

# **A Comprehensive Model of Product Development Team Formation and Performance Cycle**

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In the rapidly changing markets of today, the survival of a company may depend on their ability to respond to customer needs with new or improved products. To achieve the level of responsiveness required to remain competitive, the formation of product design teams is helpful. In theory, these teams should function as a cohesive unit to successfully facilitate product ideas. There are two causes of inadequate yield from team focused work organizations. First, the team may lack the necessary knowledge and skills required. This problem is remedied by adding to the team people who are specially trained in the necessary area. A second issue causing poor performance within a team can be interpersonal dynamics. Finding and implementing a remedy for this issue can become more complex. It is possible, for instance, to reassign individuals to other projects and thus eliminate tensions, or to reassign individual members of the team to other projects. However, either solution to this problem will cost time and money. In product design teams, these issues may result in delayed product launches and lost market shares. Therefore, the initial team formation is crucial to ensure a high probability of success.

Even assuming the product design team is ideally formed, a structured management plan needs to be in place to assure high yield performance. This is only possible with a continuous cycle of observing, learning, inferring, assessing, and communicating within the team.

Researchers at the University of Nebraska-Lincoln and Pennsylvania State University have developed a Model for the Development and Facilitation of Effective Teaming. This model encompasses an examination of both the collective team and individual in the team process along with team formation strategies and task complexity. This examination is predicated on the belief that individually and collectively the members must have the technical knowledge and skills to perform their own tasks. If this model is successful it should reveal: a) individually, team members grew in their understanding of effective teaming; b) the team as a whole grew in their understanding of effective teaming; and c) proper synergy of task and team process occurred which will produce an effective teaming experience.

## **Introduction**

The objective of this article is to present a model currently in development to facilitate and measure the effectiveness of teams. The need for a model of this nature is driven by an increase in organizations moving toward a structure based on teams rather than the traditional emphasis on individual contributors. Employers expect college students to possess these skills and often complain that recent graduates have not learned the team approach to problem solving<sup>1</sup>.

Buckenmyer (2000) observed that an announcement of a team project was frequently received with moans, complaints, or other indicators of displeasure. Upon further discussions with members of teams the following reasons for their negative attitudes toward teams were provided:

1. In general, teams members do not work well together; they are a collection of individuals rather than a united entity,
2. Members are unclear about expectations for the team,

3. Some members become free riders or social loafers,
4. Group members do not know how to build a team and maintain team efforts,
5. Team members do not know how to handle conflict within the team,
6. Team members do not know how to choose a leader,
7. Teams fail to establish definite work assignments for members or create specific due dates,
8. There is no recourse for dealing with noncontributing or dysfunctional members,
9. Inclusive meeting times are difficult to set, and
10. Multiple team assignments.

Jones (1996) indicates that a well-structured, robust system for developing teams can overcome the flaws in the trial and error model and can energize the teaming process, while an improperly structured team system can undermine the goals. Furthermore, the inappropriate use of teams can not only undermine the teaming process but also foster an attitude of contempt amongst participants towards future teaming experiences. Buckenmyer (2000) suggests, "What is taught poorly may contribute later to poor performance on the job."

It is well reported that organizations that effectively use teams spend long hours and millions of dollars training individuals, teams, team leaders, and managers. For example, Motorola has reported spending about \$30 million a year on training, mostly on teams (Buckenmyer, 2000). Unfortunately, many organizations don't make this kind of investment; instead they leave the training of teams to chance.

Therefore it is important that a model be developed to assist with successful implementation of teams. The model should be independent of the individual and deliver both effectiveness and efficiency regardless of the diversity of team members. Without a model of this nature, team members will continue to experience the negative attitudes articulated by Buckenmyer (2000). Furthermore, a model for the development, facilitation, and measurement of effective teaming will promote patterns of behavior that support the goals of teaming. Researchers at the University of Nebraska-Lincoln and Pennsylvania State University have developed a conceptual model to address this need.

## **Background**

During the last 15 years, scholars and researchers in academia and industry have studied, evaluated, and recommended changes in the fields of engineering and business education. A consistent finding has been the need for graduates to demonstrate their ability to work in teams, communicate effectively, provide leadership, and demonstrate a basic understanding and proficiency with financial and economic matters. (Bellamy, Evans, Linder, McNeill, & Raupp, 1994; The Green Report, 1994; Tao, Peltier & Altia, 1996; McGourty & DeMeuse, 1996; Seat and Lord, 1999; Rugarcia, Felder, Woods, & Stice, 2000)

Many scholars have tried to identify the skills that yield an effective team. Researchers have generated multiple lists of skills constituting effective teams. Skills and factors identified include: team empowerment, clear mission/purpose, role clarity, team size, rewards, open communication, group task, group composition, group process, accountability, interdependency, feedback, autonomy, and conflict resolution (Shea & Guzzo, 1987; Sundstrom, DeMeuse, & Futrell, 1990; Katzenbach & Smith, 1993; Cohen, Ledford & Spreitzer, 1996; Cohen & Bailey, 1997).

Furthermore, several models have been proposed and used to improve our understanding relevant to: (1) how teams function, and (2) how their performance can be improved. Input-Process-Output Model (McGrath, 1964), Normative Model (Hackman, 1983), Time and Transition Model (Gersick, 1985), General Model of Group Effectiveness (Gladstein, 1984), Team Evolution and Maturation Model (Morgan et al., 1986), Conceptual Model of Team Performance (Nieva, Fleishman, and Reick, 1978), Integrated Model of Team Performance and Training (Salas, Dickinson, Converse and Tannenbaum, 1992), and a Heuristic Model of Group Effectiveness (Cohen and Bailey, 1997) are among these models.

All of these models aid in the understanding of team performance. Perhaps the most widely accepted is McGrath's (1964) Input-Process-Output Model. This model categorizes the factors that influence team performance into three major classes: input variables, which determine the givens associated with the composition and the characteristics of the team as well as the task and the situational requirements of the environment in which the team operates; process variables, which include the behavioral processes through which team members interact, communicate, and coordinate activities in order to complete their mission; and output variables which include the measures of team performance and cohesion and other outcomes that result from the actions of the team. According to this model input variables are further subdivided into three groups: environmental factors, individual characteristics level, and group level or team difference variables which serve to define the nature and characteristics of the overall team.

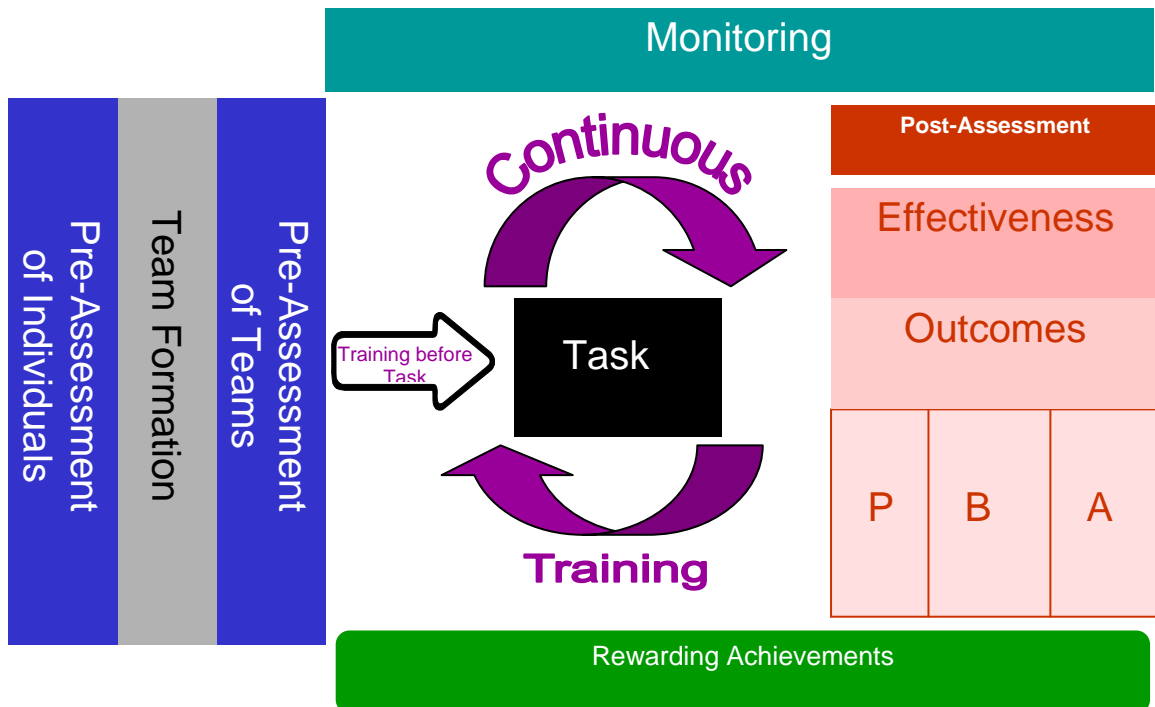
Hackman's (1983) model contributes by emphasizing organizational context as well as the effort, skills, and strategies of team members in performing tasks. The Gersick (1988) model highlights the dynamic and evolving nature of team performance. Nieva et al. (1978) emphasize that individual characteristics cannot be ignored in team functioning. The task-oriented model conveys the criticality of task and work structures in understanding team performance. Salas et al.'s (1992) model is an integrated version of the above models. Cohen and Bailey's model (1997) moves away from the "input-process-output" approach by depicting design factors, which have an indirect impact on outcomes via group processes and psychological traits, as also having a direct impact on outcomes. It suggests that group psychological traits are real group level phenomena. These traits directly influence them through shaping internal and external processes. The framework illustrates that group processes can become embedded in psychosocial traits such as norms, shared mental models, or affective states. Environmental factors meanwhile have direct influence on design factors. Altogether, environmental factors, design factors, internal and external processes, and group psychosocial traits predict effectiveness outcomes.

Moreover, models of team effectiveness developed with a business emphasis suggest that performance is only one component of effectiveness. Researchers introduce a number of variables related to effectiveness, such as: design (autonomy, interdependence), process (helping behavior), context (adequate resources); satisfaction cost savings; and productivity improvement (Gladstein, 1984; Shea & Guzzo, 1987; Sundstrom, DeMeuse, & Futrell, 1990; Cohen & Bailey, 1997; Adams, 1998). With an increased focus on teams a broader definition of team effectiveness is needed. Therefore, a comprehensive model is developed that would provide this needed broader definition of team effectiveness.

## The Model

This section provides an overview of the model. The goals for the model shown in Figure 1 are as follows:

1. to assist with the facilitation of teamwork;
2. to assist with the measurement of individual growth with regards to work in a team; and
3. to assist with the measurement of effective teamwork.



**Figure 1. Model for the Development and Facilitation of Effective Teaming.**

This model is different from the models in the literature in the following ways:

1. This model looks at both the team's output and the process of getting the work done.
2. The model examines the impact on the team performance as a function of the individual member perceptions.

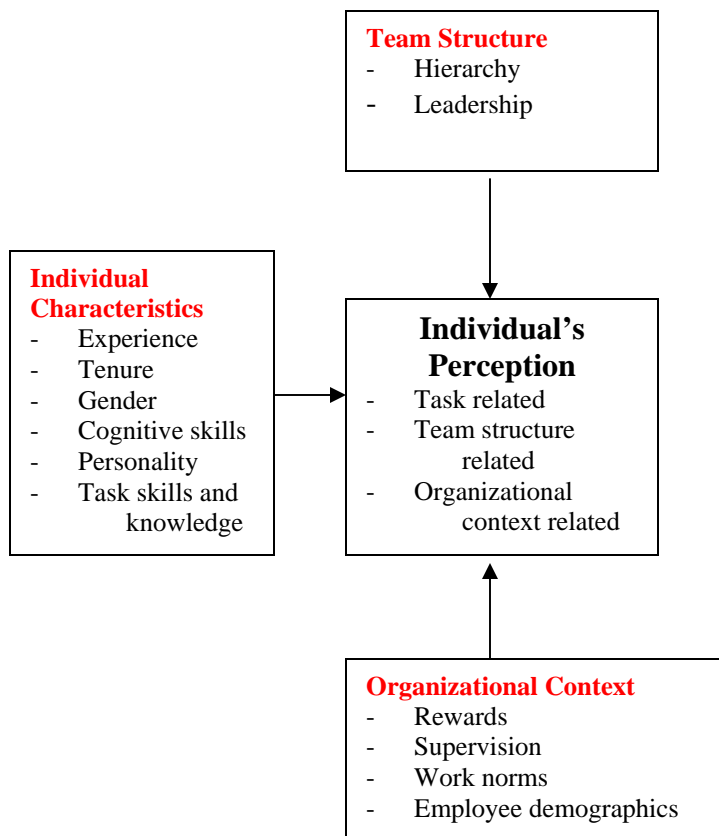
Measures of effectiveness should include both the individual and team unit of analysis, capture the process as well as outcome, describe and diagnose performance, and help to provide knowledge of the results to the team for developmental feedback (Brannick & Prince, 1997). An alignment of the needs of the individual, the dynamics of the team, and the requirements of the task will produce a high-performing, synergistic team.

According to Brannick and Prince (1997), before a group of individuals can function effectively as a team, the members must have the technical knowledge and skills to perform their own tasks. After all, effective teamwork requires team members who have positive attitudes toward the team and its task, have been provided adequate direction and support for accomplishing team goals, and know their responsibilities and those of other team members with

whom they interact. Therefore, efforts to improve team performance must focus on the performance of individuals (Brannick & Prince, 1997).

The model begins with the pre-assessment of individual members. The pre-assessment is being administered to establish a baseline for training purposes and growth measurement. It is important, when trying to understand team behavior, to remember that a group is a system of associations and that if the nature of those associations is changed, the behavior of the group has no choice but to follow the directions dictated by those associations, and that no individual in the group has to change to elicit a new behavior (Salton, 2000).

The next step in the model is the formation of teams. Successful team formation takes into account various perceptions of the individuals. Individual perceptions are influenced by member characteristics, team structure, task characteristics, and organizational context. Member characteristics are shaped based on their experience, tenure, gender, cognitive skills, personality traits, task relevant skills and knowledge. For example, in a team where individual recognition is emphasized and a hierarchical team structure is chosen, the ideal individual characteristics of team members may be very different than in a team environment in which each member has an "equal say" and the recognition is collective. This is illustrated with the Team Formation Sub-Model shown Figure 2 below.



**Figure 2. Team Formation Sub-Model**

Once the team is formed an additional pre-assessment is conducted of the collective team, on their attitudes regarding teaming, their experiences with teaming, and their proficiency with

the characteristics leading to an effective team experience. As individuals and teams complete the pre-assessment period, training should be provided to all teams prior to their work on the task. The convener of the teams sets forth the task to be completed. Training is recommended in subjects such as: role clarification, effective communication, conflict resolution, running effective meetings, decision making techniques, setting goals, and proper evaluation techniques.

At this point the task is assigned. When assigning a task important characteristics to consider are domain, gender orientation, complexity, and interdependence. Each of these may affect the performance of an individual within the team environment in relation to other team members. Monitoring should begin in conjunction with task assignment.

During the monitoring process team facilitators, conveners, coaches, instructors, etc. should observe the dynamics of the team, the attitudes of the members throughout the teaming process and the stages of development the team exhibits. Monitoring should be objective and done qualitatively. The team convener should observe the teams in action as well as query members via focus groups and interviews as to their experiences. This information will be beneficial in evaluating the behaviors and attitudes of team members.

Also, during this time it is important to reward team members. Rewards are typically given upon completion of a task or project. However, this model promotes rewards throughout the teaming process for meeting major deadlines, meeting them ahead of schedule, or other acts that demonstrate success by the team. Rewards might consist of a “pat on the back” for a job well done, a certificate of achievement, a pizza party for all team members, verbal acknowledgement, or some other motivational event. Once the task is completed, a post-assessment should be conducted to measure the effectiveness of the team.

Highly effective teams exhibit certain characteristics. A review of the literature produced numerous characteristics for consideration. The hypothesis for this model is that the following seven characteristics (to be referred to in the remainder of this article as “constructs”) are the most critical for an effective teaming experience in the classroom: common purpose, clearly defined goals, psychological safety, role clarity, mature communication, productive conflict resolution, and accountable interdependence. A description of each construct follows:

**Common purpose** is the main objective of the team. This should be understood and shared by all team members. Common purpose should lead to the development of the team’s goals. Successful teams shape their purposes in response to a demand, or opportunity, put in their path (Katzenbach & Smith, 1993). This helps teams get started by broadly framing the convener’s expectation.

**Clearly defined goals** are quantifiable and commonly agreed upon statements that define the actions to be taken by the team. The attainment of specific goals helps teams maintain their focus.

**Psychological safety** is the shared belief that the team is safe for interpersonal risk taking (Edmonson, 1999). Psychological safety is a sense of confidence that the team will not embarrass, reject or punish someone for speaking up. Psychological safety leads to a team climate characterized by interpersonal trust and mutual respect in which people are comfortable being themselves.

**Role clarity** is the team members’ common understanding of each individual’s expected role. The presence of role clarity minimizes misunderstandings regarding task assignments.

**Mature communication** refers to team members’ ability to:

1. articulate ideas clearly and concisely
2. give compelling reasons for their ideas

3. listen without interrupting
4. clarify what others have said
5. provide constructive feedback

Mature communication among team member ensures a higher level of understanding.

**Productive conflict resolution** refers to the procedures and actions taken when a conflict occurs. Productive conflict resolution leads to results such as:

1. facilitating the solution of the problem,
2. increasing the cohesiveness among team members,
3. exploring alternative positions,
4. increasing the involvement of everyone affected by the conflict and
5. enhancing the decision-making process (Capozzoli, 1995).

**Accountable interdependence** is the mutual dependence that all team members have regarding the quality and quantity of each individual's work within the team. Mutual dependence generates a shared sense of security.

In order to measure these constructs we must look at the process of completing the task and the satisfaction of the team members. Task completion and satisfaction can be further studied by examining the relationship between performance, behavior, and attitude to effectiveness. The hypothesis of the model regarding team effectiveness is that effectiveness (E) is defined as a function of *team performance* (P), *members' behaviors* (B), and *members' attitudes* (A) and can be represented by the equation, shown in Figure 2. Future work will allow the team of scholars to quantify the relationship that performance, behavior, and attitude have with effectiveness.

$$E = f(P, B, A)$$

**Figure 2. Mathematical Representation of Effectiveness**

Performance considers the extent to which the outputs meet the standards of quantity, quality, and timeliness according to those who use the product or receive the service (Adams, 1998). Behavior considers the extent to which the team experience contributes to the growth and personal well being of team members (Adams, 1998). Attitude is concerned with examining how the process of carrying out the work enhances the capability of members to work together interdependently in the future (Adams, 1998). For the purposes of this model, the outcomes for performance, behavior, and attitude, along with the tools for measurement, are shown in Table 1.

**Table 1. Outcomes of Model**

Outcomes	Measurement	Tools
Performance (P) (on the assigned task)	-Knowledge about the subject -Quality of the results -Timeliness -Quantity of the results -Skills mastery	-Project report -Project presentation -Knowledge test (for declarative and procedural knowledge) -External assessment -Concept map -Vee diagram -Case studies
Behavior (B) (as a team)	-Behaviors identified with each of the construct contributing to team effectiveness	-Direct observations -Interview -Video tapes
Attitude (A) (toward teamwork)	-Willingness of continuing working in team -Satisfaction for the teamwork experience and the work done	-Questionnaire -Interview -Video tapes

### Summary

A conceptual model has been developed to assist in the development of effective teams, to assess team effectiveness, and to measure the growth of individuals working in teams. The model shows the essential components in building teams and determining whether or not teams are effective. Development, testing and validation of the model will occur in four phases. The first phase consists of the development of a feedback form, the Team Effectiveness Questionnaire (TEQ). The instrument will be used to measure performance and attitude. To date, an instrument has been tested with three groups of engineering students working in design teams. Results of these tests can be found in the proceedings of the 2002 American Society of Engineering Educators Conference.

The second phase of the validation of the model was to develop and test a protocol for behavioral observation. A checklist form was designed to aid observation, along with a protocol that details the requirements and instructions on how to organize and prepare the observation of a team. Additionally, instructions on completing the forms, obtaining, and interpreting data were included. This tool provides an assessment of the extent to which each of the seven constructs of the model is present in a team, based on the behavior exhibited by the team members. A pilot study was conducted to test the reliability of the tool. At this time the reliability of the tool is 62%. Creswell states the 80% is necessary to ensure reliability. With proper training on the use of the instrument the reliability can be improved. Additional studies are currently underway to improve the reliability.

The third phase of the model will be to test team formation strategies and their relationship to task complexity. The final phase of the model is to test the applicability of the model in an industrial setting.

If this model is successful it should reveal: a) a team that is suitable to the task at hand, organizational context, and the necessary team structure is formed based on individual characteristics of members, b) individually, team members grew in their understanding of the team constructs; c) the team as a whole grew in their understanding of team constructs and d) proper synergy of task and team process occurred which will produce an effective teaming experience.

## References

Adams, S.G., (1998). An Investigation of the Attributes Contributing to Team Effectiveness of Engineering and Science Faculty, Texas A&M University, Dissertation Abstracts International, 59, no. 08B.

Bellamy, L., Evans D. L., Linder, D. E., McNeill, B. W., and Raupp, G., (1994). *Teams in Engineering Education*, A Report Submitted on Work Completed Under Sponsorship of the National Science Foundation.

Brannick, MT. and Prince, C. (1997). An Overview of Team Performance Measurement. In M. T. Brannick, E. Salas, & C. Prince (Eds.), *Team Performance Assessment and Measurement* (pp.3-16). Mahwah, NJ: Lawrence Erlbaum Associates.

Buckenmyer, J.A., (2000). Using Teams for Class Activities: Making Course/Classroom Teams Work, *Journal of Education for Business*, pp. 98-107.

Capozzoli, T. K., (1995). Resolving conflict within teams, *Journal for Quality and Participation*, Vol. 18 No. 7, pp.28-31.

Cohen, S. G., Ledford, Jr., G.E. and Spreitzer, G.M., (1996). A Predictive Model of Self-Managing Work Team Effectiveness, *Human Relations*, vol.49 no, 5, pp.643-676.

Cohen, S. G. and Bailey, D. E., (1997). What Makes Teams Work: Group Effectiveness Research from the Shop Floor to the Executive Suite, *Journal of Management*, vol.23 no.3, pp.239-290.

Edmonson, A., (1999). Psychological safety and learning behavior in work teams, *Administrative Science Quarterly*, vol.44 no.2, pp.359-383, June.

Gersick, C.J.G. (1988). Time and transition in work teams: Towards a new model of group development. *Academy of Management Review*, 31, 9-41.

Gladstein, D.L., (1984). Groups in Context: A Model of Task Group Effectiveness, *Administrative Science Quarterly*, 29, pp. 499-517.

The Green Report Engineering Education for a Changing World, (1994).  
[www.asee.org/pubs/html/greenworld.htm](http://www.asee.org/pubs/html/greenworld.htm).

Hackman, J.R. (1983). *A Normative Model of Work Team Effectiveness*. (Tech. Rep. No.2), New Haven, CT: Yale School of Organization Management.

Jones, D.W., (1996). Empowered Teams in the Classroom Can Work, *Journal of Quality and Participation*, 80-86.

Katzenbach, J.R. and Smith, D.K., (1996). The Discipline of Teams, *Harvard Business Review*, 11-120, Mar/Apr 1993.

McGourty, J. and DeMeuse, K.P., *The Team Developer: An Assessment and Skill Building Program*, Gateway Engineering Education Cognition, John Wiley and Sons, Inc.

McGrath, J.E. (1964). *Social Psychology: A Brief Introduction*. New York: Holt.

Morgan, Jr., B. B., Glickman, A.S., Woodard, E. A., Blaiwes, A. S. and Salas, E., (1996). *Measurement of Team Behaviors in a Navy Environment*, (14TSV TR-86-0 14).

Nieva, V.F., Fleishman, E.A. and Reick, A. (1978). *Team Dimensions: Their identity, their measurement and their relationships* (Contract No: DAHC 19-78-C-0001). Washington, D.C.: Advanced Research Resources Organization,

Peltier, R.V. and Altia, F. (1996). A Profile of the 21st Century Engineering Technology Graduate: An Industry Perspective, *1996 ASEE Conference Proceedings*, ASEE, 1996.

Rugarcia, A. Felder, R.M., Woods, D.R. and Stice, J.E., (2000). The Future of Engineering Education. I. A Vision for a New Century, *Chem. Engr. Education*, 34(1), 16-25.

Salas E., Dickinson, T.L., Converse, and Tannenbaum S.I. (1992). Toward and Understanding of Team Performance and Training. In *Teams: Their training and performance* / edited by Robert W. Swezey and Eduardo Salas. Norwood, N.J.: Ablex Pub. Corp.

Salton, C. J., (2000). Getting a Grip on Groups, *Industrial Management*, 26-33.

Seat, E. and Lord, S., (1999). Enabling Effective Engineering Teams: A Program for Teaching Interaction Skills, *Journal of Engineering Education*, vol.88, num. 4, pp. 385-390.

Shea, G.P. and Guzzo, R., (1987). Group Effectiveness: What Really Matters? *Sloan Management Review*, 3, 25-31.

Sundstrom, E., DeMeuse, K.P. and Futrell, D., (1990). Work Teams: Applications and Effectiveness, *American Psychologist*, Vol.45, No.2, pp. 120-133.

Tao, B.Y., (1993). Senior/Sophomore Co-Class Instruction: Teaching Interpersonal Management Skills in Engineering, *Journal of Engineering Education*.

