122nd ASEE Annual Conference & Exposition
June 14 - 17, 2015
Seattle, WA
Making Value for Society
Paper ID #12468

Sharing the Full Range of Leadership in Student Teams: Developing an Instrument

Lt. Col. Brian J. Novoselich, Virginia Tech

Brian Novoselich is an active duty Lieutenant Colonel in the United States Army and currently a Ph.D. Candidate in the Department of Engineering Education at Virginia Tech. His is a former assistant professor at the United States Military Academy. His research interests include capstone design teaching and assessment, undergraduate engineering student leadership development, and social network analysis.

Dr. David B Knight, Virginia Tech Department of Engineering Education

David Knight is an Assistant Professor in the Department of Engineering Education and affiliate faculty with the Higher Education Program, Center for Human-Computer Interaction, and Human-Centered Design Program. His research focuses on student learning outcomes in undergraduate engineering, learning analytics approaches to improve educational practices and policies, interdisciplinary teaching and learning, organizational change in colleges and universities, and international issues in higher education.

Sharing the Full Range of Leadership in Student Teams: Developing an Instrument

Introduction

The federal government and industry have called for engineers to play a more prominent leadership role in business and public service.[1-3] Increasing the technical literacy in high levels of leadership may help shape decisions which support well-informed, economically sustainable innovation and solutions to problems facing our planet.[1; 3] Because formative experiences during undergraduate years help engineers shape their professional identities,[4; 5] purposefully helping students cultivate their leadership skills is an important step toward meeting those calls. Leadership scholars suggest that shared leadership may be a more effective leadership model for knowledge work that is creative, complex and interdependent[6] compared to the historical norm of hierarchical, individual leadership.[7] Newstetter's[8] description of student engineering design team work closely resembles this creative, complex, and interdependent knowledge work where shared leadership can be effective. Because shared leadership departs from historical norms of leadership [9], novel methods are required to study leadership in this shared paradigm, including the use of social network analysis and round-robin data collection.[10] Historically individualistic leadership theory must also be examined in light of this shifting paradigm.[11] These developments require novel instruments for leadership study in this new paradigm.

This paper begins to address the measurement of shared leadership within the undergraduate mechanical engineering student design team context by examining the Full Range of Leadership model[12] as measured by the Multifactor Leadership Questionnaire (MLQ) Form 5X.[13] Through exploratory factor analysis (EFA) of round-robin data collected from mechanical engineering design team students, factor scales are examined for reliability and adequacy for use in follow-on statistical analysis.

Research Purpose

The purpose of this study was to examine the variables of the MLQ Form 5X in the undergraduate engineering student design team context to determine its utility for round-robin data collection and subsequent social network analysis. Specifically, we address the following research questions:

> **RQ1:** What constructs emerge from the application of the Full Range of Leadership Model to the undergraduate engineering student design team context?
>
> **RQ2:** How can the variables of the MLQ Form 5X be reduced to maintain reliability of the factors but reduce the length of the survey?

Review of Literature

Leadership and Team Effectiveness

Leadership scholars consistently assert leadership's impact on team effectiveness. Yukl[14], in his discussion of processes affecting team performance, states that "leaders can improve team performance by influencing these processes in a positive way" (p. 324). Stagl et al. [15] summarize current work in team leadership research and find that "the totality of research supports this assertion; team leadership is critical to achieving both affective and behaviorally based team outcomes" (p. 172). Hill [16], supports this position in her team leadership chapter. In the development of their integrative team effectiveness framework, Salas et al.[17] assert that leadership plays a central role over the lifespan of the team, claiming that despite the complexities of team leadership, "most would agree that team leaders and the leadership processes that they enact are essential to promoting team performance, adaptation, and effectiveness."[17] Additionally, Salas et al.[17] assert that team leaders play an essential role due to their synchronization of task and development cycles and for their ability to set conditions for task cycles.

The most common entry point for leadership development within the engineering curriculum has been the student design team.[18; 19] In recent years, design has increasingly been taught in project based, senior-level capstone design courses.[20] In addition to meeting ABET's culminating design experience requirements,[21] these courses often provide the context through which to bolster students' professional skills[22] in preparation for professional practice.[23]

Within the context of engineering education, recent studies of leadership development for undergraduate engineers show that faculty and programs are aware of the need for leadership development, but, due to the technical curriculum requirements for students, disagree on the best method for implementation[24-26] or ignore its development.[18] A small number of colleges and universities have developed programs that include leadership in their curriculum e.g.[27]; Bayless, Mitchell, & Robe[28] found seven, which is only a small fraction of the over 300 ABET accredited engineering colleges and universities across the United States. More often, faculty perceive leadership development as a by-product of student in-class teaming experiences or co-curricular activities.[24; 25] This disagreement in leadership development strategy for undergraduate engineers is particularly concerning due to the wide body of research that has linked leadership to team effectiveness mentioned previously.

Even though this link between leadership and team performance is described repeatedly in industrial organizational psychology literature, Borrego, Karlin, McNair, and Beddoes[29] contend that engineering faculty are not informed enough by industrial and organizational psychology literature to draw lessons from this body of knowledge. In their comprehensive review of 104 engineering education publications on team effectiveness, only seven articles showed leadership as a positive outcome of the teaming experience and did not advocate leadership as a strong method for increasing team performance.[29] This is particularly concerning in light of the scholarly literature linking leadership to team effectiveness mentioned previously. Paretti et al. [30] corroborate this gap, indicating that capstone design faculty may lack the skills necessary to contend with teaming issues overall. Based on the sharp contrast between the academy's call for increased leadership from engineers and an apparent lack of faculty emphasis on the critical role leadership can play in positive team outcomes, design education faculty may need additional tools to better understand, visualize, and mentor leadership for undergraduate engineering students.

The Shared Leadership Paradigm

Because leadership has historically been viewed as an individual, hierarchical phenomenon,[7] the current conceptualization of leadership within the engineering community and student design courses specifically may be in need of updating to a shared leadership paradigm. In this modern age of increased technology and rapid industrial pace, the shared leadership paradigm's development takes into account that it is nearly impossible for one person to have the knowledge, skills, and abilities for all aspects of highly intellectual work[6] or necessary to make well-informed leadership decisions independently. This concept of knowledge distribution across multiple people is an accurate description of a situated learning environment. Similarly, Wageman and Gardner [31] call for a re-examination of team leadership in light of the new landscape of modern collaboration. In their description of situated learning, Greeno et al. [32] describe knowledge as, "distributed among people and their environments, including the objects, artifacts, tools, books, and the communities for which they are apart."[32] This is nearly identical to Newstetter's [8] paradigm shift description of student learning in engineering design teams. This environment is also consistent with Salas et al.'s [17] integrative model of team effectiveness. In describing the theory, Salas et al. reference team leaders (plural) not team leader (singular) and describe how shared cognition affects leadership and vice-versa. Within the context of engineering education, this situated learning environment has been described by Johri & Olds [33] as a promising construct from the learning sciences that shows great potential for the transformation of learning within engineering education. To date, however, a review of design team literature shows only one study that examined shared leadership in a student design team context[34] but the researchers for this study admit that the degree of shared leadership was not measured.

Measuring Leadership Sharing

Gockel and Werth [35] advise two different methods for measuring shared leadership in teams: *rating the team* or *rating the members*. By interpreting shared leadership as an aggregated team attribute, researchers *rate the team* through a survey using direct-consensus (agreement among the members) or referent-shift consensus where the referent becomes the team or the individual members rather than the single external leader.[35-38] By interpreting shared leadership as an emerging, dyadic phenomenon, researchers *rate the members* through social network analysis of individual team member data.[35-38] Within the social network analysis, three approaches to measuring leadership sharedness have been used: 1) network centralization (variability of individual indices, 2) network density (number of influence relationships within the team) , and 3) coefficient of variation (variation of team member influence scores).[35] Meta-analyses have not addressed the use of coefficient of variance measures (see [36; 37; 38]). Gockel and Werth [35] provide only one study example using coefficient variation and that study did not actually measure shared leadership. Results of meta-analyses indicate that the interpretation of shared leadership may have an effect on the relationship between shared leadership and team performance. D'Innocenzo et al. [36] found a statistically significant difference among the two study techniques, with *rating the members* providing a stronger overall relationship. Density and centralization measures showed no significant differences in terms of effect size.[36] Wang et al. [37] and Nicolaides et al. [38] found non-significant differences, but again saw *rating the members* as providing stronger relationships.

Studying leadership in a *rating the members* approach using social network analysis creates unique challenges in data collection. Typical surveys of leadership ask participants to rate the leadership abilities of themselves or a person they recognize as holding a leadership position. For social network analysis, however, a team leadership network can only be established when data are available regarding each member's ratings of all other team members[10; 39; 40] collected in some type of round-robin fashion.[41] Due to the round-robin nature of the data, participants must respond to multiple instances of each survey question. Surveys consisting of a large number of leadership variables may be susceptible to error from survey fatigue.[42] For instance, for a five person team, one team member would be required to respond to 144 individual items as a part of a leadership survey consisting of 36 questions. As a result, survey instruments may need to be adapted to meet the demands of round-robin data collection.

A Theoretical Framework

The Full Range of Leadership model provided the leadership framework for this study. This model, which helps explain the interplay between *transactional*, *transformational*, and *laissez-faire* leadership (further described below), was first developed by Burns[43] and expanded by Bass[44] as an individual, vertical leadership model in the transformational leadership paradigm. More recent work by Avolio et al.[45; 46] has validated the study of this leadership theory within groups, which enhances its potential for utility in a shared paradigm. Recent theoretical work by Pearce and Conger[11] and refined by Pearce[6] contends that transactional and transformational leadership can and should be shared by members of a team to achieve the highest outcomes, especially in knowledge work that is interdependent, complex, and creative. This work environment is conceptually similar to Newstetter's[8] description of student work in a senior level engineering design course.

Figure 1 depicts the theoretical constructs of the Full Range of Leadership model. Transactional leadership is the baseline for adequate performance in meeting expected outcomes. This aspect of leadership focuses on the exchange of valued outcomes between leaders and followers (i.e., special recognition for adequately completing a complex task).[47] The model divides transactional leadership into three components: 1) Management By Exception-Active (MEA) (leaders actively seeking to correct mistakes through negative reinforcement and corrective criticism, i.e. "putting out fires"), 2) Management By Exception-Passive (MEP) (leaders passively seeking to correct mistakes through negative reinforcement and corrective criticism; i.e., 'if it ain't broke, don't fix it'), and 3) Contingent Reward (efforts of followers are rewarded).[12; 46] These actions enable a group to perform at expectations.[47; 48]

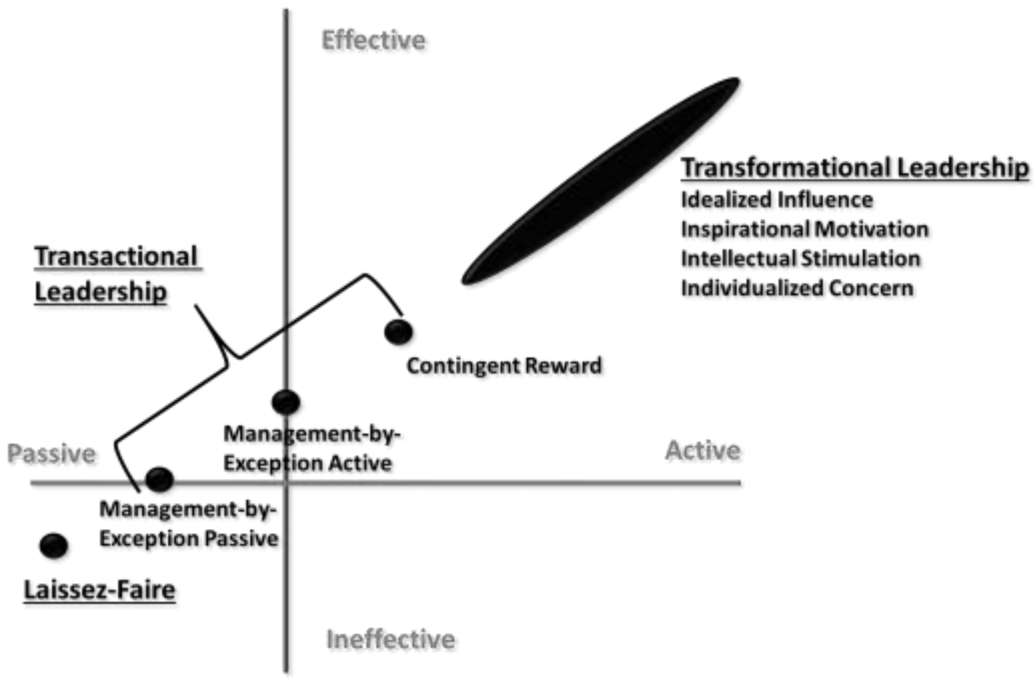


Figure 1: Full Range of Leadership; adapted from [48]

Transformational leadership, alternatively, is a set of behaviors that unites followers and changes their goals and beliefs.[47] In the Full Range of Leadership model, transformational leadership behaviors are broken down into four categories: 1) Idealized Influence (i.e., charisma, or providing a strong role model), 2) Individualized Consideration (attending to follower needs), 3) Inspirational Motivation (high performance expectations), and 4) Intellectual Stimulation (innovative thinking and challenging the status quo).[12; 46] The model contends that when transformational leadership behaviors augment transactional behaviors, group outcomes can exceed expectations.[47; 48] The Full Range of Leadership model also supports the notion of non-leadership, or laissez-faire. Non-leadership within a team directly relates to poor team outcomes.[48] The non-leadership dimension has logical correlations to the phenomenon of *social loafing* or students that do not adequately contribute within student design teams.[29]

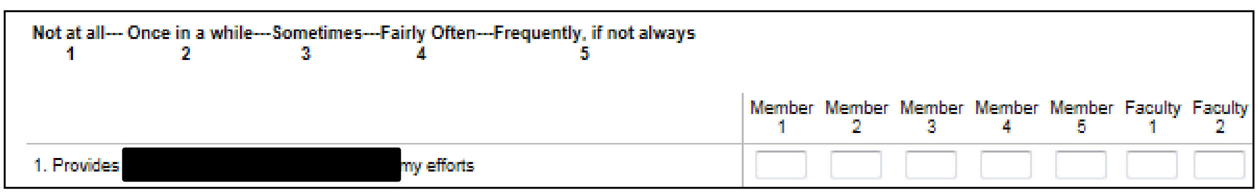
In summary, the Full Range of Leadership model provides an empirically tested framework that will be applied to analyze leadership processes within student design teams. It has a long history of use in a variety of contexts and allows for analyses at both the individual and team levels. It has also been shown to be effective in mitigating common challenges often associated with student design team effectiveness. Finally, recent theoretical literature supports its use in a shared leadership paradigm for knowledge work conditions that are consistent with the engineering student design team environment.

This model has been routinely measured for more than a decade using the Multifactor Leadership Questionnaire (MLQ),[12] the most prolific measure of transformational leadership currently in use.[48; 49] The MLQ has demonstrated adequate construct validity in both individual and group transformational leadership research[45] and has both individual and team based formats.[13] The MLQ has been validated across a wide range of contexts to include US and international graduate students, the US military, research facilities,[12; 45] business settings,[50] and project based professional environments.[51] Although studies have not specifically addressed applications to undergraduate engineering design teams, its construct validity is well established and the breadth of contexts in which the instrument has been validated indicate high probability of discriminant validity for leadership within undergraduate student engineering design teams. The challenge, however, is that the MLQ involves 36 descriptive leadership statements, which when multiplied by the multiple team members in a round-robin fashion, creates a taxing survey, especially for the study of large teams. Such a daunting survey instrument may decrease student motivation to complete the survey, leading to lower survey participation and decreased research effectiveness. To use the survey for a *rating the members* approach, the instrument must be adapted to a round-robin format which is discussed below.

Data and Methods

Sample and Data Collection

Data for this study were drawn from a total of 435 mechanical engineering capstone design students at a large, mid-Atlantic engineering research institution (n=203) as well as a smaller northeastern military focused engineering college (n=22). These responses represent 56.7% and 25.5% of the course enrollments, respectively. The data were collected in a combination of paper with online follow-up and online only survey formats at the midpoint of their year-long teaming experience. Questions stemmed from the MLQ Form 5X,[12] adapted for round-robin data collection where each team member rated each of their teammates and faculty advisor on each leadership question. Figure 2 provides an example survey item.


Not at all--- Once in a while---Sometimes---Fairly Often---Frequently, if not always
1 2 3 4 5

	Member 1	Member 2	Member 3	Member 4	Member 5	Faculty 1	Faculty 2
1. Provides [redacted] my efforts							

Figure 2: Sample round-robin MLQ survey item (text blacked out due to MLQ copyright agreement).

The students were spread across a total of 71 teams. Of these 71, only seven had 100% participation from all team members. Because this analysis analyzed the individual dyadic rating between team members, all complete surveys could be included in the analyses. A comparison of site sample demographics and program level mechanical engineering degrees awarded demographics[52] is shown in Table 1. Table 1 indicates that the site 1 sample is slightly more representative of the larger program than the site 2 sample. In particular, the site 2 sample failed to represent women and Asian students proportionally to the population.

Table 1: Study Demographics

	Gender			Race						
	Male	**Female**	**Unreported**	**African American**	**Asian**	**Hispanic**	**Pacific Islander**	**White**	**Other**	**Unreported**
Site 1 Program	90%	10.0%	0.0%	1.7%	7.3%	4.5%	0.0%	78.2%	8.3%	0.0%
Site 1 Sample (n=203)	88.2%	10.8%	1.0%	3.0%	10.8%	4.4%	0.5%	75.4%	3.4%	2.5%
Site 2 Program	97.0%	3.0%	0.0%	4.5%	6.0%	3.4%	0.0%	73.1%	3.0%	0.0%
Site 2 Sample (n=22)	100.0%	0.0%	0.0%	4.5%	0.0%	4.5%	0.0%	86.4%	4.5%	0.0%
Sample Overall	**201 (89.3%)**	**22 (9.8%)**	**2 (0.89%)**	**7 (3.1%)**	**22 (9.78%)**	**10 (4.4%)**	**1 (0.4%)**	**172 (76.4%)**	**8 (3.9%)**	**0 (0%)**

A factor analysis of pilot data responses to the 36 individual MLQ Form 5X leadership descriptive statements was conducted to investigate the scale creation of the Full Range of Leadership model (transactional, transformational, and laissez-faire). Reducing the multiple independent variables into larger factors will simplify the ability to understand latent constructs of student leadership actions within the teams and produce variables less susceptible to individual item variance. By examining factor loadings and subsequent measures of reliability using Cronbach's alpha, the factor analysis also provided justification for reduction of survey items for full data collection.

To conduct the analysis of the pilot data, all individual team member ratings were treated as separate cases. Within the context of EFA, this process is justified under the assumption that each dyadic team member relationship can be considered a specific case. Forming the data into dyads, a total of 1165 cases resulted. This was deemed sufficiently large based on Pedhazur and Schmelkin [53] discussion, and is consistent with the guidance of Cliff [54], who states, "with 40 or so variables, a group of 150 persons is about the minimum, although 500 is preferable" (p. 339). For EFA, analysis used the maximum likelihood method, consistent with Avolio et al. [12] in their previous examinations of the MLQ. The maximum likelihood method employs the likelihood ratio theory by comparing the likelihood of observing the data at hand with and without the validity of a hypothesis under consideration.[55] In this context, that hypothesis is the existence of the factors generated. EFA analysis also incorporated oblique rotation using the Oblimin with Kaiser normalization. Because all factors were related to the same phenomenon (leadership), oblique rotation was appropriate.[53; 55] Because sufficient data existed to support solution convergence, Oblimin rotation was chosen over the promax method.[56] This factor rotation helps the researcher better interpret the resulting factors by obtaining an equivalent solution to the un-rotated solution, but one where variables tend to load highly on only one factor and small loading on the rest.[55]

Due to the use of oblique rotation in the analysis, both pattern and structure matrices were considered, consistent with the recommendations of Raykov and Marcoulides [55] and Pedhazur and Schmelkin.[53] For clarity, in the discussion below only the largest factor or component loadings were reported for both the pattern and structure matrices. The pattern matrix loadings can be interpreted similar to a partial regression coefficient, indicating the unique relationship between the variable and the factor.[55] The structure matrix coefficients are computed from the pattern matrix and the variable correlation matrix. These coefficients represent correlations between the variable and the factor.[55] Taken together, loadings indicate how strongly the variable contributes to the interpretation of the factor.

Tests of the correlation matrices preceding all analyses showed adequate correlation to proceed with EFA successfully. Bartlett's test for sphericity tests the null hypothesis that the population correlation matrix is an identity matrix, meaning the analyzed variables are unrelated to each other.[55] For all analyses, statistically significant Bartlett's test of sphericity allowed for the rejection of this null hypothesis, indicating that the population correlation matrix is diagonal and allowing for successful analysis through EFA.[55] If the test failed to reject this null hypothesis, further analysis could not proceed because the items would have no relation to each other with which EFA could capitalize. Without some form of relationship between the variables, trying to group the variables in a meaningful way would not be possible. Analysis proceeded using three different factor models: an eigenvalue supported six factor model, three factors, and nine factors.

Limitations

This research design has multiple limitations. First, the sample used in this study only involves senior level mechanical engineering students at two institutions. As a result, the generalizability of these findings beyond the mechanical engineering discipline is limited, and investigating other engineering disciplines and class years should be an area of emphasis for future work. Second, because this study inordinately represents white males relative to current national engineering enrollment trends, findings may not be representative of more diverse populations. Third, sample items from the MLQ cannot be included in published documents due to copyright agreements. This limitation prevents greater clarity regarding the actual survey items with which students were asked to rate their peers. Finally, because the data analyzed in this study was a result of round-robin data collection, the independence assumption of EFA was potentially violated. This violation will be further discussed in the results section below.

Results

Eigenvalue Supported Models

Consistent with Raykov and Marcoulides [55], the Kaiser eigenvalue criterion for extraction of factors or components coinciding with eigenvalues >1 was used to extract the appropriate number of factors from the data. EFA results showed six eigenvalues greater than one, resulting in the extraction of six factors. The greatest pattern matrix and structure matrix (in parentheses) loadings are shown on Table 2 below.

Table 2: Eigenvalue supported six factor model pattern matrix loadings (structure matrix loadings in parentheses).

		Factor					
Leadership Attribute	**Item***	1	2	3	4	5	6
Transformational	IC 15	**0.400 (0.668)**					
	IC 19					**0.504 (0.595)**	
	IC 29						**-0.335 (-0.427)**
	IC 31						**-0.558 (-0.756)**
	IIA 10	**0.369 (0.644)**					
	IIA 18	**(0.599)**					**-0.233**
	IIA 21					**0.357 (0.582)**	
	IIA 25	**0.390 (0.673)**					
	IIB 14	**0.725 (0.800)**					
	IIB 23	**(0.534)**		**-0.294**			
	IIB 34	**0.396 (0.702)**					
	IIB 6	**0.445 (0.547)**					
	IM 13	**0.576 (0.730)**					
	IM 26	**0.478 (0.750)**					
	IM 36					**0.503 (0.693)**	
	IM 9	**0.612 (0.657)**					
	IS 2				**0.502 (0.689)**		
	IS 30						**-0.685 (-0.819)**
	IS 32						**-0.587 (-0.755)**
	IS 8	**0.416 (0.571)**					
Laissez-Faire	LF 28		**0.570 (0.620)**				
	LF 33		**0.456 (0.493)**				
	LF 5		**0.611 (0.693)**				
	LF 7		**0.446 (0.565)**				
Transactional	CR 1				**0.782 (0.857)**		
	CR 11	**0.492 (0.683)**					
	CR 16	**0.634 (0.756)**					
	CR 35					**0.459 (0.657)**	
	MEA 22			**-0.750 (-0.783)**			
	MEA 24			**-0.734 (-0.753)**			
	MEA 27			**-0.645 (-0.709)**			
	MEA 4			**-0.359 (-0.460)**			
	MEP 12		**0.666 (0.689)**				
	MEP 17		**0.263 (0.219)**				
	MEP 20		**0.423 (0.439)**				
	MEP 3		**0.609 (0.616)**				

*IC=Individualized Concern; IA= Idealized Influence (Attributed); IB=Idealized Influence (Behavior); IM=Inspirational Motivation; IS=Intellectual Stimulation; LF=Laissez Faire; CR=Contingent Reward; MEA=Management by Exception (Active); MEP=Management by Exception (Passive)

Cumulative R^2 values indicated that the six factor EFA model explained 50.023% of the variance of the 36 leadership items. Factors 1-3 indicated the emergence of constructs fairly consistent with the theoretical constructs of the MLQ Form 5X itself as categorized by sub-constructs of the model. Specifically, laissez-faire (LF) and passive management by exception (MEP) items loaded in factor two and active management by exception (MEA) loaded in factor three. The large majority of transformational leadership items loaded in Factor 1. Factors 4-6 demonstrated less succinct aggregation of the items than those in Factors 1-3.

Three Factor Model

As a result of the strong aggregation of items within Factors 1-3 of the eigenvalue supported (six) factor model with high consistency to the transactional, transformational, and laissez-faire constructs of the Full Range of Leadership model, a second analysis was conducted, specifying three factors for extraction. Greatest pattern matrix and structure matrix (in parentheses) loadings for the three factor EFA model is shown in Table 3.

Table 3: Three factor model pattern matrix loadings (structure matrix loadings in parentheses).

		Factors		
Leadership Attribute	**Item***	1	2	3
Transformational	IC 15	**0.681 (0.701)**		
	IC 19	**0.526 (0.512)**		
	IC 29	**0.480 (0.412)**		
	IC 31	**0.840 (0.796)**		
	IIA 10	**0.695 (0.712)**		
	IIA 18	**0.573 (0.706)**		
	IIA 21	**0.653 (0.712)**		
	IIA 25	**0.631 (0.709)**		
	IIB 14	**0.714 (0.746)**		
	IIB 23	**0.455 (0.616)**		
	IIB 34	**0.658 (0.740)**		
	IIB 6	**0.359**		**(-0.501)**
	IM 13	**0.587 (0.711)**		
	IM 26	**0.750 (0.783)**		
	IM 36	**0.747 (0.730)**		
	IM 9	**0.605 (0.627)**		
	IS 2	**0.484 (0.623)**		
	IS 30	**0.786 (0.761)**		
	IS 32	**0.793 (0.748)**		
	IS 8	**0.598 (0.586)**		
Laissez-Faire	LF 28		**0.513 (0.586)**	
	LF 33		**0.490 (0.504)**	
	LF 5		**0.664 (0.704)**	
	LF 7		**0.553 (0.604)**	
Transactional	CR 1	**0.491 (0.613)**		
	CR 11	**0.473 (0.620)**		
	CR 16	**0.696 (0.727)**		
	CR 35	**0.719 (0.723)**		
	MEA 22			**-0.727 (-0.709)**
	MEA 24			**-0.788 (-0.766)**
	MEA 27			**-0.646 (-0.711)**
	MEA 4			**-0.342 (-0.458)**
	MEP 12		**0.620 (0.656)**	
	MEP 17		**0.258 (0.207)**	
	MEP 20		**0.375 (0.419)**	
	MEP 3		**0.586 (0.596)**	

*IC=Individualized Concern; IA= Idealized Influence (Attributed); IB=Idealized Influence (Behavior); IM=Inspirational Motivation; IS=Intellectual Stimulation; LF=Laissez Faire; CR=Contingent Reward; MEA=Management by Exception (Active); MEP=Management by Exception (Passive)

In Factor 1, contingent reward (CR) items loaded heavily with the transformational leadership items instead of the transactional leadership items. The high loadings with the transformational items indicate the potential to combine the CR and transformational items into a new construct. Additionally, Factor 2 indicates that LF and passive management by exception (MEP) items loaded on the same scale. Factor 3 showed MEA items loading on a separate factor. These variable loadings indicate a departure from the original construct of the MLQ, but with the retention of the sub-components of the leadership model. As a result, the factors would need to be re-named to better describe the content of the scale variables created.

Cumulative R^2 values indicated that the three factor EFA model explained 44.698% of the variance of the 36 leadership items, slightly lower than that of the six factor models previously discussed. The results indicated that the three factor model largely mirrors the original construct of the theory. Factor 1 shows that the transformational leadership construct remains largely intact. This leadership construct remained consistent with the original MLQ development.[12] The only outlier was Item 6 which questioned a leader's discussion about values and beliefs.

Nine Factor Model

For completeness of the analysis, nine factors were also examined, consistent with the five sub-constructs of transformational leadership, three sub-constructs for transactional leadership, and one sub-construct for laissez-faire (see Figure 1). The pattern matrix loadings are shown in Table 4.

Table 4: Nine factor model pattern matrix loadings (structure matrix loadings in parentheses).

		Factor								
Leadership Attribute	**Item***	1	2	3	4	5	6	7	8	9
Transformational	IC 15						**(-0.612)**		**0.391**	
	IC 19					**0.468 (0.596)**				
	IC 29						**-0.315 (-0.435)**			
	IC 31						**-0.549 (-0.773)**			
	IIA 10									**-0.464 (-0.675)**
	IIA 18				**(-0.561)**				**0.284**	
	IIA 21				**(0.577)**				**0.303**	
	IIA 25	**0.404 (0.664)**								
	IIB 14							**-0.535 (-0.729)**		
	IIB 23					**0.268 (0.508)**				
	IIB 34	**(0.598)**				**0.331**				
	IIB 6							**-0.429 (-0.578)**		
	IM 13							**-0.27**		**(-0.600)**
	IM 26	**0.711 (0.859)**								
	IM 36					**0.520 (0.727)**				
	IM 9									**-0.481 (0.650)**
	IS 2				**0.684 (0.780)**					
	IS 30						**-0.835 (-0.886)**			
	IS 32						**-0.465 (-0.724)**			
	IS 8	**(0.476)**					**(-0.476)**	**-0.195**		
Laissez-Faire	LF 28		**0.533 (0.601)**							
	LF 33		**0.428 (0.482)**							
	LF 5		**0.572 (0.685)**							
	LF 7		**0.384 (0.536)**							
Transactional	CR 1				**0.749 (0.821)**					
	CR 11				**(0.517)**			**-0.278**		
	CR 16							**-0.424 (-0.653)**		
	CR 35					**0.633 (0.773)**				
	MEA 22			**0.750 (0.760)**						
	MEA 24			**0.698 (0.753)**						
	MEA 27			**0.600 (0.689)**						
	MEA 4			**0.279 (0.432)**						
	MEP 12		**0.648 (0.682)**							
	MEP 17		**0.247 (0.231)**							
	MEP 20		**0.389 (0.427)**							
	MEP 3		**0.633 (0.638)**							

*IC=Individualized Concern; IA= Idealized Influence (Attributed); IB=Idealized Influence (Behavior); IM=Inspirational Motivation; IS=Intellectual Stimulation; LF=Laissez Faire; CR=Contingent Reward; MEA=Management by Exception (Active); MEP=Management by Exception (Passive)

These models showed the highest explanation of variance of the three models at 53.491%. Although this model had the highest explanation of variance, this values was still less than desirable. The nine factor model showed less consistency with the theory than the three or six factor models. Although factors two and three show aggregation of items similar to those of the three and six factor models, the transformational leadership items are well distributed across the other seven factors. From a dimension reduction standpoint, this model proved much less useful than the three or six factor models previously discussed. Due to the scattering of variables across factors, interpretation of the factors to identify the higher order constructs they represent were challenging to identify. For completeness, in interpretation of the factors, statistical results were also compared across the three models.

Model Comparison

Inconclusive statistical findings added greater weight to the subjective judgment of model utility. Table 5 summarizes statistical findings for the three models analyzed. As mentioned previously, R^2 values showed that the factoring of the data resulted in generally low explanation of the total variance of the 36 leadership variables and provided little influence on model utility. In all cases analyzed using EFA, and consistent with use of the maximum likelihood method previously discussed, chi-square goodness of fit tests of the null hypothesis that the factor model was sufficient for explaining the interrelationships of the items were significant at the $\alpha=0.05$ level. These results indicated that the number of factors were insufficient for all models examined. Although this test indicated that more factors were appropriate, analysis of the communalities of the nine factor model showed this model was a, "Heywood Case".[55] In other words, regression of one or more variables on the factors resulted in a communality estimate (R^2 coefficient) greater than one and was not valid for interpretation. The Heywood Case is an indication of an improperly specified model, potentially with too few or too many factors.[55] The nine-factor model was the only model that resulted in this condition. This Heywood Case indicated that further factor analysis using additional factors to reach a non-significant chi-square goodness of fit test was inappropriate. Subjective interpretation of the three and six factor models with respect to consistency with the original Full Range of Leadership model as discussed previously in this section, ultimately indicated that that three-factor model was more suitable for use due to its consistency with the theory. Although the variables did not load consistently with the original constructs of the MLQ, the three factors extracted from the 36 variables were readily interpretable, and somewhat consistent with previous analyses of the Full Range of Leadership model, which will be further discussed below.

Table 5: Model Comparison

Six Factor	R^2	50.00%
	χ^2	1848.715
	df	42
	Sig.	0
Three Factor	R^2	44.70%
	χ^2	3171.982
	df	525
	Sig.	0
Nine Factor	R^2	53.50%
	χ^2	1197.536
	df	342
	Sig.	0

Due to substantive differences between the theory's original leadership constructs and those that resulted from data analysis, the three scales were renamed. Factor 1, which was comprised of the theory's transformational items as well as contingent reward items was named *developing*. This name articulates the notion that all items relate to leadership in a positive and constructive sense. Factor 2, comprised of both laissez faire and passive management by exception was named *passive-avoidant/laissez faire,* consistent with previous analyses of the MLQ (e.g.[12]). All of the items of management by exception-active (MEA) loaded on Factor 3. Correspondingly, the factor was renamed *active management by exception* (MEA) to reflect the fact that this factor maintained the same dimensions as the original MLQ sub-component. Table 6 shows the reliabilities of the resulting scales. The resulting three scales showed adequate reliability for use. Cronbach's Alpha scales greater than 0.70 are often referred to as adequate reliability.[57; 58] Because the end goal of the analysis is dimension reduction from the original 36 variables to their larger latent leadership constructs, in order to proceed with team level analyses, the three factor model was deemed appropriate for further analysis

Table 6: Scale reliability

Scale	Items	Cronbach's Alpha
Developing	15, 19, 29, 31, 10, 18, 21, 25, 14, 34, 6, 13, 26, 36, 9, 20, 30, 32, 8, 1, 11, 16, 35, 23	0.950
Passive-Avoidant/ Laissez-Faire	28, 33, 5, 7, 12, 17, 20, 3	0.764
Active Management by Exception	22, 24, 27, 4	0.757

Final Factor Assessment

The factor analyses conducted provide justification for studying shared leadership in three leadership factors. Both pattern and structure matrix loadings indicated that a three-factor model provided similar explanation of variance as the eigenvalue supported six-factor model. In general, the three factor model remained consistent with constructs of the original MLQ Form 5X with two notable exceptions. Although inconsistent with the current interpretation of the MLQ, previous studies corroborate these findings and give insight into the construct validity of the scales developed in this study.

First, the *developing* scale that emerged is largely comprised of transformational leadership behaviors, but with the inclusion of contingent reward behaviors. Considering the fact that contingent reward behaviors are often considered the quintessential components of transactional leadership[44; 48; 59] these loadings may appear problematic. These loadings are, however, consistent with very early examinations of transformational leadership (see [60]). This loading could be potentially explained by the fact that students typically have very little at their disposal to reward other team members other than praise, positive reinforcement, and additional help on project tasks, which may be construed as transformational in nature. When compared to more tangible reward offerings in a professional setting such as promotions, bonuses, and additional vacation time, the fact that contingent reward behaviors load quite strongly with the MLQ's transformational behaviors is not surprising. This conceptual understanding of the leadership phenomenon, corroborated by early works in the theory indicate that this scale may be measuring leadership behaviors consistent with the experiences of student mechanical engineers in a capstone setting.

Next, the *passive-avoidant/laissez-faire* scale developed departs from the current construct of the MLQ Form 5X but is consistent with previous analyses of the Full Range of Leadership. Bass's original six factor leadership model consisted of transformational, transactional, and a *passive-avoidant/laissez-faire* constructs. His subsequent five factor model separated the management by exception and laissez-faire factors.[44] Further studies in the 1990's, as described by Avolio et al. [12] and more recent studies e.g. [61; 62] recommend the return to the *passive-avoidant/laissez-faire* construct. In this scale, leadership, if it is demonstrated at all, is not exerted at the time and place where it is either most effective or most needed. The conceptual similarity of delayed and non-existent leadership provide and overarching understanding that either can be ineffective for the team. Due to its recurrence in the Full Range of Leadership literature, there is ample reason to believe this scale variable can effectively measure delayed or non-existent leadership within the engineering student design team context.

Decreasing Survey Questions

Due to overall low response rate of online surveys, a reduction of survey items from the original 36 items was desired for future administrations of the survey. Initial survey review by the research team indicated that the survey was taxing for participants in teams comprised of over 8-9 students because of the high number of responses involved with the round-robin survey items. Our data collection also demonstrated that the length of the survey may have decreased the overall response rate. Students spent from 11-27 minutes to complete the full survey. Anecdotal comments from students who completed the survey identified survey fatigue as a concern, especially for larger teams. In addition, and consistent with research on survey-based data collection (e.g. [63]), online response rates were significantly lower than the paper format. At one institution, 49% of responses were incomplete despite indications that the students opened the survey and viewed the round-robin questions. These observations all point to the need for a reduced survey length with the hope of generating a higher response rate.

Small and Rentsch [64] provided a benchmark of 12 items for a methodologically similar leadership study. To reduce the survey length, strength of factor loadings, resulting Cronbach's alpha values, face validity, and preserving the structure of the Full Range of Leadership Model were considered in that order. The survey items were rank ordered based on factor loadings to conduct the analysis. Table 7 shows a rank ordering of all items from the MLQ along with associated overall scale Cronbach's alpha and alpha-if-item-deleted values for each variable.

Table 7: MLQ survey items with factor loadings and alpha values.

		Factor			Alpha	Alpha	Alpha
Leadership Attribute	**Item**	**1**	**2**	**3**	**0.950**		
Transformational	IC 31	**.840**	.039	.054	**0.947**		
Transformational	IS 32	**.793**	.007	.076	**0.947**		
Transformational	IS 30	**.786**	.052	.011	**0.947**		
Transformational	IM 26	**.750**	-.026	-.040	**0.947**		
Transformational	IM 36	**.747**	-.029	.050	**0.948**		
Transactional	CR 35	**.719**	.000	-.007	**0.948**		
Transformational	IIB 14	**.714**	.011	-.066	**0.947**		
Transactional	CR 16	**.696**	.039	-.083	**0.948**		
Transformational	IIA 10	**.695**	-.092	.031	**0.948**		
Transformational	IC 15	**.681**	.003	-.038	**0.948**		
Transformational	IIB 34	**.658**	-.002	-.146	**0.947**		
Transformational	IIA 21	**.653**	-.264	.064	**0.948**		
Transformational	IIA 25	**.631**	-.120	-.060	**0.948**		
Transformational	IM 9	**.605**	-.030	-.020	**0.949**		
Transformational	IS 8	**.598**	-.042	.049	**0.949**		
Transformational	IM 13	**.587**	-.110	-.149	**0.956**		
Transformational	IIA 18	**.573**	-.202	-.105	**0.948**		
Transformational	IC 19	**.526**	-.047	.056	**0.950**		
Transactional	CR 1	**.491**	-.282	-.032	**0.949**		
Transformational	IS 2	**.484**	-.285	-.060	**0.949**		
Transformational	IC 29	**.480**	.231	-.031	**0.952**		
Transactional	CR 11	**.473**	-.151	-.162	**0.949**		
Transformational	IIB 23	**.455**	-.070	-.242	**0.949**		
Transformational	IIB 6	**.359**	.097	-.308	**0.950**		
						0.764	
Laissez Faire	LF 5	-.089	**.664**	.106		**0.717**	
Transactional	MEP 12	-.083	**.620**	.086		**0.715**	
Transactional	MEP 3	-.012	**.586**	.075		**0.724**	
Laissez Faire	LF 7	-.123	**.553**	.079		**0.732**	
Laissez Faire	LF 28	-.183	**.513**	.075		**0.726**	
Laissez Faire	LF 33	-.021	**.490**	.093		**0.743**	
Transactional	MEP 20	-.143	**.375**	-.133		**0.749**	
Transactional	MEP 17	.111	**.258**	-.148		**0.793**	
							0.757
Transactional	MEA 24	-.048	-.064	**-.788**			**0.666**
Transactional	MEA 22	-.049	-.121	**-.727**			**0.652**
Transactional	MEA 27	.118	.007	**-.646**			**0.683**
Transactional	MEA 4	.212	.032	**-.342**			**0.780**

A review of each factor indicated that consideration of factor loadings and Cronbach's alpha values was sufficient for survey item reduction. The research team reviewed all survey items for face validity and did not identify any items for exclusion or inapplicable to a student design team context. Analysis of the first scale indicated that maintaining the highest loading item from each of the six Full Range of Leadership model sub-components present in the scale would ensure strong factor loadings (over 0.695), decrease the scale to six items, and maintain at least one measurement of each sub-component. Because pattern and structure matrix loadings showed overall agreement in Table 3 above, only pattern matrix loadings are reported in Table 6. For Factor 2, the four highest loaded items provided equal representation of both the laissez-faire and passive management by exception sub-components within the scale and a reasonable expectation of keeping an alpha value greater than 0.70. Finally, for Factor 3, the presence of only four items and an indication of coefficient alpha values below 0.70 if any variable other than Variable MEA

4 were deleted, all four variables were maintained. Overall, these reductions would bring the original 36-item survey down to 14 items, much closer to the benchmark of 12 items.

A follow-up analysis showed that retaining only 14 items maintained the three factor leadership construct of the original data while maintaining sufficient reliability. EFA was performed on the 14 items. In this case the eigenvalues supported a three factor model. The results are shown in Table 8. Additionally, all scales showed adequate reliability as measured by Cronbach's Alpha,[58] with alpha values greater than 0.70. As a result, the full study survey included the 14 retained items from the original 36 item survey. Because violation of case independence was a concern due to the round-robin data collection process, EFA was also conducted on a random sample of the data incorporating only one dyadic pairing for each team member (N=103). In this analysis the three factor model remained consistent with alpha values greater than 0.70. These findings indicated that any violation of the independence assumption was not detrimental to study results.

Table 8: Reduced item EFA results.

			Factor			
	Leadership Attribute	**Item**	1	2	3	Alpha
Developing	**Transformational**	IC 31	**.803**	-.004	.007	0.875
	Transformational	IS 32	**.771**	-.064	-.008	
	Transformational	IM 26	**.736**	.051	-.030	
	Transactional	CR 35	**.707**	.028	-.009	
	Transformational	IIB 14	**.640**	.081	-.029	
	Transformational	IIA 10	**.673**	-.008	-.058	
Active Management by Exception	**Transactional**	MEA 22	-.110	**.795**	-.085	0.757
	Transactional	MEA 27	.126	**.648**	.038	
	Transactional	MEA 4	.162	**.371**	.056	
	Transactional	MEA 24	-.042	**.775**	-.026	
Passive-Avoidant /Laissez-Faire	**Laissez-Faire**	LF 5	-.076	-.014	**.643**	0.757
	Transactional	MEP 12	-.010	.034	**.707**	
	Transactional	MEP 3	.062	-.010	**.681**	
	Laissez-Faire	LF 7	-.069	-.033	**.557**	

The results also indicate that instrument reliability can be maintained with a reduction in variables. Through the analysis, the number of variables was reduced by 61% from 36 items to 14 items. Within this reduction, each sub-factor of the Full Range of Leadership Model was represented. These reductions maintained scale variable reliability as measured by Cronbach's Alpha at greater than 0.70 which can be considered strong scale reliability. These factors will facilitate the study of the latent constructs of the shared Full Range of Leadership within the capstone design context using variables that are less susceptible to individual item variance.

Conclusions and Future Work

This analysis indicates that a three-factor leadership model may be adequate for exploring shared leadership using a social network approach in the undergraduate, mechanical engineering capstone design team context. The factors developed in this study incorporate all aspects of the Full Range of Leadership model, using a reduced set of variables from the original MLQ Form 5X. The factors extracted from the pilot data are consistent with previous interpretations of the Full Range of Leadership and subsequent studies using this model. Although the context explored in this study is a novel application of the Full Range of Leadership, consistency with previous work is encouraging.

The results of this study have informed on-going shared leadership research within the mechanical engineering capstone design team context, and data using the reduced factors derived in this study are currently being collected. When available, these data will be further examined using confirmatory factor analysis to verify that the latent constructs of the Full Range of Leadership model elucidated in this study hold across the sample. In addition, concurrent validity of the constructs developed will be verified by exploring significant differences across race, gender, self-report leadership ability, and engineering-GPA variables. In addition, the three factors that emerged from this research will be used to conduct social network analyses of the participant teams to determine how shared team leadership relates to overall team performance and effectiveness.

References

1. National Academy of Engineering. (2004). The Engineer of 2020: Visions of Engineering in the New Century. Washington D.C., National Academies Press.
2. National Academy of Engineering. (2004). Educating the Engineer of 2020: Adapting Engineering Education to the New Century. Washington D.C., National Academies Press.
3. Wepfer, W., and Warrington, R. (2010). Vision 2030: Creating the Future of Mechanical Engineering Education. New York, American Society of Mechanical Engineers.
4. Tonso, K.L. (2014). Engineering Identity. In. Cambridge Handbook of Engineering Education Research, A. Johri and B.M. Olds, eds. New York: Cambridge, pp: 267-282.
5. Tonso, K.L. (2006). Teams that Work: Campus Culture, Engineer Identity, and Social Interactions. Journal of Engineering Education, 95 (1): pp: 25-37.
6. Pearce, C.L. (2004). The future of leadership: Combining vertical and shared leadership to transform knowledge work. The Academy of Management Executive, 18 (1): pp: 47-57.
7. Markham, S.E. (2012). The evolution of organizations and leadership from the ancient world to modernity: A multilevel approach to orgnaizational science and leadership. The Leadership Quarterly, 23: pp: 1136-1151.
8. Newstetter, W.C. (1998). Of Green Monkeys and Failed Affordances: A Case Study of a Mechanical Engineering Design Course. Research in Engineering Design, 10: pp: 118-128.
9. Pearce, C.L., and Conger, J.A. (2003). All Those Years Ago. In. Shared Leadership: Reframing the hows and whys of leadership, C.L. Pearce and J.A. Conger, eds. Thousand Oaks: Sage Publications, pp: 1-18.
10. Mayo, M., Meindl, J.R., and Pastor, J.-C. (2003). Shared Leadership in Work Teams. In. Shared Leadership: Reframing the hows and whys of leadership, C.L. Pearce and J.A. Conger, eds. Thousand Oaks: Sage, pp: 193-214.
11. Pearce, C.L., and Conger, J.A. (2003). Shared leadership: Reframing the hows and whys of leadership. Thousand Oaks, Calif.: Sage Publications.
12. Avolio, B.J., Bass, B.M., and Jung, D.I. (1999). Re-examining the components of transformational and transactional leadership using the Multifactor Leadership Questionnaire. Journal Of Occupational And Organizational Psychology, 72 (4): pp: 441-462.
13. Bass, B.M., and Avolio, B.J. (2013). Multifactor Leadership Questionnaire: The benchmark measure of transformational leadership. Menlo Park, CA, Mind Garden Inc.
14. Yukl, G.A. (2006). Leadership in Organizations. Upper Saddle River, NJ: Pearson/Prentice Hall.
15. Stagl, K.C., Salas, E., and Burke, C.S. (2007). Best Practices in Team Leadership: What team leaders do to facilitate team effectiveness. In. Developing the next generation of leaders, J.A. Conger and R.E. Riggio, eds. San Francisco: Jossey-Bass, pp: 172-197.
16. Hill, S.E.K. (2013). Team Leadership. In. Leadership: Theory and Practice, P.G. Northouse, ed. Los Angeles: Sage Publications Inc., pp: 287-319.

17. Salas, E., Stagl, K.C., Burke, C.S., and Goodwin, G.F. (2007). Fostering Team Effectiveness in Organizations: Toward an Integrative Theoretical Framework. Nebraska Symposium on Motivation, 52: pp: 185-243.
18. Farr, J.V., and Brazil, D.M. (2009). Leadership Skills Development for Engineers. Engineering Management Journal, 21 (1): pp: 3-8.
19. Farr, J.V., Walesh, S.G., and Forsythe, G.B. (1997). Leadership development for engineering managers. Journal of Management in Engineering, 13 (4): pp: 38-41.
20. Dutson, A.J., Todd, R.H., Magleby, S.P., and Sorensen, C.D. (1997). A Review of Literature on Teaching Engineering Design Through Project-Oriented Capstone Courses. Journal of Engineering Education, 86 (1): pp: 17-28.
21. ABET. (2012). 2013-2014 Criteria For Accrediting Engineering Programs. Baltimore, ABET.
22. Shuman, L.J., Besterfield-Sacre, M., and Mcgourty, J. (2005). The ABET “Professional Skills” – Can They Be Taught? Can They Be Assessed? Journal of Engineering Education: pp: 41-55.
23. Kolmos, A., and Graaff, E.D. (2014). Problem-based and Project-based Learning in Engineering Education – Merging Models. In. Cambridge Handbook of Engineering Education Research, A. Johri and B.M. Olds, eds. New York: Cambridge, pp: 141-160.
24. Cox, M.F., Cekic, O., and Adams, S.G. (2010). Developing Leadership Skills of Undergraduate Engineering Students: Perspectives from engineering faculty. Journal of STEM Education: Innovations & Research, 11 (3/4): pp: 22-33.
25. Bowman, B.A., and Farr, J.V. (2000). Embedding Leadership In Civil Engineering Education. Journal Of Professional Issues In Engineering Education And Practice (January): pp: 16-20.
26. Natishan, M.E., Schmidt, L.C., and Mead, P. (2000). Student Focus Group Results on Student Team Performance Issues. Journal of Engineering Education, July: pp: 269-272.
27. Gerhart, A., Carpenter, D., Grunow, M., and Hayes, K. (2010). Development Of A Leadership And Entrepreneurship Skills Assessment Instrument. American Society for Engineering Education Annual Conference and Exposition. Louisville, KY, American Society for Engineering Education, p. 21.
28. Bayless, D.J., Mitchell, J., and Robe, T.R. (2009). Engineering Leadership Studies and the Robe Leadership Institute Model in the Russ College of Engineering and Technology at Ohio University. 39th ASEE/IEEE Frontiers in Education Conference. San Antonio, TX, IEEE, pp: 1-6.
29. Borrego, M., Karlin, J., McNair, L.D., and Beddoes, K. (2013). Team Effectiveness Theory from Industrial and Organizational Psychology Applied to Engineering Student Project Teams—A Review. Journal of Engineering Education, 102 (4): pp: 472-512.
30. Paretti, M., Layton, R., Laguette, S., and Speegle, G. (2011). Managing and Mentoring Capstone Design Teams: Considerations and Practices for Faculty. International Journal of Engineering Education, 27 (6): pp: 1192-1205.
31. Wageman, R., and Gardner, H. (2012). The Changing Ecology of Teams: Bew directions for teams research ; editorial. Journal of organizational behavior, 33 (3): pp: 301-315.
32. Greeno, J.G., Collins, A.M., and Resnik, L.B. (1996). Cognition and Learning. In. Handbook of Educational Psychology, D.C. Berliner and R.C. Calfee, eds. New York: Simon and Schuster McMillan.
33. Johri, A., and Olds, B.M. (2011). Situated Engineering Learning: Bridging Engineering Education Research and the Learning Sciences. Journal of Engineering Education, 100 (1): pp: 151-185.
34. Zafft, C.R., Adams, S.G., and Matkin, G.S. (2009). Measuring Leadership in Self Managed Teams using the Competing Values Framework. Journal of Engineering Education, July: pp: 273-282.
35. Gockel, C., and Werth, L. (2010). Measuring and Modeling Shared Leadership Traditional Approaches and New Ideas. Journal of Personnel Psychology, 9 (4): pp: 172-180.
36. D'Innocenzo, L., Mathieu, J.E., and Kukenberger, M.R. (2014). A Meta-Analysis of Different Forms of Shared Leadership−Team Performance. Journal of Management, XX (X): pp: 1-28.

37. Wang, D., Waldman, D.A., and Zhang, Z. (2014). A meta-analysis of shared leadership and team effectiveness. The Journal of applied psychology, 99 (2): pp: 181-198.
38. Nicolaides, V.C., LaPort, K.A., Chen, T.R., Tomassetti, A.J., EricJ.Weis, Zaccaro, S.J., and Cortina, J.M. (2014). The Shared Leadership of Teams: A meta-analysis of proximal, distal, and moderating relationships. The Leadership Quarterly, 25: pp: 923-942.
39. Prell, C. (2012). Social Network Analysis: History, theory & methodology. Los Angeles, Calif: SAGE.
40. Nooy, W.d., Mrvar, A., and Batagelj, V. (2011). Exploratory Social Network Analysis with Pajek. New York: Cambridge University Press.
41. Kenny, D.A., A., K.D., and L., C.W. (2006). Dyadic Data Analysis. New York: Guilford Press.
42. Singleton, R.A., and Straits, B.C. (2010). Survey Instrumentation. In. Approaches to Social Research. New York: Oxford University Press, pp: 309-351.
43. Burns, J.M. (1978). Leadership. New York: Harper & Row.
44. Bass, B.M. (1985). Leadership and Performance Beyond Expectations. New York: Free Press.
45. Avolio, B.J., Sivasubramaniam, N., Murry, W.D., Jung, D.I., and Garger, J.W. (2003). Assessing Shared Leadership. In. Shared Leadership: Reframing the Hows and Whys of Leadership, C.L. Pearce and J.A. Conger, eds. Thousand Oaks: Sage pp: 143-172.
46. Avolio, B.J., Dong I., J., Murray, W., and Sivasubramanian, N. (1996). Building Highly Developed Teams: Focusing on shared leadership process, efficacy, trust, and performance. In. Advances in Interdisciplinary Studies of Work Teams: Team Leadership, M.M. Beyerlein, D.A. Johnson, andS.T. Beyerlein, eds. Greenwich, CT: AJI Press, pp: 173-209.
47. Kuhnert, K.W., and Lewis, P. (1987). Transactional and Transformational Leadership: A Constructive/Developmental Analysis. The Academy of Management Review, 12 (4): pp: 648-657.
48. Northouse, P.G. (2013). Leadership: Theory and Practice. Thousand Oaks, CA: Sage.
49. Jackson, B., and Parry, K. (2011). A Very Short, Fairly Interesting and Reasonably Cheap Book About Studying Leadership (2nd Ed). Thousand Oaks, CA: Sage.
50. Antonakis, J., Avolio, B.J., and Sivasubramaniam, N. (2003). Context and Leadership: An examination of the nine-factor full-range leadership theory using the Multifactor Leadership Questionnaire. The Leadership Quarterly, 14 (3): pp: 261-295.
51. Keegan, A.E., and Den Hartog, D.N. (2004). Transformational Leadership in a Project-based Environment: A comparative study of the leadership styles of project managers and line managers. International Journal of Project Management, 22 (8): pp: 609-617.
52. American Society for Engineering Education. (2015). Engineering Data Management System. Washington, D.C., ASEE.
53. Pedhazur, E.J., and Schmelkin, L.P. (1991). Measurement, Design, and Analysis: An integrated approach. Hillsdale, N.J.: Lawrence Ebraum Associates.
54. Cliff, N. (1987). Analyzing Multivariate Data. San Diego, CA: Harcourt Brace Jovanovich.
55. Raykov, T., and Marcoulides, G.A. (2008). An Introduction to Applied Multivariate Analysis. New York: Routledge.
56. Pett, M.A., Lackey, N.R., and Sullivan, J.J. (2003). Rotating the Factors. In. Making Sense of Factor Analysis, M.A. Pett, N.R. Lackey, andJ.J. Sullivan, eds. Thousand Oaks, CA: SAGE Publications, Inc., pp: 131-167.
57. Gliem, J.A., and Gliem, R.R. (2003). Calculating, Interpreting, and Reporting Cronbach's Alpha Reliability Coefficient for Likert-Type Scales. Midwest Research-to-Practice Conference in Adult, Continuing, and Community Education.
58. Cortina, J.M. (1993). What Is Coefficient Alpha? An Examination of Theory and Applications. Journal of Applied Psychology, 78 (1): pp: 98-104.
59. Hinkin, T.R., and Schriesheim, C.A. (2008). A Theoretical and Empirical Examination of the Transactional and Non-Leadership Dimensions of the Multifactor Leadership Questionnaire. The Leadership Quarterly, 19 (5): pp: 501-513.

60. Bass, B.M. (1997). Does the Transactional-Transformational Leadership Paradigm Transcend Organizational and National Boundaries? American Psychologist, 52 (2): pp: 130-139.
61. Heinitz, K., Liepmann, D., and Felfe, J. (2005). Examining the Factor Structure of the MLQ: Recommendation for a Reduced Set of Factors. European Journal of Psychological Assessment, 21 (3): pp: 182-190.
62. Tejeda, M.J., Scandura, T.A., and Pillai, R. (2001). The MLQ Revisited: Psychometric properties and recommendations. The Leadership Quarterly, 12 (1): pp: 31-52.
63. Shih, T.H., and Fan, X.T. (2008). Comparing response rates from Web and mail surveys: A meta-analysis. Field Methods, 20 (3): pp: 249-271.
64. Small, E.E., and Rentsch, J.R. (2010). Shared Leadership in Teams A Matter of Distribution. Journal of Personnel Psychology, 9 (4): pp: 203-211.