Investigating Leadership Behaviors in a Mechanical Engineering Design Context

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- Personal leadership experiences
 - Undergraduate student teams
 - Industry engineering teams
 - Mechanical Engineering Graduate Student Council
- Understanding engineering leadership behaviors
 - Map generic leadership behaviors to engineering design activities
 - Observe leadership behaviors and their effect on project progression
- Develop better engineering team members
 - Improve an engineers' ability to lead
 - Improve engineers' ability to follow





Definition of Leadership...



Google search for "leadership"





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A Small Sample of Leadership Research

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Source	Type of Study	Information Gained
(Avey, Avolio, & Luthans, 2011)	User Study	Empirical study performed at an aerospace company, revealing leadership positivity's impact on follower positivity and performance.
(Born & Schmidt, 2016)	Case Study	Observational study of team behavior in an engineering design context. Revealing behavioral changes over the course of the project.
(Derue, D. S., Nahrgang, J. D., Wellman, N., & Humphrey, S. E. 2011)	Literature Review	This meta-analysis provides background information on leadership traits and behaviors. Evidence is presented that demonstrates the need for a model that has leadership behaviors meditate the relationship between leader traits and leader effectiveness.
(Kumar & Hsiao, 2007)		Engineering students are not taught leadership skills needed for success in an industry position. Drawing attention to the need of leadership training (courses).
(Morgeson, DeRue, & Karam, 2010)	Literature Review	Provides an in depth summarization of leadership structures and processes within a group setting. Task and Interpersonal leadership behaviors are presented.
(Norman, Avolio, & Luthans, 2010)	User Study	Demonstrates the impact of positivity and trust in leaders and their perceived effectiveness through an empirical study on business students.
(Ostergaard & Summers, 2009)		Overview of collaborative engineering design. Leadership styles are introduced and their effect on collaborative design is discussed briefly.
(Pahl, Beitz, Feldhusen, & Grote, 2007)	Text Book	Systematic approach to engineering design. Discusses group ideation techniques and working structures, however, leadership is not formally covered. Demonstrating a gap in the knowledge of engineering design.
(Palmer & Summers, 2011)	Case Study	Palmer observed two forms of leadership through case studies involving undergraduate engineering design teams, Task/Transactional and Transformational/Interpersonal.
(Shuffler, Jiménez- rodríguez, & Kramer, 2015)	Literature Review	Overview of multiteam systems research done and research needed.
(Seat, Parsons, & Poppen, 2001)		Explanation of the University of Tennessee's minor in Engineering Communication and Performance. Fills gap of from Kumar and Hsiao.
(Summers & Shah, 2002)		Summers and Shah describe the need for leadership evolution over the maturation of a project.
(Watson, Carolina, & Lyons, 2010)		Provides background on analyzing leadership skills in doctoral engineering students.

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Context

- Engineering design teams
- Team size \geq 3 members
- Tasked with producing a product design and functional prototype
- Leadership

The ability to motivate and guide individuals to effectively collaborate and work towards achieving a goal or vision

(Not proposing a new definition of leadership)





- Leadership Traits (Derue, D. S., Nahrgang, J. D., Wellman, N., & Humphrey, S. E. 2011)
 - Characteristics | Skills | Attributes
 - Gender & Age | Intelligence & Training | Extraversion & Communication Skills
- Leadership Behaviors (Morgeson, DeRue, & Karam, 2010)
 - Observable actions performed throughout a project
 - Transition Phase | Action Phase
 - Compose Team & Define Mission | Monitor Team & Provide Resources
 - Task Oriented | Relational Oriented
 - Structure & Plan | Support Social Climate & Encourage Self Management



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Leadership in Engineering Design

- Leadership in engineering design (Pahl, Beitz, Feldhusen, & Grote, 2007)
 - Demonstrates the need for strong leaders
 - What does being a strong leader mean?
- Leadership study on positivity (Avey, Avolio, & Luthans, 2011)
 - User study gauging team members' reaction to prompts
 - Not observing leader behaviors
- Team behaviors in engineering design (Born & Schmidt, 2016)
 - Coding of design journals
 - Lack of clarity and limited amount of information
- Leadership within design teams (Palmer & Summers, 2011)
 - Observing design reviews & questioned teammates
 - No direct observation of teams working



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- 1. What are the relationships between general leadership behaviors and engineering design activities?
- 2. Can a protocol be established to observe design leadership behaviors during a 4-6 month student project?
- 3. What insights into leadership behaviors and project progression does observing design team meetings with the protocol reveal?





Behavior Type	Behavior Category	Phase	Function			
			Compose Team			
	Task Oriented	Tropoition	Define Mission			
			Structure and Plan			
			Developing (Train and Develop)			
			Challenging the Team			
Leadership Behaviors			Monitor and Guide Team Tasks			
		Action	Providing Team Feedback			
		ACTION	Reward Achievements			
			Boundary Spanning			
			Performing Team Tasks			
			Consideration			
	Relational Oriented	Transition and Active	Empowerment			
			Enabling (Providing Resources)			

Leadership functions





Examples of Leadership Behaviors

Function	Examples of Function Behaviors				
	Designate required capabilities/ characteristics				
	Assess candidate capabilities/ characteristics				
Compose Team	Select members				
	Designate member roles				
	Define team relationships-Structural				
Define Mission	Set team goals and objectives				
	Establish decision making criteria				
	Draft timeline with deadlines and due dates				
Structure and Plan	Propose organizational structure				
Developing (Train and Develop)	Growing and enhancing their team and the processes they lead				
Challenging the Team	Setting obtainable project goals for team members to work towards (i.e. cost				
	reduction)				
Monitor and Guide Team Tasks	Take corrective actions when standards and goals are not met, makes changes to improve				
Providing Team Feedback	Providing performance reviews or 1 on 1 meetings to discuss performance and goals				
Reward Achievements	Setting clear standards of performance, rewarding good performance				
Boundary Spanning	Bringing normally separated groups together to work on one common goal				
Performing Team Tasks	Performing a Team Task (i.e. generating concepts or solutions with the team)				
Consideration	Indicating friendship and respect between the leader and followers				
Empowerment	Promoting sharing of decision making process to give followers more ownership				
Enabling (Providing Resources)	Enabling followers to address their tasks, learn, and enhance their skills				
	Examples of leadership behaviors				

Examples of leadership behaviors



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Leadership vs. Leadership Matrix







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- Engineering design behavior models
 - Task/Episode Accumulation (TEA) Model (Ullman, Dietterich, & Stauffer, 1988)
 - Established from speak a loud protocol studies
 - Ideal for individual's doing design
 - Taxonomy for Collaborative Design (Ostergaard & Summers, 2009)
 - Established a framework to characterize collaborative design
 - Provides a static characterization of the design team
 - Function Behavior Structure (FBS) Framework (Gero & Kannengiesser, 1996)
 - Identifies design process applicable to multiple fields
 - Limited application to collaborative design







- 5 Graduate student teams
 - 4 Students per team
 - Engineering design researchers
- Current Work in Process
 - Protocol being established through iterative coding sessions
 - Interrater reliability \rightarrow 10/2/17



Team of 4 performing function protocol exercise







- 1 ME 4020 project's 3 teams (N=3)
 - 4 Students per team
 - Mechanical engineering seniors
- Team observations
 - Recording weekly team meetings (≥ 1 hour per team)
 - Recording weekly design reviews (~30 minutes per team)
 - Capturing team email communication
- Each video will be coded for engineering leadership behaviors
 - Identifying leaders in team meetings
 - Identifying leaders in design reviews
 - Understand how leadership changes over the course of the project







Fall 2017 Data Collection

15/18 2017.09.19



Screen shot of a weekly team meeting recording







Fall 2017 Data Collection



Screen shot of a weekly design review







- Are the leaders identified by the protocol the same leaders identified by the project advisers?
- What level of insight into team leadership behaviors does the protocol provide when compared to surveys?
- How well do the teams' email communication align with the insight provided by the established observation protocol?





Thank You For Your Attention

QUESTIONS?





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Data Collection Tool

Observer: Analysis Date:			Leadership in Engineering Design Observation Form					Team Observed Observation Date Source Video File			
Number 1	Function (Acronym) DM	Per. A	Per. B	Per. C	Per. D	Per. E	Per. F	Quality	Star	rt Time	End Time
Observer: Analysis D	ate:			ship in E Observ	Engineer ation Fo	ring Des orm	ign			Ti Obs Sou	eam Observed servation Date urce Video File
Duration	Function (Fu Define Mission	II)	Tra	P ansition	hase	1	Behavi Task Or	or Catego iented	ory	Behavi	or Observed



