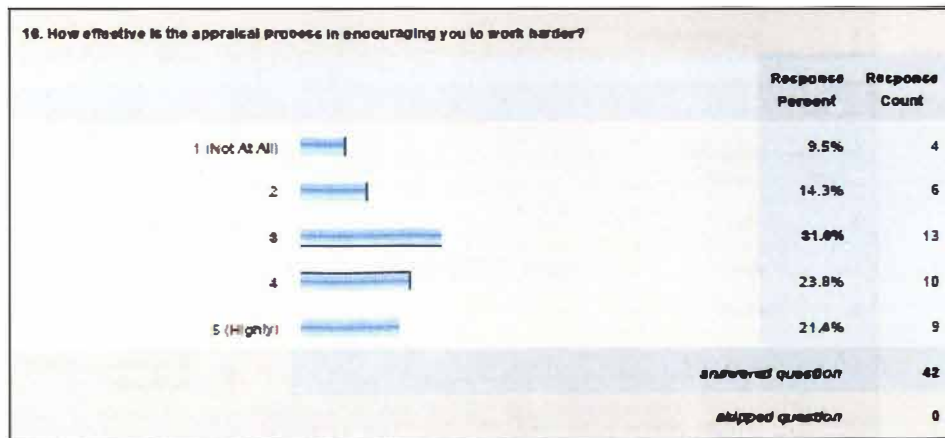
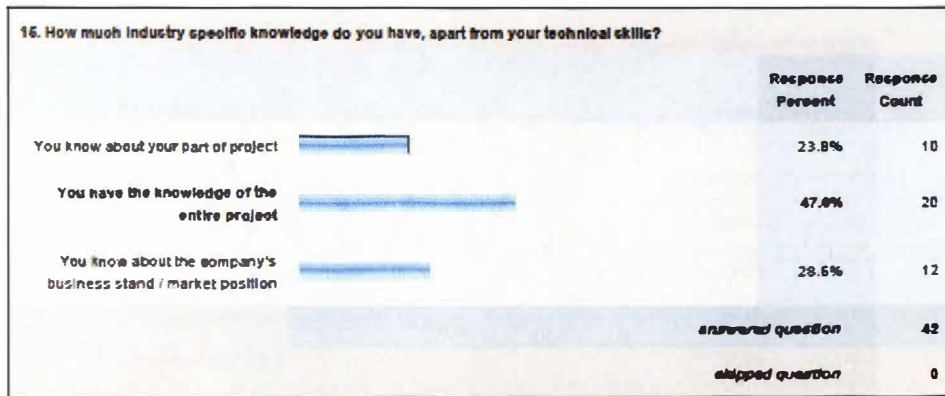


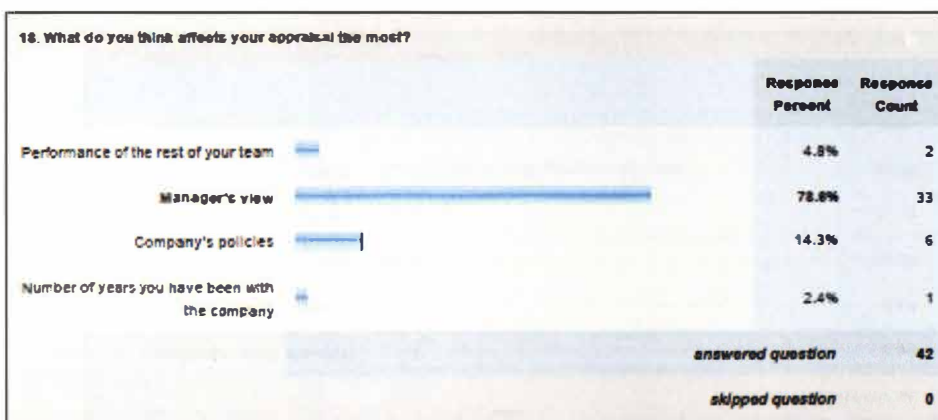
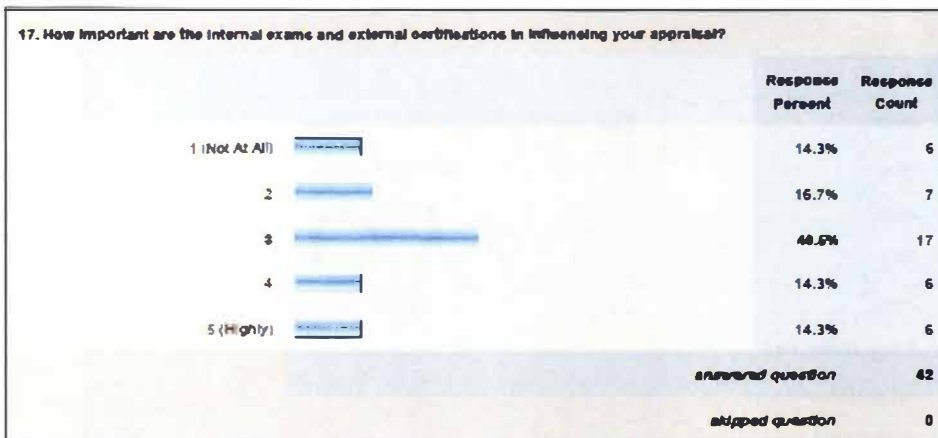


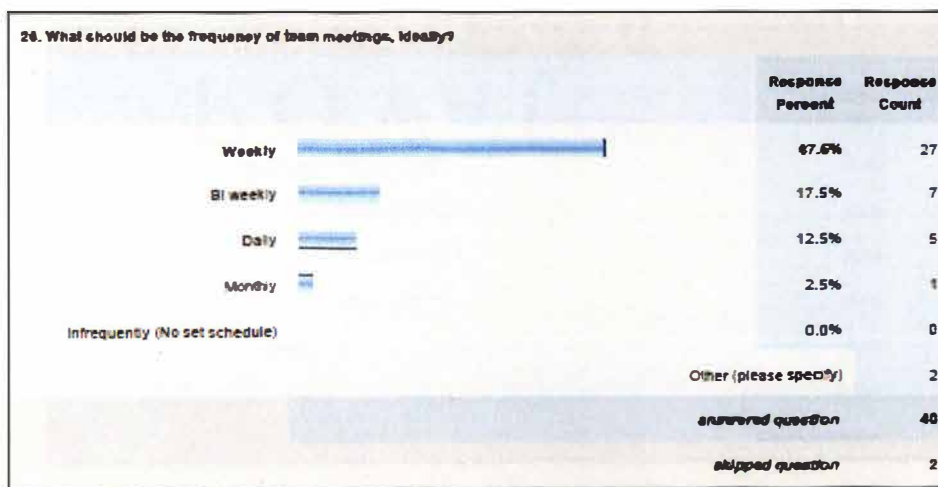
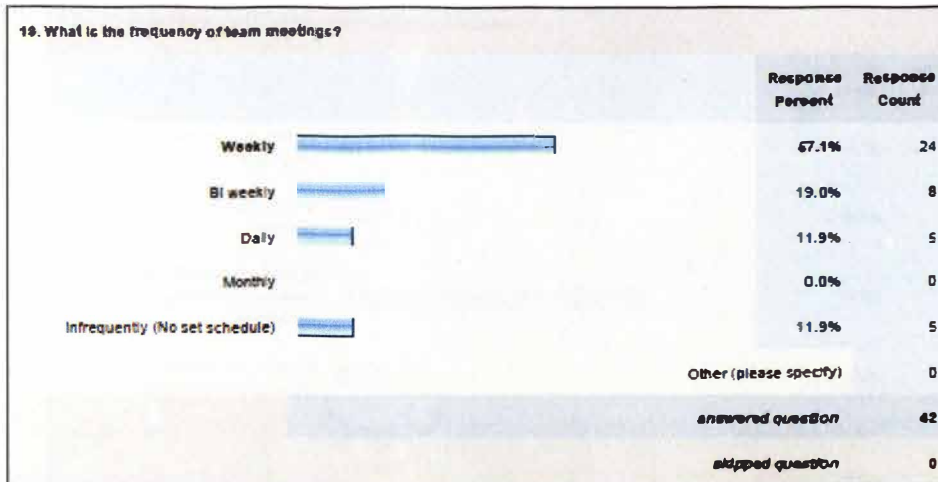


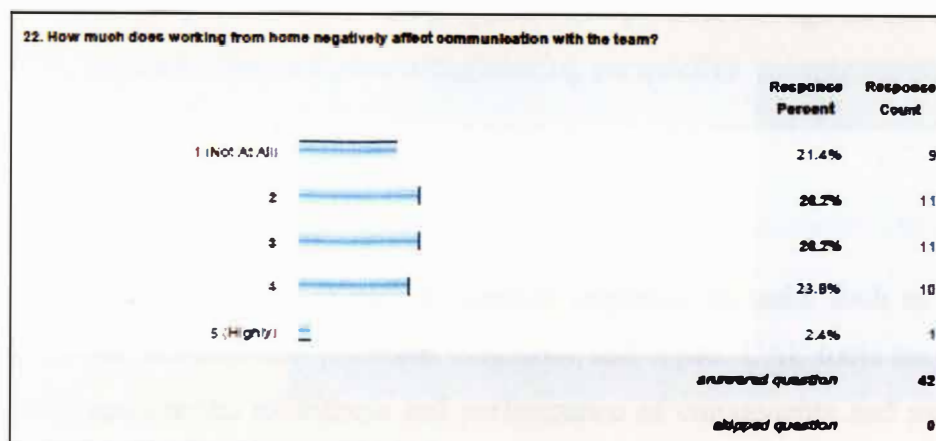
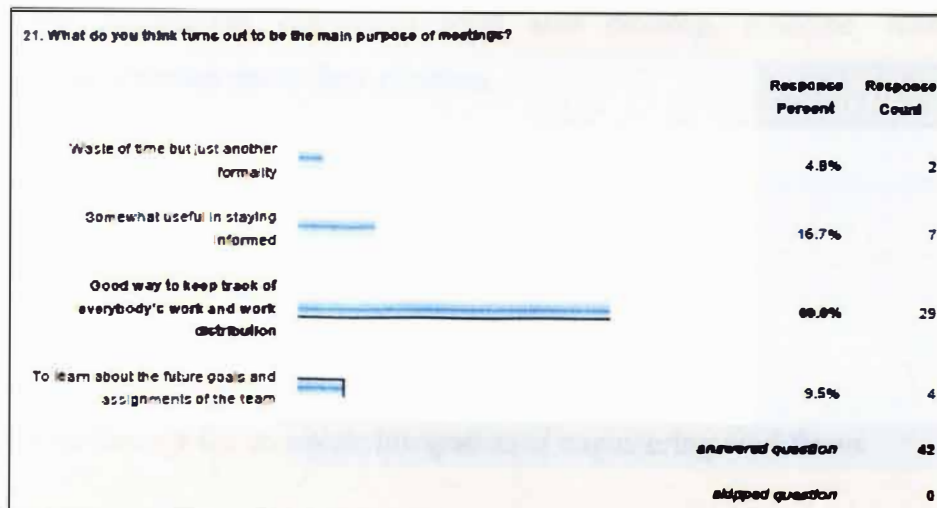












PLM (Product Lifecycle Management)¹³:

Product lifecycle management (PLM) is the process of managing the entire lifecycle of a product from its conception, through design and manufacture, to service and disposal. It is one of the four pillars of a corporation's information technology structure. PLM seeks to reduce waste at all stages of the manufacturing process by re-using data. PLM is a framework for product optimization. All companies must manage communications and information with their customers (CRM-Customer Relationship Management), suppliers (SCM-Supply Chain Management), internal resources (ERP-Enterprise Resource Planning), and teams planning (SDLC-Systems Development Life Cycle). In addition,

manufacturing engineering companies must also develop, describe, manage and communicate information about their products.

The effects of PLM include:

- Reduced time to market
- Improved product quality
- Reduced prototyping costs
- Savings through the complete integration of engineering workflows

PLM is about managing descriptions and properties of a product through its development and useful life, primarily from a business/engineering perspective

CAE¹²:

CAE uses specially designed software to support engineers in tasks such as analysis, simulation, design, manufacture, planning, diagnosis, and repair. CAE tools may be used for example to analyze the robustness and performance of components and assemblies. They permit simulation, validation, and optimization of products and manufacturing tools. CAE systems supply information to support design teams in decision making. CAE systems are an important component of information networks, representing a single node on a total information network in which each node interacts with other nodes on the network

CAE assists with the following areas:

- Stress analysis of components and assemblies using Finite Element Analysis
- Thermal and fluid flow analysis including computational fluid dynamics
- Kinematics
- Mechanical event simulation (MES)
- Analysis tools for process simulation analysis for operations such as casting, molding, and die press forming
- Product and process optimization

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VITA

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