Can team effectiveness be predicted?

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Received August 2007
Revised November 2007
Accepted March 2008

Abstract

Purpose – The purpose of this paper is to propose and support a model to predict the effectiveness of teams.

Design/methodology/approach – The literature provides a wide variety of variables or constructs to measure the effectiveness of a team. The article proposes a mathematical model to predict the effectiveness of a team. A priori comparisons are used to develop a mathematical model of the optimum team.

Findings – The study expands on the theory of team effectiveness and demonstrates that a theoretically developed empirical model can predict team effectiveness quantitatively. A mathematical model was developed as an empirical function of performance, behavior, attitude, team member style and corporate culture.

Research limitations/implications – There has been little effort to standardize the measurable variables of team effectiveness. Additionally, the means to evaluate the individual's influence on team effectiveness has not been documented in relation to the effectiveness of the team. This paper uses a specific set of constructs, which might be the optimum set of variables to measure performance, behavior, and attitude.

Practical implications – By considering the model suggested here, managers will be able to select individual team members to enhance team performance.

Originality/value – Few models have been proposed to predict the effectiveness of a team based on team member selection. This model provides anyone selecting team members with a model to use when choosing among technically qualified candidates.

Keywords Team working, Performance management, Behaviour, Attitudes

Paper type Conceptual paper

Preface

Industrial, governmental, and educational organizations rely on teams to improve the efficiency of their business. Ineffective teams cause organizations to waste resources, fall short of performance objectives, rework designs, and extend time to market. The purpose of this article is to propose a mathematical model to predict the effectiveness of teams. A literature review points to the hypothesis that team effectiveness can be evaluated by five broad principal variables: performance, behavior, attitude, team member style, and corporate culture. The model will be assessed using a highly effective team, which is considered in this study to be a 6σ (Six Sigma) process improvement team. This model can be used to create instruments for managers to use to enhance team performance through the selection of individuals for team membership.

Team Performance Management
Vol. 14 No. 5/6, 2008
pp. 248-268

1352-7592
DOI 10.1108/13527590810898518

Introduction

Using teams is widely considered to be a simple way to enhance productivity. Most managers believe teamwork is important to the success of their department and company (Dyer, 1987). Some studies place the use of teams in industry over 60 percent (Campion *et al.*, 1993; Cohen and Bailey, 1997; Milosevic and Tugrul, 1997; Mannix and Neale, 2005); some companies boast that their entire work force is team based (Thamhain, 2004). Industry's adoption of a teamwork methodology in the pursuit of cost effectiveness and greater innovation has spawned significant research to identify variables that can be measured to characterize an effective team. A review of the literature reveals tens of thousands of papers dealing with teams. It also produced hundreds of studies identifying sets of variables used to determine the effectiveness of a team (Guzzo, 1986; Hackman, 1987; Bettenhausen, 1991; Campion *et al.* 1993; Guzzo and Dickson, 1996; Cohen and Bailey, 1997; Milosevic and Tugrul, 1997; Werner and Lester, 2001; English *et al.*, 2004; Kirkman *et al.*, 2004; Mannix and Neale, 2005).

Goodman (1986) identified several issues with the models generated by current theoretical work. These models present variables that are very broad in nature and are not formulated to identify relationships among the variables. Devine and Phillips (2001) proposes that it will benefit practitioners to identify valid, low cost, practical predictors of team performance. Goodman's comparison of models results in a description of the general concepts of team effectiveness and shows that the commonalities of the models far outweigh the differences. He lists several ways that models can be improved, which include a better conceptualization of the critical variables, and a quantification of the model which will allow it to be validated.

Additionally, the preponderance of research uses teams whose membership has already been determined. Any intervention to improve the team's performance must necessarily be reactive. Ineffective teams cause organizations to waste resources, to rework designs, and to extend time to market. A means of predicting team success before the team is assembled, would allow businesses to take a proactive approach to improving team effectiveness. Therefore, an instrument to predict team success based on the uniqueness of individual team members would provide organizations with a tool for choosing team members. This paper presents a path to move from broad concepts about team effectiveness to the creation of a mathematical model of the optimum team.

Theory

The use of a model allows very complex systems to be evaluated in a simplified systematic manner (Banks and Tran, 1997). For a model to be useful or practical for implementation in industry, it must be based on measurable variables. Eykhoff (1974) defined a mathematical model as the essential characteristics of an existing system described by the knowledge of that system in useful presentation.

Mathematicians commonly consider mathematics as a study of logical consequences. The system described by the logical consequences is based on a set of axiomatic statements. The statements may be completely arbitrary about completely abstract objects. Or they may be statements about a system's (team's) output or methodology (effectiveness) described by variables that are broad in nature. (Kinsolving, 1967). A "simplified model invariably involves a number of ad hoc assumptions whose validity must be critically assessed as ... more detailed experimental data becomes available" (Heil and Jensen, 2003, p. 16).

This paper will use a priori comparisons to develop a mathematical model of the optimum team, using the variables and relationships found in the literature on teams. To quantify the relationships among the variables, the literature and my 30 years of practicing engineering and working on teams will be used to develop the *ad hoc* values. Steiger (1998) proposes a method to build a quantifiable model by considering these primary variables in relationship to the dependent variable, and to each other. Each variable is considered in its logical relationship to each of the other variables. The typical question is: how does an extreme value for one variable influence the outcome when other variables are held constant? To develop a conceptual model, a hypothesized relationship between pairs of variables will be established using the frequency and importance placed on each variable in the literature. Then these will be placed in a hierarchy based on their logical relationship and influence on team effectiveness. To develop mathematical equations for team effectiveness, four steps were followed:

(1) Identify, and standardize variables that are associated with team effectiveness.

(2) Find correlations that measure the influence of each of the variables.

(3) Develop a model that predicts whether a team will be effective.

(4) Test the model using a well-defined threshold for failure.

Step 1a: Identification of variables

Performance measures are one of the most frequently referenced variables driving team effectiveness (Guzzo and Dickson, 1996; Hackman, 1987; Bettenhausen, 1991; Campion *et al.*, 1993; Cannon-Bowers *et al.*, 1995; Wageman, 1995; Cohen and Bailey, 1997; Hoegl and Gemuenden, 2001; Werner and Lester, 2001, Thamhain, 2004; Adams *et al.*, 2002). The question, "How does the performance of team members influence team effectiveness?" will provide the basis for building the conceptual model.

There had been sufficient interest and a large enough volume of publications just from 1990 to 1996 to allow Cohen and Bailey (1997) to review and summarize approximately 200 articles. For their review, they categorized team effectiveness into three dimensions: performance effectiveness, member attitude, and behavioral outcomes. At the highest level, the preponderance of research as summarized by Adams *et al.* (2002), support Cohen and Bailey's results that the three variables of performance (P), behavior (B), and attitude (A) are the principal drivers of team effectiveness (TE) (Guzzo, 1986; Campion *et al.*, 1993; Cannon-Bowers *et al.*, 1995; Wageman, 1995; Hoegl and Gemuenden, 2001; DiSilverio, 2002; Huusko, 2007).

Performance (P) considers the extent to which the outputs conform to the customer standards of quantity, quality, and timeliness. Behavior (B) considers the extent to which team members act and react to each other, to circumstances, and to perceived behavioral controls. Attitude (A) considers how the team members' feelings of psychological safety, willingness to cooperate, reception and giving of feedback, and accepting responsibility influence team effectiveness (Gladstein, 1984; Hackman, 1987; Dyer, 1987; Ancona and Caldwell, 1992; Campion *et al.*, 1993; Wageman, 1995; Campion *et al.*, 1996; Guzzo and Dickson, 1996). Adams *et al.* (2002, p. 5) presented this functional relationship symbolically as:

$$TE = f(P, B, A) \tag{1}$$

(Team effectiveness (TE) is a function of performance (P), behavior (B), and attitude (A).)

Since teams are comprised of individuals, another attribute of the team effectiveness must be influenced by each team members' particular set of individual characteristics (Guzzo and Dickson, 1996; English *et al.*, 2004). An individual's assertiveness and responsiveness is the basis of how team members describe and perceive each other (Merrill and Reid, 1999). These characteristics manifested in the contributions of the individual team members are the foundation of the individual's *P*, *B*, and *A*. The functional relationship presented in Equation (1) is expanded to include a measure of the team members' characteristics (*M*).

As well as *P*, *B*, *A*, and *M*, the business climate in which teams operate has a significant organizational influence that either enhances or diminishes the effectiveness of the team (Gladstein, 1984; Goodman, 1986; Hackman, 1987; Ancona, 1990; Cohen and Bailey, 1997). Hence, Adams *et al.*'s (2002) functional relationship can be expanded to include corporate culture (*C*):

$$TE = f(P, B, A, M, C) \tag{2}$$

(Team effectiveness (*TE*) is a function of performance (*P*), behavior (*B*), attitude (*A*), team member style (*M*), and corporate culture (*C*).)

A simple alternative representation of this relationship is shown in Figure 1.

Step 1b: Standardization of nomenclature

P, *B*, and *A* are broad concepts, which are useful only if they can be measured and defined. Different authors have measured many of the component variables to identify correlations to team effectiveness. The comparison of their results is not straightforward because the authors used differing terminology. Adams *et al.* presented a review of 15 authors' selection of variables to evaluate team effectiveness. In those studies there are 40 unique words or phrases. Only six words are used by more than one study. The word most frequently used, in six studies, is communication. Coordination is the second most frequently used word, with four occurrences. The need to establish a standard set of variables, definitions, and measuring techniques is apparent.

Similar to Ancona (1990), Campion *et al.* (1993), Capozzoli (1995), Cohen and Bailey (1997), and Edmondson (1999), Adams *et al.* (2002) developed a model of team effectiveness based on performance, behavior and attitude. Recognizing the broad scope and difficulties of measuring, *P*, *B*, and *A*, Adams *et al.* identified seven easily measurable constructs. Of the 40 variables used by the 15 authors, the majority of their variables could be directly mapped to the set of seven variables. The four variables that did not have a direct mapping were context, organizational context, team empowerment, and group composition. When the model of team effectiveness is expanded to include individual team member style and corporate culture, these four remaining variables map into the expanded model.

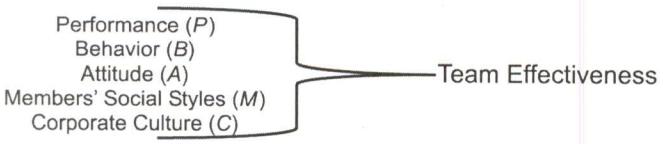


Figure 1.
Relationship to team effectiveness of *P*, *B*, *A*, *M*, and *C*

As defined by Adams *et al.* (2002) the seven constructs of effective teaming are: clearly defined goals, common purpose, role clarity, psychological safety, mature communication, productive conflict resolution, and accountable interdependence. These constructs are defined by Adams *et al.* (p. 4) as:

(1) Common purpose is the main objective of the team. All team members must agree this objective represents successful completion of the team's goal. The team members also need to share a commitment to the necessity of completing the tasks to accomplish the objective. Consequently, there needs to be a direct relationship between the main objective and the team's goals.

(2) Clearly defined goals are quantifiable and commonly agreed upon statements that define the tasks to be accomplished by the team. Clear and common goals help team members maintain their focus on the team's objective. Clearly defined goals help the team to manage the scope of the tasks, and thereby increase the probability of team success.

(3) Role clarity is the team members' common understanding of each individuals' expected role. Each team member's understanding of his/her own role and the roles of the other team members minimizes misunderstandings. Thus, task assignments are understood and not duplicated and also role ambiguity is avoided. When each team member understands her/his role, the expectations of each team member and of the team as a whole can be clearly defined.

(4) Psychological safety is the shared belief that the team is safe for interpersonal risk taking (Edmondson, 1999). If the team climate is characterized by interpersonal trust and mutual respect, team members will be comfortable being themselves. In this environment, team members are confident that the team will not embarrass, reject, or punish them for speaking up. This provides an environment accepting of questions. When questions are safe to ask, clear communication exists. Such a safe, fertile environment nurtures creativity. Additionally, in a psychologically safe context, team members are more likely to affirm each other for specific contributions, thereby encouraging individuals to perform more creatively and effectively.

(5) Mature communication refers to team members' ability to articulate ideas clearly and concisely. Additionally, each team member needs to listen without interrupting, clarify what others have said, and provide and receive constructive feedback. Team members need the ability to express compelling reasons for their ideas.

(6) Productive conflict resolution refers to the procedures and actions taken by team members when a conflict arises. When these actions lead to results such as facilitating the solution of the problem, increasing the cohesiveness among team members, exploring alternative positions, increasing the involvement of everyone affected by the conflict, and enhancing the decision-making process (Capozzoli, 1995), the team will have successfully managed the conflict.

(7) Accountable interdependence is the last of the seven constructs. The accountability for the output of the team is the responsibility of each team member. Accountable interdependence refers to each team member's

understanding the mutual dependence of all team members' responsibility for the quality and quantity of the team's work.

Hans Thamhain (2004) studied 180 projects and identified barriers and drivers of effective teams. He developed a questionnaire to measure: team performance; and the characteristics of the work environment. The questionnaire contained 25 variables.

His work found only 13 of the 25 variables studied to have significant correlations. Table I lists the 13 variables with their correlations. Only seven of those variables were directly related to Overall Team Performance (OTP). Thamhain's seven variables directly correlated to team performance are: interesting and stimulating work, clear organizational objectives, job skills and expertise, accomplishment and recognition, conflict and problem resolution, ability of dealing with risk, and effort and commitment to results. Thamhain's (2004) 13 statistically significant variables, Adams *et al.*'s (2002) Seven Constructs of Effective Teaming, and the characteristics of Performance, Behavior, and Attitude can be mapped to each other. Table II provides the mapping of the variables; Thamhain's variables are mapped through Adams' variables to *P*, *B*, and

	Driver	1	2	3	4	5	6	7	8	9	10	11	14	15
1	Interesting, stimulating work		0.38								0.38	0.43	0.39	0.43
2	Accomplishment and recognition	0.38		0.43		0.39	0.37	0.39						
3	Conflict and problem resolution		0.43		0.38			0.43	0.38	0.36	0.36			
4	Clear organizational objectives			0.38			0.40							
5	Job skills and expertise		0.39											
6	Direction and leadership		0.37		0.40									
7	Trust, respect, credibility		0.39	0.43					0.37	0.38				0.40
8	Cross-functional cooperation and support			0.38				0.37		0.47	0.37		0.37	
9	Effective communications			0.36				0.38	0.47					
10	Clear project plan and support	0.38		0.36					0.37				0.36	0.36
11	Autonomy and freedom	0.43												0.36
14	Ability of dealing with risk	0.39							0.37		0.36			
15	Effort and commitment to results	0.43						0.40			0.36	0.36		
	Overall Team Performance	**0.45**	**0.38**	**0.37**	**0.36**	**0.36**							**0.43**	**0.47**

Table I.
Thamhain's (2004) strongest drivers of team performance and statistics

Table II.
Variable mapping

Thamhain's (2004)	μ	τ	Adams *et al.*'s (2002) Seven Constructs	Performance, behavior, and attitude
Clear organizational objectives	*3.1*	*0.36*	Common purpose: $\bar{\mu} = 3.1$; $\tau = 0.36$	Performance: $\bar{\mu} = 3.56$
Direction & leadership	3.3	0.40		
Conflict & problem resolution	2.8	0.38		
Interesting, stimulating work	*3.9*	*0.45*	Clearly defined goals: $\bar{\mu} = 3.9$; $\tau =$ recognition	
Accomplishment & recognition	3.4	0.38		
Clear project plan and support	3.1	0.38		
Autonomy and freedom	3.1	0.43		
Ability of dealing with risk	2.7	0.39		
Effort + commitment to results	3.6	0.43		
Job skills & expertise	*3.6*	*0.36*	Role clarity: $\bar{\mu} = 3.6$; $\tau = 0.36$	
Accomplishment & recognition	3.4	0.39		
Accomplishment & recognition	*3.4*	*0.38*	Mature communication: $\bar{\mu} = 3.4$; $\tau = 0.38$	Behavior: $\bar{\mu} = 3.01$
Interesting, stimulating work	3.9	0.38		
Conflict & problem resolution	2.8	0.38		
Job skills & expertise	3.6	0.39		
Direction & leadership	3.6	0.37		
Trust, respect, credibility	4.1	0.31		
Conflict & problem resolution	*2.8*	*0.37*	Conflict resolution: $\bar{\mu} = 2.8$; $\tau = 0.37$	
Accomplishment & recognition	3.4	0.43		
Clear organizational objectives	3.1	0.38		
Trust, respect, credibility	4.1	0.43		
Cross-functional cooperation & support	3.5	0.38		
Effective communication	4.2	0.36		
Clear project plan and support	3.1	0.36		
Ability to deal with risk	*2.7*	*0.43*	Psychological safety: $\bar{\mu} = 2.7$; $\tau = 0.43$	
Interesting, stimulating work	3.9	0.39		Attitude: $\bar{\mu} = 3.32$
Cross-functional cooperation & support	3.5	0.37		
Clear project plan and support	3.1	0.36		
Effort & commitment to results	*3.6*	*0.47*	Accountable interdependence: $\bar{\mu} = 3.6$; $\tau = 0.47$	
Interesting, stimulating work	3.9	0.43		
Trust, respect, credibility	4.1	0.40		
Clear project plan and support	3.1	0.36		
Autonomy and freedom	3.1	0.36		

Notes: μ and τ are Thamhain's values for each of his variables as provided in Exhibit 2, p. 37 (Thamhain, 2004); drivers in italics are the seven drivers directly correlated to overall team performance with statistical significance $p = 0.01$ ($\tau \geq 0.36$); $\bar{\mu}$ and τ are Thamhain's values for the correlation of the directly correlated drive to overall team performance; $\hat{\mu}$ is the correlation weighted average of the constructs mapped to *P*, *B*, or *A*

A. This mapping combined with Adams *et al.*'s review of 15 other authors' variables, provides a beginning to the standardization of nomenclature.

As an expansion of the simple representation of Team Effectiveness and *P*, *B*, *A*, *M*, and *C* as depicted earlier in Equation (2) and Figure 1, the relationships of the Seven Constructs of Effective Teaming (Adams *et al.*, 2002) to *P*, *B*, and *A* are depicted in the Ishikawa diagram, Figure 2 (Ishikawa, 1976; Scholtes, 1993). The Ishikawa is a graphical means of displaying the relationship of the dependent variable, TE, to the principal independent variables, *P*, *B*, *A*, *M*, and *C*. Additionally, each of the principal bones of the Ishikawa have Adams' constructs (the measurable variables) depicted.

Step 2: Finding correlations

Thamhain (2004) used interviews, questionnaires, and observations to measure 25 variables related to Overall Team Performance (OTP). The Kendall's Tau Rank-order correlation values for the 25 variables ranged from $0.0 \leq \tau \leq 0.47$. Only the thirteen variables that showed a statistically significant ($p < 0.01$ ($\tau \geq 0.36$) or stronger) correlation to team performance are shown in Table I. Seven of the 13 variables correlated directly to team performance. Another six were only once removed from direct relationship to team performance, inasmuch as they correlated to one or more variables that directly related to team performance. There were no variables with significant correlations not associated to the seven directly correlated to OTP. The relationships of the Seven Constructs, Thamhain's 13 variables, and team effectiveness are depicted in the interrelationship diagram shown in Figure 3.

Step 3: Developing the model

A number of relationships need to be considered when developing the model. To ease understanding of the notation, the variables and symbols used in this paper are provided in Table III. When developing models, one tries to estimate both the functional form of relations between variables, and the numerical parameters in those

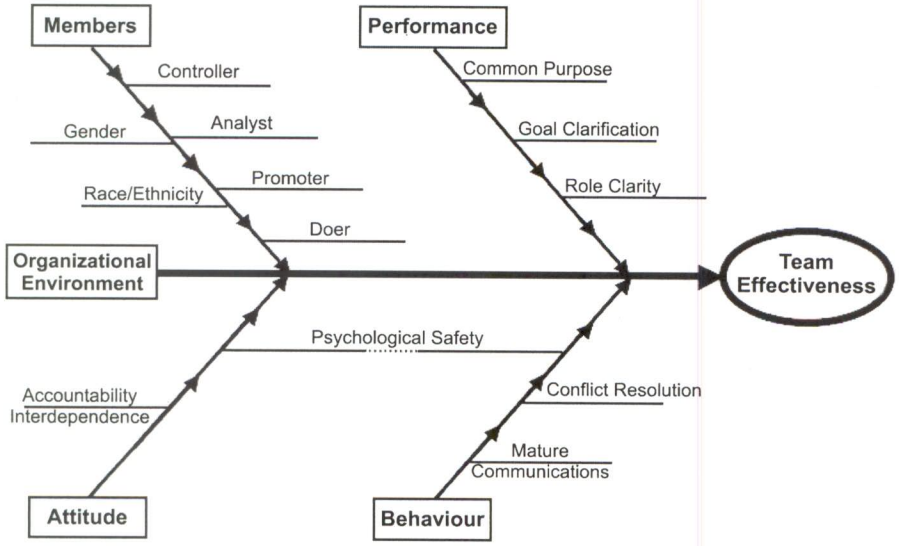
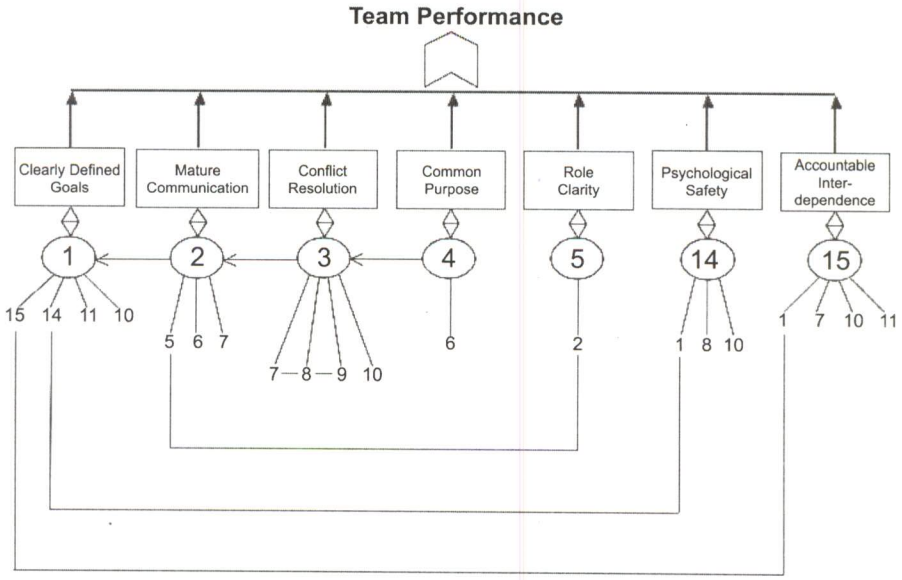


Figure 2.
Ishikawa diagram showing cause-and-effect for variables contributing to team effectiveness



In the boxes are the Seven Constructs of Effective Teaming (Adams, *et al.* 2002). In the bubbles are the variables measured by Thamhain (2004) with a statistically significance to Overall Team Performance of $p = 0.01$ ($\tau >= 0.36$) or stronger. You will note every variable is no more than once removed from its correlation to team performance. The only Thamhain variables shown are the variables that have a statistical correlation greater than 0.35. Consequently, variables numbered 12, 13, and from 16 to 25 are not represented. The following table presents the cross reference of numbers and variables used in the diagram.

1	Interesting, stimulating work	8	Cross-functional cooperation and support
2	Accomplishment and recognition	9	Effective communications
3	Conflict and problem resolution	10	Clear project plan and support
4	Clear organizational objectives	11	Autonomy and freedom
5	Job skills and expertise		
6	Direction and leadership	14	Ability of dealing with risk
7	Trust, respect, credibility	15	Effort and commitment to results

Figure 3.
Variable interrelationship diagram

functions. Using a priori relationships, a function or set of functions can be found that describe the system adequately (Eykhoff and Parks, 1990).

Several authors (Gladstein, 1984; Hackman, 1987; Ancona and Caldwell, 1992; Campion *et al.*, 1993; 1996; Wageman, 1995; Guzzo and Dickson, 1996; Janz *et al.*, 1997; Adams *et al.* 2002) have shown team performance to be a predictor of team effectiveness. This implies that performance has both a direct and strong relationship to team effectiveness. All other variables being neutral, team effectiveness will change in tandem with performance. If *P* is improved, *TE* will improve and if *P* diminished then *TE* will decline.

Variables	Symbols
Attitude	A
Accountable interdependence	ac
Behavior	B
Common purpose	cp
Conflict resolution	cr
Corporate culture	C
Function quantifying common purpose	f_{cp}
Function quantifying goal clarification	f_{gc}
Function quantifying performance	f_p
Function quantifying role clarity	f_{rc}
Goal clarification	gc
Team member style	M
Mature communication	mc
Mean	μ
Mean of common purpose measurements	μ_p
Mean of goal clarification measurements	μ_g
Mean of role clarity measurements	μ_r
Number of team members	n
Performance	P
Psychological safety	ps
Role clarity	rc
Standard Deviation	σ
Team effectiveness	TE
Kendall's Tau Rank-order correlation	τ

Table III.
Variables and symbols

Given that performance has a strong direct relationship to *TE*, performance will be used as the standard to evaluate the relationship of the other variables in Equation (2) to *TE*. How then does *P* interact with the other variables in its influence on *TE*? For example, will poor performance diminish a team's effectiveness faster than an unsupportive corporate culture? Considering just the interaction of performance and corporate culture, which is more likely:

- a team of poor performers who are in a highly supportive corporate culture will be an effective team; or
- a team of high performers in an unsupportive organization will be an effective team?

It would be highly unusual for poor performers to be an effective team just because of working in an environment supportive of teams (Eckes, 2003). On the other hand, a team of high performers will tend to accomplish whatever needs to be done regardless of environmental issues (Fisher *et al.*, 1995). Therefore, in all but the absolutely worst corporate cultures, high performers will perform. The resulting hypothesis is that performance (*P*) has significantly greater impact on team effectiveness (*TE*) than does corporate culture (*C*). In other words, corporate culture (*C*) is much much less (<<) of an influence ($\rightarrow$) on team effectiveness (*TE*) than performance (*P*). This is expressed symbolically as:

$$C << P \Rightarrow TE$$

(corporate culture (*C*) is much much less of an influence than performance (*P*) is on team effectiveness (*TE*).)

What is the relationship of *P* to *B*, *P* to *A*, and *P* to *M* in influencing *TE*? These relationships will be developed by the same logical correlation method. The relationship of *P* to *B* can be considered by evaluating if a team of good performers is going to behave in a manner that allows the other team members to perform. Data collected by Eckes (2003) documented that the root cause of the majority of team failures is poor team dynamics, which are manifested in individual member behavior. Does this imply *B* has an equal influence on *TE* as does *P*? Goodman (1986) uses a study by Kolodny and Kiggundu (1980) to propose the importance of a team's cohesiveness on team effectiveness. The study showed that in uncertain environments cohesive teams had greater productivity than teams with members who behaved badly. However, in a stable environment, the cohesiveness of the team had no influence on the productivity of the team. Behavior, then, does not carry as great an influence on *TE* compared to Performance with all other variables considered neutral.

Consider a team of high achievers, who are all accustomed to behaving as the leader and having their team following their direction. If there are more leaders than activities to be lead, the result will be tension, which will be manifested by poor Behavior. If the tension is not relieved, the team will lose effectiveness (Eckes, 2003). However, performers will perform and complete the project (Fisher *et al.*, 1995). But, will the team have been effective? Could the team have created the product better or faster, if less time and energy had been used dealing with poor behavior? The answer is yes, thus Behavior influences Team Effectiveness, but Performance moderates its effects. Symbolically, *B* has less (<) influence ($\rightarrow$) on *TE* than *P*:

$$B < P \Rightarrow TE$$

(Behavior (*B*) is less of an influence than performance (*P*) is on team effectiveness (*TE*))

Recognizing that an individual's attitudes toward a situation will be manifested in the individual's behavior, we posit a relationship of equality between the influence that behavior and attitude have on team effectiveness. Symbolically expressed as $B \approx A \Rightarrow TE$, behavior is approximately equal to attitude in its influence on team effectiveness.

Considering the influence of cognitive and social styles of the individual team members as a measurable variable (*M*), how strong a driver of team effectiveness (*TE*) is *M*? My a priori assumption is: each team member's style determines her level of productivity, manner of behavior, and attitude toward the team and project. The relationship of *M* to *TE* becomes the sum of *P*, *B*, and *A*($M \approx P + B + A \Rightarrow TE$).

The last comparison necessary deals with the relationship of corporate culture (*C*) to the other four variables. Earlier it was established *C* has much less influence on *TE* than *P* ($C << P \rightarrow TE$). The next question is whether *C* is more or less influential on *TE* than *B*, *A*, or *M*? Corporate culture is an outside influence on the team. Janz *et al.*'s (1997) empirical results supported Guzzo and Dickson's (1996) position that team effectiveness is not increased by support from the corporate culture for the team's design or process. The team's design and process are the result of the individual team member's style. The team members themselves have more influence on *TE* than an outside influence. The relationship then of *C* to *TE* is less than the influence of *M*, and

since M is the sum of P, B, and A, C is also less influential than either B or A ($C < B \approx A < M \approx P + B + A \Rightarrow TE$).

These relationships taken together are expressed as:

$$C < B \approx A < P < M \Rightarrow TE \text{ and } M \approx P + B + A \Rightarrow TE$$

(Corporate culture (C) has less influence than either behavior (B) or attitude (A), which have less influence than performance (P), all of which have less influence than team member styles (M) on team effectiveness (TE). Additionally, team member (M) styles are approximately equal to the sum of performance (P), behavior (B), and attitude (A) in their influence on team effectiveness (TE).)

When Eykhoff and Parks (1990) discuss the development of models, they refer to trying to estimate both the functional form of relations between variables and the numerical parameters in those functions. Eykhoff and Parks propose that by using a priori information, a function or set of functions that describe the system adequately can be developed. The a priori reasoning has established P carries more influence than the other variables, but how much more? The question is, how much poor behavior does it take to override good performers? The process of answering this question is used to develop a function that adequately describes the relationship between the behavior and performance of a team. If a team of five individuals is composed of five positive performers and one of those individuals exhibits negative behavior, the team is generally still capable of completing their tasks. What if of the five performers there are three positive behaviors and two negative behaviors, or two positive behaviors and three negative behaviors?

Eckes (2003) presents in detail a case study of a team of eight individuals who were considered to be the best and the brightest. Three of the eight members did not support the concepts being used on the project. They felt the project was a rerun, under a different name, of similar projects that had provided little improvements. These three members did understand the political ramifications of not appearing to support the project. Therefore, the three behaved as though they were fully supporting the project. The project moved forward, but the amount of output from the team was less than had been expected.

Looking from the other extreme, will a team of poor performers with positive behavior form an effective team? Although the team may function without conflict, would poor performers create a product in a timely manner that meets quality and quantity standards? It would be unusual for poor performers to deliver a product effectively, even with positive behavior. The question remains, how much negative behavior can team members exhibit and still have an effective team? As Eckes' (2003) case study exemplifies, one poor behaving team member does not a poor team make. As the ratio of team members with negative behavior to positive behavior becomes equal, the team's effectiveness will start to degrade significantly. When the negative behaviors out number the positive behaviors, the team will lapse into ineffectiveness. Hence, when approximately 50 percent of the team demonstrates negative behavior, the TE begins to be noticeably diminished. Thus intuitively, behavior seems to have approximately 50 percent of the influence that performance does on TE. This can be symbolically represented as $B \approx 0.5{*}P$.

From the relationships developed above $B \approx A$, behavior has approximately the same influence on TE as does attitude. What is the relative weight of relationship of B

to A? Each team member joins the team, with a specific set of psychological and emotional predispositions that are the principal drivers of the individual's attitude. Attitude is a function of the combination of the team members' acceptance of their own accountability for the team's effectiveness, their willingness to trust each other, and their comfort with the other team members. If a team member does not feel the project is worth attention and doesn't trust the other team members, but understands the political ramifications of the project, the team member can act in a cooperative manner demonstrating acceptable behavior in spite of a negative attitude.

Considering again Eckes (2003) case study, since the team member's attitude was not positive, there was still an adverse influence on the *TE*. Does the adverse influence come from B or from A? Since the B appears to be acceptable, the adverse influence is rooted in A, but the adverse impact is not as great as it would be if both the team member's attitude and behavior were negative. Because positive B mitigates negative A, but not completely, the influence behavior has on team effectiveness can be considered to be greater than attitude. Three of the eight team members of Eckes' case study, presented negative attitudes, but the entire team's behavior was positive, the resultant affect diminished *TE* slightly, and went unnoticed for a time. Mathematically, if eight positive B's and five positive A's offset the diminishing effect of three negative A's, then $A \approx 0.3B$.

The remaining relationship to determine is the relationship of *TE* to corporate culture. As defined earlier, C has the least influence on *TE*. The overall influence of C can be seen to affect the team membership since corporate culture drives the types of individuals who work within those constraints, how performance is rewarded, and what behaviors are expected and condoned. Additionally, the corporate culture directly influences the environment and supportive atmosphere in which the team must exist. Hence, there are components of corporate culture remotely related to the individual employees. However, if the team members' managers do not support the team process and provide time for team activities and team processes, the team members' ability to support the team is diminished. Therefore, corporate culture has influence on the team effectiveness separate from the individual team members.

How does C manifest its influence on the team's effectiveness? Corporate culture influences the behavior and attitude of individuals in as much as it sets the tone for office demeanor and the ramifications of political issues. Even so, what happens within a collaborative team can be well outside the direct influence of the corporate culture. C does define the norms of behavior in politically charged interactions. When teams are collaborative, the influence of C fades well into the background. Much as B can mitigate A, B can mitigate C. The weight of influence corporate culture has on team effectiveness is much much less than P, and can be mitigated by B, which is $\approx 0.5P$, then C must be much much smaller than $0.5P$. Much much smaller is interpreted to be an order of magnitude, therefore, $C \approx 0.05P$.

The relationships are $B \approx 0.5P$, $A \approx 0.3B$, $C \approx 0.05P$, and $M \approx P + B + A$. Letting the weight of $P = 1$, then $B \approx 0.5$, $A \approx 0.3B \approx 0.15$, $C \approx 0.05P \approx 0.05$ and with $M \approx P + B + A$, then $M \approx 1.65$, thus:

$$TE = P + 0.5B + 0.15A + 1.65M + 0.05C \tag{3}$$

Since the coefficients of P, B, A, M, and C sum to 3.35, to normalize *TE* to a 1 to 5 scale, it is necessary to divide Equation 3 by 3.35. Hence to express team

effectiveness in terms of performance, behavior, attitude, members, and corporate culture we have:

$$TE = \left\{ \frac{(P + 0.5B + 0.15A + 1.65M + 0.05C)}{3.35} \right\} \quad (4)$$

Step 4: Testing the model

In 1986 as a metric for measuring defects and improving quality, Motorola trademarked a set of procedures to achieve "systematic process improvement ... that relies on statistical methods and the scientific method to make dramatic reductions in customer defined" defect rates (Linderman *et al.*, 2003, p. 195). The term "Sigma" is often used as a scale for levels of "goodness" or quality. Using this scale, "Six Sigma" equates to 3.4 defects per one million opportunities (Motorola University, 2007) or 99.9999997 percent defect free. After years of teams implementing Motorola methodology, Six Sigma teams have become synonymous with the optimum efficient team. In the enormous volume of Motorola manufacturing, their automated manufacturing processes strive to meet this goal of producing all products which fall within $\pm$ 6σ of the mean. However, teams are not part of an automated system.

Many of the variables of interest to behavioral scientists are commonly assumed to be normally distributed, Normal (μ, σ^2) (Howell, 1995). This leads to the expectation that $TE \sim$ Normal (μ, σ^2). Given a normally distributed population, 68 percent of all occurrences fall within $\pm$ σ of the mean, 95 percent within $\pm 2\sigma$, 99.7 percent within $\pm 3\sigma$. For teams, 99.7 percent is considered all of the teams in the population. We label 2.5 percent of the teams that fall in that region greater than $\pm 2\sigma$, from the mean as optimum. In Figure 4, the normal distribution curve has been divided into $\pm 3\sigma$ regions.

The spectrum of teams shown in Figure 4 is:

- an Optimum team is more than 2σ from the mean (top 2.5 percent);
- an Effective team is between σ and 2σ from the mean (13.5 percent of the total);

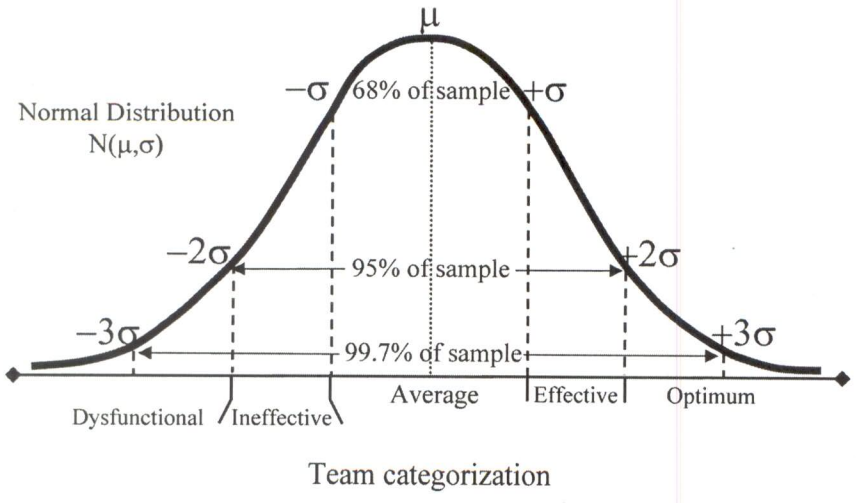


Figure 4.
Normal distribution curve

- an Average team is $\pm \sigma$ from the mean (68 percent of the total);
- an Ineffective team is between $-\sigma$ and -2σ from the mean (13.5 percent); and
- a Dysfunctional team is more than -2σ from the mean (bottom 2.5 percent).

Most nonparametric variables are measured using the Likert five point scale (1 = poorest, 5 = optimum). Assuming *TE* is measured such that 1 represents a completely ineffective team and 5 an optimum team, the mean would be three ($\mu = 3$ for *TE*) (Creswell, 2005). For the theoretically optimum team, *TE* equals five, the standard deviation is calculated from the upper limit relationship, $\mu + 3\sigma = 5$. Given a mean of three ($\mu = 3$), then the standard deviation is calculated to be two-thirds ($\sigma = 0.667$).

With a standard deviation of two-thirds and a mean of three, an average team's Team Effectiveness measure would score ($\mu \pm \sigma$) in range from 2.33 to 3.67. Looking at the entire spectrum of team effectiveness, we propose the following categorization:

$$\mu + 2\sigma = 4.3 < TE \leq 5.0 = \mu + 3\sigma \text{ Optimum team}$$

$$\mu + \sigma = 3.7 < TE \leq 4.3 = \mu + 2\sigma \text{ Effective team}$$

$$\mu - \sigma = 2.3 < TE \leq 3.7 = \mu + \sigma \text{ Average team}$$

$$\mu - 2\sigma = 1.7 < TE \leq 2.3 = \mu - \sigma \text{ Ineffective team}$$

$$\mu - 3\sigma = 1.0 \leq TE \leq 1.7 = \mu - 2\sigma \text{ Dysfunctional team}$$

Thamhain (2004) studied 76 project teams from 27 companies representing 180 projects with a total sample population of 895 professionals. His unit of study was the team. For the model presented in this paper, data from individual team members would be collected. Because conclusions from individuals' data cannot be generalized to teams without committing a fallacy of the wrong level, the team values will be aggregated by taking the average team member's responses and expressing that as a team value (Janz *et al.*, 1997). Similarly, values for the coefficients of *P*, *B*, and *A*, will be aggregated from the average responses of Thamhain's seven OTP variables. Table II mapped the OTP variables through the Seven Constructs to P, B, and A. The weighted average mean values are calculated to be:

$$P = 3.56$$

$$B = 3.01$$

$$A = 3.32$$

Before solving Equation (4) for the value of *TE* for an average team, what impact would a highly negative Corporate Culture, with a value of 1, have on *TE*? Using Equation (4), that negative environment would add to the overall effectiveness of the team. More appropriately it should subtract from the team's effectiveness. Therefore, the calculated values of *P*, *B*, *A*, *M*, and *C* components should vary from positive to negative. Consequently, the values for *P*, *B*, *A*, *M*, and *C* need to be their variance from the mean. Hence, Equation (4) is revised to:

$$TE = 3 + \{([P-3] + 0.5*[B-3]0.15*[A-3] + 1.65*[M-3] + 0.05*[C-3])/3.35\} \quad (5)$$

For the average team, using the Likert scale average of 3, it would be expected $TE = P = B = A = M = C = 3$.

From Equation (5) we calculate:

$$TE = 3 + \{([3-3] + 0.5*[3-3]0.15*[3-3] + 1.65*[3-3] + 0.05*[3-3])/3.35\} \quad (6a)$$

$$TE = 3 + \{(0+0+0+0+0/3.35)\} \quad (6b)$$

$$TE = 3 \quad (6c)$$

From Equation (6c), we see that average values for P, B, A, M, and C, do in fact produce an average score for TE.

There is, also, a growing awareness of the importance of an individual's fit within the culture of the corporation and with its team structure (English *et al.*, 2004; Maurer, 2006). Using an arithmetic average of the individual team members score (Janz *et al.*, 1997), the general Team Effectiveness function, Equation (5), using n as the number of team members, becomes:

$$TE = 3 + \left\{ \frac{\left(\frac{1}{n}\left[\sum_{i=1}^{n}(P_i - 3) + 0.5\sum_{i=1}^{n}(B_i - 3) + 0.15\sum_{i=1}^{n}(A_i - 3) + 1.65\sum_{i=1}^{n}(M_i - 3)\right] + 0.05(C-3)\right)}{3.35} \right\} \quad (7)$$

(Corporate culture is not summed over the individual team members, because it is measured, as an outside of the team variable, based on perceptions of the environment.)

To test the model, the means ($\hat{\mu}$ from Table II) calculated applying Thamhain's research for P, B, and A can be utilized. Given the significant sample size Thamhain studied, the result would be for an Average team. Thamhain's study included a measure for stable organizational process which resulted in a $\mu = 2.4$, therefore, $C = 2.4$. However, there was no measure of team composition reported in the study. Since, participation in Thamhain's study was completely voluntary and included 895 participants, we can assume the range of team member styles would be from dysfunctional to optimum, 1 to 5 ($1 \leq M \leq 5$). The mean of the range from 1 to 5 is 3, therefore, $\hat{\mu} = 3.0$ can be used to approximate M for Thamhain's teams.

Using these values for $P = 3.56$, $B = 3.01$, $A = 3.32$, $M = 3$, and $C = 2.4$, in Equation (7), TE is calculated to be equal to 3.17. The Team Effectiveness score of approximately 3.17 is within the predicted range of the Average effective team (2.3 to 3.7). Therefore, we can conclude the model did predict the effectiveness of the team.

If the argument were made that no employees of the *Fortune* 500 companies of Thamhain's study would be of the dysfunctional ($M = 1$) or even the ineffective ($M = 2$) category, thereby increasing the mean for the team Member styles to 4,

Equation (7) produces a $TE = 3.67$. A TE of 3.67 is on the top end of the Average range and the low end of the Effective range. This result further supports the validity of Equation (7) to predict TE. Additionally, this high lights the importance of the team Members style, in its influence on Team Effectiveness. Using above average team members, signified by using 4 as the mean of team Member style, and average values for all other variables, team Member styles does have a strong positive effect on the Team Effectiveness.

Completing the model

As shown in Table II, the variables of Performance, Behavior, and Attitude contributions are functions of other measurable variables. Figure 2 maps the three measurable construct variables of Common Purpose, Goal Clarification, and Role Clarity to Performance. Hence, Performance can be hypothesized as a function of the variables and represented symbolically as:

$$P^{\mathrm{TM}i} = f(cp, gc, rc) = \mathrm{a}f_{cp} + \mathrm{b}f_{gc} + \mathrm{c}f_{rc} \tag{8}$$

where the coefficients, a, b, and c are the correlation values of common purpose, goal clarification, and role clarity in relation to team effectiveness. Using Thamhain's means as the team member score ($\mathrm{x}^{\mathrm{TM}}{}_i$) of each construct (see Table II) as mapped to the characteristic, the function becomes:

$$P^{\mathrm{TM}i} f_p(purpose, goal, role) = \left\{ \frac{\left[\tau_{cp}(x_{cp}) + \tau_{gc}(x_{gc}) + \tau_{rc}(x_{rc})\right]}{(\tau_{cp} + \tau_{gc} + \tau_{rc})} \right\} \tag{9}$$

Using Thamhain's values as the scores and correlation coefficients of an average team member, a sample calculation would be:

$$P_1 = f_p(purpose, goal, role) = \left\{ \frac{0.36(3.1) + 0.45(3.9) + 0.36(3.6)}{(0.36 + 0.45 + 0.36)} \right\}$$

$$= \{(4.167)/1.17\}$$

$$= 3.56$$

Thus, the individual index of Performance is calculated. Similarly, functions for Behavior and Attitude can be developed. Thus values for each team member can be used in the appropriate summations in Equation (7). These values were calculated and are shown in Table II.

Conclusion

This study expands on the theory of team effectiveness and demonstrates that a theoretically developed empirical model can predict team effectiveness quantitatively. A mathematical model was developed as an empirical function of performance, behavior, attitude, team member style and corporate culture. The theoretical means ($\mu = 3$) of an average team showed the function does predict average Team

Effectiveness (*TE*). The values given in Thamhain's (2004) research were used to demonstrate the function's valid predication of an average team.

This study demonstrated that variables used to measure Performance, Behavior, and Attitude of a team can be mapped into the Seven Constructs of Team Effectiveness characterized by Adams *et al.* (2002). Additionally, these variables were mapped to Performance, Behavior and Attitude to provide measurable variables for the evaluation of the broad principal variables (*P*, *A*, and *B*). This empirical model accurately predicted an average Team Effectiveness rating for the amalgamation of the team members' measurements.

A method for measuring individuals and translating their results into an amalgamated measure of their combined influence on Performance, Behavior, and Attitude was developed. These amalgamated values were then used in the empirical model (Equation (7)) to predict Team Effectiveness (*TE*) of a specific set of individuals. By quantifying the values of an effective team, this research provides a valuable link from qualitative evaluation to quantifiable description of an effective team. Further research is also needed to distinguish how one individual's characteristics influence *TE*. Providing this measure will allow managers to select, from the pool of available qualified candidates, the best set of individuals to work together as an effective team.

Future research will determine what should be the standard variables to measure Performance, Behavior, Attitude, team Member style, and Corporate Culture. Once a standard set of variables is established, a specific set of instruments can be developed. The theoretical model expressed as Equation (7) for calculating a team's effectiveness (*TE*) needs additional research to refine the relationships between the high level components of performance, behavior, attitude, team member style, and corporate culture.

Then managers will have a method to select team members based on an evaluation of the probable effectiveness of a set of individuals. Having tools to predict whether a set of individuals can become an effective team will provide a company with the opportunity to be proactive, rather than having to react to an ineffective team. This early evaluation of team members gives the manager an opportunity to provide appropriate training, provide intervention, or change the mixture of individuals chosen for the team.

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