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Leroy Cox

Susan L. Murray
Missouri University of Science and Technology, murray@mst.edu

David Spurlock
Missouri University of Science and Technology, dspurloc@mst.edu

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Leroy Cox, University of Missouri-Rolla

LEROY R. COX is a postdoctoral fellow in the Engineering Management and Systems Engineering department at the University of Missouri – Rolla. He holds Bachelors degrees in Mechanical Engineering and Engineering Management (1999), a Masters degree in Systems Engineering (2002), and a Ph.D in Engineering Management (2005) all from UMR. He has industry experience in the areas of process improvement/reengineering and mechanical design. His research interests include organizational behavior, virtual teams, and managing people in organizations.

Susan Murray, University of Missouri-Rolla

David Spurlock, University of Missouri-Rolla (ENG)

DAVID G. SPURLOCK is an Assistant Professor of Engineering Management and Systems Engineering at the University of Missouri-Rolla. He earned a bachelor's degree in electrical engineering from the University of Dayton, a M.A. in psychology from Pepperdine University, and a Ph.D. in organizational psychology from the University of Illinois at Urbana-Champaign. His research interests include individual and organizational decision making.

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Abstract

Interactive video technology has become a widely used medium for education. A prominent implementation of this technology, interactive distance learning, involves groups of students at local and remote sites connected by audio and video teleconferencing. This approach has made the task of delivering vital undergraduate and graduate engineering courses to distributed audiences much easier.

As this approach has permeated more curricula, distance education instructors have increasingly assigned projects that require distance learners to work together as an element of the final course grade. This trend presents an interesting opportunity for researchers to understand the nature of interactions among course participants involved in project teams.

This paper presents the results of an investigation of project leadership behaviors in the distance learning environment. Surveys were administered via online protocol to fifty-three students, comprising nineteen project teams. Results indicate that those teams led by individuals who clarified roles and task requirements, and recognized the strengths and individual needs of teams members performed better on their assigned tasks. Implications for instructors utilizing project teams in distance education, as well as traditional teams where communication technology (e.g., email) is highly relied upon, are presented.

Introduction

Warren Bennis, in his essay, "The Coming Death of Bureaucracy," stated the following:

> The organizational structures of the future will have some unique characteristics. The key word will be temporary. There will be adaptive, rapidly changing temporary systems. There will be task forces organized around problems to be solved by groups of relative strangers with diverse professional skills. The groups will be arranged on an organic rather than mechanical model; they will evolve in response to a problem rather than to programmed role expectations. Organizational charts will consist of project groups rather than stratified functional groups. Adaptive, problem-solving, temporary systems of diverse specialists, linked together by coordinating and task-evaluating executive specialists in an organic flux – this is the organization form that will gradually replace bureaucracy as we know it. Teaching how to live with ambiguity, to identify with the adaptive process, to make a virtue out of contingency, and to be self-directing – these will be the tasks of education, the goals of maturity, and the achievement of the successful individual.[5]

Bennis's predictions, penned in the 1960s, were profound, and nearly forty years of hindsight have given validity to his predictions. The current reality in the business world is flatter organizations, an approach to operations using Total Quality Management principles, and more use of self-directed teams. Realizing that it is necessary and important to develop the interpersonal skills of engineering students so as to facilitate their smooth transition into the workplace, an ability to function on multidisciplinary teams has become a desired educational outcome. Group projects, with the motivating theme of simulating a "real world" setting, have been widely adopted in many undergraduate and postgraduate courses. They play an important role in reinforcing theoretical concepts, in highlighting the issues associated with group working, and in providing students with experience of the type of work found in industry.[8]

Group working, in an educational context, gives students a greater opportunity to engineer systems that are larger and more complex than would be possible working alone. Individuals working alone are usually ineffective in solving current, complex engineering problems; instead a well-trained multidisciplinary team can address complex issues more productively. In addition, working together provides a framework for students to learn from fellow group members. The problems associated with group working that might be highlighted include those relating to management issues (e.g., scheduling meetings, task allocation, depending on others) as well as technical issues (e.g., agreeing requirements, system partitioning, and integration).

Katzenbach and Smith have verified the appropriateness of teams when "a specific performance objective requires collective work and real-time integration of multiple skills, perspectives, or experiences."[13] Indeed, many of the tasks encountered in the practice of engineering, such as managing, designing, and improving manufacturing processes and products, are divisible, optimizing, and conjunctive. Thus, engineering tasks generally match Katzenbach and Smith's performance objectives, and require team-oriented approaches.

The traditional approach to group work in academe is to put three to five students together and let them "work it out." However, placing students in groups may not necessarily develop a team. Katzenbach and Smith hold that team effectiveness must be developed for performance to exceed that of several individuals working separately.[13] Their assertion is that students do not come to school with the social skills they need to collaborate effectively with others, so teachers need to teach the appropriate communication, leadership, trust, decision-making, and conflict management skills to students and provide the motivation to use these skills in order for groups to function effectively.

Coupled with the issue of developing individuals that can function successfully in a team is the impact of technology on teaching. Interactive video technology has become a widely used medium for education. A prominent implementation of this technology, interactive distance learning, involves groups of students at local and remote sites connected by audio and video teleconferencing. This approach has made the task of delivering vital undergraduate and graduate engineering courses to distributed audiences much easier. As this approach has permeated more curricula, distance education instructors have increasingly assigned projects that require distance learners to work together as an element of the final course grade. This is in an effort to have students experience the benefits of working together as well as reinforcing the elements of the course.

It is clear that, in the "real world," work is increasingly being carried out by virtual teams – teams which are geographically dispersed across a number of sites. The ever-increasing presence of the Internet together with improved groupware is likely to provide further support for distributed, cooperative working. Academe has been challenged to produce individuals that can function on multidisciplinary teams, and has responded from mostly a face-to-face perspective. The challenge is to now foster the development of group dynamics within the virtual environment.

The purpose of this study is to understand the facilitation of leadership in distance education teams. In particular, we wish to understand which leadership behaviors, as expressed by the team leader, have a more profound effect on the team's performance on assigned course projects. Numerous authors have sought to understand the intricacies of leadership in the face-to-face environment, and have published findings that have helped to better understand this construct as well as guide would-be team leaders. The implications of this study can better aid distance education instructors who rely on course projects to prepare students for the collaborative aspect of working as an engineer.

Methodology

This study was completed using a quantitative survey of transactional and transformational leadership behaviors and team performance. It employs a correlational approach and multiple regression analysis to determine the strength of the relationships between these sets of variables.

Sample

This study surveyed distance education students who were taking either Project Management, Systems Engineering (I and II), or Quality, Strategy, and Value Creation classes at the University of Missouri – Rolla and the University of Colorado – Boulder. These students presented wide variations in terms of age and experience; participants were either undergraduate or graduate students enrolled on campus, or working professionals completing either the Systems Engineering or Engineering Management Masters degree or the Systems Engineering certificate program as offered by their respective schools.

All of these courses required the completion of a group project as a portion of the course grade. The instructor assigned each team a project – in two cases, the instructor went so far as to assign students into particular project teams. Each team consisted of three to five members and had an identifiable team leader. Project team members were given guidelines regarding the project task and deliverables, but no advice was given as to how to complete the project – this was left up to the team to coordinate. Aside from these basic guidelines, individual teams were given complete autonomy to assign priorities, set schedules, set meeting times, and decide on which telecommunications technologies to use.

Task

Whereas there were differences in the subject matter among these classes, the tasks assigned to each team were similar. The Project Management students were to develop a project that allowed the team to track, in practice, the course concepts and gain mastery in their application. Students in one class were allowed to choose from a project concept or non-executed project related to individual work, or from a list of topics as offered by the instructor; the other class members were all to develop projects with the theme of aiding in the recent tsunami relief effort. Each group had to develop a proposal that incorporated a statement of purpose; the opportunity, problem, or need addressed; the method the project team intended to use to address this need; the plan and benefits of the plan; a schedule and proposed start and termination date; basic needed resources; and key risks and obstacles that could hinder the successful completion of the project. Upon acceptance of the proposal, each team was allowed to work on its project, and had to submit milestone reports throughout the semester, culminating in a final report or project implementation plan.

The Systems Engineering I students were from two classes offered as part of the University of Missouri – Rolla Systems Engineering Masters degree/certificate program. The first class had to develop, design, and construct a team of fully autonomous robotic soccer players who were to compete and win the small-size RoboCup soccer tournament (www.robocup.org). The key attributes of this project were to provide a mobile robot system that can successfully perform the critical skills of individual decision-making capability, passing the ball between players, moving the ball up and down the field, kicking the ball into a net to score points, and preventing the opposing team from doing the same. Each team submitted milestone reports throughout the project, and a final report and presentation at the end of the semester.

The second Systems Engineering I class had to develop an automatic system that would permit the Mars Rover to explore the surface of Mars searching for the possibility of the existence of water (in any form). Milestone reports were required throughout the life of the project, culminating in a final report and presentation at the end of the semester.

The Systems Engineering II students were from two classes offered as part of the University of Missouri – Rolla System Engineering Masters degree/certificate program. The projects that these teams developed used design material from the RoboCup robotic soccer or Mars Rover problem domain areas in order to exercise various systems engineering processes such as risk management, reliability analysis, and trade study execution. Each team used DOORS, a software tool designed to aid in requirements-driven development processes so as to aid groups in collaboration on projects, to load and organize their project material. The instructor then assigned two case studies during the semester that permitted each team to utilize their project information to perform systems engineering processes.

The Quality, Strategy, and Value Creation students were from one class offered by the University of Colorado – Boulder Engineering Management and Systems Engineering Department. The teams in this class had to develop a model for implementing the combination and juxtaposition of Deming's System of Profound Knowledge,[6] Senge's Learning Organization,[16] and Edvinsson and Malone's Intellectual Capital System[7] in a company, government, or non-profit organization. The model included, but was not necessarily limited to a vision or aim statement; a global strategy statement; a list of outcomes: decisions characterization, behaviors, personnel interactions, etc; an organizational design; specific implementation goals and guidelines; anticipated reinforcing, balancing, and lag effects; a conclusion delineating the anticipated effect on individuals in the organization; and a timeline for achieving the implementation goals. The final report was submitted at the end of the semester to be evaluated as a portion of the course grade.

Measures

The measurement instruments that were used to survey the groups were organized together to form a three-part questionnaire that began with a demographic section, followed by a measure for transformational and transformational leadership behaviors, and a measure for group performance.

The demographic survey sought to determine the number of members on the team and the team to which that member is assigned. In order to gain information as to the individual's experience working in the virtual environment, they were asked as to how many teams on which they have been in the last year that have consisted of team members who were based in the same location, and in a different location. In addition, participants were asked as to the number of members on the virtual team, their tenure on the team, the team's life span, and whether or not they were a member of the team at its inception. Finally, group members were asked about the degree of virtuality of the team on which they served by having them complete a survey asking their frequency of use of different communication technologies.

The Multifactor Leadership Questionnaire instrument was used to determine whether or not transactional or transformational leadership behaviors were being expressed by the team leader. The MLQ for teams[4] consists of 48 descriptive items that use a 5-point Likert scale ranging from "Not at all" to "Frequently or always" to measure transformational leadership behaviors including the expression of idealized influence (attributes and behaviors), inspirational motivation, intellectual stimulation, and individualized consideration. It also measures the transactional leadership behaviors of contingent reward and management-by-exception (active and passive). Group members were asked to respond to how often the group leader exhibited certain behaviors, such as "avoids controversial issues that would produce conflict," or "instills pride in being associated with the group." Two items at the end asked for the group member's perception of the effectiveness of the team and their personal level of satisfaction with the team's leadership abilities.

An objective measure of team performance based on the work of Lurey and Raisinghani[14] was used to assess team performance. This scale consists of three items, each with the team as the referent. Participants were asked to rate the overall performance of the team; an example of a survey item from this instrument would be "the team has been effective in reaching its goals." Reliability for this scale is 0.82. Group project grades were used a second measure of performance to ensure that the project, once completed, met the requirements as set forth by the instructor. In effect, just as in the business place where a manager must review the team's output or the end user reviews the product or service, someone beyond the team's boundaries was responsible, in part, for judging its level of effectiveness.

Data Analysis and Results

Fifty-three individuals, of which thirty-nine were male and fourteen were female, representing nineteen project teams, responded to the survey instrument via online protocol. These individuals ranged from twenty-two to fifty-nine years of age. All teams had been in existence for three to five months, and all team members had been a member of the team since its inception.

To understand the degree of virtuality expressed in these teams, individuals were asked to indicate the frequency with which they used various technologies to exchange information with their team members. The scale ranged from 0 = not at all to 5 = daily. Email, group telephone conferences, and telephone calls were most often used to share information. The mean scores for each technology are shown in Table 1 below.

Table 1. Mean Ratings of Frequency of Use of Communication Medium

Communication Mode	Mean
Email	3.96
Telephone Conference	2.65
Personal telephone call	2.22
Shared Databases	1.91
Voice Mail	1.35
Standard Mail Delivery	1.35
Video Conference	1.13
Face-to-face interaction	1.04
Fax	1.04

The data was first analyzed to verify the validity and reliability of the instruments used. Principal components factor analysis, with varimax rotation, was performed on each of the transformational and transactional leadership subscales, in addition to the scales for task satisfaction, group potency, and team performance. Eigenvalues and the scree test were used to help guide in determining the factor structure underlying the measurement of each construct. To consider whether an item represented a particular factor, the factor loading had to be greater than 0.45, and item cross-loading on other factors had to be less than 0.30, as put forth in previous research.[1]

The Multifactor Leadership Questionnaire consisted of forty-eight items designed to measure the nine factors of Bass's Full Range Model of Leadership. Bass and Avolio confirmed the validity of this measure through the use of confirmatory factor analysis with LISREL VII using the maximum likelihood estimation method.[3] Using data collected from nine independent researchers (N=2080), the Goodness of Fit Index (GFI) – with recommended cutoff criterion of 0.90 (Bentler, 1990) – and the Root Mean Squared Residuals (RMSR) – with recommended cutoff at less than 0.05 [12] – indicated that the nine-factor model best represented the data. These nine factors represented five transformational behaviors (idealized influence – attributed, idealized influence – behaviors, inspirational motivation, intellectual stimulation, individual consideration); three transactional behaviors (contingent reward, management-by-exception-active, management-by-exception-passive); and the non-leadership behavior of laissez-faire leadership. A template provided by Mind Garden of California, which markets the MLQ for research purposes, was used to assign particular scale items to particular factors.[15]

Cronbach's reliability analysis, which measures how well a set of items (or variables) measure a single unidimensional latent construct, was then performed on the scales. Each scale yielded high reliability coefficients ($r > 0.70$), save for the active management-by-exception scale. In the case of the laissez-faire scales, reliability was increased with the omission of the scale item "avoids confrontational issues that would produce conflict." For the idealized behaviors scale, omission of the scale item "talks about how trusting each other can help overcome their difficulties" increased the reliability of the scale. Similar results were seen with omission of scale items on the intellectual stimulation, idealized behaviors, task satisfaction, and performance (self-report) scales. Table 2 reports the scale reliabilities obtained.

Table 2. Scale Reliabilities

Variable	Abbreviation	No. of Items	Reliability
Group Potency	POT	7	0.96
Laissez-faire	LF	4	0.79
Individualized Consideration	IC	5	0.84
Passive Management by Exception	MBEP	5	0.80
Active Management by Exception	MBEA	5	0.53
Contingent Reward	CR	5	0.84
Inspirational Motivation	IM	5	0.86
Intellectual Stimulation	IS	4	0.79
Idealized Attributes	IA	5	0.85
Idealized Behaviors	IB	4	0.77
Task Satisfaction	SAT	8	0.91
Performance (self-report)	PERF	2	0.96

Due to its low reliability, the active management-by-exception scale (MBEA) was dropped from further analysis.

The data was then aggregated to the team level following the guidelines put forth by James, Demaree, and Wolf.[10] According to these authors, the estimate of interrater reliability (IRR) for judges' mean scores is based on the assumption that the items are "essentially parallel" indicators of the same construct. This implies that the variances of, and covariances among, the items are approximately equal, respectively, in their underlying domain of items. Inter-rater reliabilities were calculated for each of the leadership subscales and the potency and satisfaction scales. Values obtained were high, all above 0.6 (the cutoff suggested by these authors), and justified the aggregation of individual responses to the team level.

Multiple regression analysis with backwards elimination was performed to understand the relationships among the variables of interest. Backwards elimination begins with the full model and sequentially eliminates from the model the least important variable. Team performance, as reported by the team members' responses to questionnaire items that sought their perception of the team's performance, was regressed on the transactional and transformational leadership items. The resulting model, shown in Table 3, included only contingent reward, which is a transactional leadership behavior.

Table 3. Regression Results for Perceived Task Performance

	Unstandardized Coefficients		Standardized Coefficients		
Dependent Variable: PERF	B	Std. Error	Beta	t	Sig.
(Constant)	-0.040	0.846		-0.048	0.962
CR	1.129	0.227	0.770	4.984	0.000
R^2 = 0.594					
F = 24.836**	** p < .01				

Using the teams' actual performance, in terms of grades on the team project, as the dependent variable and the transactional and transformational leadership behaviors as independent variables, regression analysis showed that the most accurate model to predict performance consisted of both classifications of behaviors. Results of this regression are presented in Table 4 below. Individualized consideration, a transformational leadership behavior, was significant ($p < 0.05$), as was passive management-by-exception ($p < 0.05$). Important to note here is that all scales were standardized due to the wide range in report scores (0 – 100) as compared to that of the leadership scales (1 – 5); the standardized variables are represented by the character "Z" placed before the variable abbreviation.

Table 4. Regression Results for Actual Team Performance

	Unstandardized Coefficients		Standardized Coefficients		
Dependent Variable: ZSCORE	B	Std. Error	Beta	t	Sig.
(Constant)	-0.001	0.200		-0.003	0.998
ZIC	0.593	0.237	0.593	2.507	0.023
ZMBEP	0.547	0.237	0.547	2.310	0.035
R^2 = 0.327					
F = 3.888*	* p < .05				

Discussion

The results of this study indicate that, in the case of perceived self-reports of group performance, contingent reward behavior was the best predictor of performance; for actual performance, the best model included both transactional and transformational leadership behaviors. The fact that the best model of performance contains behaviors indicative of both transformational and transactional leadership is surprising only in the sense that previous research most often contrasts these two and makes the case that transformational leadership results in higher levels of performance. These results serve as evidence of Bass's assertion that these two sets of leadership behaviors are not independent of one another.[2] In a study of military officers and industrial managers, Waldman, Bass, and Einstein showed that those who had both transactional and transformational characteristics were much more successful than those who only had characteristics of one or the other leadership modes.[17]

In the case of perceived self reports of performance, contingent reward was the only significant predictor of performance. This is an interesting finding considering that the leaders of the distance education teams in this study really did not have the power to engage in contingent reward behavior. Contingent reward is characterized by interactions between the leader and follower that focuses on the exchange of what is expected and what is desired. These leaders had no power to promote or demote, or "pay" the team members, as all team members were students taking one course or the other. The finding that contingent reward was a good predictor of perceived group performance probably lies in the nature of the questions presented in the MLQ.[4] The tone of the questions was not what would normally be associated with providing one thing in exchange for another. Subjects were asked as to the leader's communication of what everyone needs to do to complete assignments, his or her making agreements about what is expected from everyone, and their specification as to what are expected levels of performance – the questions did not address a tangible award that was supplied by the leader in exchange for follower performance. These behaviors reflect the aspect of contingent reward that speaks to the clarification of roles and task requirements. The reward aspect of this exchange is probably expressed more so by the professor of a particular course. Jarvenpaa and Leidner, in their study of global virtual teams, and using student subjects, specifically mentioned that having the project on which the students were working to be of a significant portion of the course grade (at least 20% of the course grade) enhanced students' motivation levels.[11]

Howell and Hall-Merenda argued that a key contextual moderator of the quality of leader-follower relationships is physical distance.[9] They gathered measures of LMX (leader-member exchange), transformational leadership, contingent reward leadership, MBEA, MBEP, and rater performance of followers, and found that physical distance moderated the relationship the effectiveness of leadership behaviors. In particular, transformational leadership was significantly more related in performance in close rather than in distance relationships, whereas contingent reward leadership was significantly more related to follower performance in distant rather than in close conditions. This is because the processes by which the transactional leader exerts influence do not require as much face-to-face and non-verbal communication as do transformational leadership processes. It may be, in this study, the leader made sure to clarify at the outset what was expected from the team members such that the entire team would perform well.

In terms of the team's actual performance, both individualized consideration and passive management-by-exception behaviors were significant predictors of performance. Expression of these behaviors enhanced the performance of the team. The implication is virtual teams perform better when the leader takes a personal interest in the team members, recognizing the strengths and individual needs of team members. This can range from including team members in decisions affecting the team to understanding that each member of the team is unique and brings their own set of talents to the teaming situation. Delegating specifics tasks to individuals on the team is a good way of expressing this behavior, as it denotes personal attention being paid to a particular team member and allows the subordinate to participate in a learning opportunity that will help them develop their skills. Further, these results imply that the leader in the virtual team does not need to micromanage the virtual team, although this may be a function of the individuals that make up the virtual team. If these individuals are relatively adept at what they are doing and possess a good deal of expertise in their particular domain as it pertains to the team, they do not need to have as many checks as would a team of inexperienced individuals.

Conclusion

The implication for instructors relying on distance education to enhance students' team leadership capabilities is that the traditional means of grouping individuals needs to be re-examined. Instructors need to invest time in designing the team so as to make the experience as edifying as possible. This may include investing small amounts of class time to improving listening, decision-making, and conflict resolution skills as well as increasing their knowledge about team dynamics.

Leaders, or would-be leaders of virtual teams, can take away some valuable information as well. It matters that they project in their communication that they are capable of leading the team toward the accomplishment of team goals. This is especially the case given that there may not always be a chance for team members to interact in a face-to-face way that allows for them to build initial assessments of those with whom they are working. Attributed competency allows the team to feel as though they are capable of achieving the task hand and that the task, once achieved, will meet the levels of quality demanded by the client. Likewise, the leader should communicate in a manner so as to build team members' pride in being associated with the team.

Virtual team leaders should also realize that those working in the virtual team need a certain level of consideration. They must feel as though their leader treats them as though they are a valuable member of the team and that they bring something to the working relationship that no other team member does. This is not a mandate that the leader becomes involved in the intricacies of each team members' life, but that the leader realizes that "Joe is different from Sally, who is different from Erica, etc." In short, each team member is different, and the leader cannot relate to everyone in the same by-rote manner.

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