

- Education

- B.S. Mechanical Engineering, Clemson University, 2016
- Joined CEDAR August 2016

- Projects

- NASA/Freight Farms – Leafy Green Machine
- BMW Cognitive Associate

- Accepted Papers

- **Chickarello, D.**, Agyemang, M., Gill, A. S., Summers, J. D., Turner, C. J., & Wagner, J. R. (2017). Extraterrestrial Farming with the Leafy Green Machine – LED Performance Testing. In *47th International Conference on Environmental Systems*. Charleston, SC.
- Righter, J., **Chickarello, D.**, Stidham, H., O'Shields, S., Patel, A., & Summers, J. D. (2017). Literature Based Review of a Collaborative Design Taxonomy. In *ICED17 21st International Conference on Engineering Design*. Vancouver, BC, Canada.
- Righter, J., **Chickarello, D.**, Kramer, W. S., Summers, J. D., & Shuffler, M. L. (2017). The Classification And Conduct Of Engineering Team Design Review Meetings: An Organizing Taxonomy of Influencing Factors. In *The Twelfth Annual INGroup Conference*. St. Louis, MO.
- Righter, J., Blanton, A., Stidham, H., **Chickarello, D.**, & Summers, J. D. (2017). A Case Study of the Effects of Design Project Length on Team Collaboration and Leadership in Senior Mechanical Engineering Projects. In *2017 International Design Engineering Technical Conference & Computers and Information in Engineering Design*. Cleveland, OH: ASME.
- Patel, A., O'Shields, S., **Chickarello, D.**, Summers, J. D., & Turner, C. J. (2017). Change in Peer Efficacy of Senior Design Students During a Design Project: A Case Study. In *ICED17 21st International Conference on Engineering Design*. Vancouver, BC, Canada.

- Papers in Review

- **Chickarello, D.**, Righter, J., Patel, A., Summers, J.D. (2018). Establishing a Protocol to Observe Leadership Behaviors in Engineering Design Teams. In *2018 International Design Engineering Technical Conference & Computers and Information in Engineering Design*. Quebec City, Canada: ASME.

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# **Establishing a Protocol to Observe Leadership Behaviors in Engineering Design Teams**

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Doug Chickarello

## Committee Members

Dr. Joshua D. Summers, Mechanical Engineering

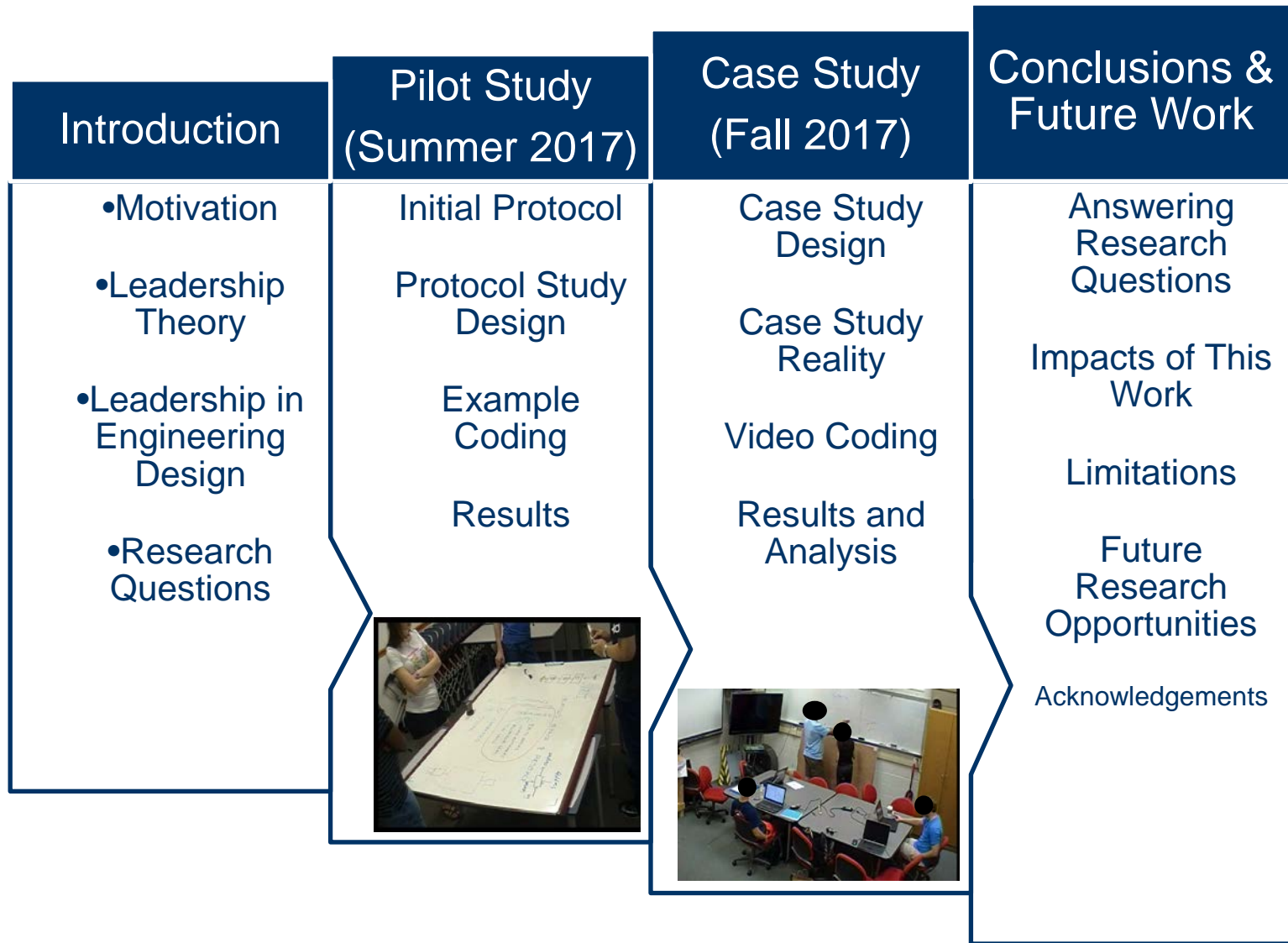
Dr. Marissa Shuffler, Industrial/Organizational Psychology

Dr. Gregory Mocko, Mechanical Engineering

Department of Mechanical Engineering

Clemson University

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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
  - Identify technical leadership
- Develop better engineering team members
  - Improve an engineers' ability to lead
  - Improve engineers' ability to follow



- Trait theory
- Behavior theory
- Contingent
- Functional Leadership
  - Observable actions performed throughout a project
  - Functions represent roles a leader routinely performs
- Leader-Member Exchange theory
- Transformational and Transactional theories



Table 5 Leadership function types (Marks et. a. 2001)

Leadership Function Type	Definition
<b>Transition</b>	In transition phases, teams are establishing goals and plans to achieve the overall team mission. Leaders are also reviewing team performance and providing feedback to ensure team members understand how to better focus their efforts.
<b>Action</b>	Teams are working to achieve the goals established in the transition phases. In action phases leaders are managing the team boundary, solving problems, and monitoring and guiding team tasks.
<b>Interpersonal</b>	Interpersonal leader functions focus on building effective team member relationships that improve the function of the team. The functions include supporting the social climate, consideration, and empowerment.



Leadership Function	Type	Definition
Compose Team	Transition	Selecting individuals that can achieve the goals outlined for the team.
Define Mission	Transition	Determining and communicating the <u>organization's</u> performance expectations for the team.
Establish Expectations and Goals	Transition	Identifying internal performance expectations for <u>team</u> members and setting internal team goals.
Structure and Plan	Transition	Developing an understanding of how best to coordinate team actions and work together to achieve the established goals and expectations.
Train and Develop	Transition	Identifying deficiencies in team capabilities and providing training and opportunities for the team to enhance its skill set.
Sensemaking	Transition	Identifying and interpreting essential environmental events and communicating this interpretation.
Provide Feedback	Transition	Providing feedback on performance against established goals and milestones.
Monitor Team	Action	As team is actively involved in work, the team's progress and performance must be monitored to ensure the team is on target for reaching their goals.
Manage Team Boundaries	Action	Managing the relationships between the team and the external environment (other teams, the larger organization, customers, and other influences on the team).
Performing Team Task	Action	Performing work required for the team activity or project.
Challenge Team	Action	Challenging the team with respect to their performance levels, processes, standards (rules & regulations), and attitudes.
Solve Problems	Action	Diagnose and solve any problems that keeps the team from achieving its potential.
Provide Resources	Action	Acquiring financial, informational, material, and personnel resources for the team to use to complete their tasks and achieve the team mission.
Encourage Team Self-Management	Action	Encouraging the team to manage itself and perform its own leadership functions.
Support Social Climate	Interpersonal	Supporting the team's social climate involves dealing with interpersonal issues that may hinder the team's performance.
Empowerment	Interpersonal	Showing concern and respect for individual team members.
Consideration	Interpersonal	The act of strengthening an individual's beliefs in his or her sense of effectiveness.

Type of Study				Study Information	Leadership Characteristic Studied									
Case Study	Experimental Study	Literature Study	Simulation Study	Reference	Collaboration	Team Distribution	Leadership Education	Communication	Style	Boundary Spanners	Transformation & Transactional	Leader Positivity	Structure	Project Length
X				Hitt, Nixon, Hoskisson, and Kochhar, 1991	X	X								
X				Seat et al., 2001			X							
X				Osborn et al., 2006				X						
X			X	Schreiber and Carley, 2006					X					
		X		Ostergaard and Summers 2004 & 2009	X									
X				Kumar and Hsiao, 2007			X							
X				Kratzer et al., 2008				X						
X				Di Marco et al., 2010						X				
X				Watson and Lyons, 2010			X							
X				Palmer and Summers, 2011							X			
	X			Avey et al., 2011								X		
X				Taylor and Ahmed-Kristensen, 2015		X								
X				Novoselich et al., 2016									X	
X				Knight and Novoselich, 2017			X							
X				Righter, Blanton, et al., 2017										X
13	1	1	1	Total	2	2	4	2	1	1	1	1	1	1



RQ.1. What are the relationships between functional leadership behaviors and engineering design space?

RQ.2. What insights into functional leadership behaviors and project progression does observing design team meetings with a leadership protocol reveal?

MQ.1. Can a protocol be established to observe functional leadership behaviors in student teams during a 4-6-month design project?



Introduction	Pilot Study (Summer 2017)	Case Study (Fall 2017)	Conclusions & Future Work
<ul style="list-style-type: none"><li>•Motivation</li><li>•Leadership Theory</li><li>•Leadership in Engineering Design</li><li>•Research Questions</li></ul>	<p>Initial Protocol</p> <p>Protocol Study Design</p> <p>Example Coding</p> <p>Results</p>	<p>Case Study Design</p> <p>Case Study Reality</p> <p>Video Coding</p> <p>Results and Analysis</p>	<p>Answering Research Questions</p> <p>Impacts of This Work</p> <p>Limitations</p> <p>Future Research Opportunities</p> <p>Acknowledgements</p>

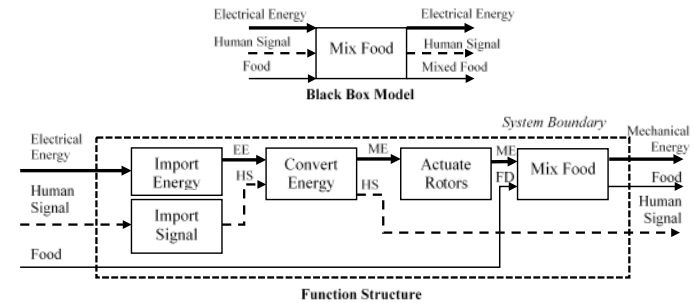
Summer 2017

# PILOT STUDY

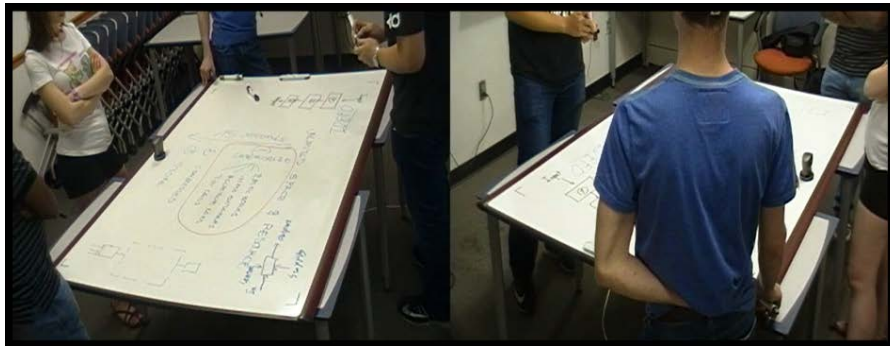


- Protocol Study
  - Graduate student team (4)
  - Engineering design researchers
  - Different universities
  - Multicultural
- Data Collection
  - Recorded 2 cameras

- Function Modeling



Example of a black box function structure



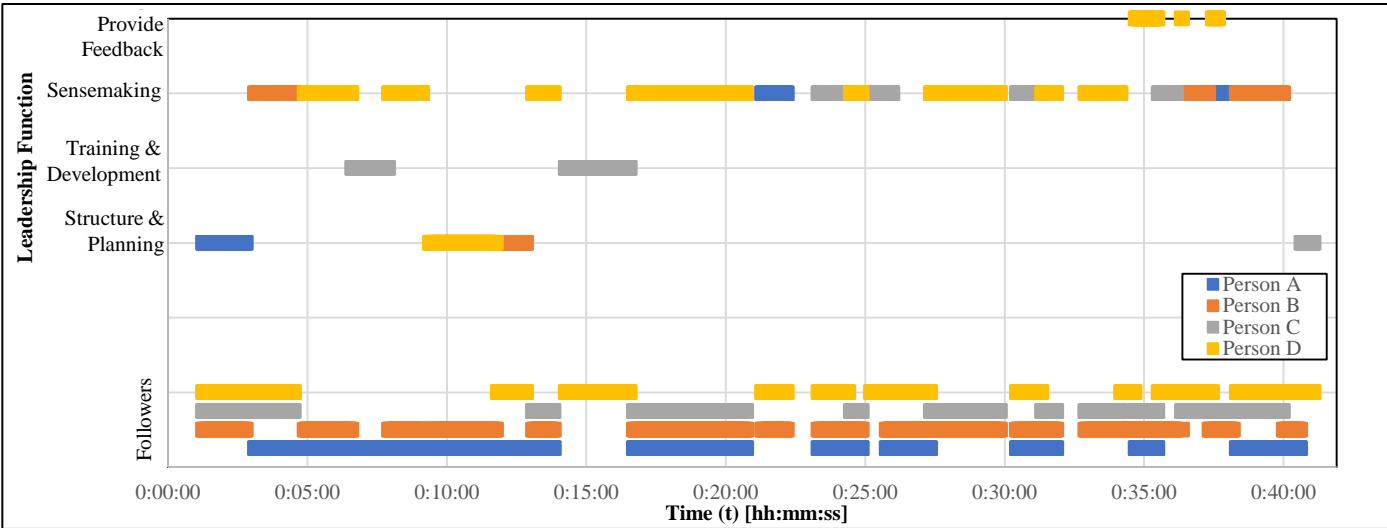
Team performing function structure activity

“Design an automatic recycling machine for household use. The device should sort plastic bottles, glass containers, aluminum cans, and tin cans. The sorted materials should be compressed and stored in separate containers. The amount of resources consumed by the device and the amount of space occupied are not limited. However, an estimated 15 seconds of recycling time per item is desirable.”

Activity Prompt

IRB2016-343





Graphic representation of code from Rater A'

Start Time	End Time	Duration	Number	Function (Acronym)	Per. A	Per. B	Per. C	Per. D
0:01:15	0:02:47	0:01:32	1	SP	L	F	F	F
0:03:06	0:04:31	0:01:25	2	SM	F	L	F	F
0:04:53	0:06:35	0:01:42	3	SM	F	F		L
0:06:35	0:08:12	0:01:37	4	TD	F		L	
0:07:55	0:09:07	0:01:12	5	SM	F	F		L
0:09:23	0:11:45	0:02:22	6	SP	F	F		L
0:11:48	0:12:50	0:01:02	7	SP	F	L		F
0:13:04	0:13:50	0:00:46	8	SM	F	F	F	L
0:14:14	0:16:34	0:02:20	9	TD			L	F
0:16:42	0:20:44	0:04:02	10	SM	F	F	F	L

Code from Rater A' (partial)



- Each code aligned (0-40:00)
- Evaluates levels of agreement between raters
  - Rater agreement higher or lower than statistically expected
- Achieved fair agreement
  - Acceptable for number of fields

Levels of agreement for Cohen's Kappa (Viera & Garrett, 2005)

Kappa Value	Agreement Level
< 0	Less than chance agreement
0.0 – 0.2	Slight agreement
0.2 – 0.4	Fair agreement
0.4 – 0.6	Moderate agreement
0.6 – 0.8	Substantial agreement
0.8 – 1.0	Almost perfect agreement

Protocol Study Percent Cohen's Kappa Analysis

Cohen's Kappa Value - Time Analysis																			
Event ID				LF Type				Leadership Function ID				Leader ID							
				Rater 1								Rater 1							
				J	C	D2	J					C	D2	J	C	D2			
Rater 2	D	0.34	0.13	0.28	Rater 2	D	0.27	0.09	0.35	Rater 2	D	0.09	0.20	0.36	Rater 2	D	0.26	0.24	0.36
	J		0.45	0.34		J		0.37	0.35		J		0.24	0.29		J		0.10	0.39
	C			0.10		C			0.09		C			0.16		C			0.24

- Results

- Protocol did not capture engineering design context
- Leadership requires influence

- Protocol Modifications

- Design Space
- Design Activity
- Performing Team Task
- Attendance

Design Space	Definition
Problem	Working on understanding the problem, the users, or the use cases.
Solution	Work revolving around the design of potential solutions. (concept generation, prototyping, detailed design, etc.)
Project	Planning team meeting/work sessions, identifying team goals for the semester, assigning responsibilities to team members, etc.

Design Activity	Definition
Synthesis	The creation of new material that is relevant to the problem, solution, or project.
Analysis	Studying, testing, or predicting the current design information that the team has available.
Decision Making	Review of the current design information and analyses to change the make a choice or decision influencing the project.
Communication	Any communication of design information or material internal or external to the design team.
Transformation	Process of taking design information in one representational state and transforming it into another



Observer:

## Leadership in Engineering Design Observation Form

Team Observed:

Analysis Date:

Observation Date:

Source Video File:



Leadership Behavior Coding		Design Activity Coding		Individual Behavior Coding						Attendance						Time Recording		
Number	Leadership Function	Design Space	Design Activity	Per. A	Per. B	Per. C	Per. D	Per. E	Per. F	Per. A	Per. B	Per. C	Per. D	Per. E	Per. F	Start Time	End Time	
<ul style="list-style-type: none"> <li>• Compose Team</li> <li>• Define Mission</li> <li>• Establish Expectations and Goals</li> <li>• Structure and Plan</li> <li>• Train and Develop</li> <li>• Sensemaking</li> <li>• Provide Feedback</li> <li>• Monitor Team</li> <li>• Manage Team Boundaries</li> <li>• Challenge Team</li> <li>• Performing Team Task</li> <li>• Solve Problems</li> <li>• Provide Resources</li> <li>• Encourage Team Self-Management</li> <li>• Support Social Climate</li> <li>• Empowerment</li> <li>• Consideration</li> </ul>		<b>Design Space</b>	<ul style="list-style-type: none"> <li>• Problem</li> <li>• Project</li> <li>• Solution</li> </ul>	<ul style="list-style-type: none"> <li>• Leader</li> <li>• Follower</li> </ul>						<ul style="list-style-type: none"> <li>• Absent</li> </ul>								

Page 1 | 2

Template Updated: 1/24/2018



Introduction	Pilot Study (Summer 2017)	Case Study (Fall 2017)	Conclusions & Future Work
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Fall 2017

# CASE STUDY

- ME 4020 project teams (N=3)
  - 3 Teams tasked with the same project
  - Team – 4 students
  - Mechanical engineering seniors
  - 15 Weeks
- Team observations
  - **Weekly team meetings (60 minutes per team)**
  - **Weekly design reviews (30 minutes per team)**
  - Captured the teams' email communication
- Project Objective
  - Design a material handling unit to raise, lower, & translate up 6,000 lbs



Meeting

Design Review



IRB2016-343



- 9/11/7 – 9/12/17 – Hurricane Irma
  - Clemson closed → No data collection
- 10/23/2017 – Sponsor altered the project format
  - Combining the 3 independent teams into 1 multiteam system
  - Teams to build Team A's concept design
  - Case study terminated after week 6

Breakdown of team meetings captured

Week	Date	Team A	Team B	Team C
1	9/14/2017	Hurricane		60 min
2	9/21/2017	60 min	60 min	60 min
3	9/28/2017	60 min	60 min	30 min
4	10/5/2017	60 min	60 min	60 min
5	10/12/2017	60 min	60 min	60 min
6	10/19/2017	Fall Break		60 min
Totals		240 min	240 min	330 min

Breakdown of design reviews captured

Week	Date	Team A	Team B	Team C
1	9/14/2017	30 min	30 min	30 min
2	9/21/2017	30 min	30 min	30 min
3	9/28/2017	30 min	30 min	30 min
4	10/5/2017	30 min	30 min	30 min
5	10/12/2017	30 min	30 min	30 min
6	10/19/2017	30 min	30 min	30 min
Totals		180 min	180min	180 min

810 min  
(13.5 hr)

1,350 min  
(22.5 hr)

540 min  
(9 hr)



- Practice coding sessions
- Watch each video in its entirety
- Watch video again, pausing to capture each observation of functional leadership
- Processing time = 2.5 – 3.0 hours/video

Breakdown of recording analysis

Rater A	Rater B
Weekly Team Meeting	Weekly Design Reviews



1

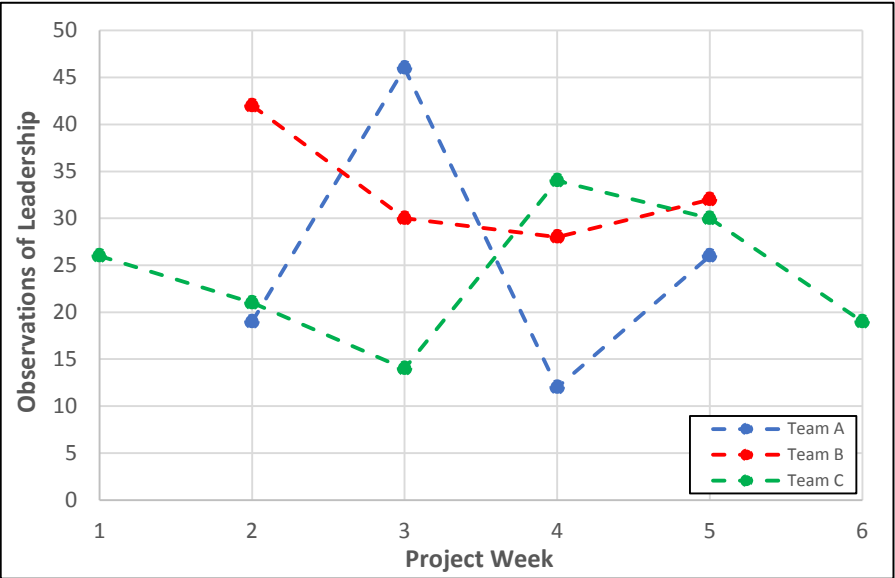


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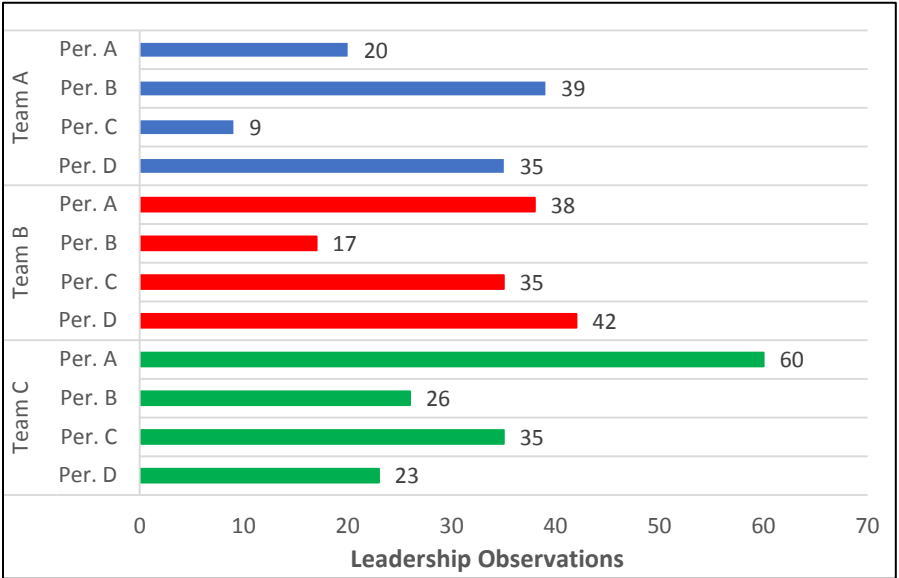


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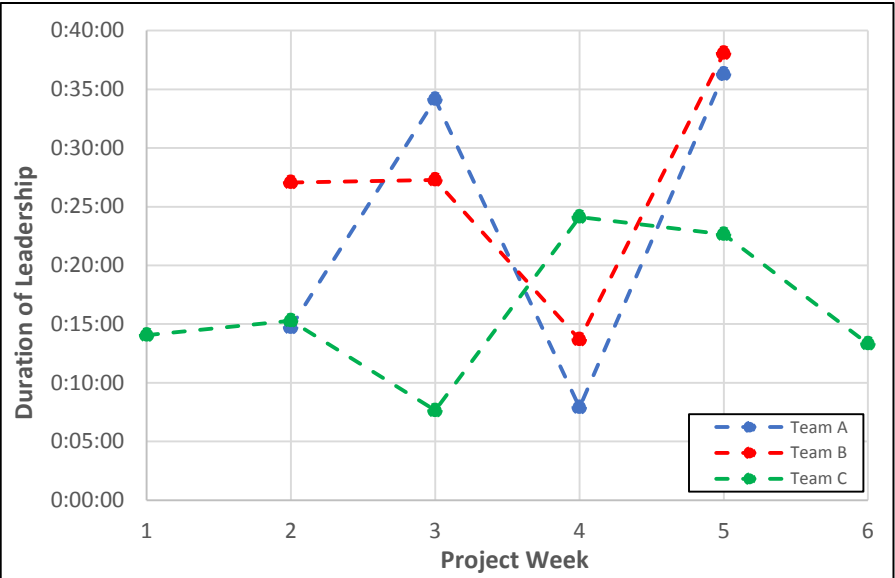




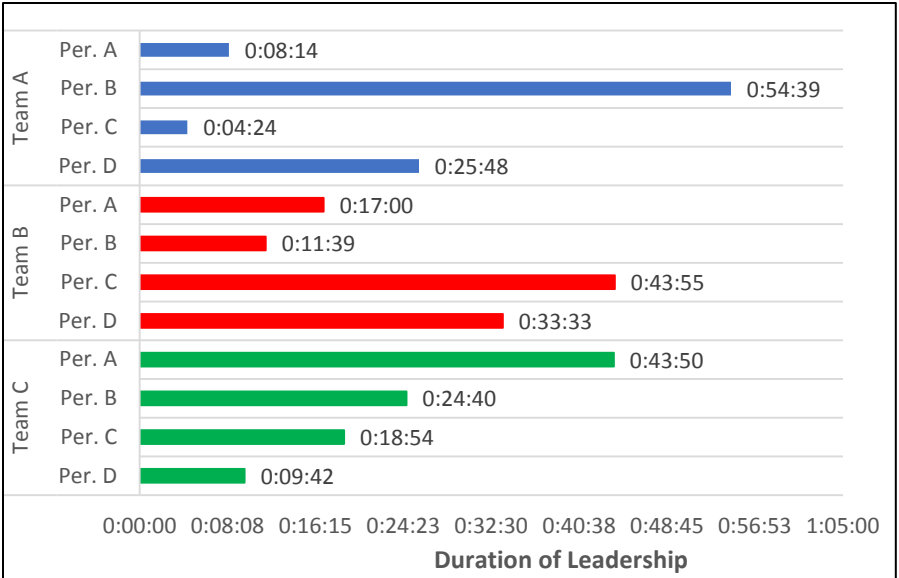
Number of team leadership observations



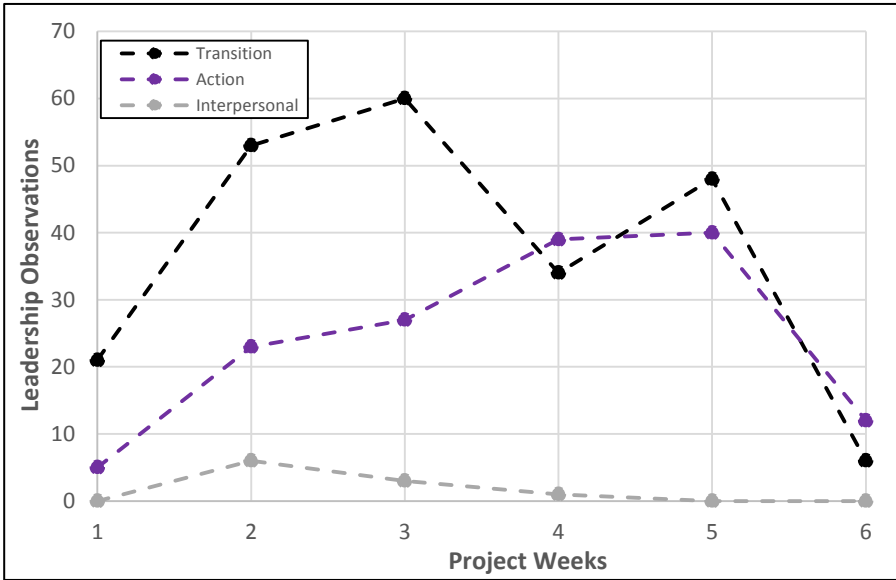
Number of individual leadership observations (total)



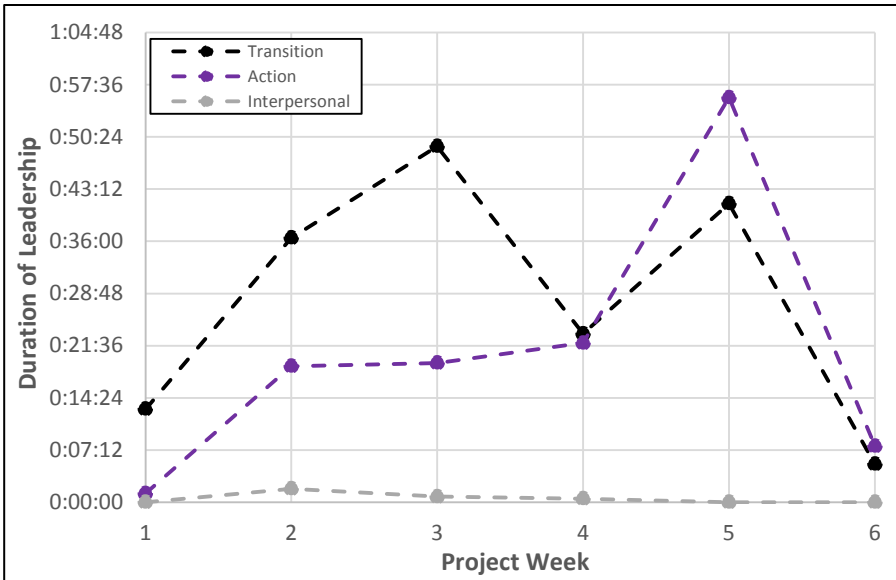
Duration of team leadership observations



Duration of individual leadership observations (total)



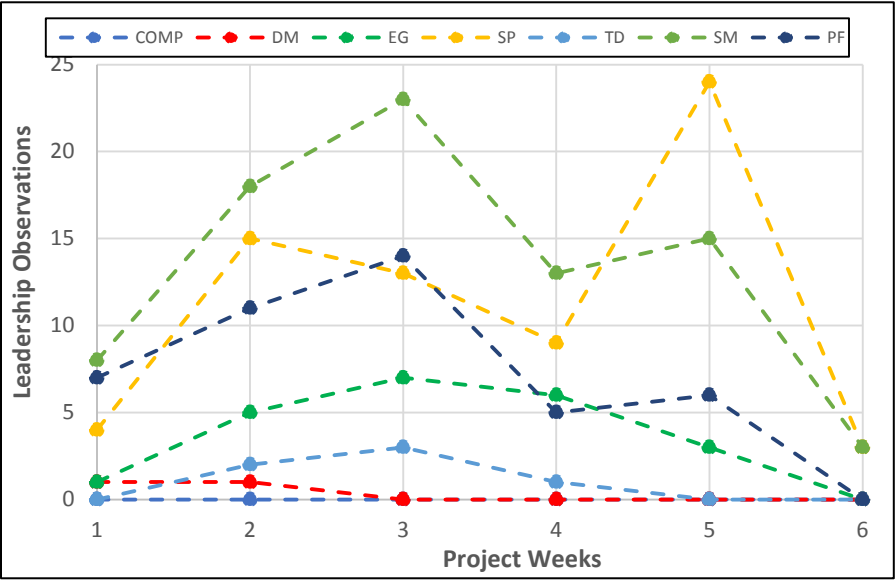
Number of leadership type observations



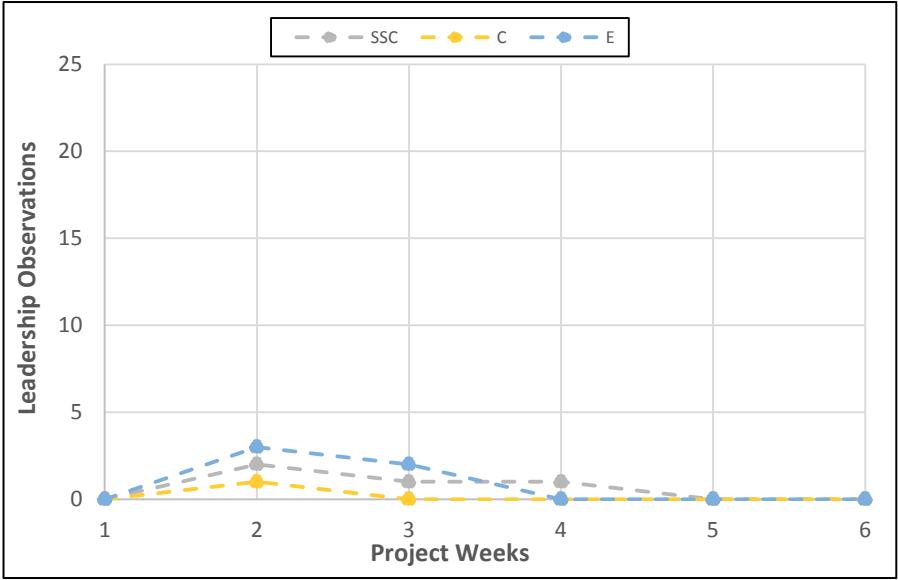
Duration of leadership type observations

- All Teams
- Transition behaviors observed first
- Action behaviors increased over time

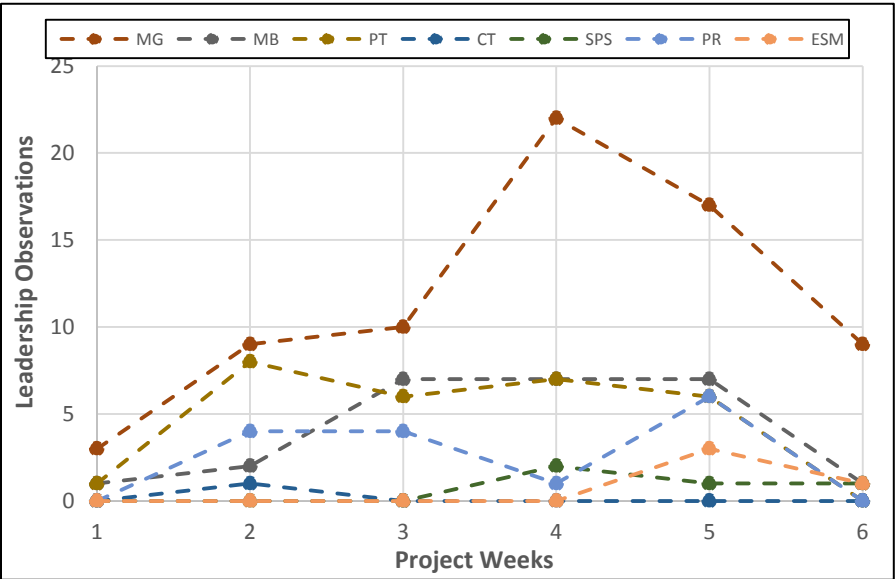
Teams A and B did not meet on  
Weeks 1 & 6



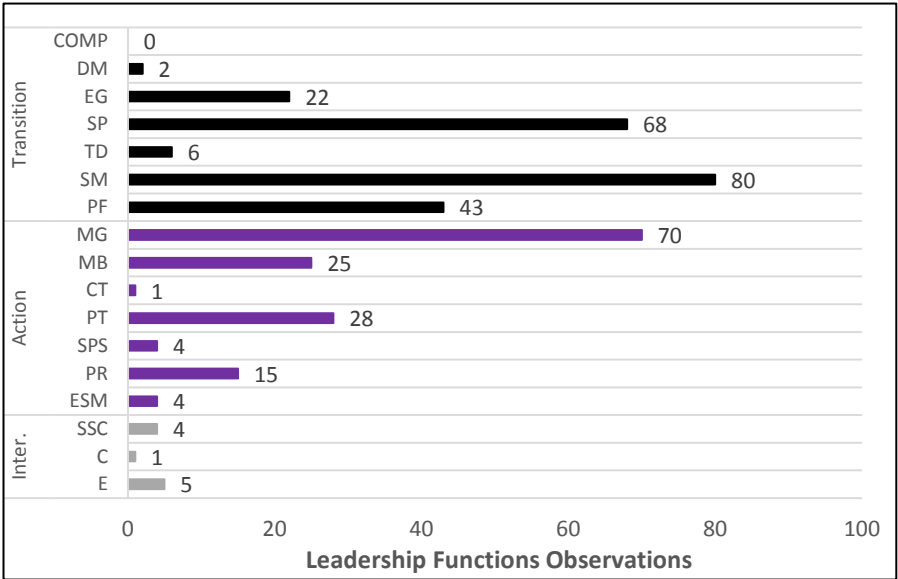
Transition functions over time



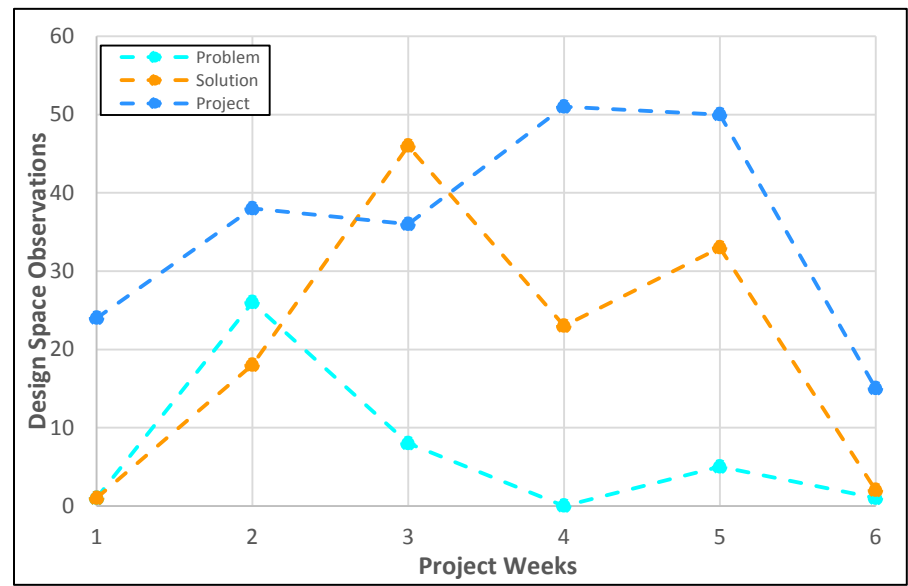
Interpersonal functions over time



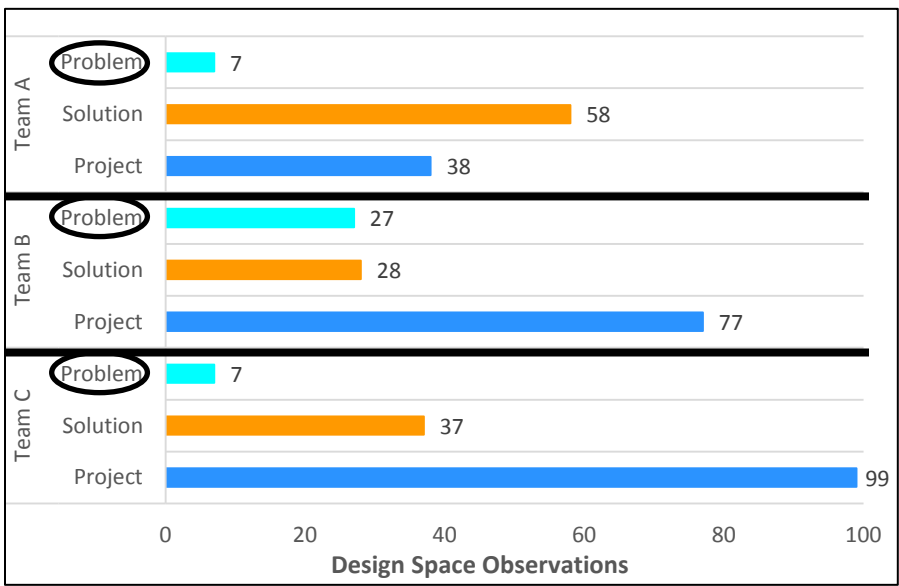
Action functions over time



Leadership function observations (total)

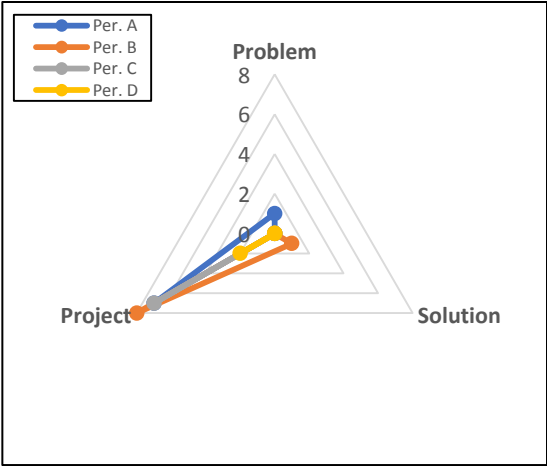


Number of design space observations

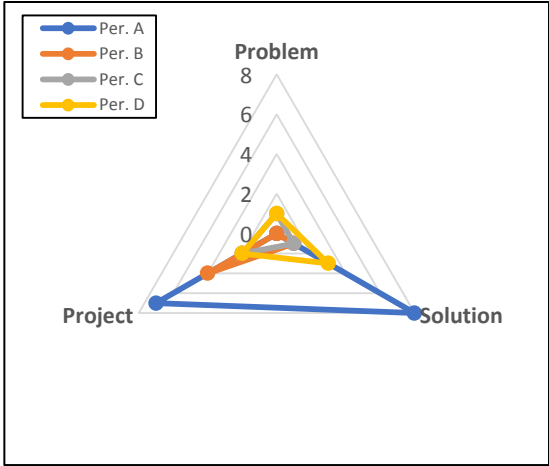


Number of design space observations (total)

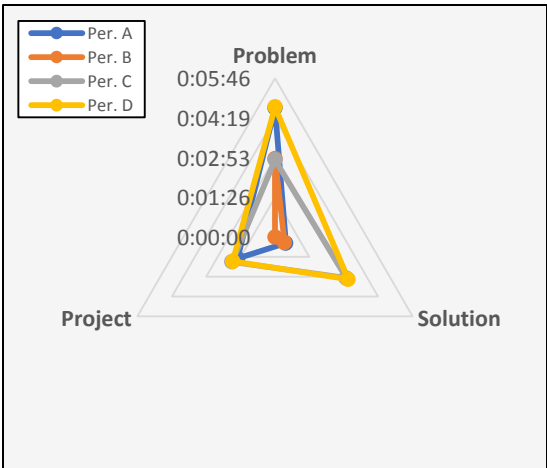




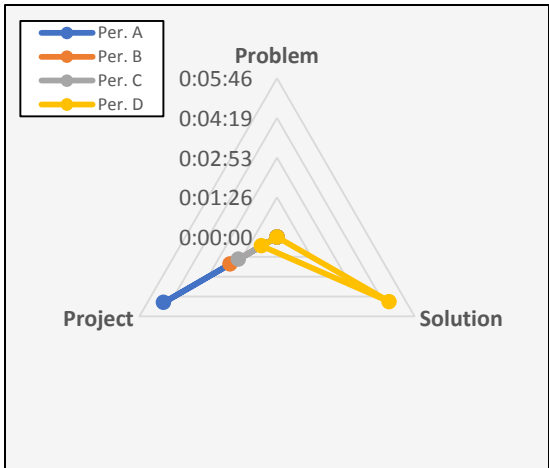
Team C, Week 1 Space  
Observations



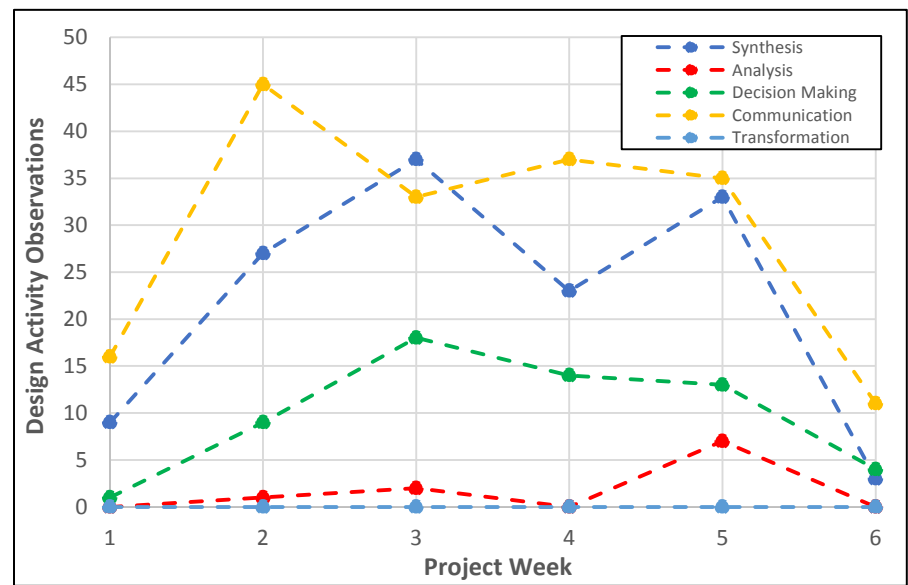
Team C, Week 5 Space  
Observations



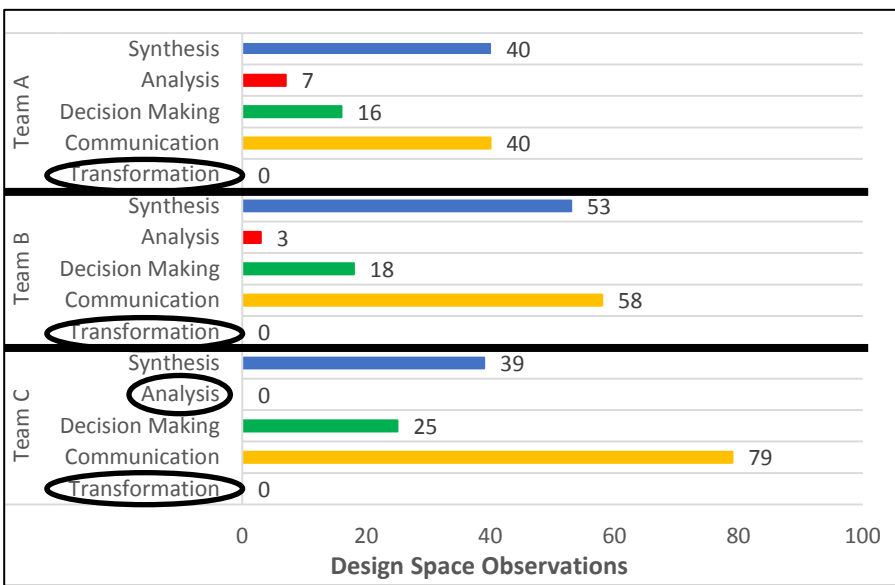
Team B, Week 2 Space  
Observations



Team B, Week 4 Space  
Observations

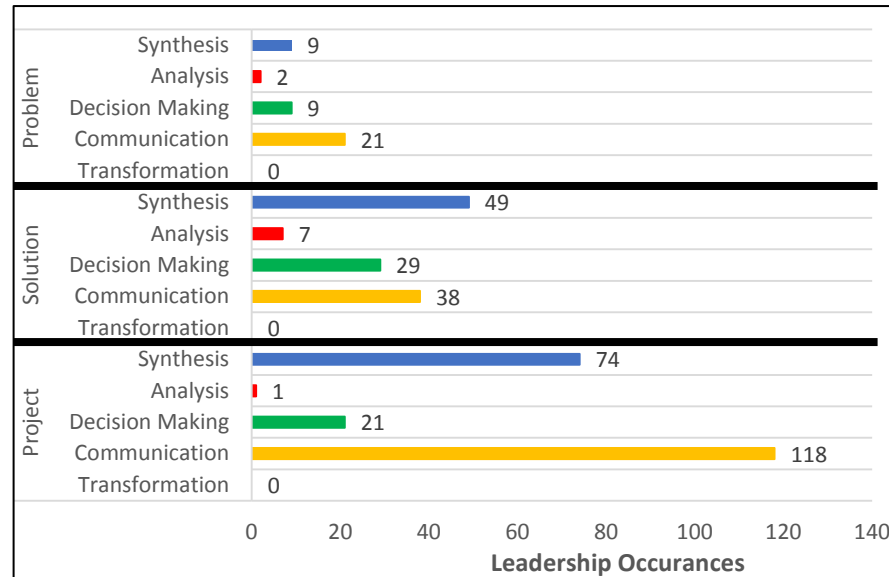


Number of design activity observations (weekly)



Number of design activity observations (total)

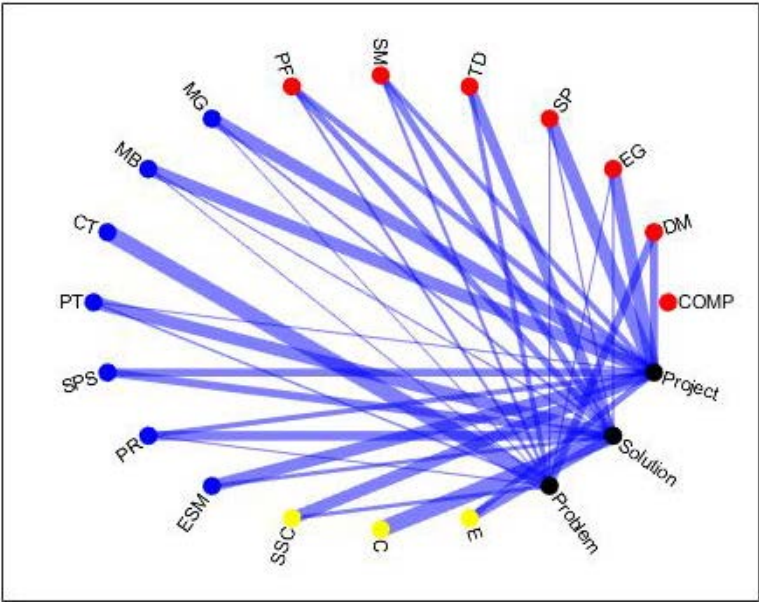
- Design activity trend consistent across design spaces



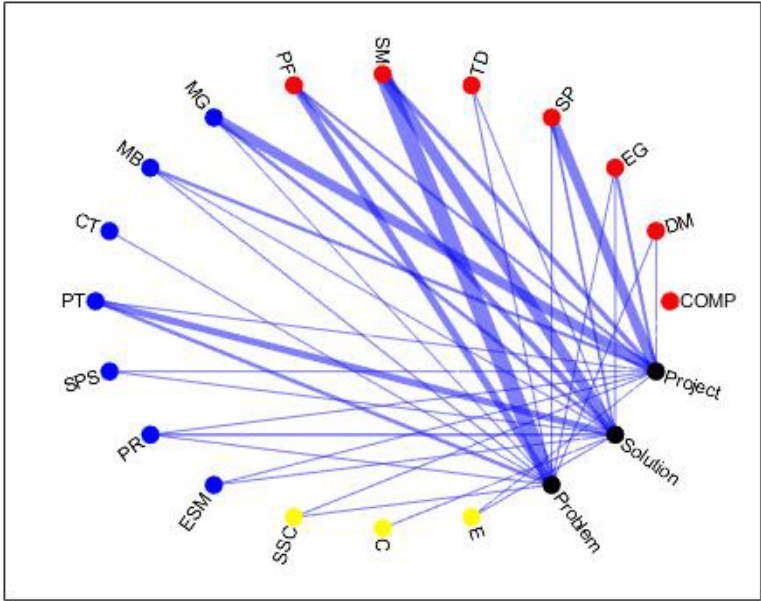
Number of design activity observations in Design Spaces  
(total)

## Leadership Functions and Design Space Observations

Design Space	All Teams																	Total
	Leadership Functions																	
	COMP	DM	EG	SP	TD	SM	PF	MG	MB	CT	PT	SPS	PR	ESM	SSC	C	E	
Problem	0	1	1	2	2	17	8	1	2	1	4	0	1	0	1	0	0	41
Solution	0	0	3	9	4	36	18	12	3	0	22	2	9	1	0	1	3	123
Project	0	1	18	57	0	27	17	57	20	0	2	2	5	3	3	0	2	214
Total	0	2	22	68	6	80	43	70	25	1	28	4	15	4	4	1	5	378



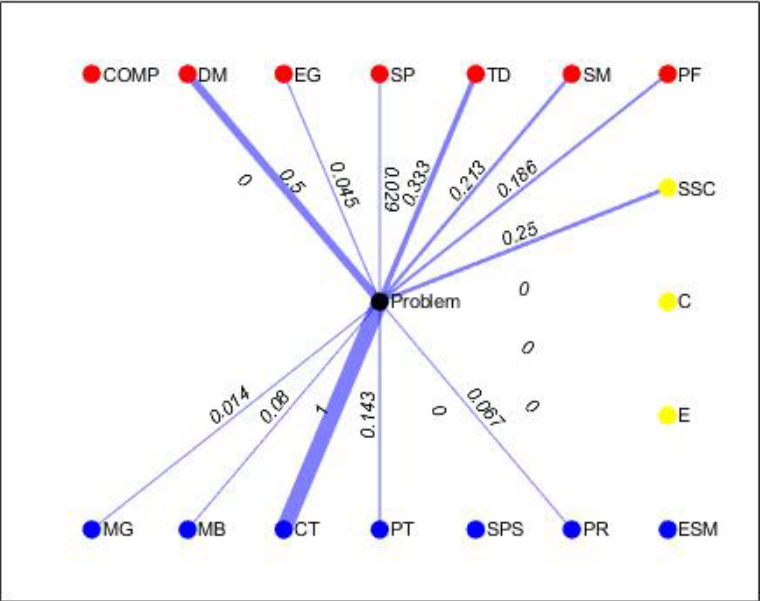
Leadership Function Breakdown



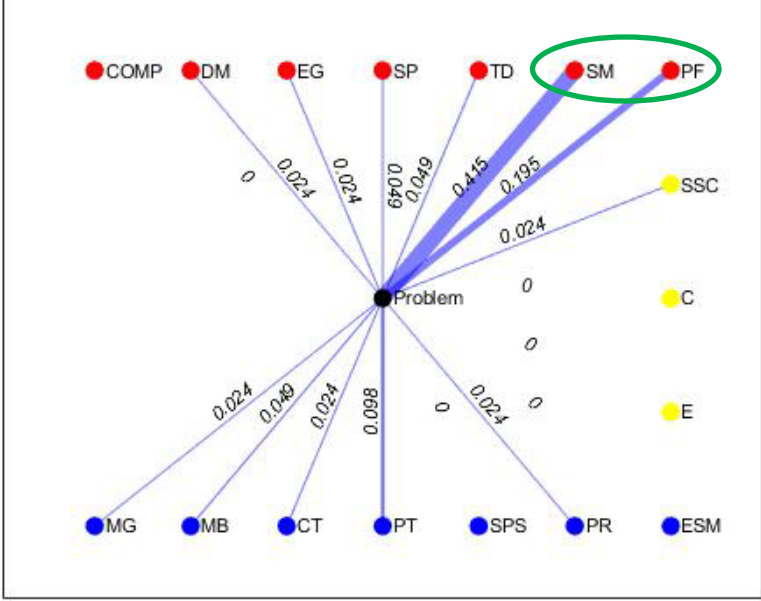
Design Space Breakdown

## Leadership Functions and Design Space Observations

Design Space	All Teams																	Total
	Leadership Functions																	
	COMP	DM	EG	SP	TD	SM	PF	MG	MB	CT	PT	SPS	PR	ESM	SSC	C	E	
Problem	0	1	1	2	2	17	8	1	2	1	4	0	1	0	1	0	0	41
Solution	0	0	3	9	4	36	18	12	3	0	22	2	9	1	0	1	3	123
Project	0	1	18	57	0	27	17	57	20	0	2	2	5	3	3	0	2	214
Total	0	2	22	68	6	80	43	70	25	1	28	4	15	4	4	1	5	378



Leadership Function Breakdown

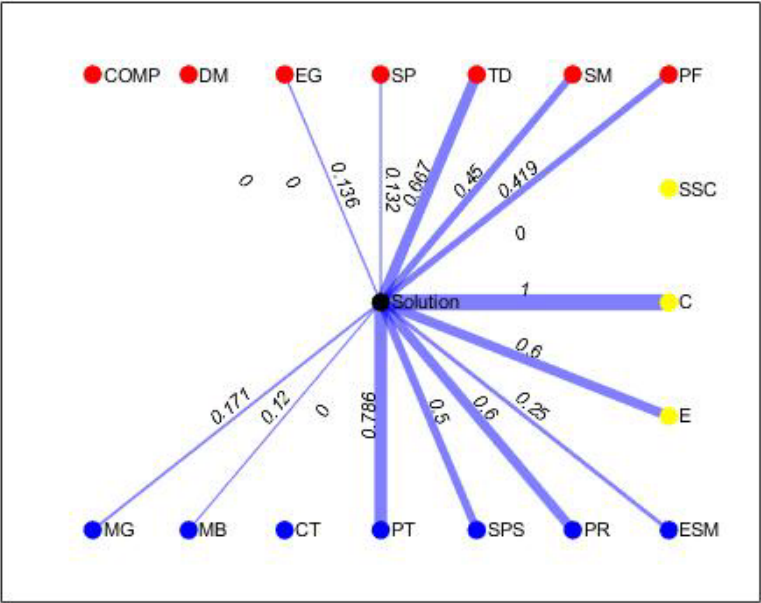


Design Space Breakdown

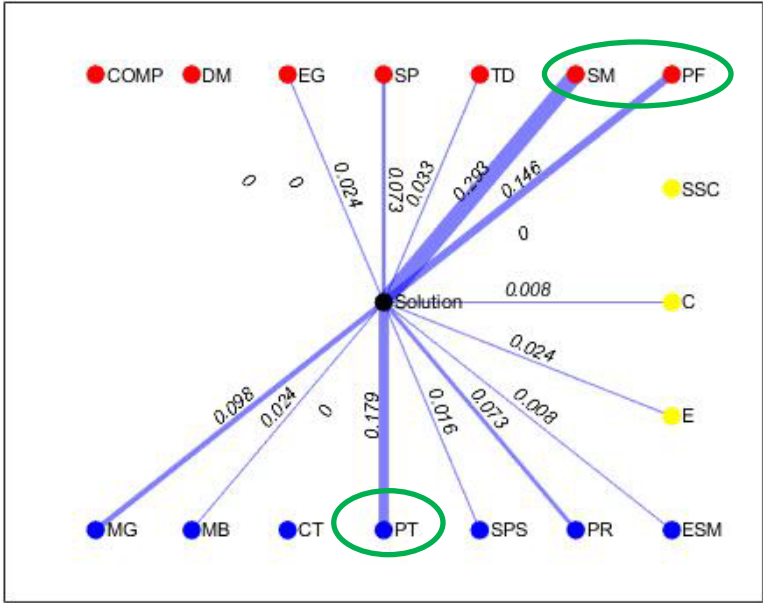
## Problem Space

## Leadership Functions and Design Space Observations

Design Space	All Teams																	Total
	Leadership Functions																	
	COMP	DM	EG	SP	TD	SM	PF	MG	MB	CT	PT	SPS	PR	ESM	SSC	C	E	
Problem	0	1	1	2	2	17	8	1	2	1	4	0	1	0	1	0	0	41
Solution	0	0	3	9	4	36	18	12	3	0	22	2	9	1	0	1	3	123
Project	0	1	18	57	0	27	17	57	20	0	2	2	5	3	3	0	2	214
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Leadership Function Breakdown

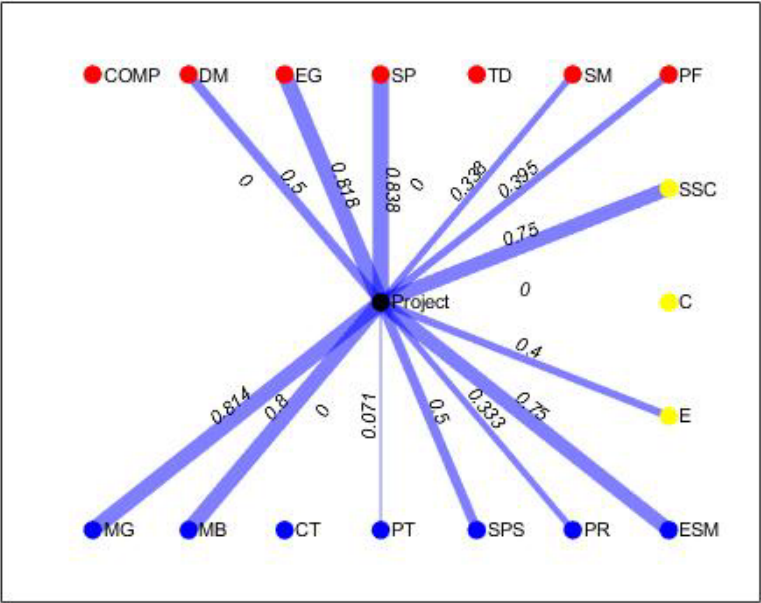


Design Space Breakdown

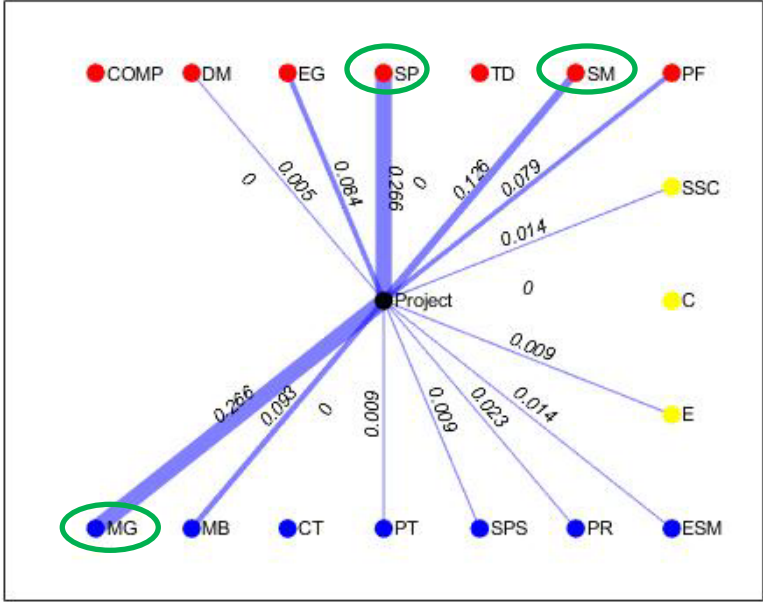
## Solution Space

## Leadership Functions and Design Space Observations

Design Space	All Teams																	Total
	Leadership Functions																	
	COMP	DM	EG	SP	TD	SM	PF	MG	MB	CT	PT	SPS	PR	ESM	SSC	C	E	
Problem	0	1	1	2	2	17	8	1	2	1	4	0	1	0	1	0	0	41
Solution	0	0	3	9	4	36	18	12	3	0	22	2	9	1	0	1	3	123
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Total	0	2	22	68	6	80	43	70	25	1	28	4	15	4	4	1	5	378



Leadership Function Breakdown



Design Space Breakdown

## Project Space



Introduction	Pilot Study (Summer 2017)	Case Study (Fall 2017)	Conclusions & Future Work
<ul style="list-style-type: none"><li>•Motivation</li><li>•Leadership Theory</li><li>•Leadership in Engineering Design</li><li>•Research Questions</li></ul>	<p>Initial Protocol</p> <p>Protocol Study Design</p> <p>Example Coding</p> <p>Results</p>	<p>Case Study Design</p> <p>Case Study Reality</p> <p>Video Coding</p> <p>Results and Analysis</p>	<p>Answering the Research Questions</p> <p>Impacts of This Work</p> <p>Limitations</p> <p>Future Research Opportunities</p> <p>Acknowledgements</p>

# CONCLUSIONS & FUTURE WORK



- Limited observations of leadership in the Problem Space
- Identify technical leadership
  - Problem and Solution Spaces
- Relationships between leadership and engineering space

Leadership Functions	Sensemaking	Providing Feedback	Total
Problem Space	41.5 %	19.5 %	61.0 %
Solution Space	29.3 %	14.6 %	43.9 %

- Leadership behaviors' effect on project progression
  - Teams B and C focused in Project Space / Team A Solution Space

Team	Technical Spaces (#)	Technical Spaces (Time)
Team A	65	1:10:36
Team B	55 (-10)	56:09 (-14:27)
Team C	44 (-21)	(-30:24)

- Team members focused on certain design spaces

MQ.1. Can a protocol be established to observe functional leadership behaviors in student teams during a 4-6-month design project?

A protocol has been established to identify functional leadership behaviors and the engineering design spaces.

RQ.1. What are the relationships between functional leadership behaviors and engineering design space?

Technical leadership takes the form of Sensemaking, Providing Feedback, and Performing Tasks.

RQ.2. What insights into functional leadership behaviors and project progression does observing design team meetings with a leadership protocol reveal?

The leadership distribution in the design spaces differed between Team A (solution) & Teams B & C (project).



- Limited sample size (N=3)
- Clemson mechanical engineering seniors
  - Limited diversity
  - Limited experience
- Focused on conceptual design
- Teams met more than once a week
  - Leadership occurred outside the recordings
- Design reviews only revealed 3 instances of functional leadership



- Second half of case study videos

**F.RQ.1** What are the differences in functional leadership behaviors in multi-team systems compared to traditional design teams?

Prototype fabrication and functional leadership

- Investigating Technical Leadership

**F.RQ.2** How does an increased amount of leadership in the problem and solution spaces effect the design outcome?

**F.RQ.3** What specific actions make up sensemaking and providing feedback in an engineering design space?



- Dr. Joshua Summers
- Dr. Marissa Shuffler
- Dr. Gregory Mocko
- ME 4020 Participants
- ME 4020 Sponsor
- ME 4020 Advisers
- Pilot Study Participants
- CEDAR Lab Mates
- Dr. Shuffler's Students

*While completing this work I failed (often) and learned (lots). Research requires a team. Without this team, I would have accomplished little.*

*My Thanks to All*



Thank You For Your Attention

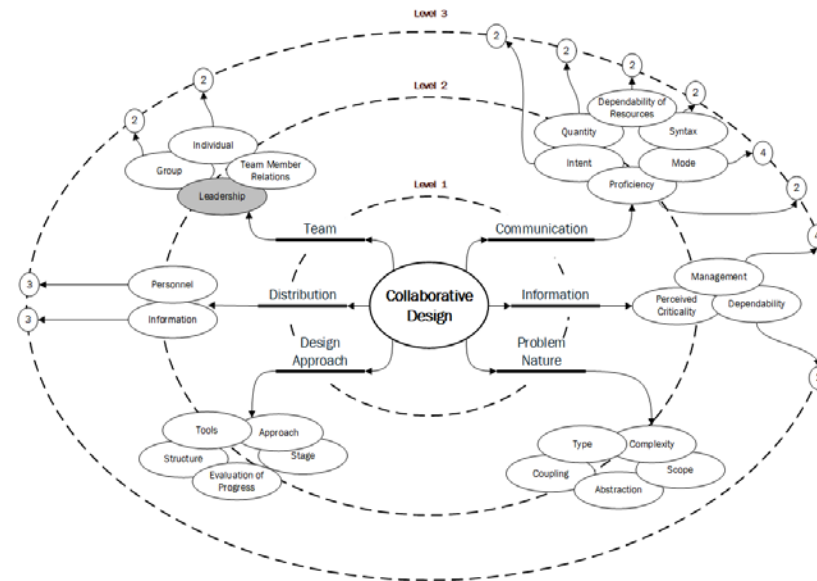
# QUESTIONS?

Introduction	Pilot Study (Summer 2017)	Case Study (Fall 2017)	Conclusions & Future Work
<ul style="list-style-type: none"><li>•Motivation</li><li>•Leadership Theory</li><li>•Leadership in Engineering Design</li><li>•Research Questions</li></ul>	Initial Protocol  Protocol Study Design  Example Coding  Results	Case Study Design  Case Study Reality  Video Coding  Results and Analysis	Answering the Research Questions  Impacts of This Work  Limitations  Future Research Opportunities  Acknowledgements

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Collaborative design taxonomy from

## ● Research interest areas


- Team distribution (Stoeckert et. al 2010) (Taylor and Ahmed-Kristensen 2015) (Stenholm et al., 2016)
- Team composition (Kress and Schar 2011) (Wilde, 1997) (\*Stidham and Summers, 2018)
- Design tools (Yang, 2009) (Shah et. al, 2001) (Linsey et. al, 2011)

\*In Review



Dictionary

leadership


**lead·er·ship**  
/ˈlēdərˌSHɪp/ 

*noun*

the action of leading a group of people or an organization.  
"different styles of leadership"

*synonyms:* guidance, direction, control, management, superintendence, supervision; [More](#)

- the state or position of being a leader.  
"the leadership of the party"  
*synonyms:* directorship, governorship, governance, administration, captaincy, control, ascendancy, supremacy, rule, command, power, dominion, influence  
"the leadership of the Coalition"
- the leaders of an organization, country, etc.  
plural noun: **leaderships**  
"a change of leadership had become desirable"

 Translations, word origin, and more definitions

Google search for "leadership"



- Context

- Engineering design teams
  - Individuals working to solve engineering problems
- Scale
  - Design Tools
  - Full Scale Projects
- Team size  $\geq 3$  members

- Leadership

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

(Not proposing a new definition of leadership)



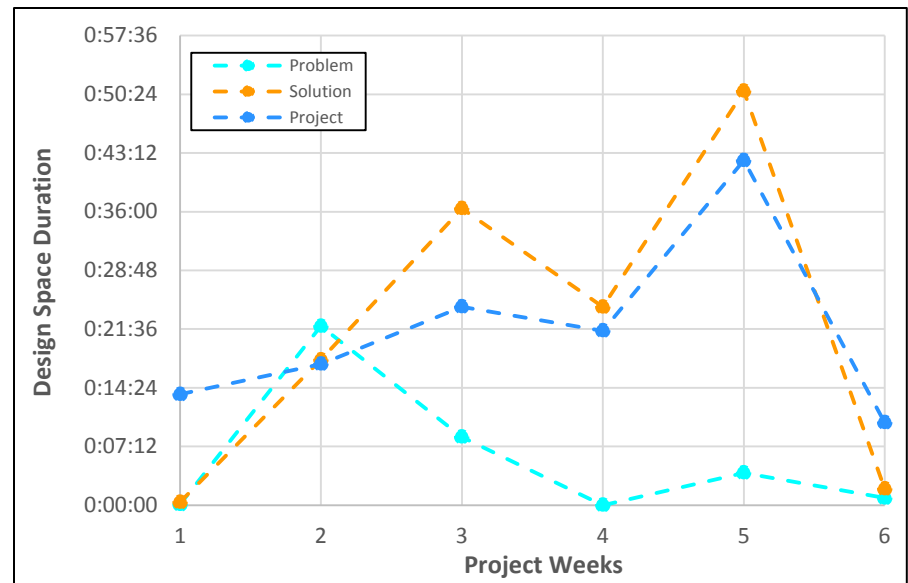
- Leadership in engineering design (Pahl, Beitz, Feldhusen, & Grote, 2007)
  - Demonstrates the need for strong leaders
  - What does being a strong leader mean?
- Leadership study on positivity (Avey, Avolio, & Luthans, 2011)
  - User study gauging team members' reaction to prompts
  - Not observing 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



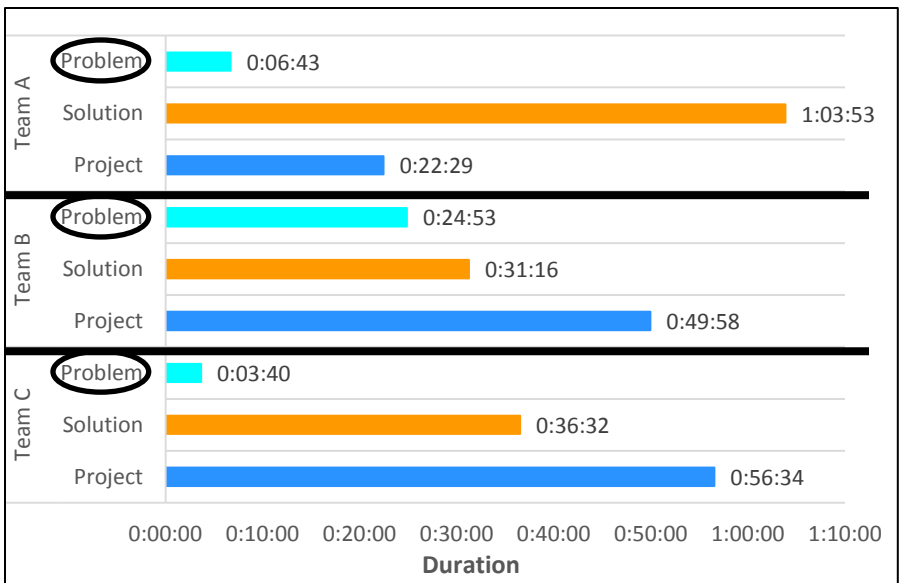
## Protocol Study Percent Agreement Analysis

% Agreement - Time Analysis																			
Event ID				LF Type				Leadership Function ID				Leader ID							
		Rater 1					Rater 1					Rater 1					Rater 1		
		J	C	D2			J	C	D2			J	C	D2			J	C	D2
		J	C	D2			J	C	D2			J	C	D2			J	C	D2
Rater 2	D	0.68	0.56	0.71	Rater 2	D	0.56	0.51	0.69	Rater 2	D	0.31	0.48	0.54	Rater 2	D	0.48	0.51	0.52
	J		0.73	0.75		J		0.65	0.62		J		0.41	0.45		J		0.37	0.55
	C			0.46		C			0.40		C			0.30		C			0.38

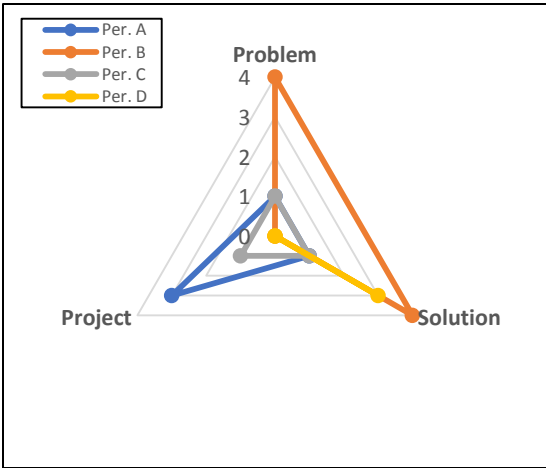




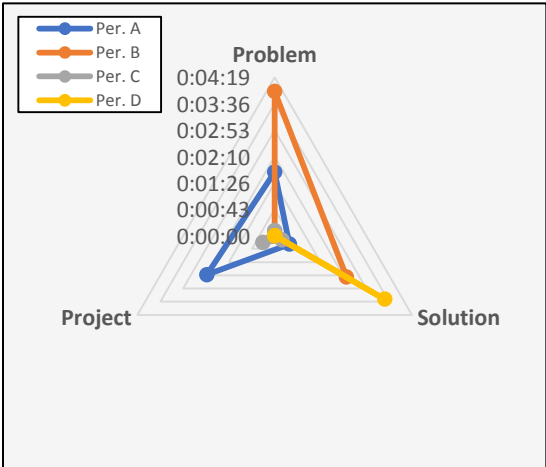
Duration of design space observations



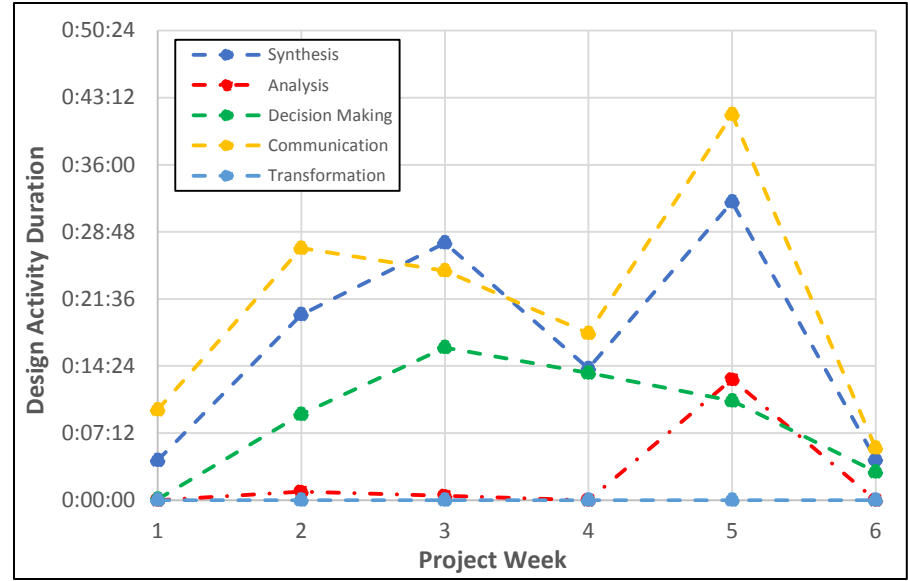
Duration of design space observations (total)



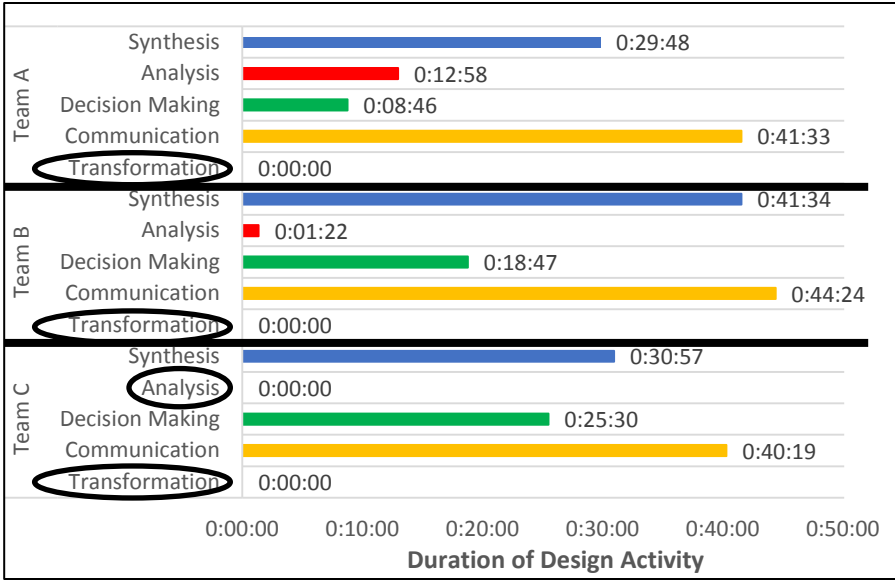
Team A, Week 2 Design Space Observations



Team A, Week 2 Space Observations

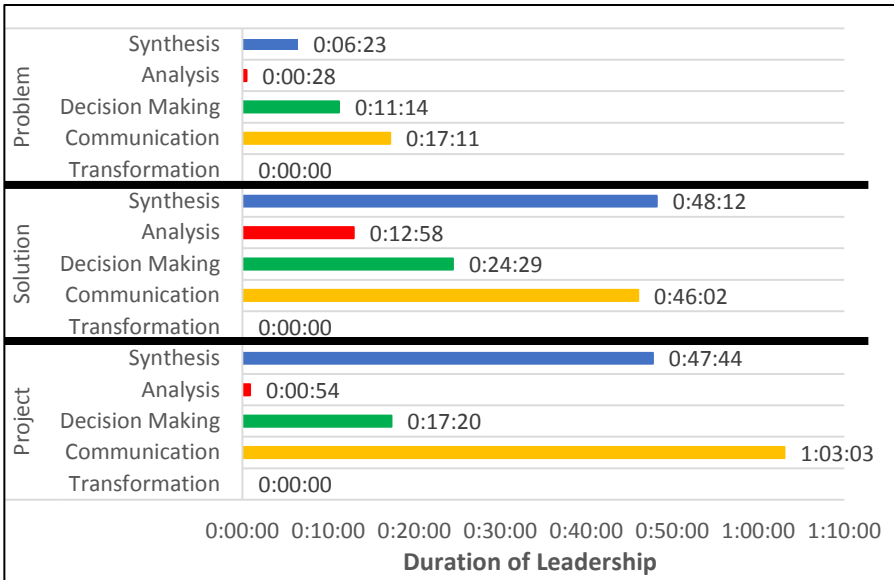


Duration of design activity observations (weekly)



Duration of design activity observations (total)

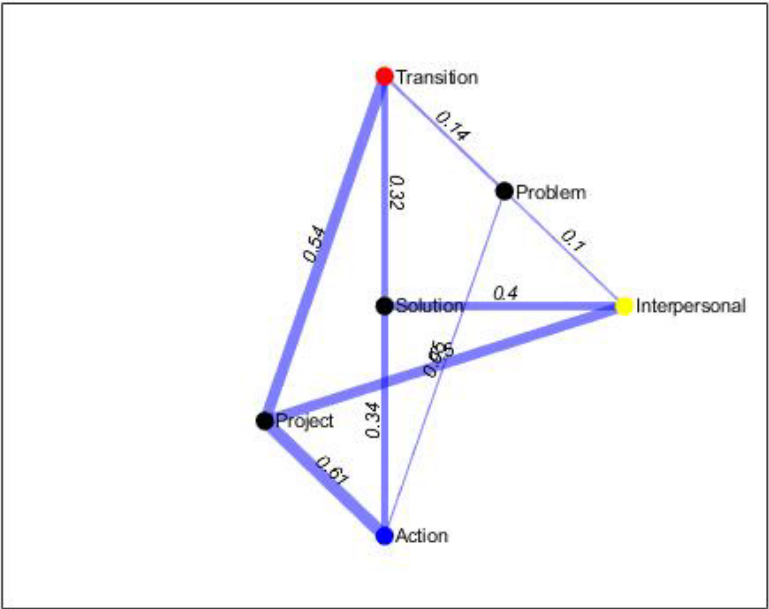




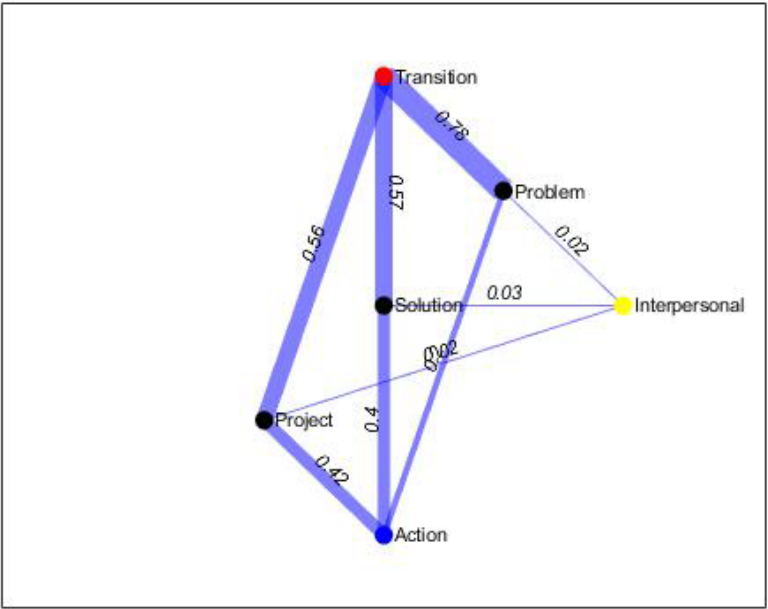
Duration of design activity observations in Design Spaces (total)

## Leadership Type and Design Space Observations

Design Space	All Teams			Total
	Leadership Function Type			
	Transition	Action	Interpersonal	
Problem	32	8	1	41
Solution	70	49	4	123
Project	120	89	5	214
Total	222	146	10	378



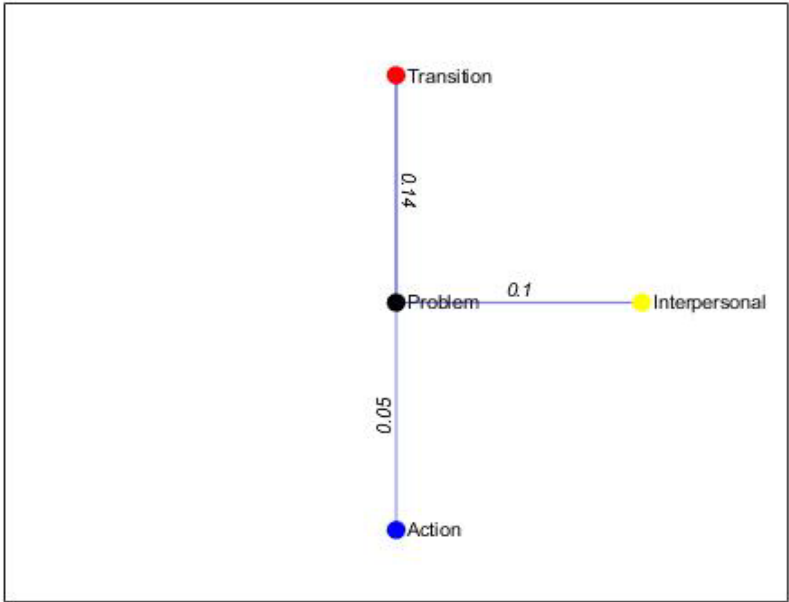
Leadership Function Type Breakdown



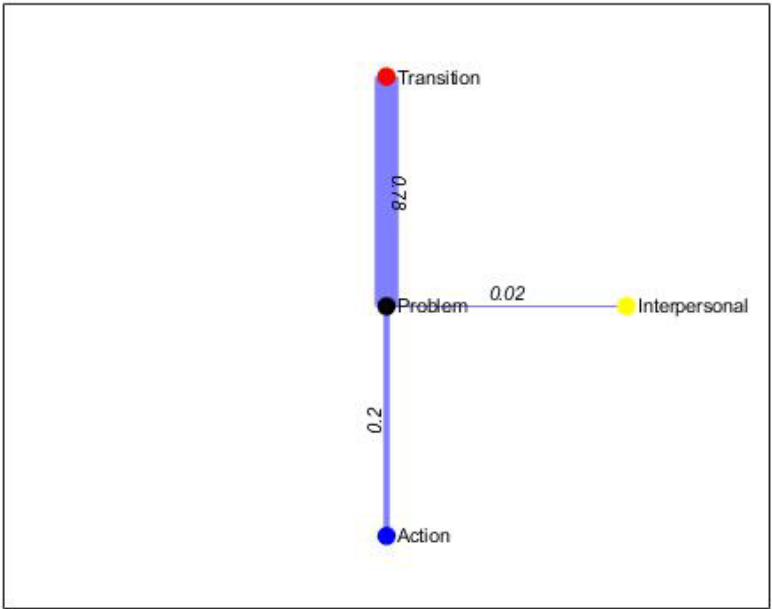
Design Space Breakdown

Leadership Type and Design Space Observations

Design Space	All Teams			Total
	Leadership Function Type			
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Leadership Function Type Breakdown

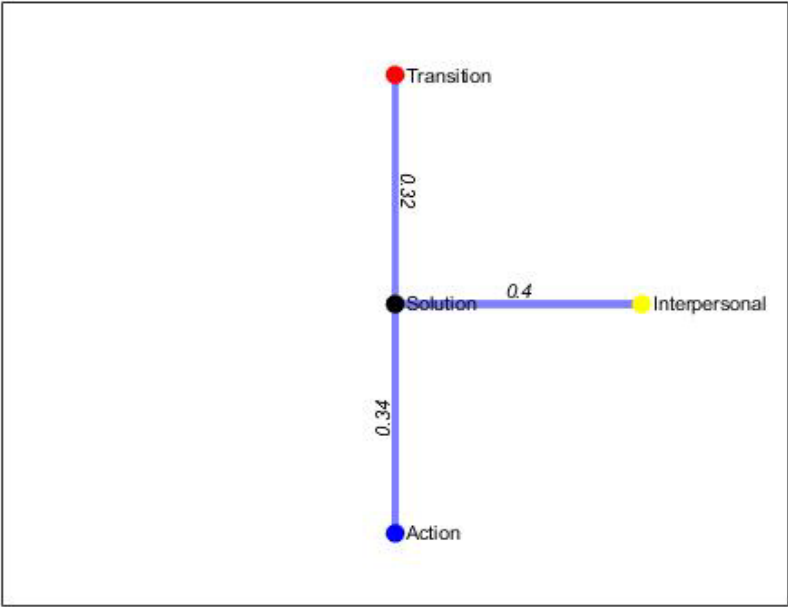


Design Space Breakdown

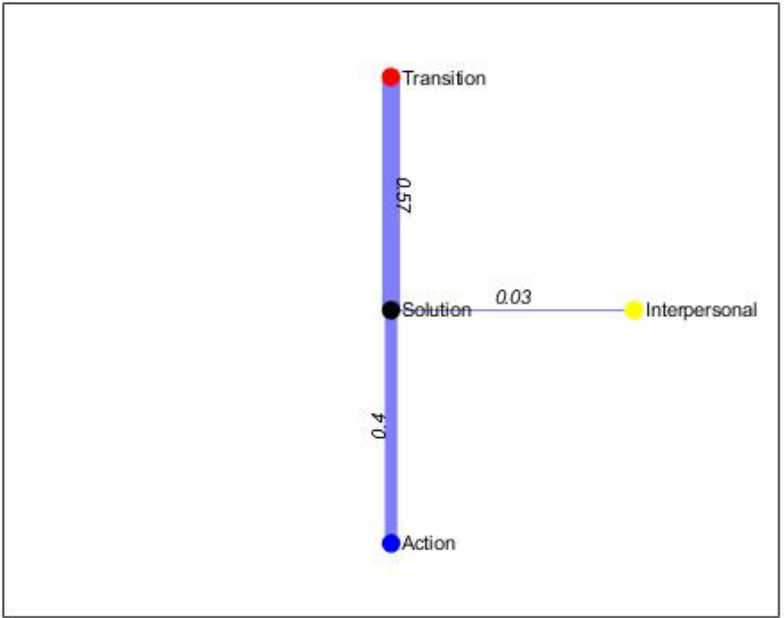
## Problem Space

## Leadership Type and Design Space Observations

Design Space	All Teams			Total
	Leadership Function Type			
	Transition	Action	Interpersonal	
Problem	32	8	1	41
Solution	70	49	4	123
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Leadership Function Type Breakdown

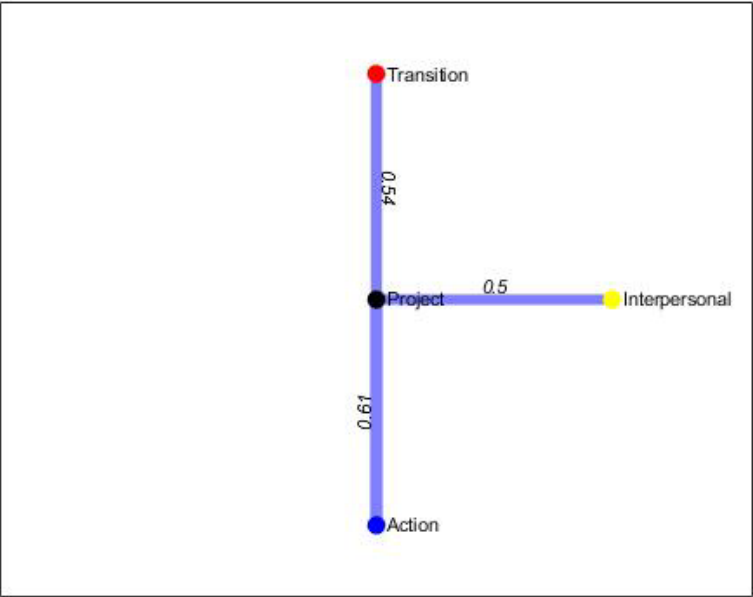


Design Space Breakdown

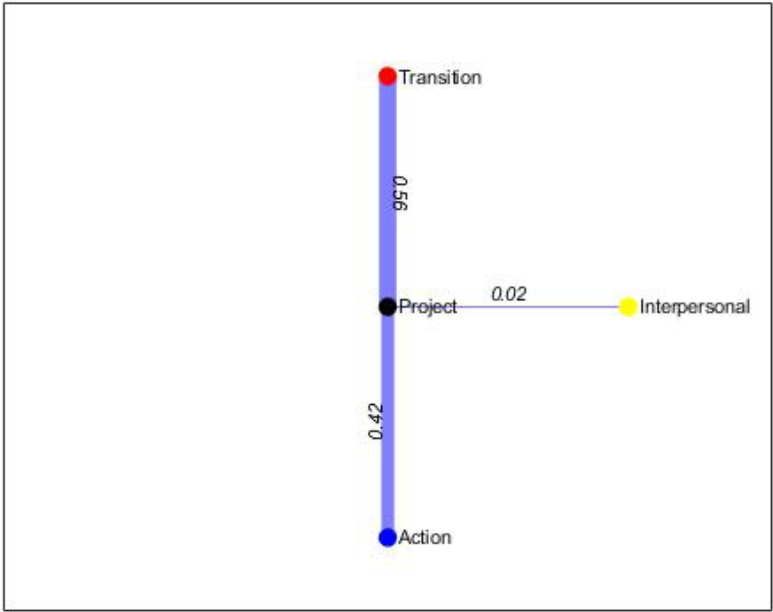
## Solution Space

Leadership Type and Design Space Observations

Design Space	All Teams			Total
	Leadership Function Type			
	Transition	Action	Interpersonal	
Problem	32	8	1	41
Solution	70	49	4	123
Project	120	89	5	214
Total	222	146	10	378



Leadership Function Type Breakdown



Design Space Breakdown

## Project Space

Leadership Function Types and Design Activity Observations

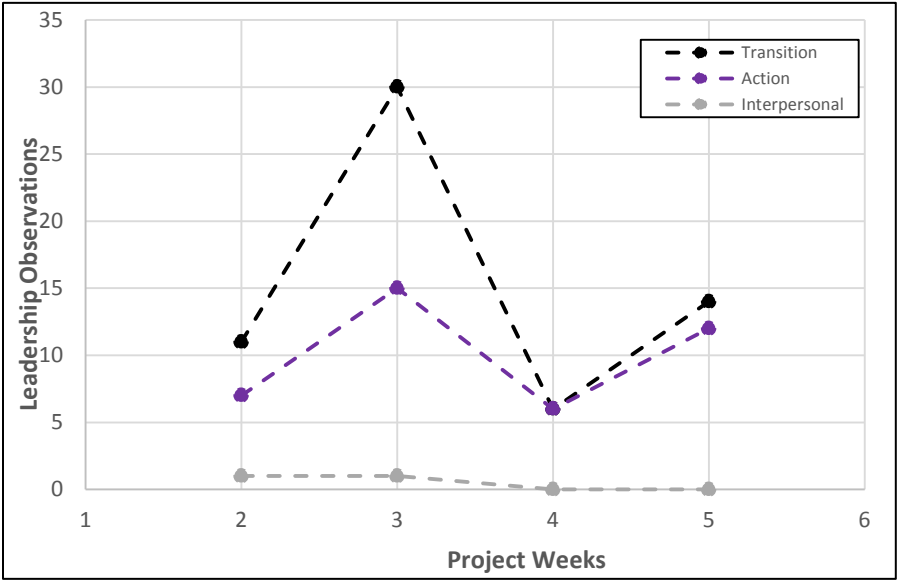
Design Activities	All Teams			Total
	Leadership Function Type			
	Transition	Action	Interpersonal	
Synthesis	89	41	2	132
Analysis	4	6	0	10
Decision Making	48	10	1	59
Communication	81	89	7	177
Transformation	0	0	0	0
Total	222	146	10	378

Leadership Functions and Design Activity Observations

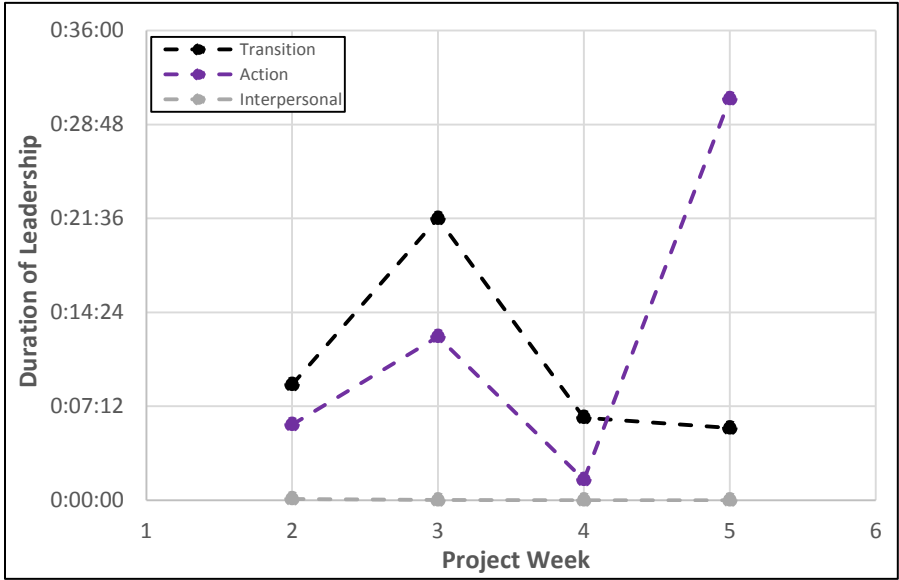
Design Activities	All Teams																	Total
	Leadership Functions																	
	COMP	DM	EG	SP	TD	SM	PF	MG	MB	CT	PT	SPS	PR	ESM	SSC	C	E	
Synthesis	0	1	18	43	1	13	13	10	2	0	21	3	2	3	0	1	1	132
Analysis	0	0	0	2	0	1	1	1	1	0	3	0	1	0	0	0	0	10
Decision Making	0	1	3	9	0	21	13	6	0	1	1	1	1	1	0	0	1	59
Communication	0	0	1	14	5	45	16	53	22	0	3	0	11	0	4	0	3	177
Transformation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	2	22	68	6	80	43	70	25	1	28	4	15	4	4	1	5	378

- Highlighted the need to reinforce importance of Problem Definition
- Develop better engineering team members
  - Demonstrate how students perform technical leadership
- Identified areas where more leadership is required
  - Problem Space
- Introduce leadership behaviors with lower frequencies
  - Problem Solving
  - Interpersonal Functions

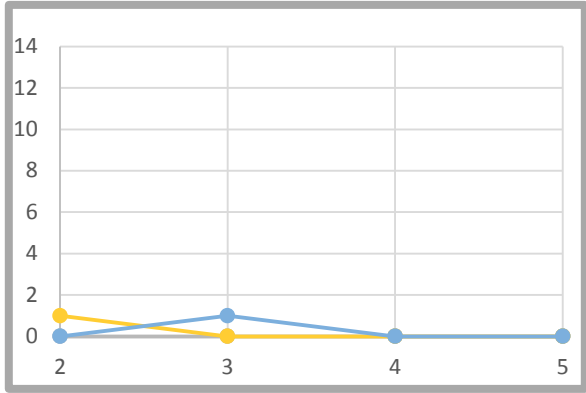
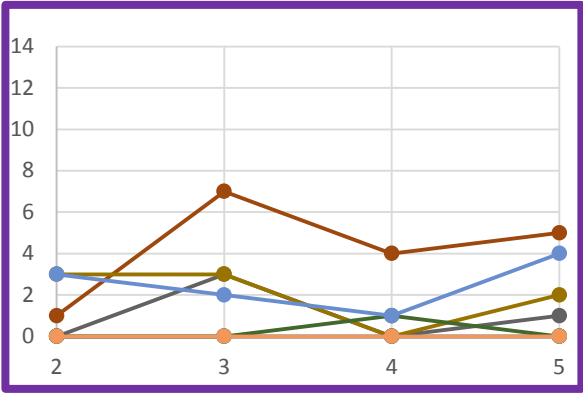
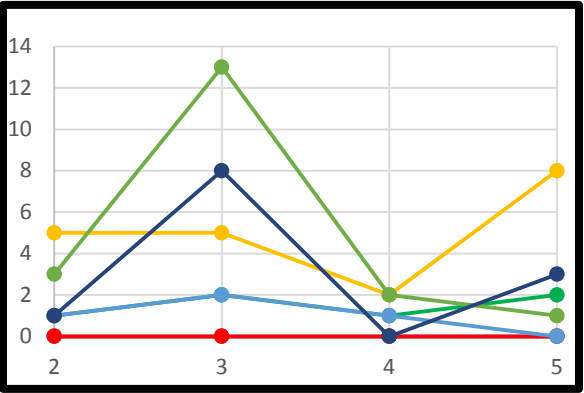




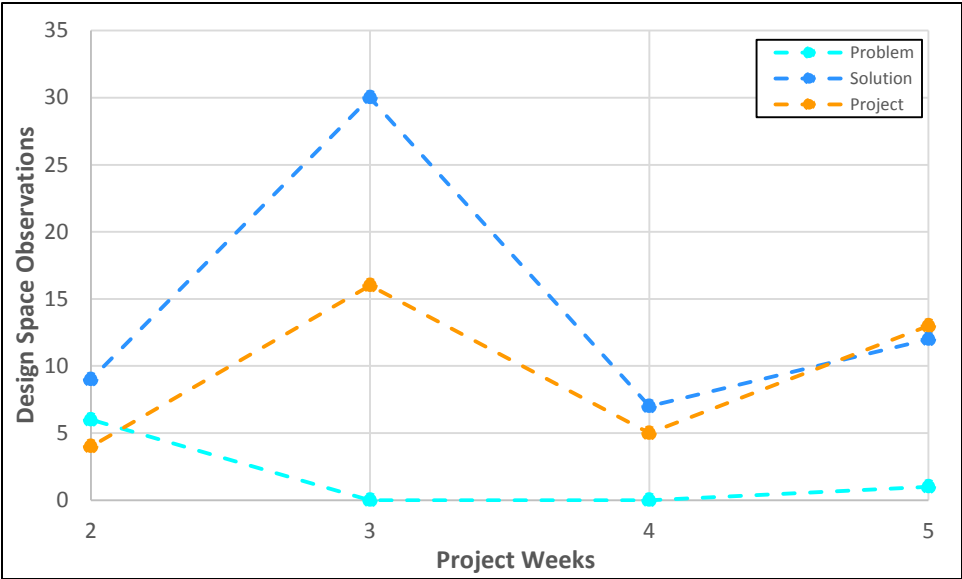
Team A function types over time

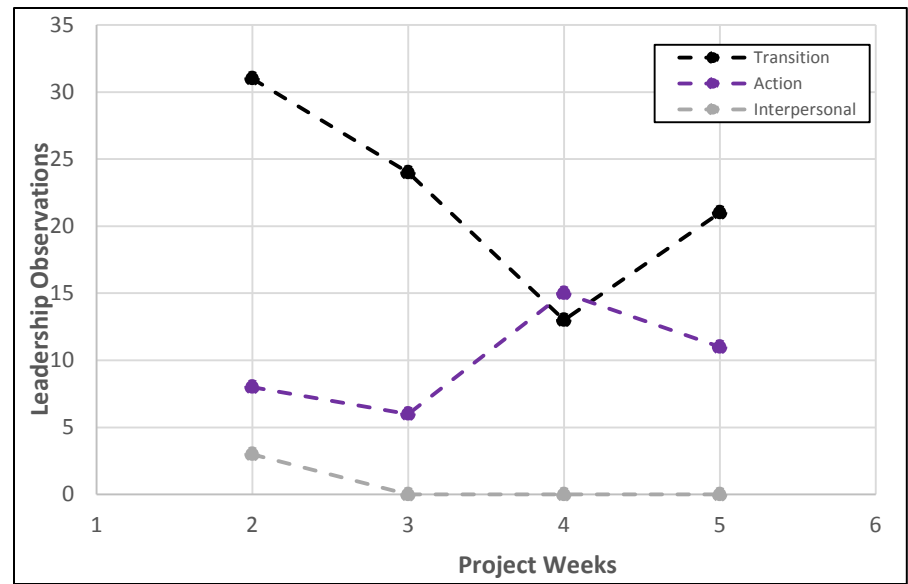


Team A function types (duration) of time

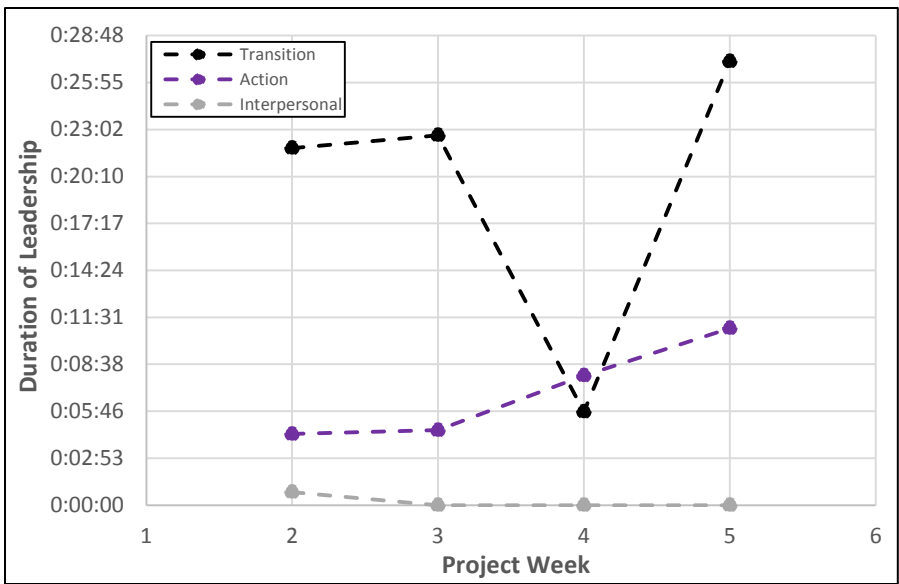




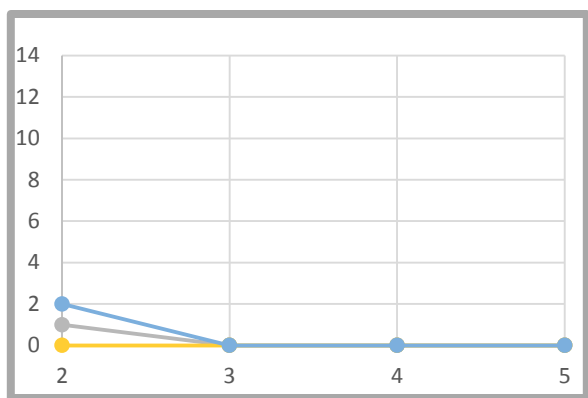
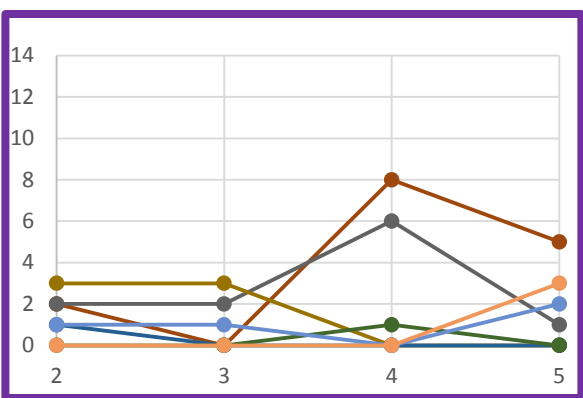
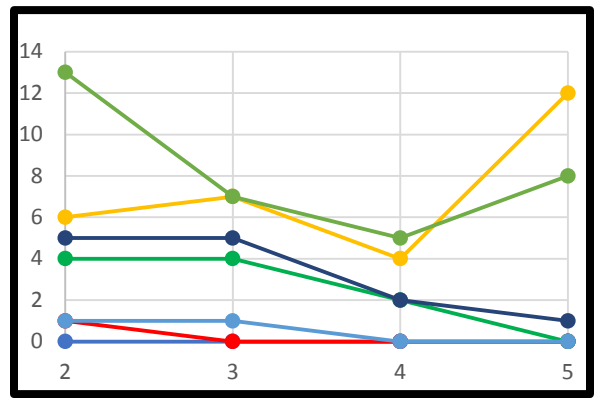


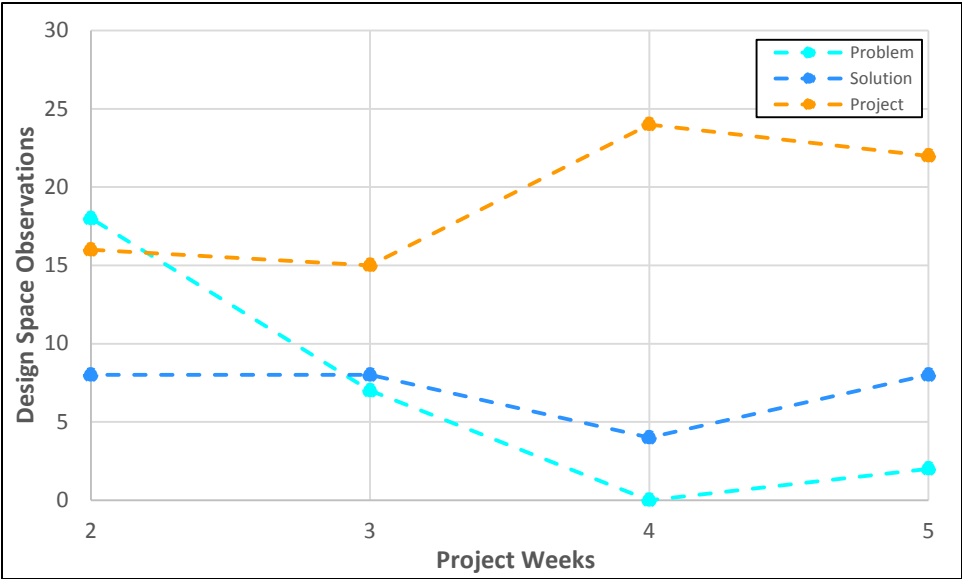


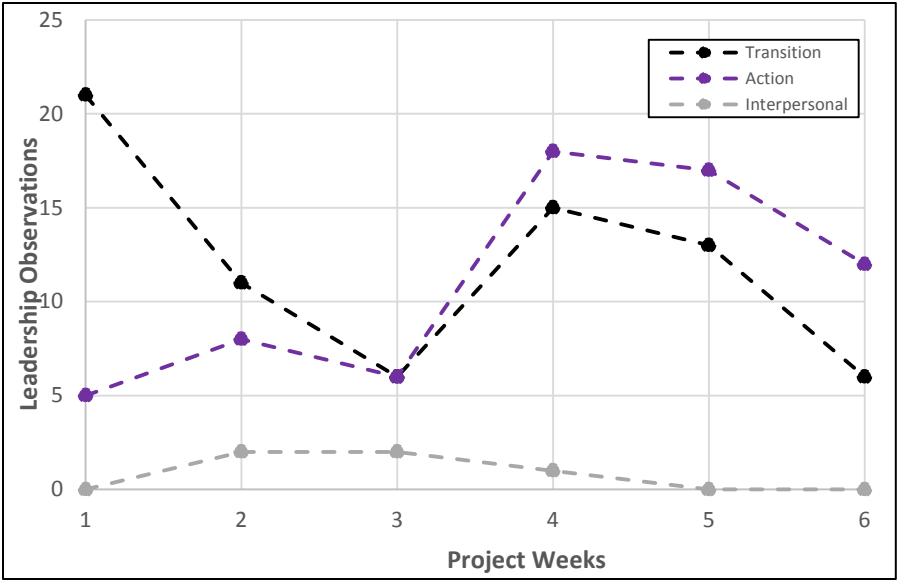
Team B function types over time



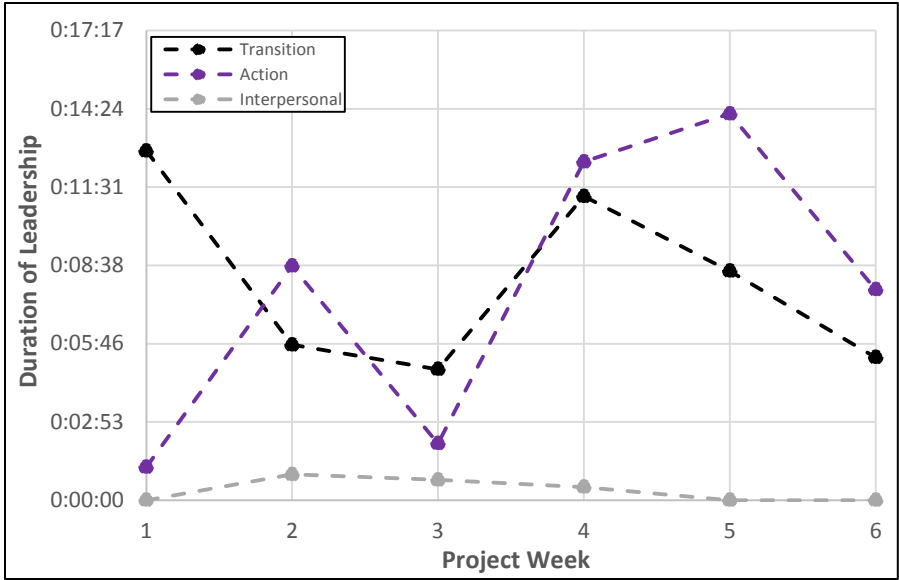
Team B function types (duration) of time







Team C function types over time



Team C function types (duration) of time

