Relating Shared Leadership to Team Effectiveness

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Waning student engagement over the course of year-long capstone design projects may decrease team effectiveness and create challenges for team faculty advisors and student team leaders. As an influence process, reframing leadership processes for students may provide a tool that can bolster student effort and overall team effectiveness. Recent literature suggests that sharing leadership may be more effective than vertical leadership for complex design work, but little is known regarding shared leadership within the undergraduate engineering context. This study examines the relationship between shared leadership and team effectiveness for undergraduate, mechanical engineering capstone design teams using an adaptation of the Full Range of Leadership model. Results indicate that the overall strength and a limited sharing of select team leadership behaviors relates to a team's group process and individual satisfaction, but not task performance. This study provides capstone faculty with insights into effective leadership behaviors that may be encouraged within the capstone design experience.

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Introduction

Capstone design courses can be challenging for students because of their project-based, open-ended and collaborative nature, leading to waning student engagement[1]. When faced with such challenging academic work, students may attempt to negotiate less demanding requirements[1]. Over the course of a semester or quarter, this degradation in effort may decrease team effectiveness.

The applied nature of capstone projects, where a prototype design must perform for a customer, separates capstone courses from conventional classroom environments and requires increased self-directed learning from students. As a result, both faculty and students undergo a learning process in real-time. Faculty do not necessarily know how to address the design problem[2] or have the knowledge to navigate various team issues[3]; thus, students may be forced to navigate some of these challenges on their own. Sustaining self-directed learning may require additional support from faculty or team advisors[4].

Helping shape leadership behaviors may be one way to mitigate this potential decline in team effectiveness. Yukl[5], in his discussion of processes affecting team performance, states that "leaders can improve team performance by influencing these processes in a positive way"[6]. Stagl et al.[7] 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." Empirically, leadership has shown to significantly predict team outcomes such as team effectiveness and team performance (e.g.,[7]) in a wide variety of contexts outside of engineering design.

Currently, however, leadership is not widely perceived as an integral skill in the development of students in most engineering disciplines. Beyond engineering disciplines, shared conceptualizations of leadership[8] are calling to question long-held, vertical leadership models[9]. A gap in the literature may partially explain this perception that leadership is not integral to engineering practice, as recent work suggests that an empirically tested model for effective leadership in a team-based engineering context does not exist e.g.,[10]. Although conceptualizations of engineering leadership are beginning to depart from traditional, vertical views (i.e., a hierarchical structure with a single team leader), there is no literature that describes how leadership relates to design team effectiveness; this study provides that reference for design team faculty.

Purpose Statement and Research Questions

The purpose of this quantitative study was to examine how sharing the ME Capstone version of the Full Range of Leadership Model[11, 13] within a capstone team related to team effectiveness. The Full Range of Leadership Model accounts for multiple leader behaviors ranging from inspirational motivation to 'laissez-faire' inaction. The study addressed the following research question:

Research Question: How does the degree of shared leadership across the Full Range of Leadership relate to undergraduate mechanical engineering capstone design team effectiveness?

Leadership Framework

The Full Range of Leadership model informs this study; it has been in existence for over two decades (see[11]) and has an associated, well-established survey instrument known as the Multifactor Leadership Questionnaire (MLQ)[12]. Recent work by Novoselich and Knight[13] examined the full 36 leadership descriptive statements of the MLQ in the capstone design team context. Their study resulted in a reduced set of 14 items which were used to validate an ME Capstone version of the Full Range of Leadership model for shared leadership research[13].

Using factor analysis to examine the model for capstone design teams, Novoselich and Knight[13] identified conceptually similar combinations of the eight leadership factors relative to the original model (Figure 1). Their modified model includes transformational/ contingent reward (TCR), active management by exception (MEA) and passive-avoidant (PA) forms of leadership. The sub-constructs comprising TCR leadership involve developing team member strengths, maintaining a compelling vision, showing strong sense of purpose, and instilling pride in team members for being associated with those enacting leadership[13]. MEA leadership primarily utilizes negative reinforcement, having a consistent focus on maintaining standards in addition to identifying, and tracking mistakes among team members[14]. Passive-avoidant leadership means a delay in action until serious issues arise or a total absence of involvement, especially when needed[15].

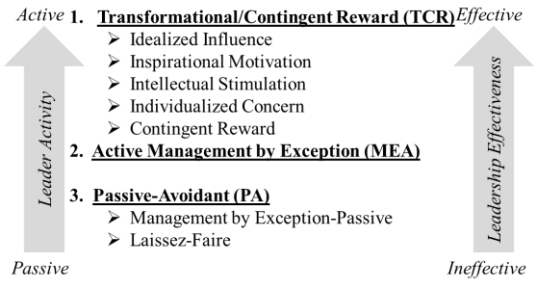

Figure 1: ME Capstone Full Range of Leadership Model

Data and Sample

Students provided a Likert scale evaluation of various leadership behaviors based on the MLQ for each team member as well as the faculty advisor. The surveys were administered to students online during the 2014-2015 academic year at the end of spring semester. Participants were enrolled in year-long, team-based, mechanical engineering, senior-level capstone design courses at a large, mid-Atlantic research university and two military-focused undergraduate institutions. This study examined the responses of 209 students (49% of survey responses) who comprised 45 complete design teams because analysis required a team-level 100% response rate.

Variables

This study used two social-network derived measures of shared leadership: 1) **network decentralization** (i.e., a measure of network dispersion) and 2) **network density** (i.e., proportion of influence relationships within the team compared to the total number possible)[16]. These two measures were calculated for each form of leadership within the teams (TCR, MEA, and PA) using the round-robin (360-degree) leadership survey data collected—To date, researchers have focused on either decentralization or density independently[17]—this research investigated both measures simultaneously as well as the interaction between the two variables. Mayo et al.[16] assert that leadership networks characterized by both high decentralization and density exhibit shared leadership.

Team effectiveness was a composite measure of group process, individual satisfaction, and task performance, consistent with Wageman[19] (Table 1).

Table 1: Team Effectiveness Variables

Effectiveness Component	Measure	Source	Description
Group Process	Extra Effort Scale	Survey MLQ form 5X	Team average 3-item scale (α=0.90)
Individual Satisfaction	Satisfaction Scale	Survey MLQ form 5X	Team average 2-item scale (α=0.90)
Task Performance	Final Presentation Grade	Course Coordinator	Grade 100 pt scale
	Final Report Grade	Course Coordinator	Grade 100 pt scale

Because faculty highlight challenges with maintaining student motivation and thoughtfulness during a prolonged project-based learning experience[1], group process measured the team's ability to garner extra effort from its members. Team members rated the frequency by which the rated member got the rater to exceed their expected level of work and willingness to succeed.

Individual satisfaction was a measure of the team's overall satisfaction with the leadership and teamwork of its members. The two items of this scale required team members to rate the frequency by which the rated member worked with and led them in satisfactory ways.

Final design presentation grades and final design report grades comprised this study's measure of task performance, reported as numerical grades by the course coordinators using a 100-point scale.

To account for potential relationships that may provide alternate explanations of team effectiveness, control variables included team size, team engineering GPA, team engineering GPA diversity, team sex (proportion female), and team leadership skills.

Methods

This study used ordinary least squares (OLS) regression to investigate the relationships between shared leadership and team effectiveness. Consistent with the recommendations of Keith[19], analyses investigated the main effects and interaction effects of the density and decentralization measures across the TCR, MEA, and PA networks for each team effectiveness dependent variable. Models with statistically significant main or interaction effects were then aggregated into more complex models and evaluated with the inclusion of control variables to determine if the relationships held while controlling for other potential explanations of team effectiveness.

To evaluate model fit, we considered the variance explained by the models adjusted for the degrees of freedom (adjusted R^2), Akaike's Information Criterion (AIC) [20], and the Bayesian Information Criterion (BIC) [21]. Including these multiple criteria allowed for better assessment of the complexity of the regression models[22]. Although multiple models were investigated within this study, only the parsimonious models are presented in this paper for clarity purposes.

Results

The results of ordinary least squares regression models (abbreviated results shown for clarity) indicated that TCR leadership was the only statistically significant predictor of team effectiveness (Table 2). Table 2 shows independent variables in columns and dependent (team effectiveness) variables in rows.

Table 2: Summarized OLS Regression Results†

N=45	Extra Effort	Satisfaction	Final Report	Final Presentation
Constant	**3.95*** **	**4.09*** **	-0.02	0.01
Team Size			-0.09	0.18
Team Eng. GPA			**0.37***	0.33
Eng. GPA Diversity			0.29	-0.03
Team Leadership Skills			0.07	-0.12
Team Sex			0.21	0.13
MEA Decentralization		0.12		
MEA Density		0.01		
INT MEA Decen Dens				
TCR Decentralization	**-0.40*** **	**-0.24** **		
TCR Density	**0.94*** **	**0.86*** **		
INT TCR Decen Dens	**-0.27** **			
PA Decentralization		-0.03		
PA Density		-0.24		
INT PA Decen Dens				
Model Adjusted R2	**0.72** **	0.78	0.08	0.05
AIC	-88.65	-114.01	0.39	1.55
BIC	-81.42	-101.36	11.10	12.25
†Standardized Coefficients; Centered Independent Variables				
*p ≤ 0.05; **p ≤ 0.01; ***p ≤ 0.001				

The parsimonious regression models for both the extra effort and satisfaction variables showed negative relationships with TCR decentralization and positive relationships with TCR density. The interaction between TCR decentralization and TCR density also showed a negative relationship with extra effort. Shared MEA and PA leadership had no significant relationship with any of the team effectiveness variables. Only the team's average GPA showed a significant relationship with the team's final report grade.

The statistically significant interaction effect between TCR density and TCR decentralization shows the moderating effect that TCR decentralization has on TCR density. Teams with low TCR decentralization show a stronger relationship between the density of TCR leadership within the team and *extra effort*. As the level of TCR decentralization increases, however, that relationship tends to get weaker. From this perspective, the amount of TCR leadership enacted by the team matters and positively relates to team members' engagement in the project, but this relationship is strongest for more vertical than shared leadership teams (teams with a smaller number of influential leaders).

Discussion

These results show that the leadership behaviors associated with TCR leadership may increase the extra effort and satisfaction of capstone design teams, but have no relationship with how the teams may perform on their final design report or presentation. More specifically, vertical leadership, when distributed across a limited number of team members, positively related to team effectiveness measures of group process (*extra effort*) and individual satisfaction (*satisfaction*) but not to task performance (course grades). These findings are consistent with Wang et al.[9] whose meta-analytic study found weaker relationships between shared leadership and task performance than the attitudinal and behavioral process aspects of team effectiveness. Across the group process and individual satisfaction measures of team effectiveness, the amount (density) of TCR leadership demonstrated positive relationships, indicating 'more is better' with regards to certain forms of leadership. The way in which the leadership is distributed across the team matters as well. As leadership is more distributed across team members (decentralization), *extra effort* and *satisfaction* tend to decrease. Descriptive statistics of the shared leadership network measures showed that no teams were characterized with decentralization scores of zero; thus, "vertical leadership" should not be synonymous with "individual leadership" for design teams. In this sample, leadership emanated from multiple team members but not all team members. Correspondingly, these results suggest there may be an optimal model that is characterized by vertical leadership being distributed across a limited number of team members as a scenario that garners greater team effectiveness in terms of extra effort and satisfaction. Advisors may encourage leadership behaviors by all

team members, but hold a smaller subset responsible for managing team efforts.

The lack of relationships between shared leadership and the measures of task performance could be explained by the subjectivity of grading a capstone design team's report and presentation. Relationships may have been confounded by several other factors, including the teams' presentation and writing ability, which were grading criteria within the rubrics of each study site.

Conclusions

This study showed that TCR leadership behaviors may enhance the extra effort and satisfaction of capstone team design teams. These behaviors include developing team member strengths, maintaining a compelling vision, showing strong sense of purpose, and instilling pride in team members for being associated with those enacting leadership. Capstone design faculty may consider helping students identify and develop these leadership behaviors as a part of the capstone design experience. Faculty should encourage TCR behaviors amongst the students. This study indicates that training both advisors and students in effective leadership practices may enhance the capstone learning experience for students.

References

1. Blumenfeld, P.C., Soloway, E., Marx, R.W., Krajcik, J.S., Guzdial, M., and Palincsar, A. (1991). Motivating project-based learning: sustaining the doing, supporting the learning. Educational Psychologist 26, 369-398.
2. Powers, L.M., and Summers, J.D. (2009). Integrating graduate design coaches in undergraduate design project teams. International Journal of Mechanical Engineering Education 37, 3-20.
3. 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, 1192-1205.
4. Pembridge, J., and Paretti, M. (2010). The Current State of Capstone Design Pedagogy. American Society for Engineering Education, 00496-00413.
5. Yukl, G.A. (2006). Leadership in Organizations.(Upper Saddle River, NJ: Pearson/Prentice Hall).
6. 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.
7. Lowe, K.B., Kroeck, K.G., and Sivasubramaniam, N. (1996). Effectiveness correlates of transformational and transactional leadership: A meta-analytic review of the mlq literature. The Leadership Quarterly 7, 385-425.
8. Pearce, C.L., and Conger, J.A. (2003). Shared leadership: Reframing the hows and whys of leadership.(Thousand Oaks, CA: Sage).
9. Wang, D., Waldman, D.A., and Zhang, Z. (2014). A meta-analysis of shared leadership and team effectiveness. The Journal of applied psychology 99, 181-198.
10. Reeve, D., Rottmann, C., and Sacks, R. (2015). The Ebb and Flow of Engineering Leadership Orientations. In 122nd ASEE Annual Conference and Exposition. (Seattle, WA, ASEE.
11. Bass, B.M., and Avolio, B.J. (1994). Improving Organizational Effectiveness Through Transformational Leadership.(Thousand Oaks: Sage).
12. Bass, B.M., and Avolio, B.J. (2013). Multifactor Leadership Questionnaire: The benchmark measure of transformational leadership. In. (Menlo Park, CA, Mind Garden Inc.
13. Novoselich, B.J., and Knight, D.B. (2015). Sharing the Full Range of Leadership in Student Teams: Developing an Instrument. In American Society for Engineering Education Annual Conference and Exposition. (Seattle, WA, ASEE.
14. Antonakis, J., and House, R.J. (2013). The Full-Range Leadership Theory: The Way Forward. In Transformational and Charismatic Leadership: The Road Ahead, B.J. Avolio and F.J. Yammarino, eds. (New York, Emerald Group Publishing), pp 3-34.
15. 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, 441-462.
16. 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, CA, Sage), pp 193-214.
17. D'Innocenzo, L., Mathieu, J.E., and Kukenberger, M.R. (2014). A Meta-Analysis of Different Forms of Shared Leadership−Team Performance Relations. Journal of Management, 0149206314525205.
18. Wageman, R. (2001). How Leaders Foster Self-Managing Team Effectiveness: Design Choices versus Hands-on Coaching. Organization Science 12, 559-577.
19. Keith, T. (2006). Multiple Regression and Beyond.(New York: Pearson).
20. Akaike, H. (1974). A new look at the statistical model identification. IEEE Transactions on Automatic Control 19, 716-723.
21. Schwarz, G. (1978). Estimating the Dimension of a Model. The Annals of Statistics 6, 461-464.

22. Miller, A. (2002). Subset Selection in Regression.(Washington, DC: Chapman & Hall/CRC).