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Discerning attributes which stimulate performance in quality improvement teams

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Discerning Attributes Which Stimulate

Performance in Quality Improvement Teams

by

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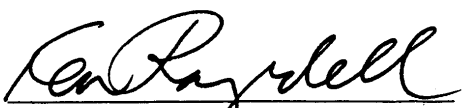

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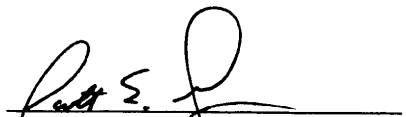

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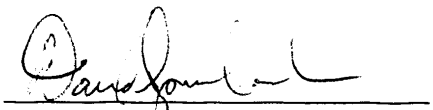

Dr. Dave Spurlock

ABSTRACT

Total quality management (TQM) can be summed up as people and the way they work. One key element of the philosophies of TQM is the heavy emphasis on utilizing quality improvement teams (QITs) and quality tools to effectively create high performance organizations. Specifically, this investigation asks the following questions: 1) What are the key attributes that contribute to performance in QITs? 2) What is the relationship between team communication and QIT performance? 3) What is the relationship between the number of quality tools utilized in a team and QIT performance? Participants for this study were 101 students from the University of Missouri-Rolla that participated in teams with at least one group project and had exposure to at least one of the 14 quality improvement tools in their team projects. Data was collected during the Winter 2004 semester. Individual perspective on the team's performance was measured quantitatively by the team performance score. Four key attributes were identified that influence team performance. We found a significant positive relationship between team communication and team performance. Our results also provide insight on tool utilization and how it relates to team performance.

ACKNOWLEDGEMENTS

I would like to thank my Lord and Savior, Jesus Christ. I have always known that my faith should not stand in the wisdom of men, but in the power of God. I would like to also thank my advisor, Dr. Ken Ragsdell, for believing in me and teaching me the importance of focusing on the things that really matter in life. A special thanks to my thesis committee, Dr. Grasman and Dr. Spurlock, for their constructive criticism and laughter. Thanks to Krista, Mandy, Linda, Cindy, Debbie, Diane, and Theresa for smiling when I bugged them with twenty plus questions. I would like to dedicate this thesis to my wife, LaChelle, my two daughters, Amethyst Grace and Emerald Faith, and my son, Jasper Isaac, who kept me smiling and gave my heart joy when no one else was there. I also dedicate this writing to my parents, Carl E. Prude, Sr. and Lillie B. Prude, who were willing to allow me to leave home at the age of fourteen to attend the Illinois Mathematics and Science Academy for my high school education and life experiences; my seven older siblings Avis, Edwin, Mark, Vian, Lili, Dona and Paul; my other parents Terry Harton and Karen Harton, who have always displayed benevolence toward me. Most importantly, I dedicate this writing to my "Grandpa Aaron Harton" and "Grandma Theresa Harton."

TABLE OF CONTENTS

Page

LIST OF ILLUSTRATIONS

LIST OF TABLES

Table Page

1. INTRODUCTION

1.1 BACKGROUND

Total Quality Management (TQM) revolves around people and the way they work. Some of the topics of TQM are customer focus, worker empowerment, and continuous improvement. Backing TQM are renowned gurus of quality that have made their mark in history as they have sought to better organizations through infrastructure change. These include J. M. Juran, W. E. Deming, K. Ishikawa, and A. V. Feigenbaum. Historically, each has played an important role in the development of the philosophies of TQM.

A current theme in today's corporate world is the increased use of teams in business, government, and industry (Sweeney and Lee, 1999). Teams have become a key factor in increasing organizational productivity over the last two decades. Huber and Glick (1993) concluded that effective teams enable organizations to achieve the high levels of performance that are essential to survival and prosperity in today's extremely competitive and rapidly changing environment. TQM is also grounded on the effective use of quality improvement teams.

For our study, we will adopt the definition of a quality improvement team as "A team responsible with performing the minimal tasks of shaping, planning, and implementing quality goals by utilizing quality tools to solve specific problems in the organization." Should organizations focus on utilizing quality improvement teams to increase productivity? In this study, we hope to answer this question by focusing on the six attributes (Hagen, 1985) which improve performance in teams. In this study, the following questions will be posed and answered: 1) Which of the six attributes are key attributes that contribute to performance in quality improvement teams? 2) What is the relationship, if any, between communication and quality improvement team performance? 3) What is the relationship between the number of quality tools utilized in a team and quality improvement team performance? The model is depicted in Figure 1.1 below and will be discussed in detail. We will address the predictor variables and the outcome variable. The method and measures employed in this investigation will be examined as well.

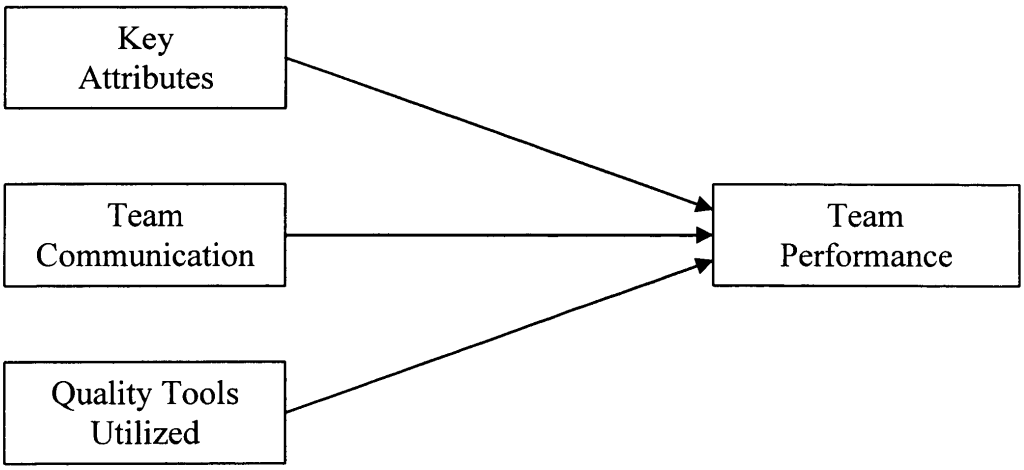

Figure 1.1 Theoretical Model

1.2 LITERATURE REVIEW

Much of the existing quality improvement team literature is limited in attempting to support the use of quality improvement teams in organizations. Not much literature could be found which attempts to support the relationship between team communication, quality tools, and team performance. Even less literature was found which attempts to provide a model which predicts team performance. In theory, QITs are effective because of the use of tools which ultimately are the driving force behind the performance of quality improvement teams. The communication amongst team members is high due to the open sharing of information, listening between team members, and completion of individual tasks on time. If the team wants to succeed, its members must communicate effectively.

One area of literature which deserves attention is the management and utilization of teams in an organizational structure. The literature is abundant in terms of teams as a function of a whole system be it organization, business, or government facility. The work of Hagan (1985) suggests that there are six essential team building elements that ensure high performance and productivity among team members. Table 1.1 describes these attributes in brief detail. The attributes are Respect and Consideration, Loyalty and Leadership, Individual Job Responsibility, Communication, Group Goals, and Rewards. To support the use of Hagan's six key team building elements for this study, we will

focus on the literature of other authors which support the use of Hagan's criteria as a means of developing teams to operate within an organizational structure.

Table 1.1 Hagen's Six Key Team Building Elements

Respect and consideration for all team members
Accountability for job responsibilities and performance standards
Effective individual and team communications
Coordinated development and alignment of individual and team goals
Recognition and reward of teamwork and team building efforts
Demonstration and encouragement of team loyalty.

Blake and Moutson (1978) combined management and team influences in the development of their team attributes. Table 1.2 suggest a combination of communication, climate, goals, and process observation are all attributes that contribute to team success. The authors also suggest that management influences are equal to team development.

Table 1.2 Blake and Moutson Necessary Team Attributes

Communication Among Team Members is with high candor
Climate for commitment so that there is a guarantee that work will get done based upon share agreements and understandings
Direction by management or the pointing of the way based upon goals
The existence of challenging and clear goals which stimulate effort
Decision making, where the team decides which way to move and pools its human resources
Critique of the team or stepping back to examine processes when the team is working on problems or issues

Through the study of cadet squadrons at the U.S. Air Force Academy, Hughes, Rosenbach and Clover (1983) concluded that nine principles of teamwork are essential for any team to function at their highest level. Contained in Table 1.3, the authors focus on the changes that occur over time, the importance of mentoring one another, and the use of feedback within the team.

Table 1.3 Hughes, Rosenbach and Colvers' Nine Principles of Teamwork

Teamwork involves effective communication among members, which often involves closed loop communication
Teamwork means fostering within-team interdependence
Teams change over time
Teamwork and task work are distinct
Teamwork means that members monitor one another's performance
Teamwork implies the willingness, preparedness, and proclivity to back fellow members up during operations
Teamwork is characterized by a flexible repertoire of behavioral skills that vary as a function of time
Teamwork implies that members provide feedback to and accept it from one another
Teamwork involves group members' collectively viewing of themselves as a group whose success depends on their interactions

The effective team building attributes in Table 1.4, as defined by Katzenbach and Smith (1993), give eight important characteristics of team building. Included in Table 1.4 are direction, the following of rules, and external challenge to produce internal conflict resolution techniques.

Table 1.4 Katzenbach and Smith's Effective Team Building Attributes

Establish urgency and direction
Select members based on skills and skill potential, not personalities
Pay particular attention to first meetings and actions
Set some clear rules of behavior
Set and seize upon a few immediate performance-oriented tasks and goals
Challenge the group regularly with fresh facts and information
Spend lots of time together
Exploit the power of positive feedback, recognition, and reward

Kerzner (1992) concluded that an effective team possess attributes that must be developed through proper management. One of his main focuses is on the use of a program that goes beyond care for the team. He focuses on less quantifiable characteristics such as team spirit, interest in personal growth, and project commitment. In his book entitled Project Management, Kerzner (1992) sums up these effective attributes as shown in Table 1.5.

Table 1.5 Kerzner's Effective Team Attribute

Open Communication among team members and support organizations
Sincere interest in personal growth of the team members
Good program leadership
Involved and supportive top management
Clearly defined goals and program objectives
The team must have the necessary expertise and resources
Good interpersonal relations and team spirit
Team members must be committed to the project

There is literature that exists in the areas of teams and the management thereof. In his book, The Professional Manager, McGregor (1967), focuses on both outside influence and individual effort to get effective teamwork. His work identifies six features that equal an effective management team. Table 1.6 displays what McGregor concluded was a thorough investigation of the management of teams.

Table 1.6 McGregor's Features of an Effective Management Team

Open Communication
Effective leadership
Selective use of the team
Appropriate member skills
Management of human differences
There is understanding, mutual agreement, And identification with respect to the primary task.

There is a general consensus among each of the authors above regarding what attributes or characteristics are essential for effective teams and for building effective teams. This general consensus, which is the fundamental reason for using Hagen's six key team building attributes to describe team characteristics, is summarized in Table 1.7 This table was developed by listing each of the authors from the literature search and summarizing the attributes they thought were important for teams to be effective. Each of these attributes was given in the previous tables. Although Hagen's six key team attributes are not exclusive, the majority of effective team attributes are covered by him. The approach was similar to Peters (1997) in showing support for his use of Hagen's team building elements in the development of his validated survey.

Table 1.7 Summary of Effective Team Attributes

AUTHORS	HAGEN	BLAKE & MOUTON	HUGHES	KATZENBACH & SMITH	KERZNER	MCGREGOR
TEAM ATTRIBUTES						
Respect & Consideration	X	X	X	X	X	X
Individual Job Responsibility	X	X	X	X	X	X
Communication	X	X	X	X	X	X
Group Goals	X	X	X	X	X	X
Rewards	X		X	X	X	X
Loyalty/Leadership	X	X		X	X	X
Conflict Management		X				X
Correct Skill Mix			X	X	X	X
Selective Use of the Team			X			X
Support From Management		X	X		X	
Team Adaptability						

The purpose of gathering literature from other authors was to support the use of Hagen's six key attributes in this study. Existing literature shows that Respect and Consideration, Loyalty and Leadership, Individual Job Responsibility, Communication, Group Goals, and Rewards are of high importance in team development.

In terms of the management philosophy behind quality improvement, four individuals emerge as leaders: W.E. Deming, J.M. Juran, A.V. Feigenbaum (Montgomery, 2001) and K. Ishikawa. Each set of philosophies was developed by each individual through observation and practical application of statistical methodology and quality improvement.

W.E. Deming is known as the inventor of Total Quality Management and his 14 points of management. Deming's 14 points emphasizes both the utilization of tools, and the development of people. Four points support the use of tools and teamwork. In general the points include involving the workforce in continuous improvement, providing training for employees, teamwork in the organizational units, and the use of basic

statistical process control problem-solving tools, particularly the control chart respectively (Montgomery, 2001).

J.M. Juran is most noted as the individual who added the human dimension to quality. He is the founder of the Juran Institute and his philosophies focus on quality from a management perspective. One of his most notable beliefs is that most of the opportunities (80%) for quality improvement can only be addressed by management and that a relatively small proportion of these opportunities (20%) can be dealt with at the workforce level (Juran and Gryna, 1998).

A.V. Feigenbaum is the originator of Total Quality control and is a stressor of a systematic approach to quality. Feigenbaum's solution regarding quality improvement is one that combines organizational structure and a system approach to improving quality. (Feigenbaum, 1956) He is also the originator of the Ten Tenets in Table 1.8, which are crucial benchmarks for total quality success. Observing Feigenbaum's Tenets we note that one is "Quality requires both individual and teamwork zeal." Viewing quality from a system approach also requires the involvement of people. Dr. Feigenbaum understood that quality must be improved through team effort.

Table 1.8 Dr. Feigenbaum's Ten Tenets

1. Quality is an organization-wide process
2. Quality is what your customer says it is.
3. Quality and cost are a sum, not a difference.
4. Quality requires both individual and teamwork zeal.
5. Quality is a way of managing.
6. Quality and innovation are mutually dependent.
7. Quality is an ethic.
8. Quality requires continuous improvement.
9. Quality is the most cost effective, least capital-intensive route to productivity.
10. Quality is implemented with a total system connected with customers and suppliers.

K. Ishikawa is most noted for being associated with the Company Wide Quality Control movement. He is the pioneer of Quality Circles in Japan in the 1960s and the developer of the Cause & Effect Diagram. In his philosophies, Ishikawa is noted for having believed that 95% of quality problems can be solved with simple tools. Tools then become an important part of quality improvement. We will see what the seven old and seven new tools of quality improvement are. Furthermore, a discussion on the implementation of each tool is presented as well.

Both the utilization of tools and effective teamwork are the substratum for the literature dealing with TQM implementation. People are the key resource for any organization's success particularly during times of change or restructuring (Davis and Coleman, 1999). Teams are becoming a more common method for dealing with environmental dynamics and competitive challenges (Sweeney and Lee, 1999)

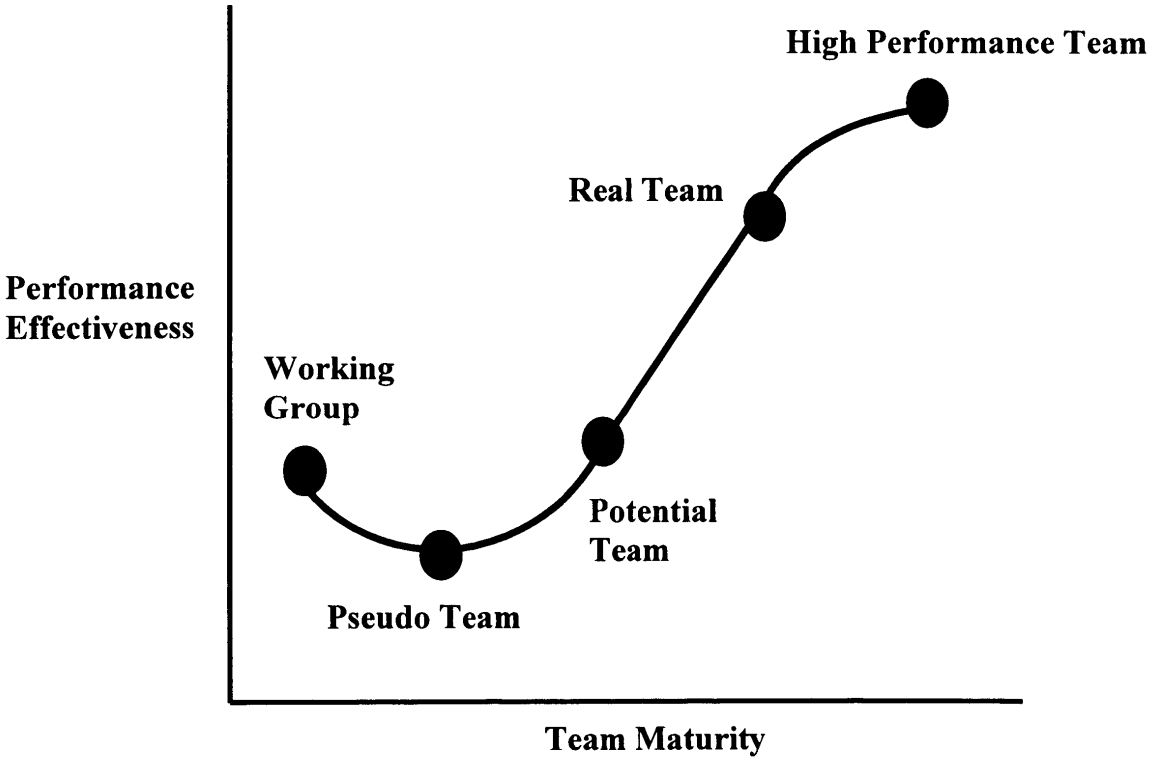

Figure 1.2 Katzenbach and Smith's Team Performance Curve

In this study, we seek to also explore Hagen's six attributes and discern which are most needed in quality improvement teams. Furthermore, we will see where quality improvement teams function on the team performance curve created by Katzenbach and Smith (1993) and further developed by Peters (1997).

All teams face maturity and performance issues in organizations and industries. Katzenbach and Smith (1993) developed the Team Performance Curve (Figure 1.2) which serves as a model of the positions that various teams transition through as they engage in team activity. In their research, they conclude that teams go through various stages of effectiveness as they mature (Katzenbach and Smith, 1993). Prior to the work of Peter's (1997), the curve was only somewhat useful to teams and managers. The curve was theoretical in its inception, but Peters (1997) developed a test instrument in the form of a survey which actually quantifies where a team performs on Katzenbach and Smith's (1993) team performance curve.

Peters focused on Hagen's (1985) six attributes that influence team performance. Although Elrod and Tippett (1999) studied the relationship between team performance and team maturity using the questionnaire developed by Peters (1997) to draw conclusions on the development of self-directed teams, this study provides another use of Peter's questionnaire for development of teams in quality management.

1.2.1 Quality Improvement Teams. The concept of teams is of central importance to quality management (Hirschhorn, 1991). As shown in Figure 1.3, there are two main types of teams in TQM: policy deployment teams and tasks teams (Wilkinson, 1992). Policy deployment teams include quality councils, process quality teams, and quality improvement teams (Oakland, 1993). Policy deployment teams are concerned with shaping, planning, and implementing quality goals, policy, and strategy within an organization (Dimitriades, 2000). Task teams comprise problem-solving teams and self-directed teams. Self-directed teams are publicized as a way to ensure organizational improvements in both productivity and profits. Self-directed teams are different from problem-solving teams because they replace rather than complement the traditional organization structure of work. Self-directed teams often handle budgeting, scheduling,

ordering supplies, and setting goals. For these reasons, self-directed teams are not considered quality improvement teams.

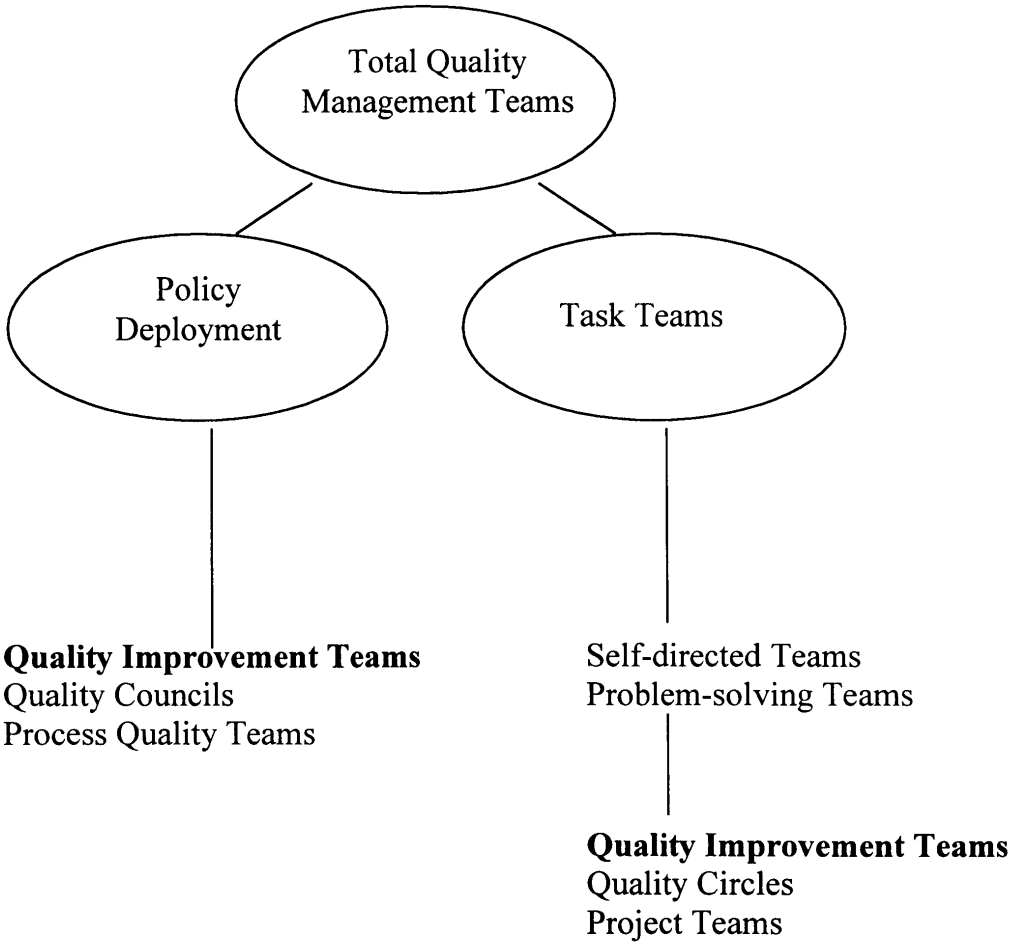

Figure 1.3 Types of Total Quality Management Teams

Problem solving teams comprise quality improvement teams, quality circles, and/or quality project teams (Dimitriades, 2000). As their name implies, problem-solving teams work "To improve quality by solving specific quality problems facing the organization," (Dean and Evans, 1994).

Quality improvement teams have also been classified as project teams. Project teams have a specific and finite mission to develop something new or accomplish a large

and complex task (Cal/EPA, 1998). For each project, a project team is assembled which is usually made up of employees (Feeder, 1993). There are some similarities between project teams and QITs. One of the similarities is that as a temporary group, a project team is formed for one main purpose: complete the assigned task by a certain date or dates, and then disband. (Ammeter and Dukerich, 2002). The importance of involvement in total quality is well established in the TQM literature (Dale and Cooper, 1993, Evans and Lindsay, Magjuka, 1993; Dean and Evans, 1994; Lawler, 1994).

Total quality management and quality improvement are not limited to one type of industry. TQM is heavily used in manufacturing environments, service organizations, government, education, and healthcare. Literature supports that using QIT to employ quality improvement leads to productivity throughout the organization. The California Environmental Protection Agency (Cal/EPA) used quality improvement teams to provide quality services and products to the public, enhance productivity, and improve the work environment (Cal/EPA, 1998). Other organizations utilize QITs to ensure high performance within the organization.

Table 1.9 Dolan's Process Improvement Process Implementation

Once a problem has been identified, take a look at the process causing the problem and identify how it impacts customer satisfaction, employee, involvement, and financial returns
Put together a team that will collect data and oversee the implementation of the recommended changes
The team's first job is to clearly articulate the project's aim and expected improvements
At the start of the project, develop communications plan and keep it updated
Select the right tools for the project, because the tools are appropriate for all projects.
Offer rewards and recognition for team achievements.
Once changes have been implemented, follow up regularly to ensure the improvement really occurred.

While there was literature found on the use of QITs and the results that are brought to the bottom line, there is very little literature that gives insight as to why QITs are so effective. Dolan (2003) outlines a process in Table 1.9 that helps managers implement a process improvement process. Dolan suggest using a team, early and often team communication, and acquiring the right tools for the project. Process improvement projects can be implemented and completed successfully, as shown in Figure 1.4 if present within the process are the three basic elements of team, communication, and tools.

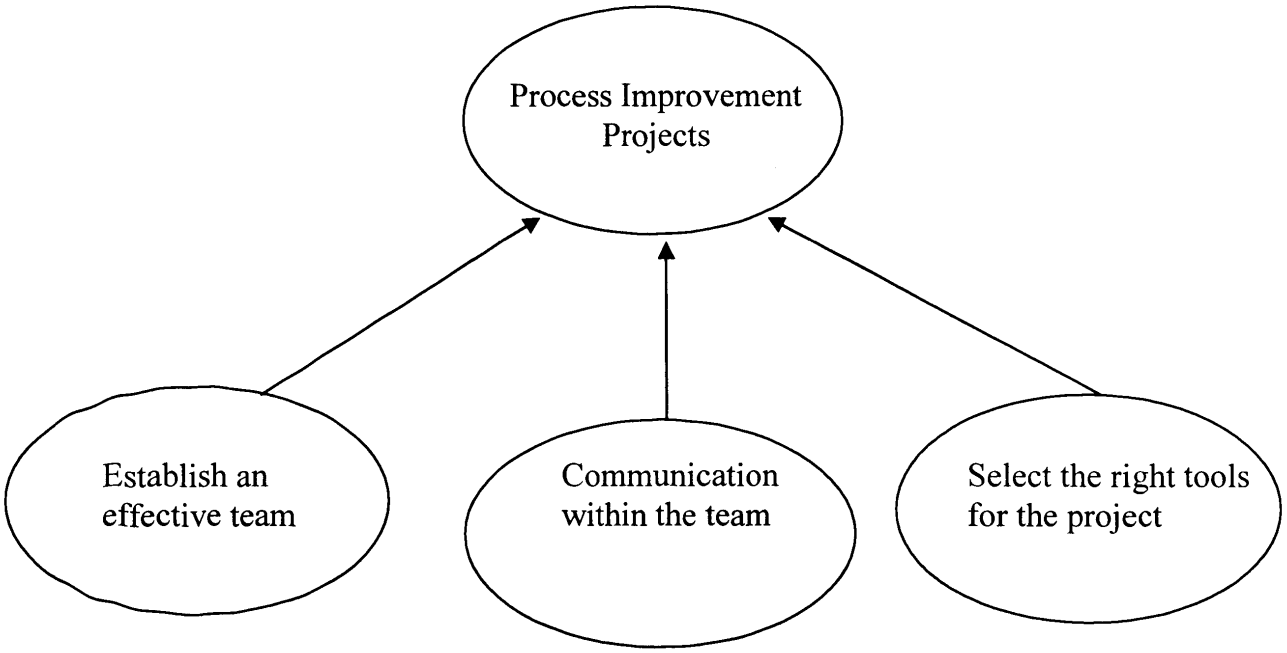

Figure 1.4 Summary of Dolan's Process Improvement Project Model

Team leaders and team members must not only share compatible knowledge of the project, they must use the shared knowledge to develop shared expectations for the task and the team in order to be effective (McComb, Green, and Dale, 1999) Then, another area of team communication is meeting with the team. Ultimately, meetings serve as a place to share information and solve problems of a technical nature, but also serve to provide a forum where the team members could interact socially with each other (Ammeter and Dukerich, 2002).

1.2.2 Communication. Revisiting the works of the previous authors in the development of support for Hagen's six key attributes, we see that each author viewed communication within the team as a key attribute for success. Table 1.10 sums up each author's perspective on communication as it relates to teams.

Table 1.10 Communication Comments by Author

AUTHOR	COMMUNICATION COMMENTS
Hagen	Effective individual and team communications
McGregor	Open Communication
Blake & Mouton	Communication Among Team Members is with high candor
Hughes, Rosenbauch, Colvers	Teamwork involves effective communication among members, which often involves closed loop communication
Kerzner	Open Communication among team members and support organizations
Dolan	At the start of the project, develop communications plan and keep it updated

In summary, much of the completed research looked at the definition of quality improvement teams, how to implement them, and theoretically what makes total quality management works. Keeping this in mind, this study focused on trying to show that performance among quality improvement teams is high due to the use of communication within the team that is fostered by the use quality tools.

1.3 THEORY AND HYPOTHESIS

1.3.1 Team Performance. Research on team performance is divided into two segments: short-term performance and long-term performance. Short-term performance is the ability to meet the traditional cost, schedule, and technical performance outcome goals. Long-term performance is the internal performance of a team as a team, the degree to which a team is growing and maturing internally. (Robertson and Tippett, 2002) Few studies measure performance of a team from an internal method. When

quantitative metrics are used, they are normally based exclusively on factors external to the team, such as number of customers served, the total number of defective units produced, and other cost, schedule, and performance numbers (Robertson and Tippett, 2002). Our goal is to measure performance from an internal perspective. In this study, we look at short-term team performance with the focus on the ability to meet the schedule of the projects performed by each QIT.

1.3.2 Team Attributes. The work of Hagan (1985) suggests that there are six essential team building elements that ensure high performance and productivity among team members. These attributes are Respect and Consideration, Loyalty and Leadership, Individual Job Responsibility, Communication, Group Goals, and Rewards. Because of the work of the authors that supported the use of Hagen's six attributes in the study of team performance and because quality improvement teams share the same key elements as teams, we predict that all of the attributes will be in a positive relationship with team performance.

H_1: All of the team attributes will positively relate to team performance

1.3.3 Team Communication. Literature suggests that effective teams enable organizations to achieve high levels of performance through communication (Huber and Glick, 1993). Team communication is a combination of sharing information, listening ability, and completing assignment or parts of the project in a timely manner. As it relates to team performance, the idea is that as team communication increases and is abundant within the team, performance expectations are increased as well. Because of the philosophy of TQM, we suggest that the team communication will be high within the team.

$H2_a$: Communication will be the most significant attribute.

$H2_b$: Communication will have the strongest positive relationship with team performance.

1.3.4 Quality Tools. Another aspect of TQM is the use of tools to facilitate teamwork and strengthen the communication barriers that teams are believed to face. The tools of quality improvement claim to facilitate teamwork and in theory should impact the performance of teams in a positive manner. According to Dolan (2003) tool selection is extremely important. He quotes, "Choose an applicable tool and work within

that framework. Select the right tools for the project, because not all tools are appropriate for all projects." Tools selection relates to performance in such a way that if the wrong tools are being used by the team members, progress impedes. However, if the right tool is selected at the initial stage of the project, progress is advanced.

For this study, the quality tools are those taught in Dr. Ken Ragsdell's Engineering Management 375 Course at the University of Missouri-Rolla during the Winter 2004 semester. There are Seven Old Tools and the Seven New Tools commonly used in quality management. The Seven Old Tools revolve around numbers and trends, while the Seven New Tools are considered management tools. A mention of each tool and the general implementation thereof becomes necessary in the study.

H_{3a}: Teams that utilize more tools will display higher team performance scores.

H_{3b}: Teams that utilize more tools will display higher communication scores.

1.3.4.1 Seven Old Tools. The Seven Old Tools of quality are used for observing, analyzing, and interpreting data. The way in which the tools are construed give rise to the way managers and team leaders direct their organization. Table 1.11 gives the name of each of the Seven Old Tools. They are the Pareto Diagram, Cause and Effect Diagram, Graphs, Check Sheets, Histogram, Scatter Diagram, and Control Charts.

Table 1.11 The Seven Old Tools of Quality

Seven Old Tools
1. Pareto Diagram
2. Cause and Effect Diagram
3. Graphs
4. Check Sheets
5. Histogram
6. Scatter Diagram
7. Control Charts

Table 1.12 gives a view of the general implementation of the Seven New Tools. In observing the implementation of the Seven Old Tools, several of the key steps rely heavily on communication. How can a team plan and implement solutions without

communicating with other team members? Reaching a final solution involves sharing information and listening. A discussion on the utilization, implementation, and an example of each of the seven tools will follow. This section will give readers insight on the types of tools that QITs utilize.

Table 1.12 Implementation of Seven Old Tools

1. Select a Theme
2. Collect and Analyze Data
3. Discover Root Causes
4. Plan and Implement Solutions
5. Evaluate Effects
6. Standardize Solutions
7. Generalize and Improve These Steps

Each quality tool is unique in implementation. For implementing the Seven Old Tools, a step by step process is necessary for managers, team leaders, and team members. Each quality tool is unique in its purpose and operation. Through training and practice the team becomes acclimated to the tools and glib in use. Implementation then is a combination of skill and familiarization of the particular tool.

1.3.4.1.1 Pareto diagram. The Seven Old Tools are all unique. The Pareto Diagram, as shown in Figure 1.5, helps to see the significant few in the presence of the insignificant many. It displays the relative importance of problems or conditions and allows one to better choose starting points. The purpose of a Pareto Diagram is to separate the significant aspects of a problem from the trivial ones. By graphically separating the aspects of a problem, a team will know where to direct its improvement efforts. Reducing the largest bars identified in the diagram will do more for overall improvement than reducing the smaller ones.

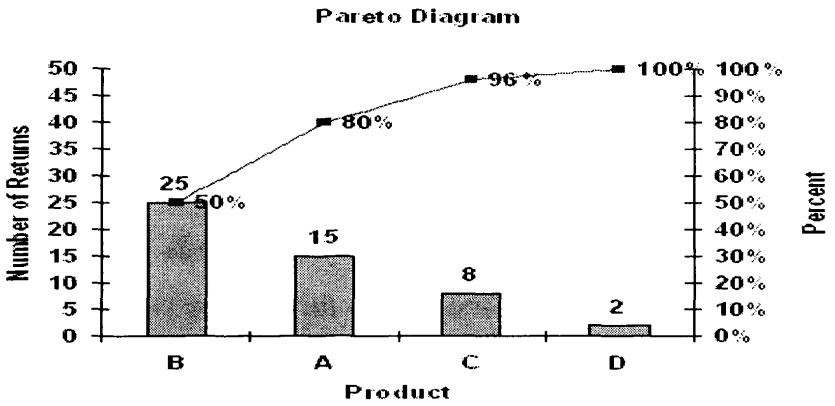

Figure 1.5 Pareto Diagram

1.3.4.1.2 Cause and effect diagram. The Cause and Effect Diagram, shown in Figure 1.6, breaks an "effect" into its possible "causes." Major causes may be broken down into the 4P's: Policies, Procedures, People, and Plant. To provide a pictorial display of a list in which you identify and organize possible causes of problems, or factors needed to ensure success of some effort. It is an effective tool that allows people to easily see the relationship between factors to study processes, situations, and for planning.

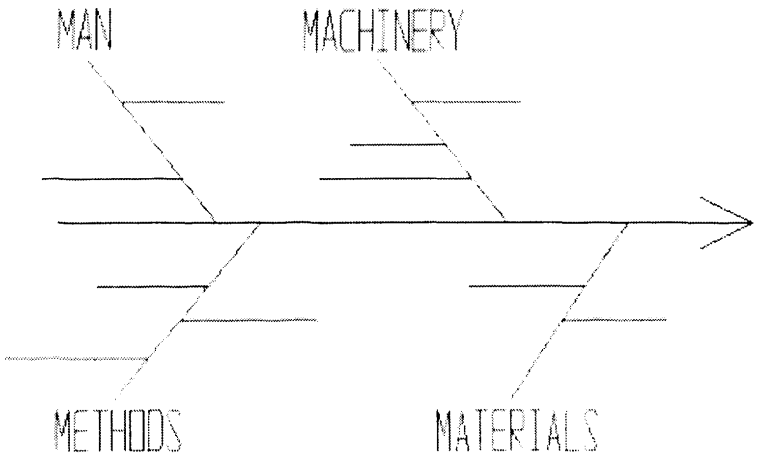

Figure 1.6 Cause and Effect Diagram

1.3.4.1.3 Graphs. Graphs and Charts are great because they communicate information visually. For this reason, Graphs are often used in newspapers, magazines and businesses around the world. The types of graphs used for the study are area graphs, bar graphs, line graphs, and pie graphs.

1.3.4.1.4 Check sheets. A Check Sheet is a simple data collection form consisting of multiple categories with definitions. Data are entered on the form with a simple tally mark each time one of the categories occurs. Check Sheets answer the question," How often is something happening?" The process begins by turning opinion into fact. A Check Sheet, viewed in Figure 1.7, is used for distinguishing between fact and opinion and gathering data about how often a problem is occurring. A Check Sheet is also used for gathering data about the type of problem occurring. It is used to facilitate the collection and analysis of data.

Date: 1/13/89 - 1/19/89

Tray Delivery Process

Floor: 4 East

Shift: 7 – 3

Check Sheet	MON	TUE	WED	THU	FRI	SAT	SUN	TOTAL
Tray Disabled	11	1111	1	1	1111	1		13
Diet Order Changed	1	1	1	11	1	111	111	12
Patient Asleep	1	1	1	1111	1111	1	1	13
Cart Faulty	111	11	111	11	1	11	1	14
Elevator Malfunction	111	1	1	1	1			7
TOTAL	10	9	7	10	11	7	5	69

Figure 1.7 Check Sheet

1.3.4.1.5 Histogram. The Histogram focuses on repeated events that will produce results that will vary over time. It also reveals the amount of variation that a process has within it. A Histogram is constructed from a frequency table.

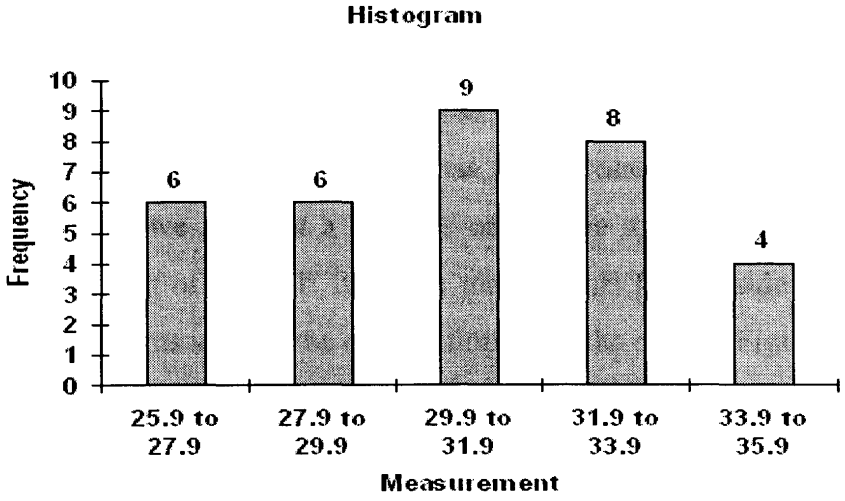

Figure 1.8 Histogram

The intervals are shown on the X-axis and the number of scores in each interval is represented by the height of a rectangle located above the interval. As shown in Figure 1.8, the histogram is a very strong tool and is often used to show if data that is being represented is normal in occurrence. For our study, the histogram was one of the most frequently used tools from our 101 respondents.

1.3.4.1.6 Scatter diagram. A Scatter Diagram is used to study the relationship

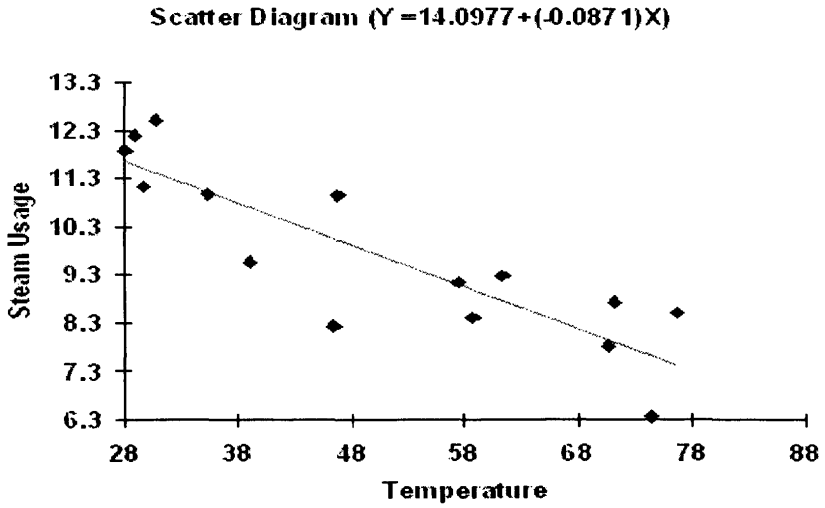

Figure 1.9 Scatter Diagram

between variables and test for cause and effect. Figure 1.9 shows the linear relationship between Temperature and Steam Usage. The tightness of the data points clues you in as to the strength of the relationship.

1.3.4.1.7 Control chart. A Control Chart is a run chart with statistically determined upper and lower control limits. These limits allow you to determine when the process is "out of control." A control chart has upper control limits and lower control limits. In Figure 1.10, we see that a few are out of the upper specification limits. A process is said to be "out of control" if one or more points fall outside of the and if the data forms unusual patterns with in the control limits. In the case in Figure 1.10, this case is out of control.

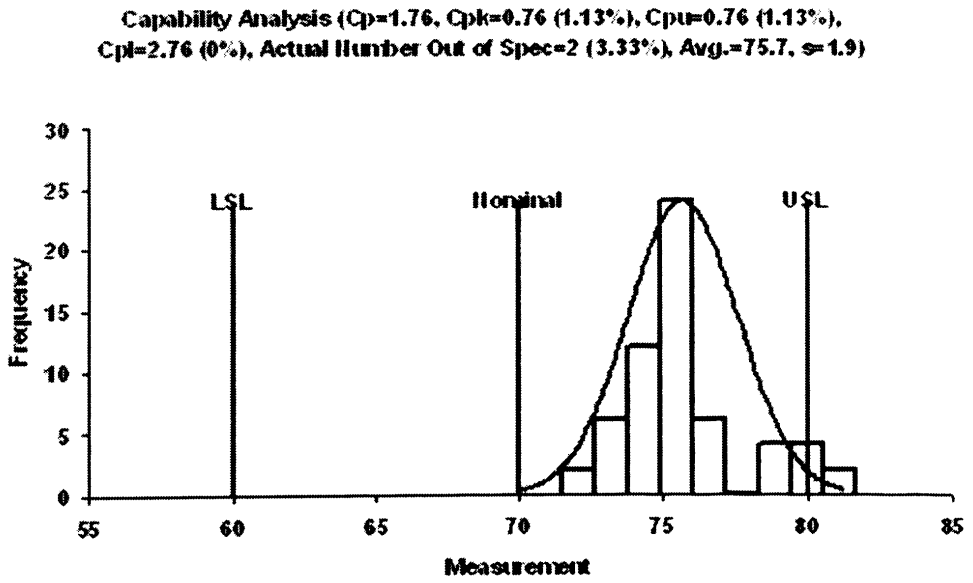

Figure 1.10 Control Chart

1.3.4.2 Seven New Tools. The Seven New Tools came about for two reasons. The first reason was because the old tools were often too basic or too technical to be of use to the manager. The second reason is because old tools deal with numerical data, whereas managers are faced with verbal data. Table 1.13 lists the Seven New Tools. These tools are believed to exert profound influence in organizational development and leadership. Managers that use these tools during major projects often boast of the way the tools help facilitate behavior of the team.

Table 1.13 The Seven New Tools of Quality

Seven New Tools
1. Affinity Diagram
2. Activity Network Diagram
3. Interrelationship Diagraph
4. Process Decision Program Chart
5. Matrix Diagram
6. Prioritization Matrices
7. Tree Diagram

1.3.4.2.1 Affinity diagram. The Affinity Diagram gathers large amounts of language data and organizes it into groupings based upon the natural relationships between the items, and defines groups of items. The Affinity Diagram helps teams attack ill-posed complex problems. It also helps teams reach consensus. Affinity Diagrams should be used when chaos exists, the only solutions are old solutions, the team is drowning in a large volume of ideas, and broad issues/themes must be identified.

The Affinity Diagram is an effective language tool that is valuable to the team and organization. It generates ideas, opinions and issues which can then be organized into natural groupings. It is a creative as well as a logical process that enables team members to participate in an issue's solution rather than simply restating the problem. It is best done with six to twelve members.

1.3.4.2.2 Activity network diagram. An activity network is a process flow chart that is useful for identifying steps in the process that are non-value added. The Activity Network Diagram, shown in Figure 1.11, is the end-product of the task decomposition process. It should be accompanied by narrative to explain any dependencies. It shows the relationships between the tasks that have to be performed, but says nothing about how long it will take to perform them. To go further we need to be able to estimate the effort, cost and elapsed time for each task or activity.

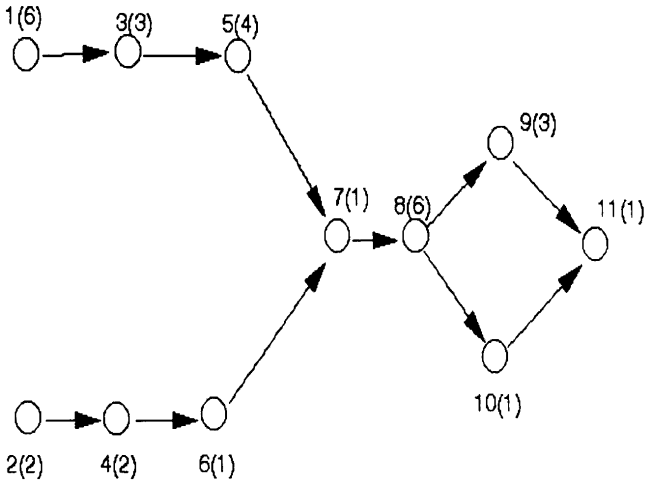

Figure 1.11 Activity Network Diagram

1.3.4.2.3 Interrelationship diagraph. The Interrelationship Diagraph takes a central issue, or problem, and maps out the logical or sequential links among related items. It also allows for "multidirectional" thinking.

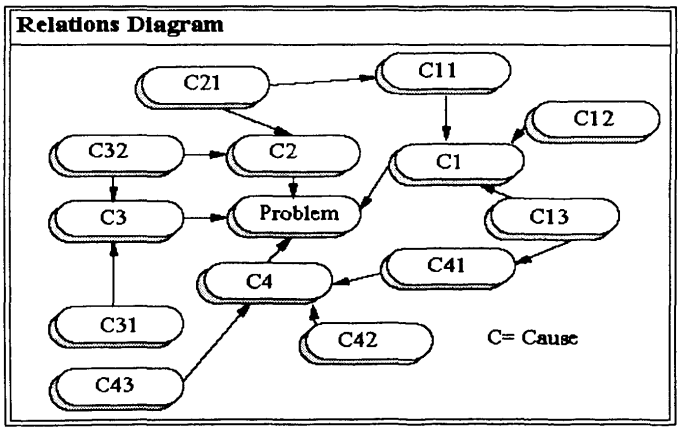

Figure 1.12 Interrelationship Diagraph

The Interrelationship Diagraph should be used when root causes of a problem of a problem must be identified and there are a large number of interrelated issues that need to

be better defined. Figure 1.12 shows that it is also used when data is not available to identify root causes and scarce resources require a carefully focused effort.

1.3.4.2.4 Process decision program chart. The Process Decision Program Chart (PDPC) is a method that maps out conceivable events and contingencies that can occur in any implementation plan. It in turn identifies feasible countermeasures in response to these problems. Figure 1.13 shows that there is a start and finish point in the PDPC.

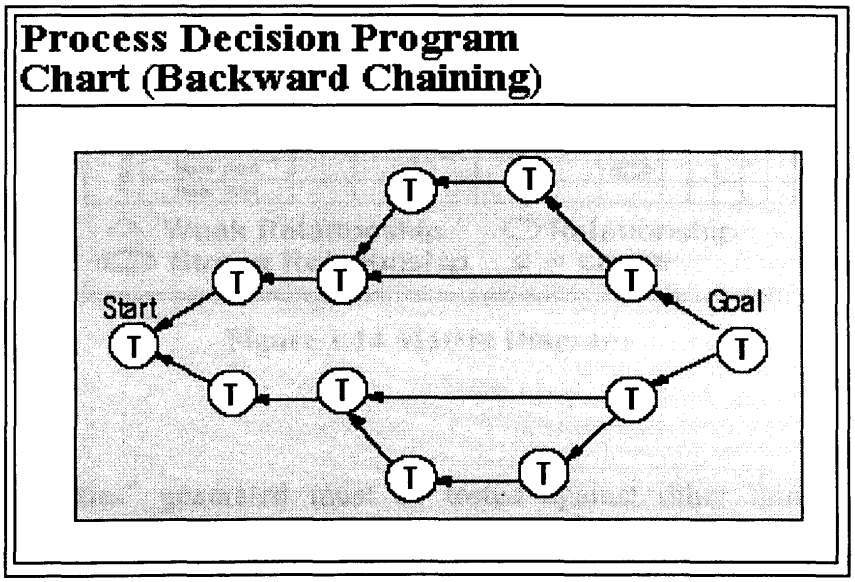

Figure 1.13 Process Decision Program Chart

The PDPC is a tool for contingency planning. It begins by listing the steps in a particular activity. It then lists what could go wrong at each step and finally it lists the counter measures for things that can go wrong. Sometimes it is drawn in the flow chart format below. Other times it is arranges as a numerical tree diagram. Use this tool when you need to map out conceivable events and contingencies that can occur in any implementation plan along with appropriate countermeasures.

1.3.4.2.5 Matrix diagram. The Matrix Diagram organizes large numbers of pieces of information and can show which items in each set are related. It can also code each relationship to show its strength and the direction of the influence. This diagram

should be used when "motherhood and apple pie" has evolved into definable and assignable tasks that must be "deployed" to the rest of the organization. It is also used

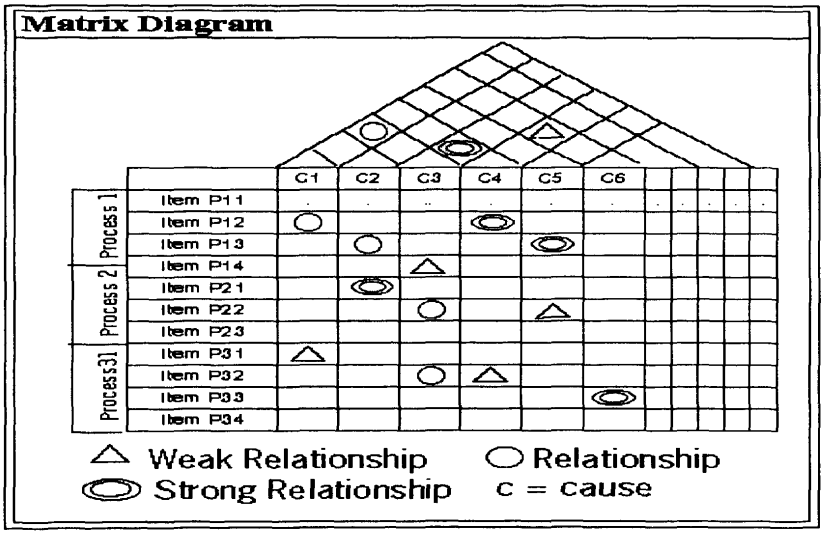

Figure 1.14 Matrix Diagram

when "focused activities" generated must be tested against other things that your organization is already doing. Figure 1.14 shows that when the organization is trying to prioritize present activities given new priorities, i.e., choose the present system(s) that helps achieve the greatest number of new objectives. Also, when there is a need to get a cumulative numerical "score" that allows you to compare any one item to say other item or all of the other items combined.

1.3.4.2.6 Prioritization matrix. The Prioritization Matrix uses a combination of tree and matrix techniques to prioritize tasks, issues, etc. The prioritization matrix should be used when the key issues have been identified and the options generated must be narrowed down. Also, when the criteria for a "good" solution are agreed upon but there is disagreement over their relative importance. The strength of this tool is that it can be implemented under various conditions within an organization. The key to utilizing this tool is understanding how it works.

It works best when there are limited resources for implementation, e.g., time, funds, and manpower. It also is beneficial when the options generated have strong interrelationships and generating options, not total "laundry lists," all of which have to be done and it is simply a matter of sequencing.

1.3.4.2.7 Tree diagram. Shown in Figure 1.15, the Tree Diagram maps out the full range of paths and tasks that need to be accomplished to achieve a primary goal and every related subgoal. The Tree Diagram should be used when a specific task has become the focus but is not a simple "assignable job."

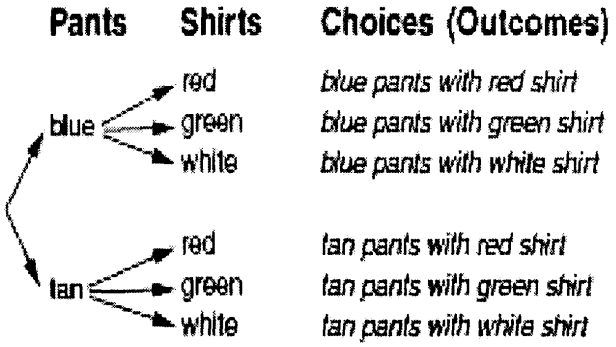

Figure 1.15 Tree Diagram

It should be used when it is known (or suspected) that implementation will be complex and when there are strong consequences for missing key tasks. It should also be used when a "simple" task has run into repeated roadblocks in implementation.

1.3.5 Team Performance Scale. The philosophies, tools, and actions seek to add value to organizations that utilize them effectively while also claiming to have promising yields. While there is much literature on the use of teams and their performance, there very little literature that offers insight on the use of quality improvement teams and the benefits thereof. The long-term benefits of successful teams include higher performance, increased morale, and a strong commitment to the mission of the organization that can withstand almost any kind of adversity (Katzenbach and Smith. 1993)

Katzenbach and Smith tracked the performance of teams as they move from one level of team effectiveness to the next. Through their research and study of all types of teams, they have concluded that teams may initially operate as a working group, but

through development internally, they can move toward becoming a high-performance team. There are three stages that occur in between functioning as a working group to a high performance team. There are a total of five classifications which they identified that all teams function on. The five classifications are the following:

1. Working Group
2. Pseudo Team
3. Potential Team
4. Real Team
5. High Performance Team

For his doctoral research, Peters created a survey to access any team's maturity as it relates to Katzenbach and Smith's five classifications. For the most part, this validated

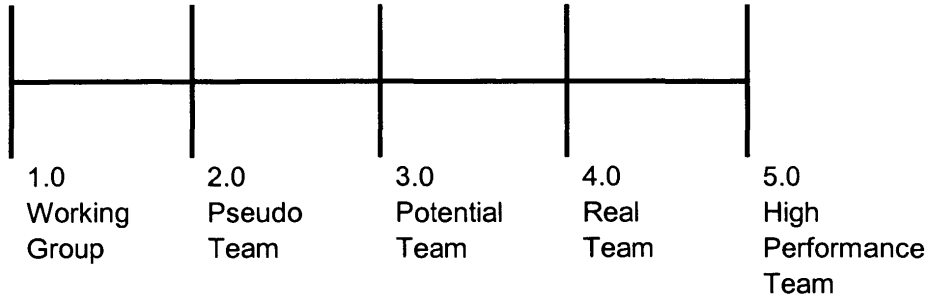

Figure 1. 16 Team Performance Scale

instrument accessed a team's maturity on the basis of a scale of 1.0 to 5.0. Figure 1.16 shows what we coin as the Team Performance Scale.

As we observe figure 1.16, we notice that there are five areas that a team can function on based on the work of Katzenbach and Smith. For the team performance scale, we will observe where the QITs in the research performed at. Peters related Katzenbach and Smith's same five phases of team development to Hagan's six key team building elements. He then created the team performance scale to show where teams perform on the basis of their position on the scale. Relating the classifications of teams to position of performance, he expanded on the work of Katzenbach and Smith to serve as a tool to assess team performance.

Elrod and Tippett Expansion of Team Performance Curve

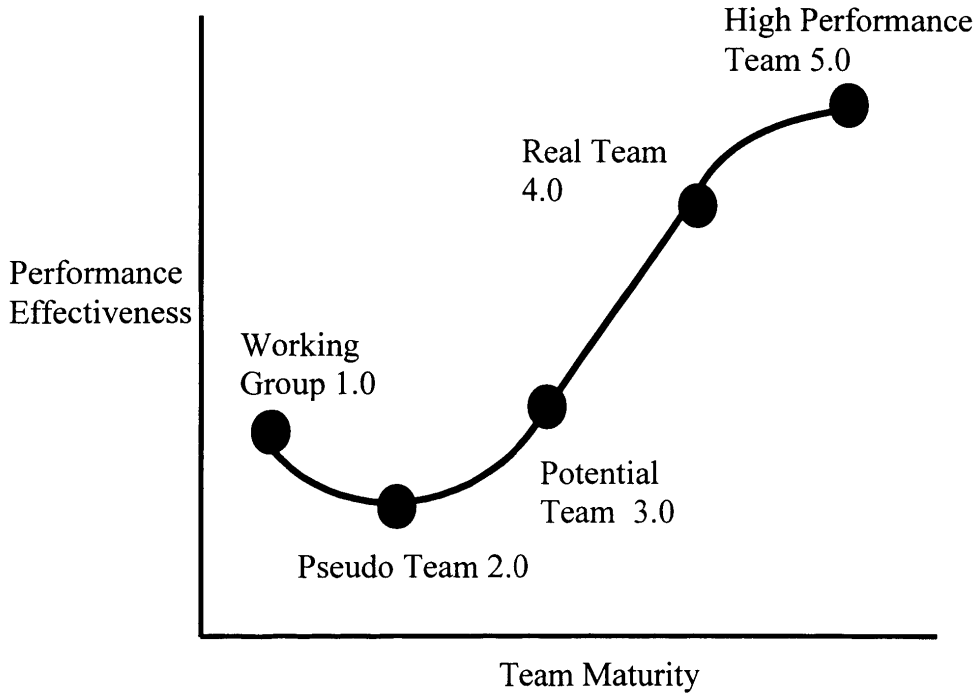

Figure 1.17 Elrod and Tippett Expansion of Team Performance Curve

Later, Elrod and Tippett used the same validated survey and Team Performance Scale to access self-directed team performance and position according to Katzenbach and Smith Team Performance Score. Their result was the development of the current model in Figure 1.17. This model with also serve as one of the primary tools we use in this study to access QIT performance. For our study, we seek to see how tools and team communication effect performance of QIT. Our final analysis will be to see where QITs function on the Team Performance Scale and Team Performance Curve. We will also draw necessary conclusions and offer recommendations at the end of the study toward quality improvement teams, communication, and team performance. A summary of our hypothesis are provided in Table 1.14:

Table 1.14 Summary of Hypotheses

H_1	H_1: All of the team attributes will positively relate to team performance.
H_2	H_{2a}: Communication will be the most significant attribute
	H_{2b}: Communication will have the strongest positive relationship with team performance
H_3	H_{3a}: Teams that utilize more tools will display higher team performance scores.
	H_{3b}: Teams that utilize more tools will display higher communication scores.

2. METHOD AND MEASURES

2.1 METHOD SURVEY 1

One hundred and one students in various classes on the campus of the University of Missouri-Rolla participated in the study. Thirty-nine percent of the respondents were students of Engineering Management 375 and had been exposed to the philosophy of TQM. Sixty-two percent of the respondents were non-Engineering Management 375 students and were not exposed to the philosophy of TQM. Because the surveys were administered in class, there was a 100% response rate.

Prior to receiving the survey, students were informed that the there was no compensation for taking the survey and that it was completely voluntary. Prior to testing, approval was obtained from the Institutional Review Board (IRB) at the University of Missouri-Rolla for this study and permission was granted to administer it to the students. The IRB application, approval and actual survey can be found in Appendices A, C, and D respectfully.

In order to measure team performance, the focus is on Hagan's (1985) team building attributes. The method that we are chose is a survey developed by Peters (1997) that tests team performance. The survey utilized a 5 response (Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree) Ordinal Likert Scale, which ranked a variables' value without regard to the distance between the values (Backstrom and Hursh-Cesar, 1981). Likert scales are among the most commonly used scaling methods in social research. In addition, the procedure is relatively easy to use and has intuitive appeal (Wright, Rossi, and Anderson, 1983). Peters related the team building elements to Katzenbach and Smith's five phases of team development in order to develop a survey instrument which would access a team's maturity on the basis of their position on the horizontal axis of Katzenbach and Smith's Team Performance Curve. This validated instrument, consisting of thirty questions, was used in the current research to measure team performance. An arithmetic mean calculation was used to determine the team performance score. The six predictor variables (30 questions total) were measured by the questionnaire with the number of questions and item numbers that compose the variables.

Each of the six variables was measured using multiple question items on a Likert 1-5 scale (1 = strongly agree, 5 = strongly disagree). The total number of questions was

kept to 30 in order to keep the survey short. Of the 30 questions, 6 were posed negatively to reduce the tendency for bias towards the "agree" end of the scale. In addition to the questions regarding team performance, other information was acquired such as project team size, tools utilized, and number of projects. A sample copy of the actual questionnaire is included in Appendix C.

The three section survey incorporates questions created by the author and that of James Peters to measure position on team performance curve (team performance score) and individual team attributes. The first section of the survey asks for identification of the person taking the survey. The second part of the survey asks about the number of team members and number of projects that will be completed by team. It also asks about the number of tools and the types of tools that are used in the team. The last part is the actual questionnaire that was developed by James Peters which test for the six attributes.

Peter's developed an algorithm to process the survey data. The algorithm converted the set of thirty responses to Peters' survey into a single numerical value that can be thought of as the team performance score. This value can range from 1.0 to 5.0 and can be viewed in Figure 1.19.

2.2 MEASURES

Measuring team performance is the first step needed to investigate team performance and team attribute relationship. Katzenbach and Smith established the team performance curve that can be used as a basis for measuring team performance. The curve is actually based on existing team performance research knowledge, past experiences and interviews with hundreds of people in dozens of organizations that were or might have been teams.

2.2.1 Independent Variables. A description of each independent variable for the study follows.

2.2.1.1 Consideration and respect. As defined by Hagan, consideration and respect is a combination of how team members take into account the daily occurrences in team circumstances and their willingness to respect ideas, personalities, and the other team members' roles on the team.

2.2.1.2 Individual job responsibility. A quality improvement culture is where everyone shares in the responsibility (Worrell, 2003). Both individuals and mangers must feel a personal level of responsibility which will lead satisfaction. Individual job responsibility is how a team member feels they are contributing significantly to the team.

2.2.1.3 Communication. Communication is an important team attribute. It combines listening ability, willingness to share information, and timeliness. When teams effectively communicate, their performance is usually high. Conversely, when teams fail at effective communication, team performance is low.

2.2.1.4 Group goals. Internalization of group goals appears to be a key factor in team members' desire to seemingly do whatever it takes to make the project succeed. (Ammeter and Dukerich, 2002) A key to superior team performance appears to be commitment (Sweeney and Lee, 1999)

2.2.1.5 Rewards. Although acknowledging the process may be difficult it is important to offer rewards and recognition for team achievement (Dolan, 2003). Some rewards are given after the project is complete. Other rewards are given throughout the duration of the project.

2.2.1.6 Loyalty and leadership. Leadership focuses on providing the initial and sustaining driving force for transformation (Kotter, 1996). For a successful change, an organization needs to disperse involvement and leadership throughout the organization (Dotlich and Noel, 1998).

2.2.1.7 Quality tools. For all intents and purposes, when we refer to the "quality tools" we are referring to the seven old quality tools and the seven new quality tools. Teams utilized these tools in their projects for the Winter 2004 semester.

2.2.2 Dependent Variables. A description of the dependent variable for this study follows.

2.2.2.1 Team performance. The respondent's team performance was measured using a 5-item scale from Peters (1997). The scale was used to assess how an individual perceives his or her teammate's performance. Items were similar to statements such as: "There is open discussion, problem-solving, and goal setting at the meeting." Some of the questions were slightly altered to change the focus of the question from individuals to team members Items were comparable to such statements as: "Team members feel

highly motivated to give their effort and feel the team experience is particularly rewarding." The respondent gave individual perception of team performance.

3. RESULTS

3.1 STUDY 1

Regression analysis serves three major purposes: (1) description, (2) control, and (3) prediction. We begin our analysis by first graphing each individual predictor variable vs the team performance. This allowed us to visually see how each predictor variable interacted with the response variable. It is important to do this because we wanted data that was not curvilinear. This means that in order to test each predictor variable, we wanted to ensure that there was an initial relationship between each one. Scatter plots are useful for discovering a potential relationship between two variables. In statistical terminology, each point in the scatter diagram represents a trial or case. For our research, we will use the term case. A statistical relation, unlike a functional relation, is not a perfect one. In general, the observations for a statistical relation do not fall directly on the curve of relationship.

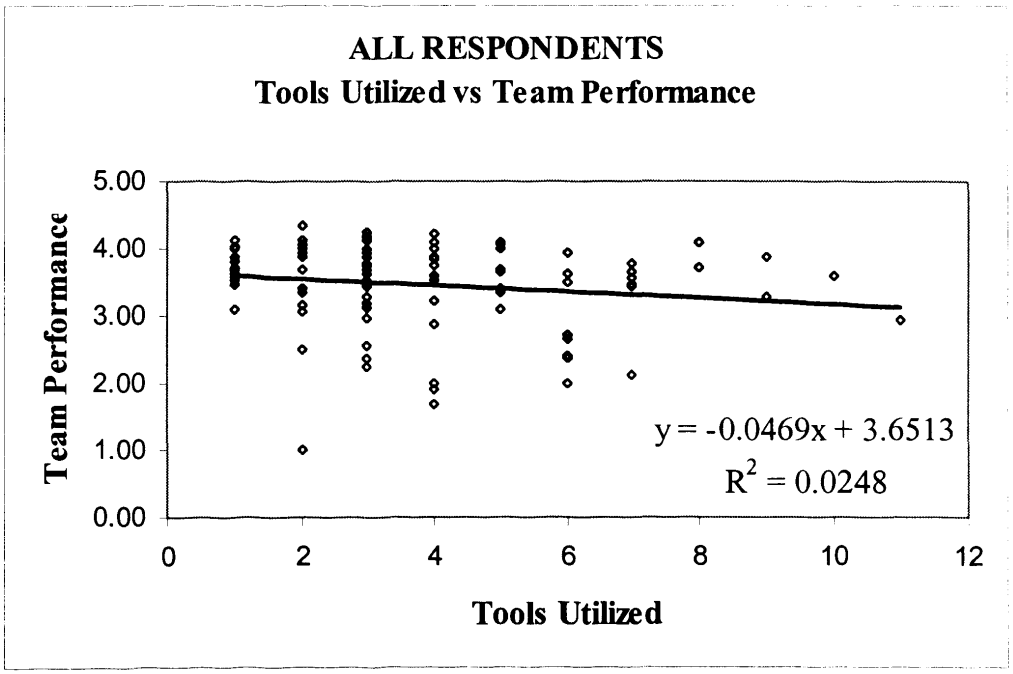

Figure 3.1 Tools Utilized vs Team Performance

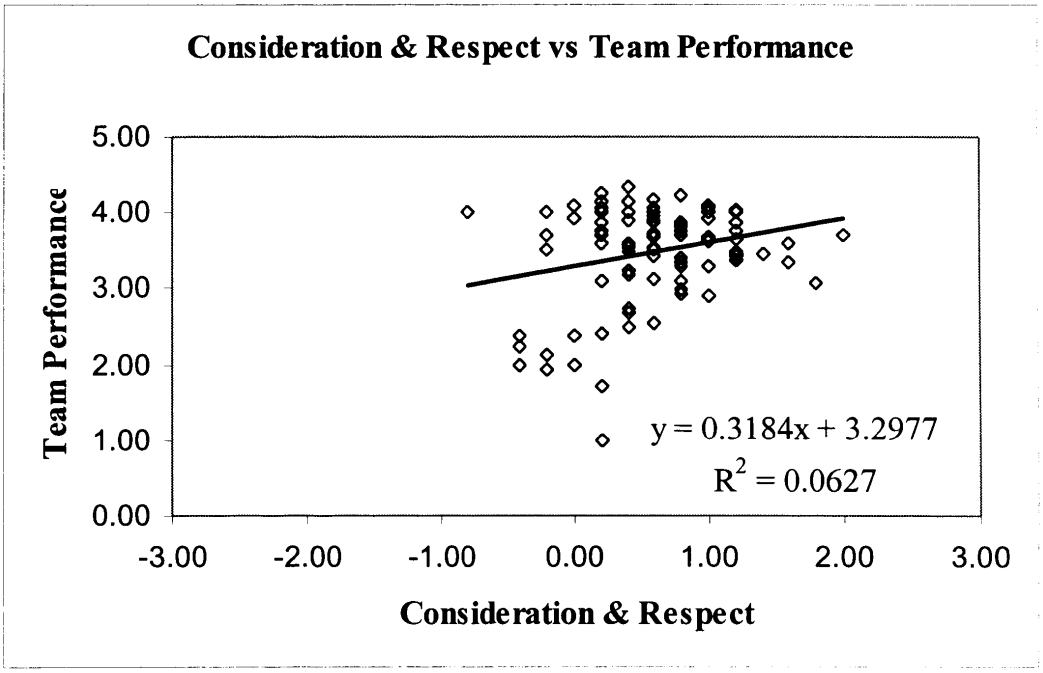

Figure 3.2 Consideration and Respect vs Team Performance

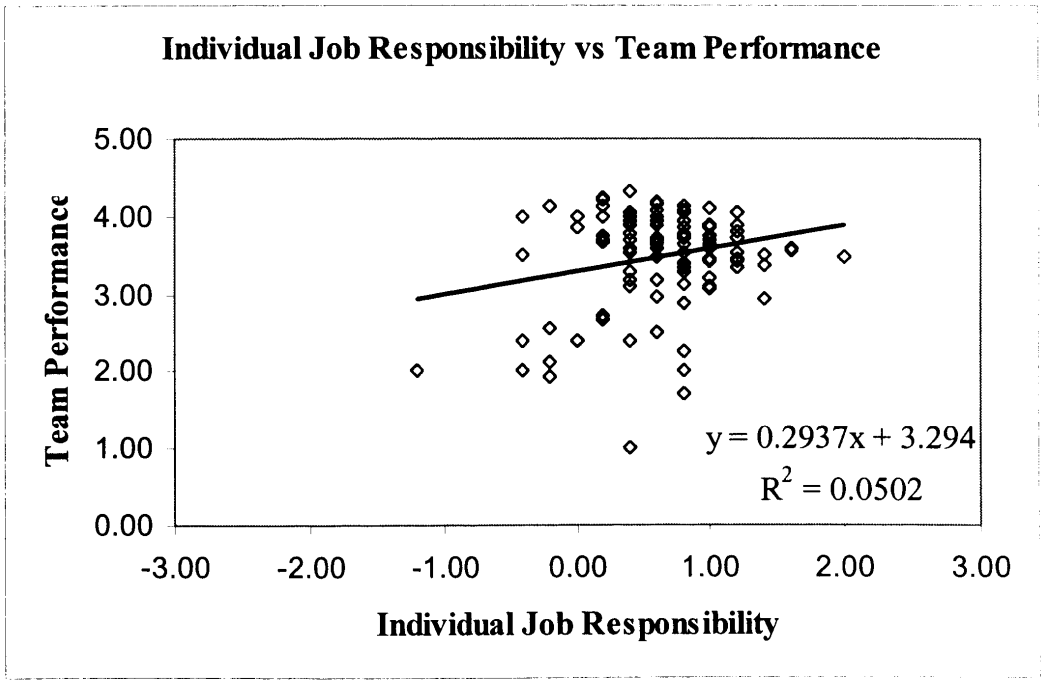

Figure 3.3 Individual Job Responsibility vs Team Performance

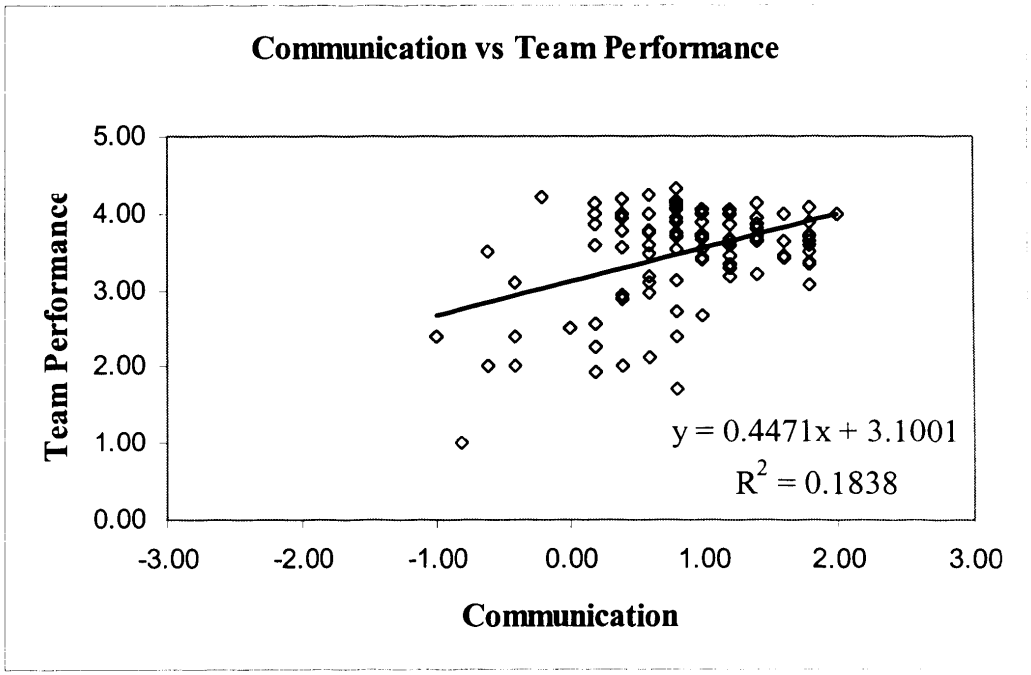

Figure 3.4 Communication vs Team Performance

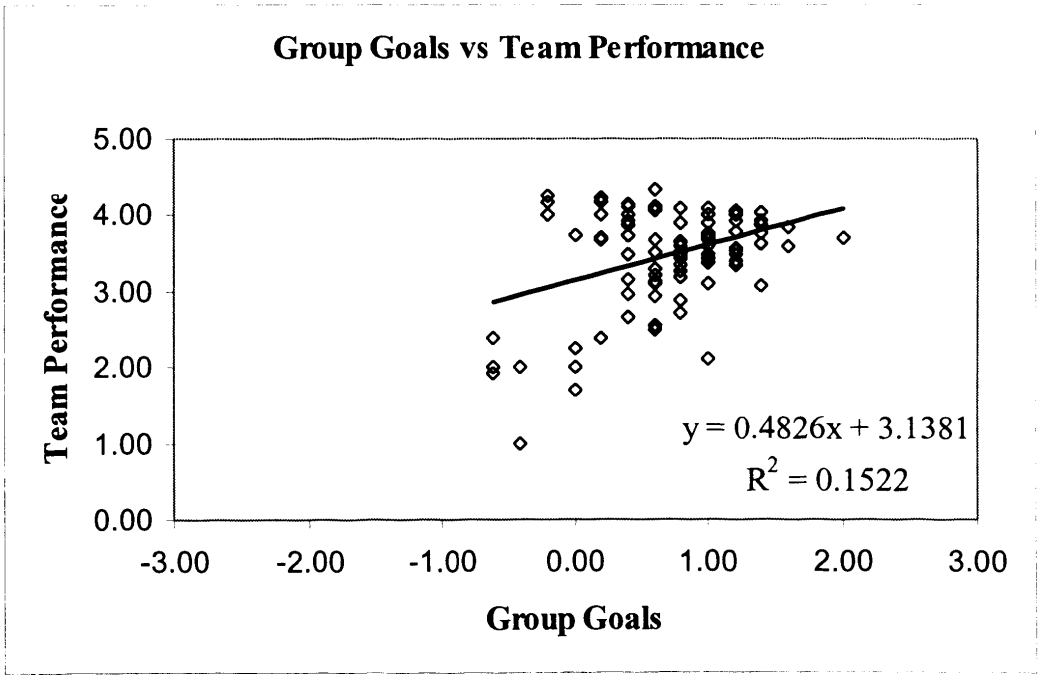

Figure 3.5 Group Goals vs Team Performance

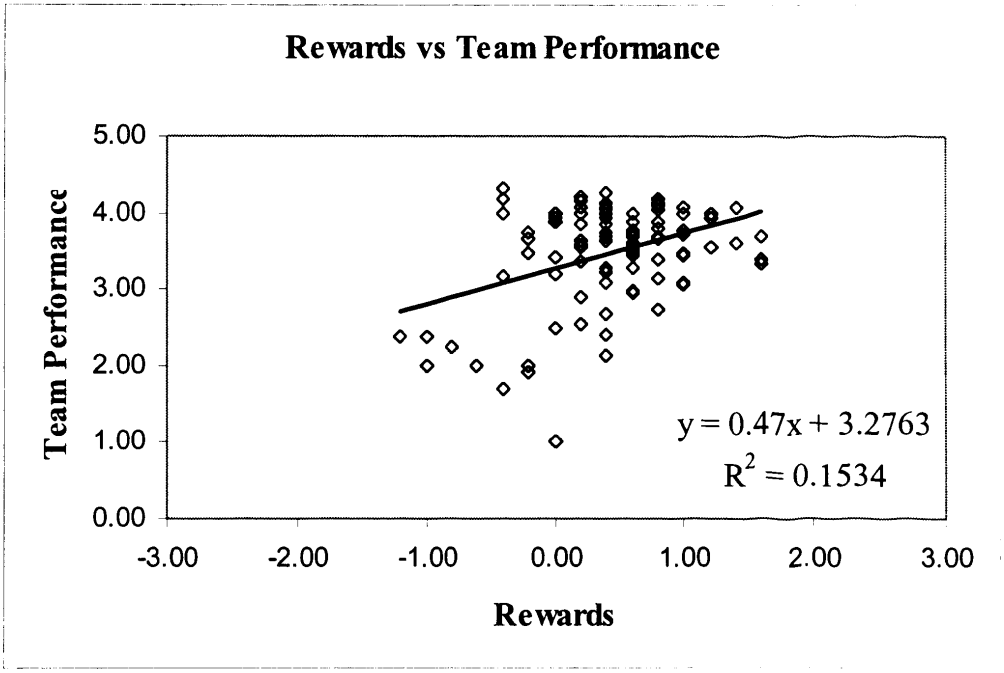

Figure 3.6 Rewards vs Team Performance

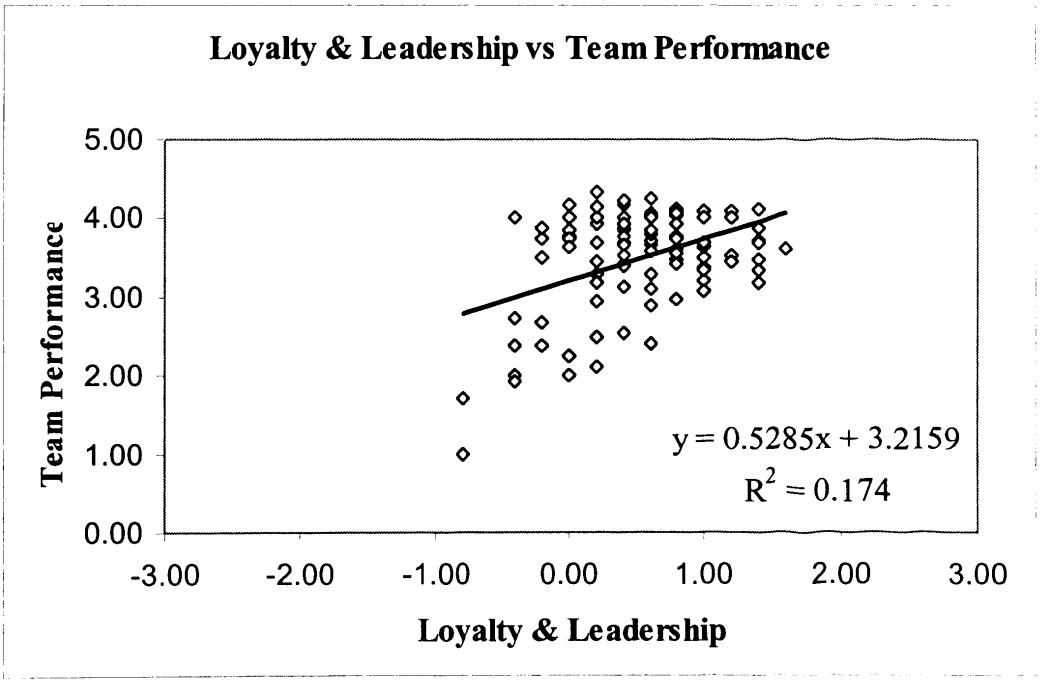

Figure 3.7 Loyalty and Leadership vs Team Performance

The graphs in Figures 3.1 – Figure 3.7 are graphs that show the linear relationship between each predictor variable and response variable based on the raw data and independent of the other variables. R^2 values are also given for each relationship. After graphing the seven predictor variables individually vs. the response variable, our next step is to look at the average scores for each attribute from our validated test instrument. The average scores are from all 101 respondents. It is safe to say that those that participated in the survey perceived these attributes were prevalent in their teams.

Table 3.1 Summary of Attribute Means and Standard Deviations

Attribute	Respect	Responsibility	Communication	Goals	Rewards	Loyalty	Tools
Mean	0.56	0.62	0.84	0.70	0.42	0.49	3.75
StndDev	0.51	0.50	0.62	0.53	0.54	0.51	2.18

The rankings, according to the respondent's averages of attributes that stimulate performance are the following:

1. Communication 2. Goals 3. Responsibility 4. Respect 5. Loyalty 6. Rewards

This is important for us to observe, but cannot serve as the conclusion of which attributes are the most important in quality improvement teams. It is now important to utilize linear modeling and multiple regression analysis to gain information about our data. We exclude the predictor variable "Tools" in the initial linear model because we are only interested in the attributes. The software gives us the option of fitting a linear model. Doing so, we get the following results shown in Table 3.2:

$$Performance = 3.07 - .12(Respect) - .19(Responsibility) + .25(Communication) + .21(Goals) - .23(Rewards) + .29(Loyalty)$$

For exploratory purposes, we notice that in Table 3.2 the value of coefficients for Consideration and Respect and Individual Job Responsibility are -.1167 and -.1937 respectively. That is a negative between the two predictor variables and performance.

Table 3.2 Results of Linear Model Fitting

	Value	Std. Error	t value	Pr(>ItI)
(Intercept)	3.0653	0.1073	28.5622	0.0000
1. Respect	-0.1167	0.1451	-0.8045	0.4232
2. Responsibility	-0.1937	0.1500	-1.2916	0.1997
3. Communication	0.2502	0.1245	2.0093	0.0474
4. Goals	0.2100	0.1453	1.4459	0.1515
5. Rewards	0.2282	0.1373	1.6616	0.0999
6. Loyalty	0.2880	0.1469	1.9611	0.0528

Residual Standard error	.5676 on 94 degrees of freedom
Multiple R-squared	0.2823
F-Statistic:	6.161 on 6 and 94 degrees of freedom
p-value	0.0000177

According to the model, four attributes relate to the performance positively. Those include Communication, Goals, Rewards, and Loyalty and Leadership. Because of the weak value of $R^2 = .28$ shown in the previous table, we would have to further analyze the data. This value interprets to only 28% of the original variable being explained by the current model. This can mean that some of the variables have very weak correlation or no correlation.

Our next step in our analysis is to determine which predictor variables should be kept and which should be dropped from the model. When we wish to test whether the term $\beta_k X_k$ can be dropped from a multiple regression model, we are interested in the alternatives. Our full model for multiple regression analysis is the following:

$$Yi = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i3} + \beta_4 + X_{i4} + \beta_5 + X_{i5} + \beta_6 + X_{i6} + \beta_7 + X_{i7} + \varepsilon i$$

(Full Model) where β_0 is a regression coefficient.

We would now like to take a look at the correlation to see if there are any values that should be dropped from the model. Table 3.4 shows the correlations between the different predictor variables and response variable.

Table 3.3 Correlation Analysis

Variable	1	2	3	4	5	6	7	8
1. Respect	1.00	0.47	0.52	0.46	0.54	0.47	-0.09	0.25
2. Responsibility	0.47	1.00	0.50	0.54	0.44	0.52	0.04	0.22
3. Communication	0.52	0.50	1.00	0.56	0.51	0.52	0.00	0.43
4. Goals	0.46	0.54	0.56	1.00	0.47	0.52	0.01	0.39
5. Rewards	0.54	0.44	0.51	0.47	1.00	0.51	-0.03	0.39
6. Loyalty	0.47	0.52	0.52	0.52	0.51	1.00	-0.05	0.42
7. Tools	-0.09	0.04	0.00	0.01	-0.03	-0.05	1.00	-0.16
8. Performance	*0.25*	*0.22*	*0.43*	*0.39*	*0.39*	*0.42*	*-0.16*	1.00

The correlation of team performance and number of tools used is R= -.16. There is a statistically significant relationship between team performance and the number of tools used, although it is a negative one. The correlation of team performance and communication used is R=.43. There is a statistically significant relationship between team performance and communication. According to the table, the correlations between team performance and the team attributes are in order of correlation with one being the highest correlation:

1. Communication 2. Loyalty 3. Goals 4. Rewards 5. Respect 6. Responsibility

Now, we will perform a stepwise regression that will give insight on which variables to keep and which ones to drop from the model. The algorithm starts with all the independent variables and then drops variables and sets of dummy variables in a stepwise manner. At each step the algorithm selects from the remaining included predictor variables the variable or set of dummy variables which yields the smallest reduction in the explained variance of the dependent variable, unless this exceeds a specified threshold. Similarly, the algorithm evaluates at each step whether the contribution of any variable or set of dummy variables previously dropped from the regression has risen above a specified threshold, in which case it is added back into the regression. We perform two step wise regressions. The first step wise regression calculation, as seen in Table 3.5 will contain the six key attributes as predictor variables only. Table 3.5 excludes tools from the model. The second stepwise regression

calculation will contain the six key predictor variables and tools as a predictor variable as seen in Table 3.6.

Table 3.4 Stepwise Analysis – Without Tools in the Model

	Value	Std. Error	t value	Pr(>ItI)
(Intercept)	3.0550	0.1073	28.5622	0.0000
1. Communication	0.2443	0.0970	31.5077	0.0000
2. Rewards	0.2003	0.1137	1.5497	0.1245
3. Loyalty	0.2656	0.1383	1.9206	0.0577

Residual Standard error	.567 on 97 degrees of freedom
Multiple R-squared	0.2532
F-Statistic:	10.97 on 3 and 97 degrees of freedom
p-value	2.898E-006

Table 3.5 Stepwise Analysis – With Tools in the Model

	Value	Std. Error	t value	Pr(>ItI)
(Intercept)	3.2166	0.1375	23.3897	0.0000
1. Communication	0.2495	0.1128	2.2114	0.0294
2. Rewards	0.1975	0.1281	1.5411	0.1266
3. Loyalty	0.2555	0.1372	1.8621	0.0656
4. Tools	-0.0426	0.0259	-1.6429	0.1037

Residual Standard error	.565 on 96 degrees of freedom
Multiple R-squared	0.2737
F-Statistic:	9.043 on 4 and 96 degrees of freedom
p-value	3.05E-006

We will further analyze the data in the next section of our findings. Fitting the linear model, using correlation analysis, and performing stepwise regression proved to give insight to the variables that stimulate performance in quality improvement teams.

3.2 STUDENT TYPE

Did students that were exposed to the philosophy of TQM have higher team performance scores than students that had not taken the course? Table 3.6 shows that of the three student types that participated in this study, current-375 students had a mean performance score of 3.54. Non-375 students and past-375 students had mean performance scores of 3.51 and 3.31 respectively. Current-375 students also had higher communication scores than that of the past-375 students and non-375 students.

Table 3.6 Team Performance by Student Type

	A - Current 375	B - Past 375	C- Non 375
N	20	19	62
Mean Performance	3.54	3.31	3.51
StndDev	0.55	0.68	0.67
1. Consideration	0.54	0.46	0.59
2. Responsibility	0.52	0.61	0.65
3. Communication	0.89	0.77	0.85
4. Group Goals	0.63	0.73	0.71
5. Rewards	0.46	0.33	0.44
6. Loyalty	0.43	0.45	0.52
Team Size	4.75	4.95	4.32
Project Size	2.00	4.37	1.92
Tools Utilized	3.50	6.95	2.85

Two other demographics, team size and project size, played a key role in team performance and team attribute scores. Team size is the number of people on a team during the completion of projects. Project size is the number of projects that teams were to complete. As shown in Table 3.6, all of the student types had team size averages of at

least 4. However, for project size, current-375 students averaged 2 projects, while past 375 student's average over 4.37 projects. Non-375 students average 1.92 projects. Another analysis that we will focus on is the average tool utilization vs the average team performance score.

We also gathered necessary information about student types by combining both current-375 and past-375 students into an all-375 category and observing mean tools utilized vs mean performance score. Figure 3.8 suggest that for both groups, mean performance scores were very close when 1, 2, or 3 tools were utilized. When 4 or more tools were utilized, there mean scores varied between the groups.

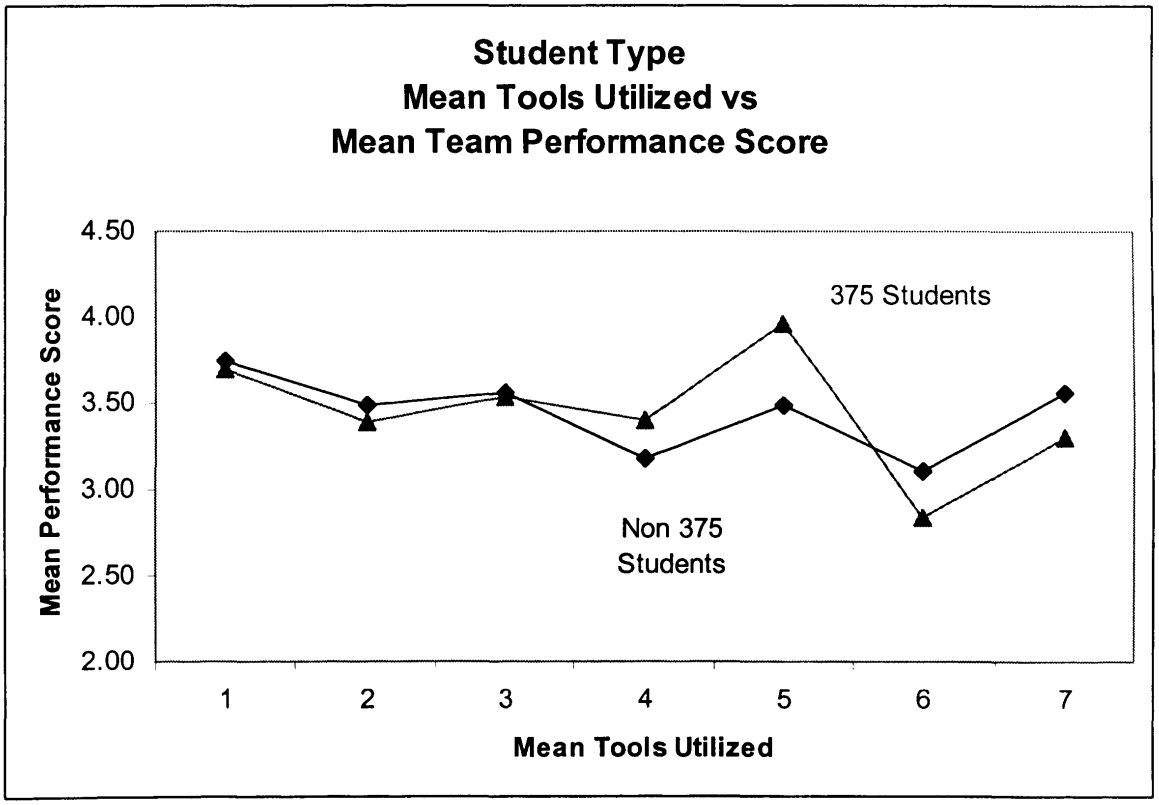

Figure 3.8 Mean Performance Score by Student Type

All-375 students performed highest when 5, 1, and 3 tools were utilized. The mean performance scores were 3.96, 3.69, and 3.54 respectively. For non-375 students, performance was highest when an average of 1, 3, and 7 tools were used. The mean performance scores were 3.75, 3.56, and 3.56 respectively. Table 3.7 shows a complete list of mean tools utilized vs mean performance scores.

Table 3.7 Mean Performance by Student Type

Tools Utilized	Mean Team Performance	
	Non 375	**375**
1	3.75	3.69
2	3.49	3.39
3	3.56	3.54
4	3.18	3.40
5	3.49	3.96
6	3.12	2.84
7	3.56	3.30

We inquired about mean attribute scores per student type. We were interested in whether or not communication is high among students that utilize the tools of quality.

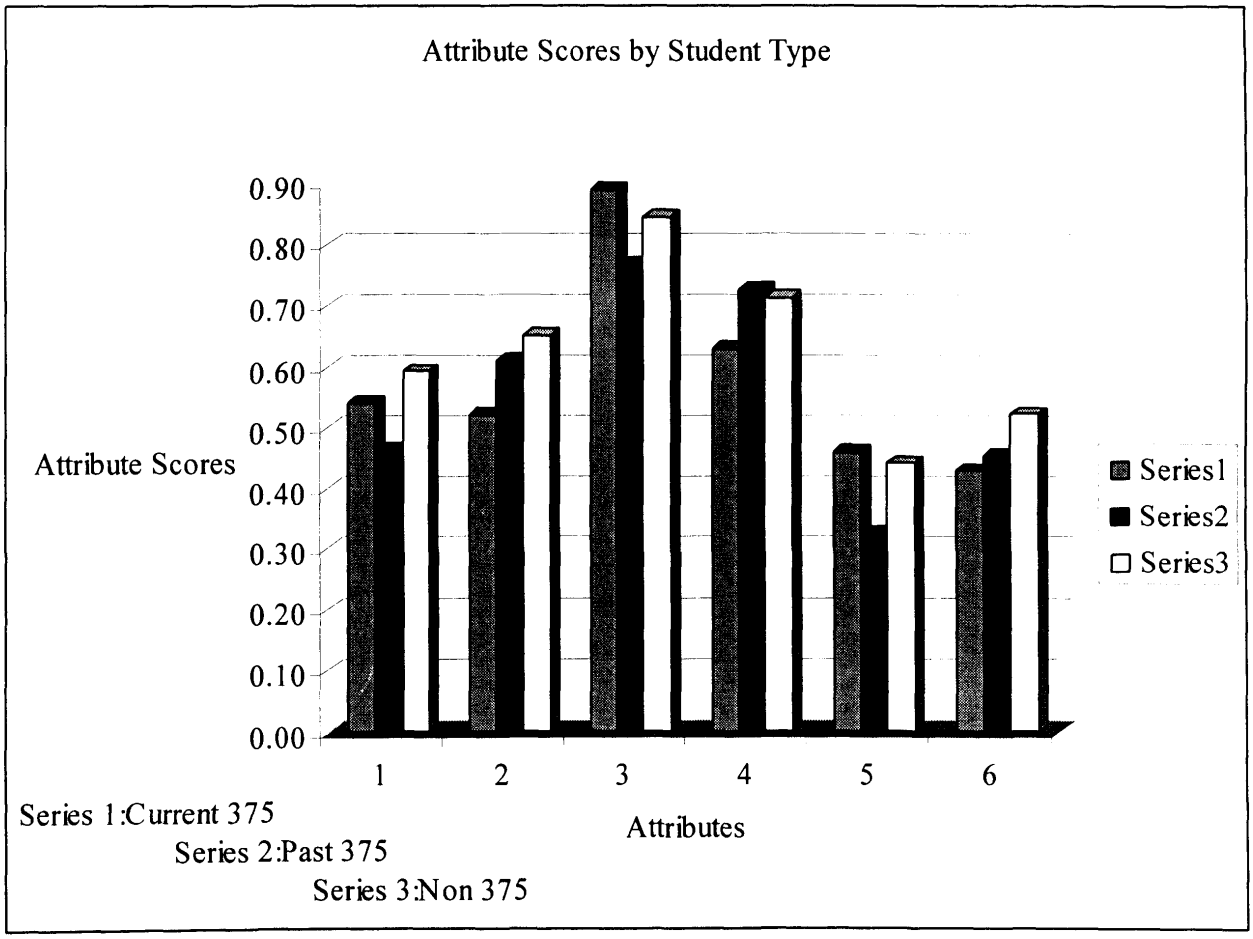

Figure 3.9 Attribute Scores by Student Type

Figure 3.9 shows the Attribute Scores by Student Type. Notice Attribute 3, which is Communication according to Table 3.6. The average communication score for current 375 students is .89. The average communication score for past-375 students is .77 while the average communication score for non-375 students is .85. Another observation is that non-375 generally scored higher on the other attribute scores. This includes Consideration and Respect, Individual Job Responsibility, and Loyalty and Leadership. These observations become useful in helping us draw conclusions as well as offering future research suggestions.

4. DISCUSSIONS

4.1 FINDINGS

Our initial research questions were 1) Which of the six attributes are key attributes that contribute to performance in quality improvement teams? 2) What is the relationship between communication and quality improvement team performance? 3) What is the relationship between the number of quality tools utilized in a team and quality improvement team performance?

According to our analysis, the key attributes which contribute to performance in quality improvement teams are Communication, Loyalty and Leadership and Rewards. Communication seemed to impact the model for team performance more than any of the final variables. Rewards and Loyalty were significant more than the three attributes that were omitted from the model (Respect, Responsibility, Goals).

According to our analysis, there is a positive linear relationship between communication and quality improvement team performance. Based on the graph of

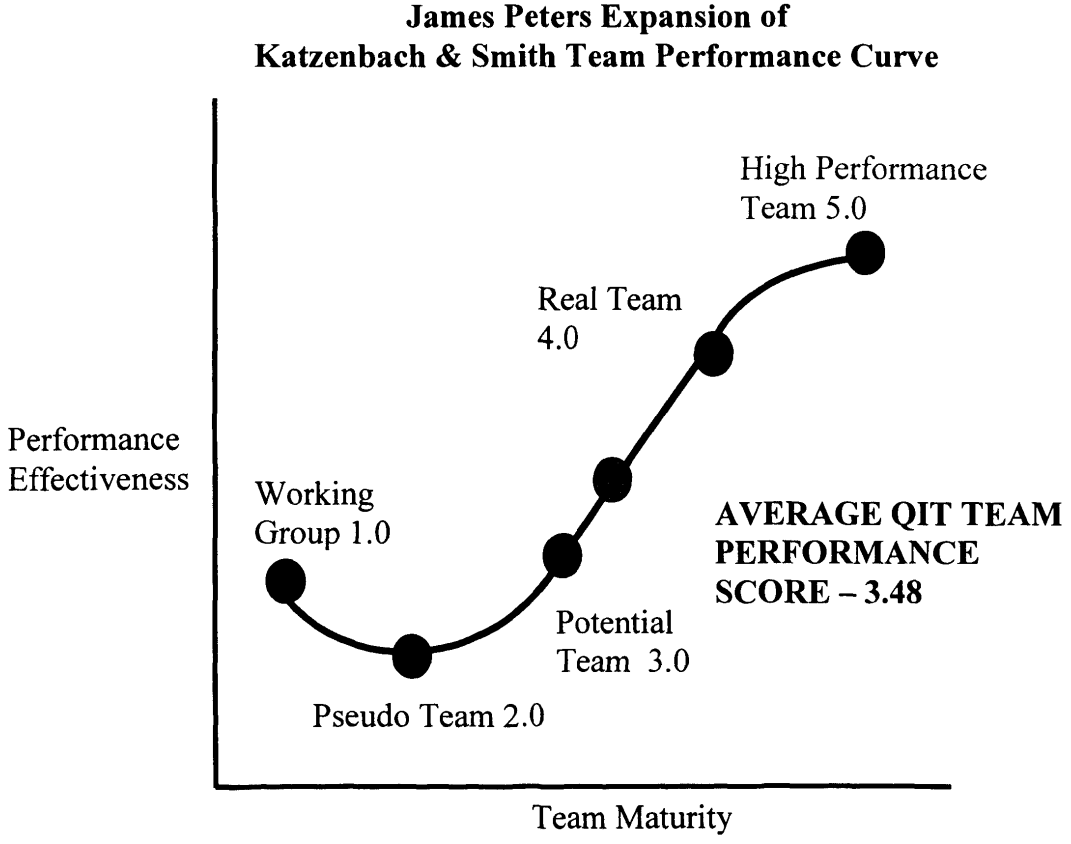

Figure 4.1 Average Quality Improvement Team Score

Communication vs Team Performance, we see that when communication scores are high, performance scores are high. Observing Katzenbach and Smith's Team Performance Curve, we see the positioning of where QITs from this research function on. We will also show a breakdown of classification and performance.

We initially thought that the more tools that were utilized led to higher performance. Our findings indicated that teams that as teams used less tools, they tended to display higher team performance. In Table 4.1, we see the number of tools utilized and the average team performance score that follows.

Table 4.1 Tool Usage and Team Performance

Tools Utilized	Average Performance Score	N
1	3.75	15
2	3.62	13
3	3.55	25

It is interesting to see that as tools increase in a team, the team performance decreases. This may be that using one tool to solve a problem gives rise to more sharing, listening, and completion of tasks. We include tools in our final model. Our final model for obtaining performance in quality improvement teams is the following:

$$Performance = 3.22 + .25(Communication) + .20(Rewards) + .26(Loyalty) - .04(Tools)$$

The way performance decreased as tools increased was not consistent. The same trend that occurred in Section 3.2 held true with total tools usage and team performance.

We also observed where all teams performed on the team performance scale. We wanted to visually see how many teams we had functioning as Working Groups, Pseudo Teams, Potential Teams, Real Teams, and Real Teams. Figure 4.2 shows the breakdown

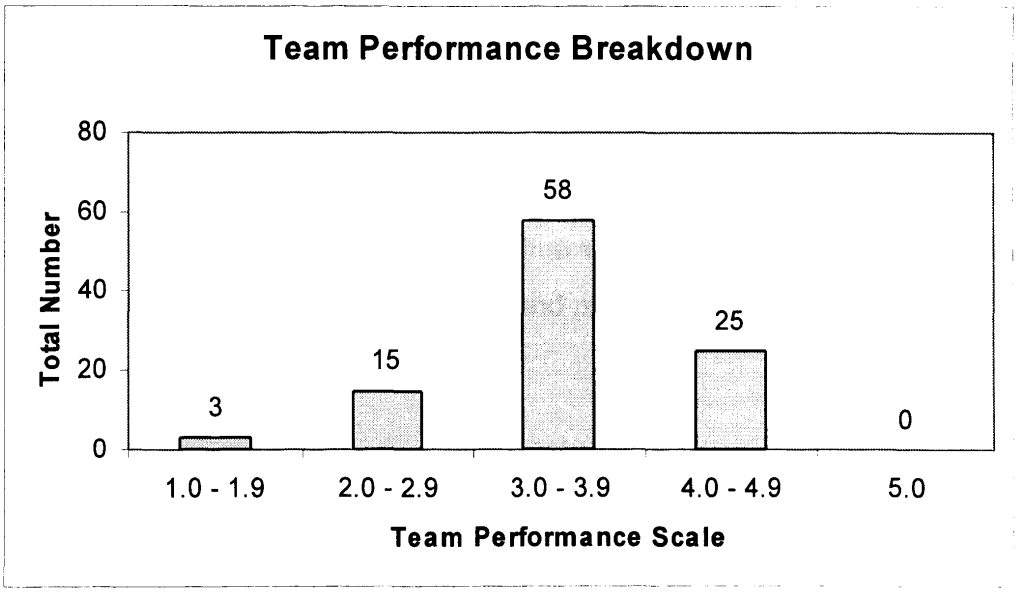

Figure 4.2 Team Performance Breakdown

of the total number of categories. There wee 3 teams that operated at the Working Group (1.0 – 1.9) category. There were 15 teams that operated on the Pseudo Team (2.0 – 2.9). There were 58 teams that operated on the Potential Team Category (3.0 – 3.9). The data shows that there were 25 teams that operated on the Real Team (4.0 -4.9) and there were no High Performance teams (5.0). Our data seemed to be skewed somewhat to the right.

4.2 LIMITATIONS

There are some limitations to the study. Our study actually takes one individual's score from a particular team and it becomes the perspective on team performance. The study could have been more effective if we could have looked at team performance as a team. For example, if we could have surveyed an entire team of 5, and then collected a mean performance team score for the team. From here, we could have actually developed the team's position on the Team Performance Curve and actually saw where the team was operating on the Team Performance Scale. This would have yielded better results and more valid statistical analysis could have been performed.

Another limitation is that we used students that were in the role of employees. Results could have been different if we surveyed real quality improvement teams that actually were involved in projects and were using certain tools. The attributes that scored

highest at the university level could have been totally different. For instance, employees that participate in quality improvement teams may experience different types of rewards and recognition. For the student, the reward could be receiving a letter grade. For employees on a job, the reward could be financial compensation, a vacation, or bonuses. This is true across the board with all of the attributes. There will be differences when we focus on other demographics such as team size and project size as well.

4.3 IMPLICATIONS

It is particularly important for managers to understand the relationship of key attributes and team performance because the team attributes are easy to understand and it gives them another tool to apply towards increasing team performance. We are currently living in a quality driven culture with programs such as Six Sigma, ISO 9000, Just-In-Time, Lean Manufacturing, and Poka-Yoke. These programs are implemented in highly technologically driven environments. Montgomery (2001) concludes that when technological advances occur rapidly and when the new technologies are used quickly to exploit competitive advantages, the problems of designing and manufacturing products of superior quality are greatly complicated. It will take managers that have been exposed to the philosophies of quality management to undertake these major problems. Although the problems will occur in the form of a project, being able to implement quality improvement teams will be a must.

When a person is involved in a quality effort and has been placed in a quality improvement team, managements understanding that using the right tools, fostering communication, having an encouraging reward system, and the developing the loyalty among the team can help ensure high performance. Future areas of research can attempt to discern other predictor variables that correlate significantly with team performance in quality improvement teams. It would be interesting to see if the attributes that were disregarded from Hagan's six key attributes would influence performance more than other attributes. Because multiple regression analysis is not limited in the number of predictor variables in a given model, it would be highly desirable to see if the eleven

variables from Table 1.7 were all placed in a validated test instrument and given to real quality improvement teams.

Engineering programs should also seek to add courses that teach the seven old and seven new tools of quality management in universities or as special classes that award certificates. This would better prepare future managers for the quality movement that is occurring in all of the industries throughout the global market.

4.4 CONCLUSIONS

Our initial hypothesis for the team attributes was that all of the attributes defined by Hagen (1985) would positively relate to team performance. When the model was fit for regression analysis, two of the variables (Consideration and Respect and Individual Job Responsibility) did not positively relate to team performance. Hypothesis H_1 was partially supported because four of the predictor variables (Loyalty and Leadership, Group Goals, Communication, and Rewards) related to team performance positively. Of those four predictor variables, three of them (Communication, Consideration and Respect, and Group Goals) were significant in predicting team performance.

Our initial hypotheses for communication were that communication would be the most significant attribute and that it would have the strongest positive relationship with team performance. Hypothesis H_{2a} was supported because Communication had the highest $\mu = .84$ based on $N = 101$ respondents. This was supported even further when we observed the Communication $\mu = .89$ current-375 students and $\mu = .85$ for non-375 students. Both proved to yield the highest attribute score for all attributes. There was partial support for Hypothesis H_{2b}, because Communication had the greatest correlation between team performance, which was .43. This was more than any of the other attributes. Although the R^2 value was weak, we did gain slight insight into the importance of Communication in the linear model.

Our initial hypotheses for tools were that teams that utilize more tools will display higher team performance scores and that teams that utilize more tools will display higher communication scores. Hypothesis H_{3a} is rejected because there was not a true relationship that supported number of tools used and team performance. The same is true

for H_{3b}. When tools decreased, performance was high, but this was not a uniform concept.

This study provided insight into the theories of TQM, specifically the ideas behind team communication within the team and tools to facilitate behavior. We were able to draw valid conclusions about team performance in quality improvement teams. We were also able to gain knowledge in managerial areas of quality. Since there were promising yields from current students of 375, future research could be one that compares current 375 students to current quality improvement teams in industry. A test instrument can be developed to access team communication, specifically sharing information, timeliness, and listening ability vs team performance. We could also focus on demographic information to gain more insight into the importance of communication.

APPENDIX A
IRB APPLICATION STUDY 1

APPLICATION TO THE UNIVERSITY OF MISSOURI-ROLLA
CAMPUS INSTITUTIONAL REVIEW BOARD
FOR THE PROTECTION OF HUMAN SUBJECTS IN RESEARCH (UMRIRB-1)

Review Requested: ☒ **Exemption** ☐ **Expedited** ☐ **Full Board**

1a. Primary Investigator: Dwan Prude

Daytime Phone Number: (573) 364-4164

Mailing Address: 1950 Farrar #1

City/State/Zip: Rolla, Mo 65401

E-Mail Address: prude@umr.edu

Department: Engineering Management

1b.Additional Applicant(s):

1c.Advisor: Dr. Ken Ragsdell

Daytime Phone Number: (573) 341-4157

Advisor's E-Mail Address: ragsdell@umr.edu

Department: Engineering Management

Campus Mailing Address: Engineering Management Building: Office 230

2. Project Period: From January 2004 **to** April 2004

3. Funding Source(s): Engineering Management Department

4. Site of Work: University of Missouri-Rolla

5a. Title of Project:

Discerning attributes which stimulate performance in quality improvement teams

5b. Brief description of its general purpose:

The purpose of the research is to explore how quality improvement teams score on the team performance curve established by researchers. The study will compare teams that are considered quality improvement teams versus teams that are not considered quality improvement teams. The study will also compare communication attributes between the two groups as well.

6. Give details of the procedures that relate to the subjects' participation, including at a minimum the following information (append additional page(s) if necessary):

a) How will the subjects be selected and recruited? (Append copy of letter, ad, or transcript of verbal announcement.)

Students in classes will be asked to participate in this voluntary survey

b) What inducement is offered?

None, but all participants will be given the opportunity to view the aggregated results of the study

c) Number and salient characteristics of subject, i.e., age range, sex, institutional affiliation, other pertinent characterizations

Approximately 130 students at the University of Missouri-Rolla will be asked to fill out the survey. No distinguishing characteristics exist between the students.

d) If a cooperating institution (school, hospital, prison, etc.) is involved, has written permission been obtained? (Append letters). N/A

e) Number of times observations will be made? 1

f) What do the subjects do, or what is done to them, in the study? (Append copy of questionnaires or test instruments, description of procedure to be conducted on the subject.

Contacted persons will be asked to participate voluntarily in a survey.

SURVEY ATTACHED

g) Is it clear to the subject that their participation is voluntary, that they may withdraw at any time, and that that they may refuse to answer any specific question that may be asked them? yes

h) Number of subjects to be used in the project: Approximately 130

i) Please indicate below if any of your proposed subjects might fit into the following categories:

Minors?	Yes		No	X	Age:		
Pregnant Women?	Yes		No	X			
Women of Child-Bearing Age?	Yes	X	No				
Institutionalized Persons?	Yes		No	X			
Incompetent Persons?	Yes		No	X			
Students?	Yes	X	No				
Low-Income Persons?	Yes		No	X			
Minorities?	Yes	X	No				

j) Cite your experience with this type of research.

I am a current graduate student conducting data collection for my Masters thesis. I have taken one research methods course. One of my committee members has conducted organizational behavior research as well

7. How do you intend to obtain the subjects' informed consent? If in writing, attach a copy of the consent form. If not in writing, include a written summary of what is to be said to the subject(s), and justify the reason that oral, rather than written, consent is being used. Also, explain how you will ascertain that the subjects understand what they are agreeing to.

When subjects take the survey, they will see the consent form. The consent form will inform them that by filling out the questionnaire, they are giving consent and that the survey is completely voluntary. They have a choice to accept or decline participation.

8. In your view, what benefits may result from the study that would justify asking the subjects to participate?

I hope to show the importance of a concentration of team communication, and the importance of focusing on using tools in teamwork that facilitate communication. I also would like to encourage engineering management departments to place an emphasis on developing courses that allows the utilization quality improvement tools. The research can also make suggestions to managers in industry that are utilizing quality improvement teams.

9a. Do you see any chance that subjects might be harmed in any way? Do you deceive them in any way? Are there any physical risks? Psychological? (Might a subject feel demeaned or embarrassed or worried or upset? Social? (Possible loss of status, privacy, reputation?)

No.

9b. How do you ensure confidentiality of information collected? (Consider 9a and 9b from the point of view of the subject.)

Subject's names, gender, or sex will not be asked. The identities of the subjects are not needed for the analysis of the study. These surveys will be completely anonymous.

Dwan Prude	Ken Ragsdell	3-3-2004
Applicant's Name (Please Print)	Faculty Advisor's Name (Please Print)	Date
Dwan L. Prude	Ken Ragsdell	4 March 04
Applicant's Signature	Faculty Advisor's Signature	Date

APPENDIX B
PREAMBLE STUDY 1

Study 1 Preamble

CONSENT: By participating in this survey, you will help learn more about the attributes that contribute to team performance. Your participation is voluntary. By filling out this survey you are giving your consent and attaining that you are at least 18 years old. If you have any questions please contact Dwan Prude (prude@umr.edu) or Dr. Ken Ragsdell (ragsdell@umr.edu). Thank you for your participation.

APPENDIX C
SURVEY STUDY 1

University of Missouri-Rolla
Survey

CONSENT: By participating in this survey, you will help learn more about the attributes that contribute to team performance. Your participation is voluntary. By filling out this survey you are giving your consent and attaining that you are at least 18 years old. If you have any questions please contact Dwan Prude (prude@umr.edu) or Dr. Ken Ragsdell (ragsdell@umr.edu). Thank you for your participation.

Section A

*Directions: Please identify yourself as one of the following by **circling the letter** of the most appropriate response.* ***Choose only one response.***

a) I am currently a student in Engineering Management 375, and have participated in a team project(s) for the course.

b) I have previously been a student in Engineering Management 375, and have participated in a team project(s) for the course.

c) I am currently a student taking a course where I am participating in a team project(s) for the course.

Section B

Directions: Please circle the appropriate response for the following questions regarding the choice from Section A.

1. The total number of team members, including myself is the following:

   NA 1 2 3 4 5 more than 5

2. The total number of projects that we have completed or will complete are the following:

   NA 1 2 3 4 5 more than 5

3. For our team projects, we utilize the following tools. **Circle all appropriate responses.**

Histograms	Control Charts	Pareto Diagram
Prioritization Matrices	Check Sheets	Tree Diagram
Cause & Effect Diagrams	Scatter Diagrams	Affinity Diagram
Interrelationship Diagraph	Activity Network Diagram	Matrix Diagram
Graphs	Process Decision Program Chart	

Section C

Directions: Please fill out the survey that asks questions regarding your experience in the team that you chose in ***Sections A and B****. Try to answer the questions to the best of your ability. The criteria are* **STRONGLY AGREE** *(SA),* **AGREE** *(A),* **NEUTRAL** *(N),* **DISAGREE** *(D), and* **STRONGLY DISAGREE** *(SD).* ***Circle*** *the response.*

TEAM PERFORMANCE SURVEY

1.	**Team members have interchangeable and complementary job skills and there is a extra sense of commitment to work as a team, and accomplish a goal.**	***SA A N D SD***
2.	**Meetings are efficient and interactions are primarily to share information and best practices or perspectives.**	***SA A N D SD***
3.	**Team members are considered valuable assets and appreciate the contributions others are making for the team.**	***SA A N D SD***
4.	**There is a high degree of decision making, action and follow through.**	***SA A N D SD***
5.	**There are no specific team performance goals, individual responsibilities or work products.**	***SA A N D SD***
6.	**There is an atmosphere of consideration and mutual respect and team members are committed to the risk of conflict and joint work products.**	***SA A N D SD***
7.	**Team members have shared leadership roles.**	***SA A N D SD***
8.	**There is a strong clearly focused leader and the group discusses, decides, and delegates.**	***SA A N D SD***
9.	**The desire and potential to shape team goal is present.**	***SA A N D SD***
10.	**Team members are deeply committed to team goals and one another's personal growth and success.**	***SA A N D SD***
11.	**Team members understand the benefits of a team approach and are moving in the direction of team building.**	***SA A N D SD***
12.	**There are active problem-solving meetings and discussions where planning, team goals, and work products are continually discussed.**	***SA A N D SD***
13.	**There is ignorance as to the teams benefits of a team approach and little or no commitment toward team building.**	***SA A N D SD***
14.	***Team members*** **have individual job responsibilities and individual work products.**	***SA A N D SD***
15.	**Performance is based on the sum of "Individual Bests" and rewards are based on individual performance.**	***SA A N D SD***

16.	**Team performance goals and purpose are very specific and ambitious and continually strengthened through effective communication.**	***SA A N D SD***
17.	**Team members perform real work together and produce joint work products.**	***SA A N D SD***
18.	**There is open discussion, problem-solving, and goal setting at the meeting.**	***SA A N D SD***
19.	**There is mutual team accountability and collective work products.**	***SA A N D SD***
20.	**Meetings are ineffective with very little open discussion, problem solving or goal setting.**	***SA A N D SD***
21.	**Team members are unclear about each others' roles and responsibilities.**	***SA A N D SD***
22.	**Team members feel highly motivated to give their effort and feel the *team experience is particularly rewarding.***	***SA A N D SD***
23.	**There are individual work products and individual accountability.**	***SA A N D SD***
24.	**The team refers to itself publicly as a "team" even though privately, its members will admit otherwise.**	***SA A N D SD***
25.	**Team members have essential skills to accomplish team goals and are equally committed to a common purpose and working approach.**	***SA A N D SD***
26.	**There are specific work products but only individual accountability.**	***SA A N D SD***
27.	**Team members are committed and prepared to do real work together.**	***SA A N D SD***
28.	**The work-products and results of the team's effort exceeds all performance expectations and goals.**	***SA A N D SD***
29.	**There is no specific requirement to form a team.**	***SA A N D SD***
30.	**There is little or no mutual accountability among team members for work products and members typically blame one another or the leader for the teams faults.**	***SA A N D SD***

APPENDIX D
IRB APPROVAL STUDY 1

Campus Institutional Review Board Approval Form
University of Missouri – Rolla

This is to certify that the research proposal entitled:

Discerning Attributes Which Stimulate Performance in Quality Improvement Teams

Submitted by: Ken Ragsdell and Dwan Prude
Department: Engineering Management

has been reviewed by the Campus IRB and approved with respect to the study of human subjects as appropriately protecting the rights and welfare of the individuals involved.

Type of Approval: __X___Exempt _____Expedited _____Full

Approval Date: March 5, 2004 Expiration Date: March 5, 2005

Note that approval of this research is contingent upon the following agreement by the researcher(s):

1) To report potentially serious events to the Campus IRB by the most expeditious means within five days of occurrence. The IRB may require an additional written report.
2) To submit a **Change in IRB Approval Form UMRIRB-2***, if the project changes in any way that affects human subjects.
3) To maintain copies of all pertinent information, including copies of informed consent agreements, for a period of three years from the date of completion of the research.
4) To adhere to all UMR Policies and Procedures relating to human subjects, as written in accordance with 45 Code of Federal Regulations 46.
5) To be aware that Federal and University Regulations require continuing review of research projects involving human subjects. Therefore, **this approval will expire one year from date of approval.** To meet this requirement, **Continuing Review Report UMRIRB-4* should be filed within one year of the original approval date.** However, projects receiving Exempt Approval and lasting less than one year do not need to provide this report. The campus IRB reserves the right, at any point, to inspect project records to ensure compliance with federal regulations.

*See http://www.umr.edu/~irb/forms.html for the necessary forms.

Approved By: Ray Kluczny Title: Chair, UMR IRB

Date: March 5, 2004

MAR - 9

APPENDIX E
TEAM PERFORMANCE CONTENT VALIDITY

TEAM PERFORMANCE CONTENT VALIDITY

TEAM ATTRIBUTE #1	Demonstrate respect and considerations for all *students* as valued members of the team
Team Category	*Corresponding Question*
Working group	Performance is based on the sum of "Individual Bests" and rewards are based on individual performance
Pseudo Team	Team members are unclear about each others' roles and responsibilities
Potential Team	There is an atmosphere of consideration and mutual respect and team members are committed to the risk of conflict and joint work products
Real Team	Team members are considered valuable assets and appreciate the contributions others are making for the team
High Performance Team	Team members are deeply committed to team goals and one another's personal growth and success
TEAM ATTRIBUTE #2	Identify individual job responsibilities and performance standards and see that they are known
Team Category	*Corresponding Question*
Working Group	Employees have individual job responsibilities and individual work products
Pseudo Team	There is little or no mutual accountability among team members for work products and members typically blame one another of the leader for the team's fault
Potential Team	There are specific work products but only individual accountability
Real Team	Team members perform real work together and produce joint work products
High Performance Team	Team members have interchangeable and

	complimentary job skills and there is a extra sense of commitment to work as a team, and accomplish team goals.
TEAM ATTRIBUTE #3	Work to secure good communication with *students* as individuals and as a team
Team Category	*Corresponding Question*
Working Group	Meetings are efficient and interactions are primarily to share information and best practices or perspectives
Pseudo Team	Meetings are ineffective with very little open discussion, problem solving or goal setting
Potential Team	There is open discussion, problem-solving and goal setting at meetings
Real Team	There are active problem-solving meetings and discussions where planning, team goals and work products are continually discussed
High Performance Team	There is a high degree of decision making, action, and follow through
TEAM ATTRIBUTE #4	Establish individual and team goals, preferably in coordination with those concerned
Team Category	*Corresponding Question*
Working Group	There are individual work products and individual accountability
Pseudo Team	There are no specific team performance goals, individual responsibilities or work products
Potential Team	The desire to shape team goals is present
Real Team	There is mutual team accountability and collective work products
High Performance Team	Team performance goals and purpose are very specific and ambitious and continually strengthened through effective communication and team building

TEAM ATTRIBUTE #5	Reward teamwork and team building efforts
Team Category	*Corresponding Question*
Working Group	Employees are committed toward individual goals and there is no specific requirement to form a team
Pseudo Team	There is ignorance as to the benefits of a team approach and little or no commitment toward team building
Potential Team	Team members understand the benefits of a team approach and are moving in the direction of team building efforts
Real Team	Team members have essential skills to accomplish team goals and are equally committed to a common purpose and working approach
High Performance Team	Team members feel highly motivated to give their best effort and feel the team experience and work is particularly rewarding
TEAM ATTRIBUTE #6	Practice and encourage team loyalty to the team
Team Category	*Corresponding Question*
Working Group	There is a strong clearly focused leader and the group discusses, decides and delegates
Pseudo Team	The team refers to itself as a "team" even though privately, its members will admit otherwise
Potential Team	Team members are committed and prepared to do real work together
Real Team	Team members have shared leadership roles
High Performance Team	The work-products and results of the team's effort exceeds all performance expectations and goals

APPENDIX F
DATA REDUCTION CALCULATIONS

DATA REDUCTION CALCULATIONS

TEAM PERFORMANCE SURVEY DATA REDUCTION

Working Group		Pseudo Team		Potential Team		Real Team		High-Per. Team	
2		5		6		3		1	
8		13		9		7		4	
14		20		11		12		10	
15		21		18		17		16	
23		24		26		19		22	
29		30		27		25		28	
	x1		x2		x3		x4		x5

Position on Team Performance Curve =

Position on the Team Performance Curve = Weighted Total / Grand Total

Note: If the individual tools are "0" or "negative", do not count them in the grand total or weighted totals

EXAMPLE

Working Group		Pseudo Team		Potential Team		Real Team		High-Per. Team		
2	1	5	1	6	0	3	2	1	2	
8	2	13	2	9	0	7	-2	4	2	
14	0	20	1	11	0	12	2	10	2	
15	0	21	2	18	-2	17	2	16	2	
23	1	24	2	26	-2	19	-2	22	2	Grand
29	2	30	1	27	2	25	-2	28	2	Total
	6		9		-2		0		12	25
	x1		x2		x3		x4		x5	Weighted Total
	6 +		18 +		-6 +		0 +		60	78

Position on Team Performance Curve =
3.12

Position on the Team Performance Curve = 78/25 = 3.12 (Potential Team)

APPENDIX G
TEAM ATTRIBUTE DATA REDUCTION

TEAM ATTRIBUTE DATA REDUCTION

	TEAM ATTRIBUTE					TOTAL	Overall Total
1	#3	#6	#10	#15	#21 -( )	/5	
2	#1	#14	#17	#26	#30 -( )	/5	
3	#2	#4	#12	#18	#20 -( )	/5	
4	#5 -( )	#9	#16	#19	#23	/5	
5	#11	#13 –( )	#22	#25	#29	/5	
6	#7	#8	#24 -( )	#27	#28	/5	

EXAMPLE

	TEAM ATTRIBUTE					TOTAL	Overall Total
1	2	2	1	2	2	9 /5	1.80
2	1	2	0	1	-1	3 /5	0.60
3	1	-1	0	0	-2	-2 /5	-0.40
4	-1	2	-2	2	-2	-1 /5	-0.20
5	2	-2	1	2	0	3 /5	0.60
6	2	2	0	0	2	6 /5	1.20

Note: Numbers 5,13,21,24, and 30 are posed negatively.

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VITA

Dwan LaMar Prude was born in East St. Louis, Il to Pastor Carl E. Prude, Sr. and Lillie B. Prude on March 4, 1979. He has three older brothers, Carl E. Prude, Jr., Mark A. Prude, and Paul L. Prude. He also has four older sisters, Avis L. Thompson, Vian J. Bass, Lili A. St. Christopher, and Dona K. Curtis.

Dwan attended high school at the Illinois Mathematics and Science Academy (IMSA) in Aurora, Il. He graduated with a Bachelors of Science degree in Engineering Management from the University of Missouri-Rolla in December 2002.

During his undergraduate years at the University of Missouri-Rolla, Dwan was a leader in every organization that he participated in. He was a Senior Staff Resident Assistant and the first VOYAGEUR resident assistant. He was president of Alpha Phi Alpha Fraternity, Inc., Voices of Inspiration Choir, and the American Society for Quality (ASQ) student section. He was also the founder of the Black Man's Think Tank at the university and the BMTT Drumline. He was named the 2002 Ford Motor "Campus Spirit Award" and was awarded the 2002 Kappa Delta "Campus Man" award. Dwan also was National Residence Hall Honorary and initiated into Blue Key National Honor Fraternity during his graduation semester (Winter 2004) for his master's degree.

Ultimately, he believes in leading by serving others. He is married to LaChelle Prude and has two daughters, Amethyst Grace Prude and Emerald Faith Prude, and one son Jasper Isaac Prude.