Successful Teaming Characteristics Revealed in an Intensive Design Experience

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Rodney began his career with Fujitsu Network Communications in 1989 as the Director of Strategic Planning. He also held the positions of Director of Transport Product Planning, Vice President of Business Management, Senior Vice President of Sales Management, Senior Vice President of Manufacturing, and Senior Vice President of Business Development. Before joining Fujitsu, Rodney worked for Bell Laboratories, Bellcore (now Telcordia), and Rockwell International. He earned both his bachelor's and master's degrees in electrical engineering at Texas A&M University.

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Introduction

In developing entrepreneurial mindsets within students, intensive design experiences challenge undergraduate and graduate students to innovate, design, build, and present solutions to real-world problems in a concentrated, 48-hour period. Through observations from previous intensive design experiences, certain team functions and characteristics emerged and appeared to be critical to team success. The author and co-authors hypothesized that team interaction, respect amongst members, and effective communication were some of the most important team dynamic characteristics in contributing to the success of teams as they developed solutions. Data was collected through the use of team characteristic assessments and direct third party observations at three critical times during the event. The data and observers' comments were analyzed in an attempt to understand which characteristics of team development during the event had the highest correlation with team success. Knowledge of which characteristics best predict team success amongst focused peers could influence the development of targeted interventions aimed at increasing team cohesion and potential for success.

Background

Jim Clifton, in his book "*The Coming Jobs War"*, writes that "Entrepreneurship is more important than innovation. Innovation is critical, but it plays a supporting role to almighty entrepreneurship… [I]t's far better to invest in entrepreneurial people than in great ideas." (Clifton, 2011) . Clifton's central argument is that entrepreneurship is about creating jobs and that for countries, particularly the US, it is critical that renewed effort must be focused on creating entrepreneurial minded people to maintain employment. Further in a 2011 letter to the Secretary of Commerce, the National Advisory Council on Innovation and Entrepreneurship recommended that universities develop programs and opportunities for students to study innovation and entrepreneurship (NACE, 2011). This letter was signed by 146 of America's leading institutions.

In creating an entrepreneurial mindset in college students, Pizarro argues that:

> "entrepreneurial education must involve more than creating a plan for a business that makes students successful. Success derives from what graduates do with that knowledge – that is entrepreneurial thinking and entrepreneurial education must go beyond content to teach students to think entrepreneurially." (Pizarro, 2014)

Simply lecturing on entrepreneurial thinking is not sufficient as students must develop a range of skills to put into practice. Neumeyer, et al. recognized that a complex set of skills must exist. These include "… opportunity recognition and development, entrepreneurial alertness, business model development, social capital, managing ambiguity and uncertainty, and raising venture capital" (Newmeyer & McKenna, 2016). Neumeyer, et al, identified these through reviewing (DeTienne, 2004) (Ardichvili, Cardozo, & Ray, 2003) (Gaglio & Katz, 2001) (Morris, Schindehutte, & Allen, 2005) (Johnson, Christensen, & Kagermann, 2008) (Kim & Aldrich,

2005) (Westlund & Bolton, 2003) (De Carolis & Saparito, 2006) (Cope, 2003) (Cope, 2005) (Gompers & Lerner, 2004) which coincides with the authors' thinking. To facilitate development of these entrepreneurship skills, many university programs have implemented entrepreneurial teams into their educational offerings. (Boni, Weingart, & Evenson, 2009) (Hackbert, December 2004) (Bousaba & Conrad, 2015)

Texas A&M University's approach to developing an entrepreneurial mindset in students is to offer an Intensive Design Experience (IDE) called Aggies Invent, held over a 48-hour period during one weekend. Approximately 40 to 60 students, freshman to PhD candidates, develop solutions to industry and agency posed problems to practice entrepreneurship. Each IDE is organized around a theme which might include solving problems in healthcare, Internet of Things (IOT), first responder's needs, social entrepreneurship, or education. Participants are recruited from all majors, but the majority of participants are engineers. Thus far, the program has been offered 14 times since the summer of 2014, with nearly 600 student participants. The following table provides a breakdown of student characteristics:

Characteristic	Statistics
Teams	127
Participants	593
Gender	28% Female, 72% Male
Undergraduate and Graduate	74% Undergraduate, 26% Graduate
Majors	82% Engineer, 18% Non-Engineer

Students arrive on Friday evening and self-form teams around a common interest in a particular submitted problem. Teams are no smaller than 4 and no larger than 6 participants, as this has been found to be the correct size to maximize student outcomes. In the allotted 48 hour time frame - teams proceed into an engineering design process to develop solutions to their problem, build prototypes, and then develop a 10-minute presentation, which must include a 90 second video that will be provided to a judging panel of experts on the final day. Judges evaluate teams on their solution in 4 different categories critical to an entrepreneurial mindset: technical performance, project feasibility, project innovation, and effectiveness of the presentation – and from the presentations, choose the top three teams which are awarded cash prizes. The competition provides teams' motivation and focus to perform at their best. Student educational outcomes from this IDE are described in a paper published in the 2015 ASEE Conference (Lagoudas, Boehm, & Wilson, 2015).

During an Aggies Invent, the combination of a short time period, working in multidiscipline groups, multiple deliverables, and competition puts teams under a tremendous time pressure to perform. This is by design and mimics an entrepreneurial endeavor. When students enter the work place, they will be required to deliver projects with limited time, budget, and will work in teams that are multidiscipline with members who have different experience and backgrounds. For teams to be successful in this stressful environment, they must develop into a cohesive unit very quickly. Sheard, et al, (Sheard, 2001) described nine key factors that describe characteristics involved in teams moving from loose groups to an effective team. These include

clearly defined goals, priorities, rolls and responsibilities, self-awareness, leadership, group dynamics, communication, context, and infrastructure.

During an Aggies Invent, facilitators have had the unique opportunity to observe effective and low performing teams, note some observed characteristics, and have intervened when teams appear to be headed into a situation where success could be compromised. Some interventions have been successful and some have not. Some teams have performed well from the start, some have started performing low and over the weekend their effectiveness improved and ended by performing well and some have started and ended as low performing. The Aggies Invent program provides an opportunity to study characteristics of effective as well as low performing teams as they work on an entrepreneurial solution.

While Sheard, et al, (Sheard, 2001) identified 9 characteristics that are present in teams vs loose groups, others have pointed out key characteristics present in high performance teams – including interactive team cognition (sharing information within the team and learning from it) (Cook, 2015), a sense of belonging, and leadership (Ammeter & Dukerich, 2002). However, a recent study by Google identified two primary characteristics of high performing teams. These are:

> "… on good teams, members spoke in roughly the same proportion, a phenomenon the researchers referred to as 'equality in distribution of conversation turn taking'"
> "… good teams all had high 'average social sensitivity' – a fancy way of saying they were skilled at intuiting how others felt based on their tone of voice, their expressions and other non-verbal cues". (Duhigg, 2016)

Edmondson wrote about this in a study published in 1999 on the concept of psychological safety (Edmonson, 1999). The study described a "team climate characterized by interpersonal trust and respect." During an Aggies Invent, facilitators observed teams who trusted each other and those who did not. Since teams work in an open environment at tables, the observations were evident in the way members communicated, how much one individual dominated the conversation, and how their team workspace was organized.

Through discussions about these observations, it was realized that the Aggies Invent program provided a unique environment to study team characteristics and how it affected performance as they developed and presented their solution in an entrepreneurial environment. Questions that were formed were:

1. What team characteristics are the most significant in predicting success in an intensive design experience that will be needed in an entrepreneurial endeavor?
2. What intervention techniques can be used to improve team performance?
3. How can these results be extended to creating and managing high performance teams

This paper is the first attempt to gather evidence sufficient to answer question 1. Questions 2 and 3 will be addressed through subsequent research efforts.

Study Design

The researchers realized an intensive approach was required to gather the data needed. Therefore, one Aggies Invent weekend was selected for the target study. For the assessment, it was decided to include both self-assessment and third party assessment through the use of graduate students trained in observational techniques. In this manner, the self-assessment data could be compared with third party observations to examine any bias that might be inside the team.

Further it was decided that the self-assessment and third party assessment would take place at three distinct times during the weekend – 10:00 am Saturday, 5:00 pm Saturday, and 10:00 Sunday. These times were chosen because during previous observations by the facilitators, teams are progressing through different stages and levels of stress at these times. For instance, at 10:00 am Saturday, teams are still in the design phase with no deliverable due. Therefore, they are normally relaxed and still in the forming stage. However, at 10:00 am Sunday, teams were under tremendous stress because their prototypes, presentations, and video were due within the next 5 hours. At this stage, if teams were not performing, then they would not present well to the judges.

A survey tool was developed based on a Griffith University tool, (Ratzburg, 2004). However, the authors included two additional questions (questions 13 and 14) based on team interactions in previous Aggies Invent programs. The tool used is included as appendix A and was selected because it contained a list of characteristics most commonly associated with high performance entrepreneurial teams. The third-party observers and the teams used the same survey tool form. Numerical data was collected at each time which allowed comparison between individual team members and the third-party observers. In addition, observers collected notes about characteristics of the teams for further analysis.

Effective team success was defined by the results of the scores by the judging panel of 5 judges. The score sheet, included as appendix B, was provided to the teams about 24 hours before the judging session so each team knew the criteria for success. Judges were asked to score teams on Technical Performance of the project, Project Feasibility, Project Innovation, and Presentation – all key skills needed in any successful entrepreneurial activity. Scores were averaged across each judge, multiplied by a weighting, and then summed for a final score. Judges included professors and industry leaders involved in the field representative of the theme of the IDE.

The study included 50 students comprising 10 teams. The smallest team included 4 students and the largest team included 6. Students were 48% female – 51% male, 66% engineer – 44% non-engineer, 38% graduate and 62% undergraduate. Research was carried out under IRB 2014-0686D.

Objective Analysis

The top and bottom performing teams, per the judge's scores, were analyzed to determine if a scoring category was common between the higher and lower placed teams. Then the self-reported and observed teaming characteristics to determine what characteristics might be

common. Data from two teams had to be discarded because no team member completed a self-reporting form for one or two of the observation periods. Therefore, data from only 8 teams was valid. This is an early report of the study and through the limited sample size, the authors were looking for data that indicated an early trend in these characteristics to help further develop a future study which would correlate team cohesion to project success. Accordingly, while none of the data was sufficient to develop statistically significant correlation, certain trends were revealed.

Judges scoring data are shown in Figure 1 for the top three teams (A, B and C) and the bottom three teams (G, I and J). Since scores in each category carried different weight, the scores were divided by the max total score in each category to reveal comparable results. In this figure, the winning teams scored well in all of the categories, with the highest placing team scoring well in all. Further, the top three teams all scored above 80% in their presentation and the bottom teams scored below 60%. One can draw from this that the ability to effectively describe their idea is one of the categories that distinguishes the top teams from the bottom ones. Note that team I scored well in Innovation, but not in Performance, Feasibility, or Presentation. Therefore, a strong Innovation score cannot overcome a low presentation score. Therefore, it appears that the team was innovative in their design, but unable to convince the judges through their presentation that their solution was complete. Many future entrepreneurs have found that effective communication is critical to their success, particularly in presentations to potential investors (Clark, July 2008).

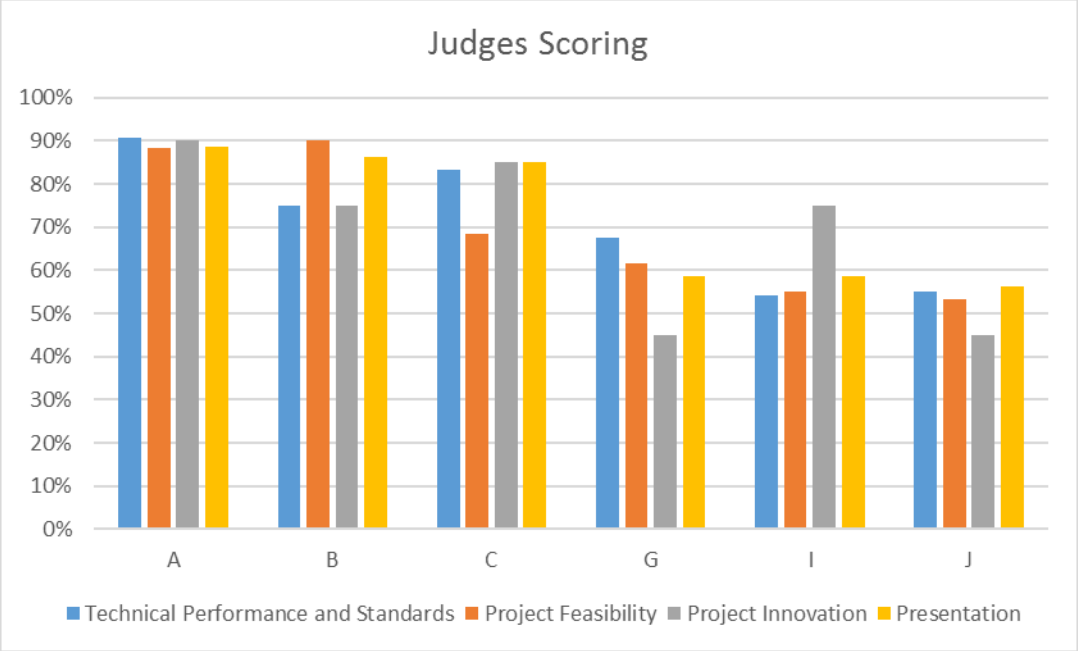

Figure 1 – Judges Scoring for Top and Bottom Performing Teams

Team characteristics were then examined by comparing the observations over time and contrasting the self-assessment and 3rd party assessment values. Examples of data collected for Team A are shown in Figures 2 and 3. The top three characteristics were identified for each team by averaging the three timed observations for self-assessment and then 3rd party assessment. This data is shown in Figure 4, where the communication related characteristics

have been shaded. As can be seen, the top three teams all had two of the communication related characteristics in their top 3. It would appear to indicate that teams who had strong communication characteristics performed better in their presentation. This might indicate that good team communication could be related to development and delivery of their design to the judges.

However, it is noted that Team G had two of the communication characteristics in their top two and had only a 55% score in their presentation. In fact, Team G reported some of the highest team characteristics in both the self-assessment and 3rd party observation. However, in examining Team G's total judges score, their Project Innovation score was the lowest in the study. Therefore, even though their intra-team functioning and team communication was high as self-reported and observed by the 3rd parties, the team was not able to overcome a low innovation score and might have scored poorly in communication because they did not convince the judges their project was innovative. Thus, it seems to indicate that to be successful, a team must have a good design and present it well even though team function might be high. It seems that good team functioning cannot overcome a bad design. One might hypothesize that Team G was too skilled in social sensitivity and may not have been able to offer constructive criticism. The fear of appearing abrasive or none compliant to the team personality could have damaged their innovation capability. Because of the small sample size and the somewhat conflicting data, only a general trend can be noted that top performing teams must be among the highest in their presentation quality and tend to have strong team communication skills.

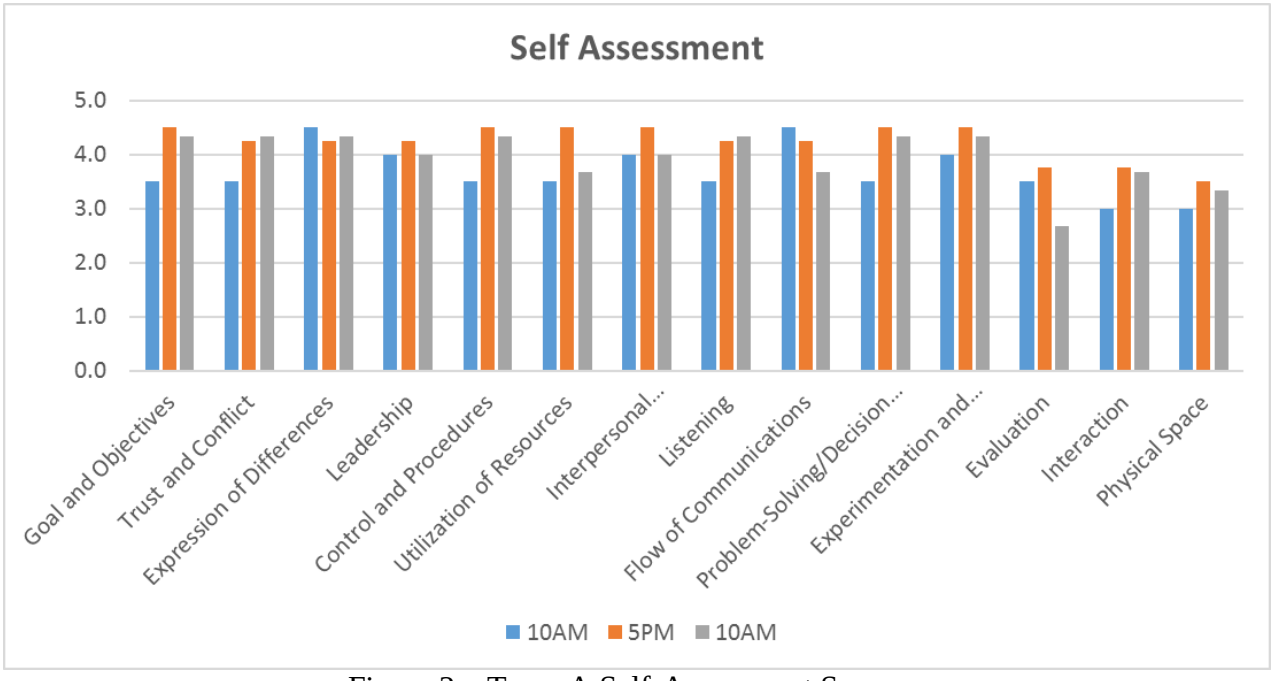

Figure 2 – Team A Self-Assessment Scores

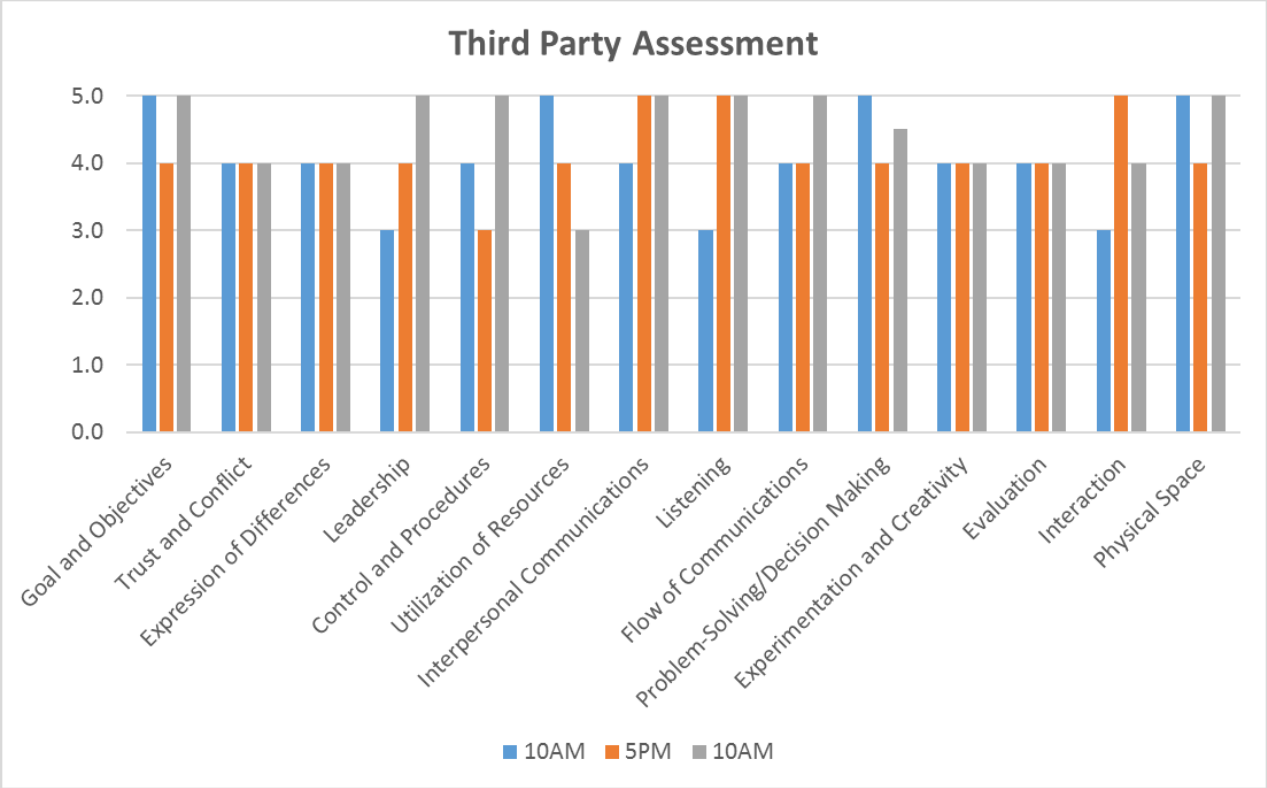

Figure 3 – Team A Third Party Scores

Team	First	Second	Third
A	Goals and Objectives	Interpersonal Communications	Problem Solving /Decision Making
B	Interpersonal Communications	Expression of Differences	Physical Space
C	Listening	Expression of Differences	Goals and Objectives
G	Interaction	Listening	Interpersonal Communications
I	Physical Space	Goals and Objectives	Interaction
J	Utilization of Resources	Goals and Objectives	Physical Space

Figure 4 – Top Characteristics of Teams

Subjective Analysis

The qualitative study for this IDE explored the unique interaction of team development over time and its ability to predict team success. Through the utilization of the survey tool, three third party observers extrapolated significant themes found across the three observation points during the intensive weekend: 10:00 am Saturday, 5:00 pm Saturday, and 10:00 Sunday. Additionally, each

team completed a team self-report on Sunday at 10:00 am as means to gather data and self-reflection from each team member.

The third party observers found that the most significant positive and negative change occurred between the first and last observation period. Specifically, the most successful teams during the Aggies Invent weekend exhibited the ability to develop as a cohesive group through effective Leadership, Listening, and Interaction. Amongst the winning team, the third party observers also found consistently high ratings in the areas of Goal and Objectives, Interpersonal Communication (i.e., communication was open and participatory), Listening (i.e., team members actively listened to each other), Flow of Communication (i.e., discussion was forward moving in nature and built upon previous responses), and Physical Space (i.e., despite having a chaotic workspace, the team maintained a focused direction). Similarly, the second place team also received consistently high ratings within the scales of Goal and Objectives, Trust and Conflict, Interpersonal Communication, Listening, and Physical Space as well. The main distinguishing factor between the two teams was in Expression of Differences (i.e., the disagreements among team members did not arouse defensive reactions). It was noted that for two out of the three observation points, the winning team did not have high ranking in regards to this scale. The third party observers found that as the weekend progressed, most teams displayed mild to moderate levels of Expression of Differences as evidenced by member disagreements, failed communication by at least one member, or high reactivity of responses within the team. Conversely, the second-place team received consistently high ratings for this scale across all three observation points. Over the course of the Aggies Invent weekend, the first and second place teams exhibited the most consistent hypothesized team development characteristics of Interaction, Respect Amongst Peers (contained in the Trust and Conflict plus Expression of Differences characteristics), and Effective Communication (contained in Interpersonal Communication and Listening characteristics) that predict quality team success.

Additionally, at the first observation point, the third party observers found that the winning team did not have delineated leadership roles defined at the initial start of the IDE. Although explicit team leadership was not initially clear for this team, individual leadership roles became more defined as the weekend progressed. It was also noted that the winning team focused on establishing a shared leadership role by delegating roles and duties to each member based on their individual strengths to contribute to team cohesion and success. The self-observation on Sunday at 10:00am indicated that the winning team exhibited the most team cohesion and respect on an internal level that aligned with the third party observers' assessment of the team. It was also noted that the winning team exhibited success in the ability to express differences effectively. The third party observers noted that aside from most other teams, the winning team displayed possible effectiveness in how the team handled disagreements in a non-defensive manner. The expression of differences was not observed for two out of the three observation points for the winning team, which potentially reinforces high ratings of interpersonal communication and goal setting.

Examining the third party observations of the lower performing teams revealed that the last place team did not perform well in Leadership, Interaction, Listening, or Interpersonal Communication when compared to the first two teams. Further, the next to last place team also performed lower in Leadership, Listening, and Interpersonal Communication.

Conclusion and Recommendations

During an Aggies Invent IDE, team characteristics were examined through a self-assessment tool and having direct third party observations. It was hypothesized that good team characteristics would be a predictor of success in the competition, as measured by the judges score in four areas of evaluation, and thus lead to stronger entrepreneurial skill development. The strongest trend in the data indicated that teams must score high in their presentation but also have a strong innovation score to be among the top three. A strong innovation score cannot overcome low presentation or implementation scores. A team is most successful when they are able to effectively communicate their innovation project solution. This is consistent with the ability to recognize an opportunity, design an innovative solution, and then communicate (pitch) their solution to judges (representing the investors). (Newmeyer & McKenna, 2016) and (Clark, July 2008) Strong communication skills start with strong interpersonal skills to effectively communicate the best ideas inside a team, listen to each other, and having a leader organize the presentation into a cohesive story.

No trends could be determined by the added questions on Physical Space (how their space was organized). Further, third-party observations were performed by directly observing teams with the third-party being physically present at the table. This proved to be intrusive and would have impacted the observations. Finally, since multiple third-party observers were used, evaluations and scoring were subjective and somewhat inconsistent.

One of the goals of this study is to examine team characteristics during an Aggies Invent IDE and use this information to perform interventions to help teams improve their performance. During this particular IDE observational weekend no team preformed sufficiently low as to require an intervention. Therefore, this portion of the research was not examined. However, findings and research have been used in subsequent Aggies Invent IDE's in the initial briefing to participating students. Team activities and exercises are outlined for the initial stage of team formation to help bring teams together quickly. The researchers have observed a decrease in the level of conflict when these exercises have been implemented. This will be the subject of a future study.

Data presented in this paper is from a small sample size and analysis did not produce a statistically significant trend in the characteristics examined. Further study is required and the authors recommend the following changes to the study:

- Larger sample size where teams are analyzed over multiple Aggies Invent IDE
- Remove the characteristics of Physical Space
- Increase the scale on the characteristics from 5 to 10 and group the scales into high, medium, and low when performing analysis
- Remove the Not Observed option for scoring
- Use a single third-party observer that is not physically present during observations. This could be accomplished by using a video feed.
- Insure that all teams who elect to participate fill in evaluations at each time period measured.

Even with these limitations, trending data indicates that positive and successful team characteristics are important in determining team performance during an Aggies Invent IDE. These include:

- Effective interpersonal skills are critical to proper team formation and thus success
- Listening to team members share ideas and concepts to increase innovation. When one person takes over and drives their solution, alternatives are not sufficiently considered.
- Shared leadership enables team members to take leadership roles when they have particular strengths
- Presentation skills, the ability to describe their solution effectively in a succinct presentation, is required
- Good presentations cannot overcome a solution with low innovation

Further study could develop statistically significant data which would validate these correlations.

Appendix A

Team Name_____

Ratings Scale (1 - Exhibits Characteristics on Left / 5 – Exhibits Characteristics on Right) N/A – Not Present or Not Applicable						
1. Goal and Objectives I believe there is confusion about the purpose and the desired outcomes	1	2	3 N/A	4	5	I believe team members understand and agree on goals and objectives
2. Trust and Conflict I believe there is little trust among members and conflict is evident	1	2	3 N/A	4	5	I believe there is a high degree of trust among members and conflict is dealt with openly and effectively
3. Expression of Differences I believe that disagreements produce defensive reactions	1	2	3 N/A	4	5	I believe that disagreements did not arouse defensive reactions
4. Leadership I believe one person dominates and leadership roles are not shared	1	2	3 N/A	4	5	I believe leadership roles are appropriately shared at the proper time
5. Control and Procedures I believe there is little control and there is a lack of procedures to guide team functioning	1	2	3 N/A	4	5	I believe there are effective procedures to guide team functioning; team members support these procedures and regulate themselves
6. Utilization of Resources I believe all member resources are not recognized and/or utilized	1	2	3 N/A	4	5	I believe member resources are fully recognized and utilized
7. Interpersonal Communications I believe communications between members are closed and guarded	1	2	3 N/A	4	5	I believe communications between members are open and participative
8. Listening I believe the team members do not listen to each other	1	2	3 N/A	4	5	I believe the team members actively listened to each other
9. Flow of Communications I believe the discussion required a great deal of backtracking and reorienting	1	2	3 N/A	4	5	I believe the discussion moved forward with succeeding points building on previous ones
10. Problem-Solving/Decision Making I believe the team has no agreed on approaches to problem solving and decision making	1	2	3 N/A	4	5	I believe the team has well-established and agreed-on approaches to problem solving and decision making
11. Experimentation and Creativity I believe the team is rigid and does not experiment with how things are done	1	2	3 N/A	4	5	I believe the team experiments with different ways of doing things and is creative in its approach
12. Evaluation I believe the team never evaluates its functioning or processes	1	2	3 N/A	4	5	I believe the group often evaluates its functioning and processes
13. Interaction Team members are working separately in areas more than 10 ft apart	1	2	3 N/A	4	5	Members are working together within 10 ft of their work area
14. Physical Space Team work area is disorganized without common focus direction	1	2	3 N/A	4	5	The team work area may be chaotic, but a common focused direction is apparent

Questions 1-12 Based on Ratzburg, W.H. *Team Effectiveness: Meeting evaluation scale.* (Retrieved from the World Wide Web on December 16, 2004), http://www.geocities.ws/frtzw906/meetingevaluationform.html

Appendix B

Project Evaluation Sheet

Project Title: _____

		Strongly Agree 5	Agree 4	Neutral 3	Disagree 2	Strongly Disagree 1
Technical Performance and Standards (25%)	Is the NEED statement / project objective clearly defined?					
	Were the design requirements clearly stated?					
	Did the team consider adequate number of design alternatives?					
	Is the conceptual design clearly defined?					
	Did the team provide a prototype demonstrating the solution?					
	Was evidence provided that the prototype met the technical performance requirements?					
Technical Performance and Standards Total (Total from above divided by 6)						
Project Feasibility (25%)	Can the proposed solution be implemented?					
	Is the proposed solution a technically sound solution?					
	Is the proposed solution usable?					
Project Feasibility Total (Total from above divided by 3)						
Project Innovation (25%)	Is the proposed solution unique or a unique adaptation?					
Project Innovation Total (Total from above)						
Presentation (25%)	Was the presentation clear and concise?					
	Was the presentation well organized and flowed smoothly?					
	Was the presentation inclusive and supportive of all team members?					
	Did the prototype(s) adequately represent the solution?					
Presentation Total (Total from above divided by 4)						
Grand Total (Performance*0.25 + Feasibility*0.25 + Innovation*0.25 + Presentation*0.25)						

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