

**EXPLORATORY INVESTIGATION INTO INFLUENCE OF EDUCATIONAL
BACKGROUND ON TENDENCY TO COLLABORATE AMONG OWNERS,
ARCHITECTS, ENGINEERS, AND CONTRACTORS**

A Thesis

by

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ABSTRACT

The construction industry is plagued by problems such as lack of collaboration and trust, ineffective communications, and lack of systems thinking, which may lead to an adversarial relationship among project stakeholders. Relatively low levels of productivity are pushing the construction industry to collaborate on a higher scale. With the introduction of Integrated Project Delivery (IPD) processes and new technologies, collaboration plays an important role. Research shows that collaboration is affected by many factors.

With Maroon-White Game as the simulation tool, this research uses game theory and prisoner's dilemma concept to verify whether the education background of owners, architects, engineers, and contractors have an influence on tendency to collaborate in the construction industry. It also verifies whether women or personality type measured by Jung/Isabel Briggs Myers Typology have an influence on tendency to collaborate. This research lays the groundwork for additional research into the factors affecting collaboration in the construction industry and the steps that can be taken to improve the same.

Although the results from the research show that there is slight variation (insignificant) in the tendency to collaborate among different disciplines, further research is needed to statistically validate the result. Also, the results show that gender and personality type do not influence the tendency to collaborate in the construction industry. However, for statistical power, further research needs to be done.

DEDICATION

In memory of my beloved sister Soumya Ramanath. You were one of the most wonderful and caring person I have ever known. I thank you for all the wonderful times we have had together which will be etched in the memory and I thank you for being there for me whenever needed. You will be in our hearts forever.

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NOMENCLATURE

AIA	American Institute of Architects
OAEC	Owners, Architects, Engineers, and Contractors
IPD	Integrated Project Delivery
TTC	Tendency to Collaborate
E	Extraversion
I	Introversion
N	Intuitive
S	Sensing
F	Feeling
T	Thinking
J	Judging
P	Perceiving
RTC	Round of Total Collaboration
RNC	Round of No Collaboration
RB	Round of Betrayal

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1. INTRODUCTION

1.1 Background of the Problem

According to the United States Census Bureau (USCB 2013), the Construction Industry in the United States accounts for an annual revenue of approximately \$850 billion. The construction industry has been serving as the foundational element in many societies. With this understanding, it is evident that construction industry should operate strategically and successfully for the benefit of the whole community it serves. However, according to Gonzales (2006) more construction projects are now involved in legal disputes than at any other time in history. Zollinger and Leary (2005) observed that the cost of lawsuits is increasing at a rate of 7% per year in the United States totaling \$2 billion annually and contractors, subcontractors, attorneys, regulators, architects, engineers, consultants, financiers, seem to agree that contracting disputes are spiraling out of control at a great cost. According to Fulbright's 9th Annual Litigation Trends Survey Report, the number of engineering/construction companies spending \$1 million or more annually in litigation increased to 71% of their sample of 392 participants. This same number was at 48% in 2011, and 33% in 2010 (Fulbright and Jaworski 2013). This increase is far outpacing inflation and indicates the increasing prevalence of litigation in the construction industry (Smith 2013).

Researchers have identified a variety of problems faced by Owner, Architect, Engineer, and Contractor (OAEC) industry participants. These problems range from skilled labor shortages and material defects to poor communication and systemic inefficiencies

(Smith 2013). Also, the construction industry is plagued by problems such as lack of collaboration and trust, ineffective communications, lack of systems thinking, all of which appear to be leading to an adversarial relationship among all project stakeholders (Elmarsafi 2008). This kind of relationship results in project delays, difficulty in resolving claims, cost overruns, litigation, and a win-lose climate and hence affecting all the project stakeholders. It is therefore worth to investigate whether lack of collaboration is common among those who are being educated to enter OAEC related profession.

1.2 Problem Statement

Research shows that with the evolution of construction projects from Design-Bid-Build^{*} to the Design-Build[†] and Integrated-Project-Delivery[‡] (IPD) methods, the need for collaboration is high. Shelbourn (2007) argues that with advancing methods, it is time for the construction industry to embrace new ways to improve productivity, mitigate litigations, and to deliver at its best the everlasting demands of the clients. Also, the construction industry's success depends on the collective efforts of players from different companies and backgrounds. To achieve this, collaboration and trust among key players in the industry plays an important role.

Problem: Research suggests that for the implementation of lean construction or IPD, collaboration plays an important role. However, we do not know which disciplines among the OAEC tend to collaborate more. With the advent of the Lean Manufacturing

^{*} Design and construction are separate contracts and lowest construction cost is the criteria for final selection (Kenig 2011)

[†] Design and construction contracts are combined (Kenig 2011)

[‡] Key parties are involved from the inception of the project and use a multi-party contract (Kenig 2011)

principles giving rise to Lean Construction, Integrated Project Delivery methods have helped to improve collaboration levels among different key players. Even with the implementation of IPD, lack of trust and collaboration among stakeholders still exists. One possible reason for deficits in collaboration is the uniqueness of the each construction project. Each project is unique and repeating partnerships do not happen often. Also, it is observed that natural competitive tendencies can often result in sub-optimization and long-term losses (Smith and Rybkowski 2012).

1.3 Research Objective

The objective of this research is to investigate the potential influence of the educational background of owners, architects, engineers, and contractors on tendencies to collaborate in the construction industry. The research also aims at explore whether, when in competitive teams, women tend to collaborate more than men. Also, with the assumption that extroverts tend to collaborate more than introverts, the research aims to find whether this is true in the case of OAEC disciplines.

1.4 Significance of the Study

Collaboration plays an important role in the success or failure of the IPD. An understanding of cultural and educational tendencies towards collaboration or non-collaboration of stakeholders offers a glimpse into factors that might facilitate or impede collaboration. By understanding which disciplines have lower tendencies to collaborate, a better curriculum in college can be built emphasizing the importance of collaboration. If this were to be implemented, higher levels of collaboration may be expected after students become professionals. Furthermore, collaboration is one of the key principles of

lean technology, and understanding of it aids in better implementation of lean principles in construction.

2. LITERATURE REVIEW

2.1 Collaboration and the Need for Inter Organizational Collaboration

Collaboration has been defined as the process of joint decision-making among independent parties, involving joint ownership of decisions and collective responsibility for outcomes (Boyle and Kochinda 2004). Collaboration includes supporting sustained team-work by creating a culture that values personal integrity, giving power and respect to each person's voice, integrating individual differences, resolving competing interests and safeguarding the essential contribution each must make to achieve optimal outcomes (Sterchi 2007). To become successful at a job it is necessary to coordinate with others (Johnson and Johnson 2004). Vygotsky (1975) claims exchange of information with classmates is a good way to enhance one's psychological growth and also increase one's level of intelligence. Collaboration can be the key to overcoming work-related obstacles (Vygotsky 1975).

Basic essential characteristics of a group setting should include the following: cooperation, conversation, teamwork, confidence and coherence (Greenlee and Karanxha 2010). Constructive conversation tends to bond all the team members together. Sarker et al. (2011) conclude that better interactions leads to better achievement.

Inter-organizational collaboration is important in construction industry for the benefit of all the stake holders involved because it is an effective means for creating a strategic advantage in any industry (Gamal 2008). According to Schifrin (2001), strategic

alliances are a common business strategy in the US with 10,000 partnerships being created each year. In an industry such as construction, the conditions for the practice of inter-organizational collaboration are ripe. Opportunism by team players is readily available in most construction projects and generally comes at the expense of the other players or the project as a whole (John 1984). Conversely, research has also identified trust as one of the most effective ways to prevent opportunism (Walker 2003). When group members are familiar with one another, it can lead to an improved team environment, which shows tendencies to collaborate (Janssen et al. 2009; Stark and Bierly 2009).

2.2 Integrated Project Delivery (IPD)-Collaboration in View of the Construction

Industry

“Integrated Project Delivery (IPD) is a project delivery approach that integrates people, systems, business structure and practices into a process that collaboratively harness the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste and maximize efficiency through all phases of design, fabrication, and construction” (AIA 2007). IPD, contrasting the traditional method of delivery, integrates all the key players from the inception. It leverages early contributions and expertise through utilization of new technologies, allowing all team members to add value and to realize their potentials for contributing to the project. IPD seeks to improve project outcomes through a collaborative approach of aligning the incentives and goals

of the project team through shared risk and reward, early involvement of all parties, and a multiparty agreement (Kent 2010).

Collaborative working is considered by many to be essential if design and construction teams are to consider the whole lifecycle of the construction process (Shelbourn 2007).

The new millennium has seen widespread recognition from research findings and the construction industry itself that the industry must embrace new ways of working if it is to remain competitive and meet the needs of its ever demanding clients. Inherent within this agenda of new ways of working is a move towards collaborative working and its associated fields: concurrent engineering and lean production (Anumba et al., 2004).

Collaborative working is essential if design and construction teams are to address the entire lifecycle of the construction product and take account of not only primary functionality but also productivity, build ability, serviceability and even recyclability (Kusiak and Wang, 1993). Cooperative relationships among the supply chain actors (often referred to as partnering) are an important element of lean construction (Naim and Barlow, 2003; Green and May, 2005; Jorgensen and Emmitt, 2008), facilitating the integration of different actors' competences and efforts in joint problem-solving.

At the core of IPD are collaborative, integrated and productive teams composed of key project participants (AIA 2007). Guided by principles of trust, transparent process, and effective collaboration, the IPD teams build upon early contributions of an individual's expertise. Recent studies have shown that out of all non-farm industry, only construction

industry's productivity has been decreased since 1964 (AIA 2007). Figure 1 shows the labor productivity index for construction and all the non-farm industries.

Also, new technologies when utilized in conjunction with collaborative processes are demonstrating substantial increase in productivity and decrease in requests for information, field conflicts, and wastes (AIA 2007). AIA claims Integrated Project Delivery is built on collaboration, which in turn is built on trust. With better collaboration, the key players focus more on the success of the project rather than on the individual goals. Without collaboration, IPD will falter and participants will remain in the adverse and antagonistic relationships that plague the construction industry (AIA 2007). Also, Kulkarni (2012) claimed that collaborative project delivery system produce a more reliable cost outcomes for the public owners. In view of the importance of IPD, collaboration plays an important role. Collaboration being important in the implementation of IPD has factors affecting it. One of the factors may be the fear of loss of individual interest. Huxom (1993) claims that the key disadvantages of collaboration are loss of control, flexibility, and glory. Despite these disadvantages, however, the benefits of collaboration override the disadvantages (Huxom 1993).

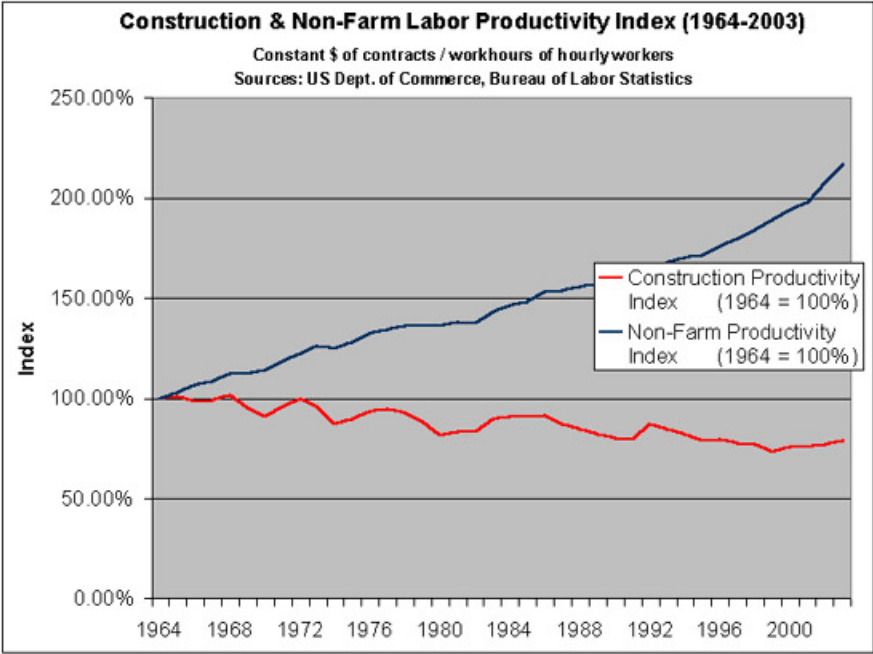


Figure 1: Labor Productivity Index for US Construction Industry and All Non-Farm Industries

2.3 Educational Influence on Tendency to Collaborate

Collaboration has been studied substantially by variety of fields. Borrego (2006) claims that engineers tend to view collaboration as an isolated division of labor and the views on collaborative relationships vary markedly between technical and social science fields. Also, Borrego (2008) observed that the way an individual understands and appreciates the nature of knowledge affects the way he or she collaborates with colleagues in different academic disciplines. Inter-organizational collaboration has been studied across industries and is shown to increase organizational capabilities and value generation through exchange of resources, thus contributing to an organization's competitive advantage (McEvily and Zaheer 1999). According to Lin (2006), some organizations find it difficult to configure alliances for mutual benefits value and hence are resulting in the failure of half of strategic alliances.

With the advent of IPD, inter-organizational collaboration plays an important role. AIA claims that without collaboration IPD fails. It has been observed that much of the recent work on collaborative working has focused on the delivery of technological solutions (Faniran et al. 2001). There is a need for research on the factors influencing the level of collaboration among the project stakeholders and this study aims at identifying whether educational influence has an impact on the level of collaboration.

Borrego (2008) observed that the way an individual understands and appreciates the nature of knowledge affects the way he or she collaborates with colleagues in different academic disciplines. Stacy (2007) claims that nurses have a better collaborative

approach than physicians. Much of the research on the topic of influence of education background on the level of collaboration has been done in the field of health care, engineering, and social science. Research has shown that there is always a difference in the level of collaborations among different educational background.

2.4 Women and Tendency to Collaborate

According to research literature, women tend to be less competitive than men. Gneezy et al. (2003) found that women were less effective than men in competitive environments, despite the fact that their performance was similar to men's in a noncompetitive environment. Niederle and Vesterlund (2007) concluded that women tend to shy away from competition. When in terms of group processes, Woolley et al. (2010), concluded that the group collaboration is greatly improved by the presence of women in the group.

In a study of group performances, Fenwick and Neal (2001) found that groups with greater number of women performed better than homogeneous groups on a management simulation task.

In a meta-analysis comparing men and women in terms of task and interpersonal styles, Eagly and Johnson (1990) found that women were significantly more interpersonally oriented than men. Men's styles tend to be more autocratic than that of women (i.e. giving orders), whereas women's styles tend to be more democratic than that of men (i.e. focus is on participation). In addition, when comparing all-female versus all-male groups, all-female groups demonstrate more egalitarian behaviors, such as equal

amounts of communication among group members and shared leadership (Berdahl and Anderson 2005; Schmid-Mast 2001).

However, these observations may be inconclusive because other researchers have reported opposite results.

2.5 Game Theory: Prisoner's Dilemma and The Maroon-White Game

Prisoner's dilemma is defined as "A paradox in decision analysis in which two individuals acting in their own best interest pursue a course of action that does not result in the ideal outcome." The typical prisoner's dilemma is set up in such a way that both parties choose to protect themselves at the expense of the other participant. As a result of following a purely logical thought process to help oneself, both participants find themselves in a worse state than if they had cooperated with each other in the decision-making process. A prisoner's dilemma explores the conflict between social incentives to compete versus those encouraging cooperation (Holt and Capra 2000). Most of the research shows that when given the option to cooperate with another party or look out for their own best interests, barring additional incentives, the selection of a cooperative move is unlikely (Axelrod 1981; James Jr 2002; Smale 1980).

The Maroon-White Game is an example of prisoner's dilemma. The Maroon-White Game is a three-group non-zero sum game. A non-zero sum game describes a situation where one team scoring points does not necessarily mean that fewer points are available for the other teams (Von Neumann and Morgenstern 2007). This type of game is commonly used in situations where cooperation between teams is a possibility.

This study using the simulation, the Maroon-White Game (Smith and Rybkowski 2013), is aimed at understanding whether the educational background of four different stakeholders (owners, architects, engineers and general contractors) influences their tendencies towards collaboration. The Maroon-White Game helps reveal whether individualism is favored over collectivism or vice versa in an organization and in the industry in general. The Maroon White game emphasizes the importance of collaboration. Also, the study aims at whether women have a higher tendency to collaborate when compared to men and whether specific personality types as defines by the by Jung/Isabel Briggs Myers Typology test are more or less likely to collaborate.

3. RESEARCH METHODOLOGY*

3.1 Introduction

The study is divided into two parts: Data Collection and Data Analysis.

The objective of the study is to investigate the influence of education background of owners, architects, engineers, and contractors on the tendency to collaborate in the construction industry. In order to accomplish this research objective, the Maroon- White Game (Smith and Rybkowski 2013) using fourth year undergraduate students at Texas A&M University as a case study was identified as the research tool.

3.2 Data Collection

Selection of Classes for Administering the Game:

- The four disciplines of Business, Architecture, Engineers, and Construction Science representing the Owners, Architects, Engineers, and Contractors in the construction industry were selected.
- Texas A&M University was identified as the source of collecting the data for different disciplines because of the vicinity and the availability of all the disciplines in the University.

* The research game is reprinted with permission from "The Maroon and White Game: A simulation of trust and long-term gains and losses" by Smith, J. P. and Rybkowski, Z. K, 2013. *Proceedings of the 21th annual conference for the International Group for Lean Construction*; July 31-August 2, 2013: Fortaleza, Brazil.

- For the business class, real estate development was chosen as it represents the construction industry.
- Civil Engineering was selected for the engineering disciplines as it is one of the most important engineering field in the construction industry.
- Construction Science which represents the contractors in the industry was selected for administering the game.

The recruitment email was sent to the professors of the above said disciplines at Texas A&M University asking their permission to administer the game in one of their classes. When the permission was given and the informed consent was taken from the participants, the game was administered on the set date and time.

The game administration in the class included:

- Explaining the concept of prisoner's dilemma and game theory to the class.
- Explaining the Maroon-White Game.
- Playing the Maroon- White Game.
- Discussions and Reflections on the game.

The game was administered for 2 Business Senior Classes, 1 Business Graduate Class, 3 Architecture Senior Classes, 2 Construction Science Classes, and 1 Civil Engineering Senior Class. Also, the game was administered to one Construction Company during a lean facilitation by Dr. Zofia Rybkowski.

3.3 Research Tool: The Maroon- White Game

The game shall be played as per the description and abiding the following rules in Appendix A. The Appendix A has been directly excerpted from Smith, J. P. and Rybkowski, Z. K. (2013). "The Maroon and White Game: A simulation of trust and long-term gains and losses," *Proceedings of the 21th annual conference for the International Group for Lean Construction*; July 31-August 2, 2013: Fortaleza, Brazil.

The teams were built either by counting off the numbers or randomly. However, in the case of the construction company, the participants formed their own teams. Before the game, two placards of Maroon and White were given to each team. While selecting the color choice all the teams had to hold up placard showing the color choice simultaneously on the count of three. This was followed for all the rounds during the game. After the game was administered, the result of the game was recorded. The discussions on the game reflecting thoughts on the game followed.

The discussion included asking the following questions:

- What was the best way to maximize the points?
- What can we learn from this game?
- Once the trust is lost by selecting white, what effect it had on the participants?
- How can this game be applied to construction?
- What are the factors affecting to maximize the points?

Observations while administering the Maroon-White Game included:

- How many female students were present in each team?
- How the students behave when they win a round?
- What were the feelings of the teams that were betrayed?
- What was the feeling of the team that betrayed the other two teams?
- How does the betrayal affect the decision of the teams?

Also, the human metrics test to determine the personality of each student was collected.

The Human Metrics test was useful in determining the personality types of the participants. The students were asked to take the Jung/Isabel Briggs Myers Typology test before the administration of the game to help in determining the personality type of the participants. The human metrics test is attached in APPENDIX D.

There are 16 possible personality type combinations:

- E (Extraverted) vs. I (Introverted)
- N (Intuitive) vs. S (Sensing)
- F (Feeling) vs. Thinking (Thinking)
- J (Judging) vs. P (Perceiving)

3.4 Data Analysis

The data analysis included:

- Calculating the Tendency to Collaborate (TTC) for each of the class.

$$\text{TTC} = (\text{Number of Maroon Responses} \div \text{Total Number of Responses}) * 100$$
- The average TTC for each discipline was calculated.

- The TTC's for different disciplines was compared to verify whether there is any significant influence of the discipline on TTC.
- The percentage of women in each team was calculated for all the games administered.
- TTC of that each team was calculated for all the games administered.
- The percentage of women in a team was compared to the TTC of each team to verify whether gender influences the level of collaboration.
- The percentage of extroverts in a team was compared to the TTC of each team to verify whether personality trait influences the level of collaboration.
- Rounds of Total Collaboration (RTC), where all the teams selected maroon, were labelled.
- Rounds of No Collaboration (RNC), where all the teams selected white, were labelled.
- Rounds of Betrayal (RB), where at least one of the teams selected white even after meeting and agreeing as a group to select maroon were labelled.

The summary of data analysis and discussions will be made in Results and Discussion.

3.5 Assumptions

As in most research, a number of assumptions have been made to facilitate the completion of this project. They are as follows:

- Students studying real estate and finance accurately represents Owners in the construction industry.
- Attitudes of undergraduate students accurately reflects attitudes of the persons in the OAEC industries.
- Student data and analysis is an appropriate stepping stone to industry application of the tool.
- Extroverts tend to collaborate more than Introverts.

3.6 Limitations to the Study

This study has several limitations. The sample being collected from the same geographical area neglects the influence of cultural differences due to the geographical area. Also, by conducting this study in higher educational institution, we are assuming this will also predict their behavior in the industry. Therefore, a more scientific result can be obtained by studying the influence of education on collaboration among the construction professionals. The study also does not consider the cultural differences among the same geographical area in the chosen sample. Furthermore, although the choices of disciplines considered represents the stakeholders in the construction industry, not all disciplines are considered. Also, there is a danger that students of one section might have shared their experience of playing the game with students of other section who had not yet played the game. This would invalidate all results. To limit this risk, I had asked students not to share their experience with other students both before the game begins and after the game. The other limitation the research has is that it considers only

the comparison of percentage of extroverts per team to their TTC. It does not consider all the personality traits of the individual. The scope of this project is limited to interactions and relationships involved in the construction industry. Findings are specific to construction industry and may not have applicability outside of this context.

4. RESULTS AND OBSERVATIONS

4.1 Introduction

This chapter summarizes the study results and the observations during the administration of the game. The results of the Maroon White game that was administered for the construction science, architecture, business, and the civil engineering classes have been tabulated. Also, the result of the Maroon White game that was administered in one of the company which was trying to implement the lean technology in their company has been tabulated.

The personality types of each member of the team have been tabulated. After the results of the Maroon White game and the personality types had been collected, the Tendency to Collaborate was calculated for each class. The average of the TTC for each discipline was calculated. The TTC was then compared with different disciplines.

To see if there is any difference in the Tendency to collaborate based on the gender, the TTC was then compared with percentage of women in each team.

Also, to verify the influence of the personality types on the level of collaboration, the percentage of each personality types in each team was compared to their tendency to collaborate.

4.2 Results

4.2.1 Business Seniors

Class 1

This was a large class. The class consisted of 30 students. There were 9 women students and were distributed among the teams. The results of the game show that there is no point of total collaboration among the teams. The game was played for four rounds by not allowing the teams to discuss among other teams the strategy for maximizing the points. When it was observed that there was no total collaboration, for round 5, the teams were allowed to discuss among other teams their strategies for maximizing the points. After discussing, each of the team had agreed to collaborate for the sixth round and thereafter. However, Team 2 betrayed the other two teams and chose white, gaining hundred points for the round. It was observed that after the betrayal, the other two teams got furious and each of the team chose white subsequently.

It can be observed from Table 1 that they chose maroon 5 out of possible 21 times and their TTC was 23.80%. The percentage of women in each team was calculated and the TTC of each team was calculated and tabulated in Table 2. The personality types of each member in the team has been tabulated in Table 3. Also, the percentage of each personality type in each team was calculated and the TTC of each team was calculated and tabulated in Table 4.

After the game, the aim of the game was explained. It was observed that everyone understood the concept that collaboration maximizes the overall points. However, most of them were of the opinion that collaboration cannot be achieved because of lack of trust and that they would not tend to collaborate given different payoffs.

Table 1: Result-Business Seniors-Class 1

	Team 1		Team 2		Team 3		Total Team Points	RTC	RNC	RB
	Color Choice	Points	Color Choice	Points	Color Choice	Points				
Round 1	Maroon	0	White	0	White	0	0			
Round 2	White	0	White	0	White	0	0		X	
Round 3	White	0	White	0	Maroon	0	0			
Round 4	White	0	White	0	Maroon	0	0			
Round 5	Maroon	0	White	100	Maroon	0	100		X	
Round 6	White	0	White	0	White	0	0		X	
Round 7	White	0	White	0	White	0	0		X	
Total Individual Points		0		100		0	100			

$$TTC = (5/21) * 100 = 23.80\%$$

Table 2: Percentage of Women in Business Seniors-Class 1 and Their TTC

	Team 1	Team 2	Team 3
Percentage of Women	3/10= 30%	2/10= 20%	4/10= 40%
Tendency to Collaborate	2/7 = 28.57%	0/7 = 0%	3/7 = 42.85%

Table 3: Personality Type Distribution for the Teams-Business Seniors-Class1

Team 1	Team 2	Team 3
ESFJ	ESFP	INTJ
ESTJ	ENFJ	ESFJ
ISTJ	ESTJ	ISTJ
INTJ	ESTJ	ENTJ
ENTJ	ENTJ	ENTJ
ENTJ	ENFJ	ENFJ
ENFJ	ISTP	INTJ
ESTJ	ESTP	ENFJ
INTP	ENFJ	ENTJ
INTJ	ENTJ	ENFJ

Table 4: Percentage of Each Personality Type in Business Seniors-Class 1 and Their TTC

	Team 1	Team 2	Team 3
Percentage of Extroverts	60	90	70
Percentage of Intuits	60	50	80
Percentage of Feelers	20	40	40
Percentage of Judgers	90	70	100
TTC	28.57	0	42.85

Class 2

Similar type of result was observed in this class as well. Observing no point of total collaboration until the fourth round, they were allowed to discuss among other teams for round 5 and thereafter. It was observed that every team understood that they need to collaborate to maximize their points and hence decided upon choosing maroon for the subsequent rounds. However, Team 1 betrayed on round 5 and gained 100 points. The betrayal from team 1 resulted in infuriating the other two teams thereby choosing white for the remaining rounds.

It can be observed from Table 5 that they chose maroon 7 out of possible 21 times and their TTC was 33.33%. The percentage of women in each team was calculated and the TTC of each team was calculated and tabulated in Table 6. The personality types of each member in the team has been tabulated in Table 7. Also, the percentage of each personality type in each team were calculated and the TTC of each team was calculated and tabulated in Table 8.

After the game, the aim of the game was explained. It was observed that most of them understood the concept that collaboration maximizes the overall points. However, most of them were of the opinion that they would not tend to collaborate given different payoffs.

Table 5: Result-Business Seniors-Class 2

	Team 1		Team 2		Team 3		Total Team Points	RTC	RNC	RB
	Color Choice	Points	Color Choice	Points	Color Choice	Points				
Round 1	White	100	Maroon	0	Maroon	0	100			
Round 2	Maroon	0	Maroon	0	White	100	100			
Round 3	White	0	White	0	White	0	0		X	
Round 4	White	0	White	0	White	0	0		X	
Round 5	White	100	Maroon	0	Maroon	0	100			X
Round 6	Maroon	0	White	0	White	0	0			
Round 7	White	0	White	0	White	0	0		X	
Total		200		0		100	300			
Individual Points										

$TTC = (7/21) * 100 = 33.33\%$

Table 6: Percentage of Women in Business Seniors-Class2 and Their TTC

	Team 1	Team 2	Team 3
Percentage of Women	1/4= 25%	1/5= 20%	2/5= 40%
Tendency to Collaborate	2/7 = 28.57%	3/7 = 42.85%	2/7 = 28.57%

Table 7: Personality Type Distribution for the Teams-Business Seniors-Class 2

Team 1	Team 2	Team 3
ESTJ	ENFJ	ISFJ
ENTJ	ESFJ	ENTP
INTJ	ESTJ	ISFJ
ENTJ	ISTP	ENTJ
	ESTJ	ENTJ

Table 8: Percentage of Each Personality Type in Business Seniors 2 and Their TTC

	Team 1	Team 2	Team 3
Percentage of Extroverts	75	80	60
Percentage of Intuits	75	20	60
Percentage of Feelers	0	40	40
Percentage of Judgers	100	80	80
TTC	28.57	42.85	28.57

4.2.2 Business Graduates

It was interesting to observe in the graduate class that all the teams realized right after round 2 that they needed to collaborate but none of them collaborated. One male student from team 3 had a collaborative approach right from the start. He explained the concepts of overall efficiency and individual efficiency and insisted on selecting maroon each time. Similarly, after the fourth round, the teams were allowed to discuss their strategies. This resulted in a point of total collaboration in round 5. However, betrayal followed the point of total collaboration and the male student who had insisted on selecting maroon each time, expressed his discontent on his fellow classmates.

It can be observed from Table 9 that they chose maroon 8 out of possible 21 times and their TTC was 38.09%. The percentage of women in each team was calculated and the TTC of each team was calculated and tabulated in Table 10. The personality types of each member in the team has been tabulated in Table 11. Also, the percentage of each personality types in each team was calculated and the TTC of each team was calculated and tabulated in Table 12.

When the game was explained later, few of them were of the opinion that collaboration would lead to socialism. However, most of them agreed that collaboration increases the overall points but they would not tend to collaborate because they had different payoffs and the lack of trust among the teams will not initiate them to collaborate.

Table 9: Results-Business Graduates

	Team 1		Team 2		Team 3		Total Team Points	RTC	RNC	RB
	Color Choice	Points	Color Choice	Points	Color Choice	Points				
Round 1	White	0	Maroon	0	White	0	0			
Round 2	White	0	White	0	White	0	0		X	
Round 3	White	0	White	0	White	0	0		X	
Round 4	White	0	White	0	Maroon	0	0			
Round 5	Maroo	50	Maroon	50	Maroon	50	150	X		
Round 6	Maroo	0	White	100	Maroon	0	100			X
Round 7	Maroo	0	White	0	White	0	0			
Total		50		150		50	250			
Individual Points										

$TTC = (8/21) * 100 = 38.09\%$

Table 10: Percentage of Women in Business Graduates and Their TTC

	Team 1	Team 2	Team 3
Percentage of Women	2/5= 40%	1/5= 20%	1/6= 16.67%
Tendency to Collaborate	3/7 = 42.85%	2/7 = 28.57%	3/7 = 42.85%

Table 11: Personality Type Distribution for the Teams-Business Graduates

Team 1	Team 2	Team 3
INFJ	ESFJ	ISTP
INTJ	INTJ	ISTJ
ISTJ	ENTJ	ENFJ
INTJ	ENTJ	INTJ
INTJ	ENTJ	ENTJ
		INTJ

Table 12: Percentage of Each Personality Type in Business Graduates and Their TTC

	Team 1	Team 2	Team 3
Percentage of Extroverts	0	80	33.33
Percentage of Intuits	80	80	66.67
Percentage of Feelers	20	20	16.67
Percentage of Judgers	100	100	83.33
TTC	42.85	28.57	42.85

4.2.3 Construction Science

Class 1

It was surprising to see that the teams attained point of total collaboration on round 1 itself. It seemed that all the teams had a collaborative approach right from the start.

However, subsequent rounds differed. Similar to the other classes, the team was allowed to discuss their strategies after round 4. Similar results were observed. A male student from team 3 suggested to collaborate and asked everyone to choose maroon for the subsequent rounds. However, it was surprising to see that the male student who had suggested to collaborate himself betrayed the other teams and chose white in round 5. Similar infuriating reactions were seen among the other two teams which resulted in everyone choosing white for the subsequent rounds.

It can be observed from Table 13 that they chose maroon 8 out of possible 21 times and their TTC was 38.09%. Team 1 had the highest TTC. The percentage of women in each team was calculated and the TTC of each team was calculated and tabulated in Table 14. The personality types of each member in the team has been tabulated in Table 15. Also, the percentage of each personality type in each team was calculated and the TTC of each team was calculated and tabulated in Table 16.

When the game was explained later, most of the students differed in their opinion. It was observed that most of the students did not agree to collaborate even if they realized that

collaboration results in maximizing the points. Comments such as “Collaboration is for Sissies” were observed.

Table 13: Result-Construction Science Seniors- Class 1

	Team 1		Team 2		Team 3		Total Team Points	RTC	RNC	RB
	Color Choice	Points	Color Choice	Points	Color Choice	Points				
Round 1	Maroon	50	Maroon	50	Maroon	50	150	X		
Round 2	Maroon	0	White	0	White	0	0			
Round 3	Maroon	0	White	0	White	0	0			
Round 4	White	0	White	0	White	0	0		X	
Round 5	Maroon	0	Maroon	0	White	100	100			X
Round 6	White	0	White	0	Maroon	0	0			
Round 7	White	0	White	0	White	0	0		X	
Total		50		50		150	250			
Individual Points										

$$TTC = (8/21) * 100 = 38.09\%$$

Table 14: Percentage of Women in Construction Science Seniors- Class 1 and Their TTC

	Team 1	Team 2	Team 3
Percentage of Women	1/6= 16.67%	1/5= 20%	1/6= 16.67%
Tendency to Collaborate	4/7 = 57.14%	2/7 = 28.57%	2/7 = 28.57%

Table 15: Personality Type Distributions for the Teams- Construction Science Seniors- Class 1

	Team 1	Team 2	Team 3
	ISTJ	ESTJ	ESTJ
	INFJ	ESTJ	ENTJ
	ISTJ	ESTJ	ESTP
	ESTJ	ESTJ	ENFJ
	ESFJ	INFJ	ESTJ
	ISTJ		ESTJ

Table 16: Percentage of Each Personality Type in Construction Science Seniors-Class 1 and Their TTC

	Team 1	Team 2	Team 3
Percentage of Extroverts	33.33	80	100
Percentage of Intuits	16.67	20	33.33
Percentage of Feelers	33.33	20	16.67
Percentage of Judgers	100	100	83.33
TTC	57.14	28.57	28.57

Class 2

There was no point of total collaboration. It appeared that most participants were very competitive although team 3 appeared to have a better collaborative approach. It was interesting to see that none of the team agreed to collaborate with each other when allowed to discuss their strategies with the other teams. Hence, in round 5 it can be observed from the table 17 that only team 3 chose maroon. With further instigation to change their strategy to maximize the points, they were once again given a chance to discuss among other teams. In this discussion, it was observed that everyone decided to choose maroon. Nevertheless, team 2 betrayed and ended up gaining a 100 points for the round. With the betrayal the following round resulted in each team selecting white. Everyone wanted another round to be played. In this round as well they were given a chance to discuss their strategy. Similar conclusions to choose maroon was attained. It was expected to attain a point of total collaboration. Interestingly, there was betrayal from team 1.

It can be observed from Table 17 that they chose maroon 9 out of possible 24 times and their TTC was 37.50%. Team 3 had the highest TTC with 62.50%. The percentage of women in each team was calculated and the TTC of each team was calculated and tabulated in Table 18.

The personality types of each member in the team has been tabulated in Table 19. Also, the percentage of each personality types in each team was calculated and the TTC of each team was calculated and tabulated in Table 20.

With the explanation of the game, it was observed that most of the students did not agree with collaboration. Most of them were of the opinion that they would not tend to collaborate since the payoffs were different and also they were of the opinion that the lack of trust or the fear of betrayal always results in not collaborating. Comments such as “This is America. This is how it works” and “Collaboration kills capitalism” were observed.

The average TTC for construction science seniors is found to be 37.80%.

Table 17: Result- Construction Science Seniors- Class 2

	Team 1		Team 2		Team 3		Total Team Points	RTC	RNC	RB
	Color Choice	Points	Color Choice	Points	Color Choice	Points				
Round 1	Maroon	0	White	0	White	0	0			
Round 2	White	0	White	0	Maroon	0	0			
Round 3	White	0	White	0	Maroon	0	0			
Round 4	Maroon	0	White	0	White	0	0			
Round 5	White	0	White	0	Maroon	0	0			
Round 6	Maroon	0	White	100	Maroon	0	100			X
Round 7	White	0	White	0	White	0	0		X	
Round 8	White	100	Maroon	0	Maroon	0	100			X
Total		100		100		0	200			
Individual Points										

$TTC = (9/24) * 100 = 37.5\%$

Table 18: Percentage of Women in Construction Science Seniors- Class 2 and Their TTC

	Team 1	Team 2	Team 3
Percentage of women	1/6= 16.67%	1/6= 16.67%	1/6= 16.67%
Tendency to Collaborate	3/8 = 37.5%	1/8 = 12.5%	5/8 = 62.5%

Table 19: Personality type distribution for the teams- Construction Sciences Seniors- Class 2

Team 1	Team 2	Team 3
ENTJ	ENFJ	ESTJ
ISTJ	ENTJ	ENTJ
ENTJ	ENTJ	ESTJ
ESTJ	EITP	ISTJ
ESTJ	INTJ	ESTJ
INTJ	ENFP	ENTJ

Table 20: Percentage of Each Personality Type in Construction Science Seniors-Class 2 and Their TTC

	Team 1	Team 2	Team 3
Percentage of Extroverts	66.67	83.33	83.33
Percentage of Intuits	40	83.33	20
Percentage of Feelers	0	33.33	0
Percentage of Judgers	100	66.67	100
TTC	37.5	12.5	62.5

4.2.4 Civil Engineering

There was no point of total collaboration. It appeared that team 1 had a more collaborative approach since they chose maroon 5 out of 7 times with TTC of 71.42%. The overall TTC for all the teams was 38.09% since they chose maroon 8 times out of possible 21 times. Team 2 had a TTC of 0 % since they chose white all the 7 times.

Similar results of betrayal was observed after the teams were allowed to discuss their strategy. After deciding to choose maroon in the fifth and seventh round team 2 betrayed the other teams by choosing white. It was observed that team 2 had a sense of accomplishment after winning two rounds.

When the game was explained and the concept of collaboration made clear, it was seen that some of the students agreed that collaboration was essential for maximizing the points while other students differed in their opinion.

It can be observed from Table 21 that they chose maroon 8 out of possible 21 times and their TTC was 38.09%. The percentage of women in each team was calculated and the TTC of each team was calculated and tabulated in Table 22. The personality types of each member in the team has been tabulated in Table 23. Also, the percentage of each personality types in each team was calculated and the TTC of each team was calculated and tabulated in Table 24.

Table 21: Result- Civil Engineering Seniors

	Team 1		Team 2		Team 3		Total Team Points	RTC	RNC	RB
	Color Choice	Points	Color Choice	Points	Color Choice	Points				
Round 1	White	0	White	0	White	0	0		X	
Round 2	Maroon	0	White	0	White	0	0			
Round 3	Maroon	0	White	0	White	0	0			
Round 4	White	0	White	0	Maroon	0	0			
Round 5	Maroon	0	White	100	Maroon	0	100			X
Round 6	Maroon	0	White	0	White	0	0			
Round 7	Maroon	0	White	100	Maroon	0	100			X
Total Individual Points		0		100		0	100			

$TTC = (8/21) * 100 = 38.09\%$

Table 22: Percentage of Women in Civil Engineering Senior and Their TTC

	Team 1	Team 2	Team 3
Percentage of Women	$2/5 = 40\%$	$1/4 = 25\%$	$1/5 = 16.67\%$
Tendency to Collaborate	$5/7 = 71.42\%$	$0/7 = 0\%$	$3/7 = 42.85\%$

Table 23: Personality Type Distribution for the Teams- Civil Engineering Seniors

Team 1	Team 2	Team 3
ENFJ	ISTJ	ESTJ
INTJ	ISTJ	ENFJ
ESTJ	INTJ	ESFP
ESFJ	ENTJ	ISFJ
ESFJ		ISTJ

Table 24: Percentage of Each Personality Type in Civil Engineering Seniors and Their TTC

	Team 1	Team 2	Team 3
Percentage of Extroverts	80	25	60
Percentage of Intuits	40	50	20
Percentage of Feelers	60	0	60
Percentage of Judgers	100	100	80
TTC	71.42	0	42.85

4.2.5 Architecture

This part of the results of architecture seniors have been taken from the thesis “Exploratory Investigation of the Impact of Professional Architectural Education on Tendencies toward Work Collaboration” by Neal Gandhi (2014) in which I was involved in the data collection. In this thesis report the average TTC of the first year architecture students was compared with the fourth year architecture students. The thesis concluded that it appeared a mild decrease of 6.08% in the tendencies to collaborate from the first year students to the fourth year students. In addition to the TTC, I have added in my analysis the influence of personality type on the tendency to collaborate.

Class 1

It can be observed from the Table 25 that there was one point of total collaboration in round 5. However, the desire to win the game resulted in the teams selecting white most of the times. They chose maroon 8 times out of possible 21 times and their TTC was calculated to be 38.09%. The personality types of each member in the team has been tabulated in Table 26. Also, the percentage of each personality types in each team was calculated and the TTC of each team was calculated and tabulated in Table 27.

Table 25: Result- Architecture Seniors- Class 1

	Team 1		Team 2		Team 3		Total Team Points	RTC	RNC	RB
	Color Choice	Points	Color Choice	Points	Color Choice	Points				
Round 1	White	0	White	0	Maroon	0	0			
Round 2	White	0	White	0	White	0	0		X	
Round 3	Maroon	0	White	0	White	0	0			
Round 4	Maroon	0	White	0	White	0	0			
Round 5	Maroon	50	Maroon	50	Maroon	50	150	X		
Round 6	Maroon	0	White	0	White	0	0			
Round 7	White	0	White	0	Maroon	0	0			
Total		50		50		50	150			
Individual Points										

$$TTC = (8/21) * 100 = 38.09\%$$

Table 26: Personality Type Distribution for the Teams- Architecture Seniors- Class 1

Team 1	Team 2	Team 3
INTJ	INFJ	ENTJ
ENFJ	INFJ	ISTJ
INTJ	INFJ	
	INTJ	

Table 27: Percentage of Each Personality Type in Architecture Seniors- Class 1 and Their TTC

	Team 1	Team 2	Team 3
Percentage of Extroverts	33.33	0	50
Percentage of Intuits	100	100	50
Percentage of Feelers	33.33	75	0
Percentage of Judgers	100	100	100
TTC	57.14	14.28	42.85

Class 2

This class was observed to have the highest TTC among the fourth year architecture students. The results have been tabulated in Table 28. They had 2 points of total collaboration. It was observed that once the class got hold of the concept of collaboration, they chose to collaborate in the other round as well trying to maximize the points. They chose maroon 12 out of possible 21 times and had TTC of 57.14%. The personality types of each member in the team has been tabulated in Table 29. Also, the percentage of each personality types in each team was calculated and the TTC of each team was calculated and tabulated in Table 30.

Table 28: Result- Architecture Seniors- Class 2

	Team 1		Team 2		Team 3		Total Team Points	RTC	RNC	RB
	Color Choice	Points	Color Choice	Points	Color Choice	Points				
Round 1	White	0	White	0	White	0	0		X	
Round 2	White	100	Maroo	0	Maroon	0	100			
Round 3	White	0	White	0	White	0	0		X	
Round 4	Maroo	0	Maroo	0	White	100	100			X
Round 5	Maroo	0	White	100	Maroon	0	100			X
Round 6	Maroo	50	Maroo	50	Maroon	50	150	X		
Round 7	Maroo	50	Maroo	50	Maroon	50	150	X		
Total		200		200		200	600			
Individual Points										

$TTC = (12/21) * 100 = 57.14\%$

Table 29 : Personality Type Distribution for the Teams- Architecture Seniors- Class 2

Team 1	Team 2	Team 3
ENFJ	INFJ	ENFJ
ESFJ	INFJ	ESFJ
ESFP	INTJ	ESTJ
ISFJ	ESFJ	ESTJ
ENFP	ENFJ	INFJ
ENFJ		INTJ
ISTJ		

Table 30 : Percentage of Each Personality Type in Architecture Seniors – Class 2 and Their TTC

	Team 1	Team 2	Team 3
Percentage of Extroverts	71.42	40	66.67
Percentage of Intuits	42.85	80	50
Percentage of Feelers	85.71	80	50
Percentage of Judgers	71.42	100	100
TTC	57.14	57.14	57.14

Class 3

This class was observed to have the lowest TTC among the fourth year architecture students. They had no point of total collaboration. The results have been tabulated in Table 31. They chose maroon 4 times out of possible 18 times. The TTC of this group was calculated to be 22.22%. It was observed that when one female student suggested to collaborate by choosing maroon, she was mocked upon. The personality types of each member in the team has been tabulated in Table 32. Also, the percentage of each personality types in each team was calculated and the TTC of each team was calculated and tabulated in Table 33.

Table 31 : Result- Architecture Seniors- Class 3

	Team 1		Team 2		Team 3		Total Team Points	RTC	RNC	RB
	Color Choic	Points	Color Choice	Points	Color Choice	Points				
Round 1	White	0	White	0	White	0	0		X	
Round 2	White	0	White	0	White	0	0		X	
Round 3	White	0	White	0	White	0	0		X	
Round 4	White	0	White	0	White	0	0		X	
Round 5	Maroo	0	White	100	Maroon	0	100			X
Round 6	White	100	Maroon	0	Maroon	0	100			X
Total		100		100		0	200			
Individual Points										

$$TTC = (4/18)*100 = 22.22\%$$

Table 32 : Personality Type Distribution for the Teams- Architecture Seniors- Class 3

Team 1	Team 2	Team 3
ENTJ	INTJ	ENFJ
ISFP	INFJ	ENFJ
ENFP	INTJ	INFJ
ISFJ	ESFJ	INFJ
ENFJ	ISTJ	INTJ

Table 33 : Percentage of Each Personality Type in Architecture Seniors- Class 3 and Their TTC

	Team 1	Team 2	Team 3
Percentage of Extroverts	60	20	40
Percentage of Intuits	60	60	100
Percentage of Feelers	80	60	80
Percentage of Judgers	60	100	100
TTC	16.67	16.67	33.33

4.2.6 Construction Company

This construction company is a general contracting company and has been in the industry for nearly 50 years. At the time of administering the game, the company was focusing on incorporating lean technology into their system of working. On the request of the company, a lean facilitation was conducted by Dr. Zofia Rybkowski. I assisted Dr. Rybkowski during the lean facilitation and administered the Maroon White game for the employees of the company. There were 18 male employees for the Maroon White game. Three teams of 6 members each were formed and the game was administered.

The results are tabulated in Table 34. It was surprising to see that the collaboration at the industry was not better than that of with the students from the university. There was no point of total collaboration and teams chose maroon 5 out of possible 21 times. Their TTC was calculated to be 23.80%. It was observed that team 1 had a better collaborative approach when compared to the other two teams since they selected all the 5 maroon choices. Teams 1 and 3 were observed to choose white in all the rounds. All the teams were given a chance to discuss their strategy after the first four rounds. Although team 1 insisted on choosing maroon and maximizing the points, team 2 and team 3 were competitive and always chose white. It was observed that only team 1 had a collaborative approach to the game and was willing to choose maroon most of the times. Team 1 chose white 5 out of possible 7 times. Their TTC was 71.42%. However, since the other teams chose white in each round, the overall TTC of the group fell to 23.80%. It was observed during the game that team 2 and team 3 had no intentions of

collaborating and comments such as “Our team wins or every team will fail” were heard during the game.

Once the game was explained to the employees, it was observed that most of the employees agreed to the fact that collaboration might increase the overall performance of the teams. However, most of them expressed their concerns about not collaborating.

It was observed that the team 1, which had some tendency to collaborate, consisted of people mostly from the estimating department of the company. By contrast teams 2 and 3 were consisted of people from the site who would deal with the sub-contractors on a day to day basis.

The people who expressed their concerns for not collaborating were mostly from the site and they felt that since team 1 had the estimators, their level of trust and collaboration was higher since they were not exposed to the lack of trust or the betrayal from people at the site. They also expressed their concern over the fact that knowing people better and having a long term relationship with that person increases the level of collaboration. However, they explained that the people at site are betrayed on a day-to-day basis by the sub-contractors, and many other people and hence they have little trust for collaborating.

It was interesting to observe that the people who had worked in the industry for many years had little trust for the sub-contractors and had very low tendency to collaborate between different stakeholders. The employees explained that few of the factors that play an important role in the level of collaboration are trust, personalities of people in the industry, incentives, past experience, struggle for power, and the contract type.

Table 34: Result- Construction Company

	Team 1		Team 2		Team 3		Total Team Points	RTC	RNC	RB
	Color Choice	Points	Color Choice	Points	Color Choice	Points				
Round 1	White	0	White	0	White	0	0		X	
Round 2	Maroon	0	White	0	White	0	0			
Round 3	White	0	White	0	White	0	0		X	
Round 4	Maroon	0	White	0	White	0	0			
Round 5	Maroon	0	White	0	White	0	0			
Round 6	Maroon	0	White	0	White	0	0			
Round 7	Maroon	0	White	0	White	0	0			
Total Individual Points		0		0		0	0			

$$TTC = (5/21) * 100 = 23.80\%$$

5. ANALYSIS

Table 35 shows the average TTC for Business Seniors, Business Graduates, Construction Science Seniors, Civil Engineering Seniors, Architecture Seniors, and The Construction Company. Figure 2 shows the bar chart comparing their TTC.

It is surprising to see from the Figure 2 that the TTC is the lowest for the construction company when compared to the average TTC across Business Seniors, Business Graduates, Civil Engineering Seniors, Construction Science Seniors, and Architecture Seniors at Texas A&M University.

The average TTC for all the academic disciplines was found to be 36.34% and the TTC for the construction company was found to be lesser by 12.54% less than the average TTC among disciplines.

Table 35 : Disciplines and Their Average TTC

Discipline	TTC
Architecture Seniors	39.15
Business Graduates	38.09
Civil Engineering Seniors	38.09
Construction Science Seniors	37.80
Business Seniors	28.57
Construction Company	23.80

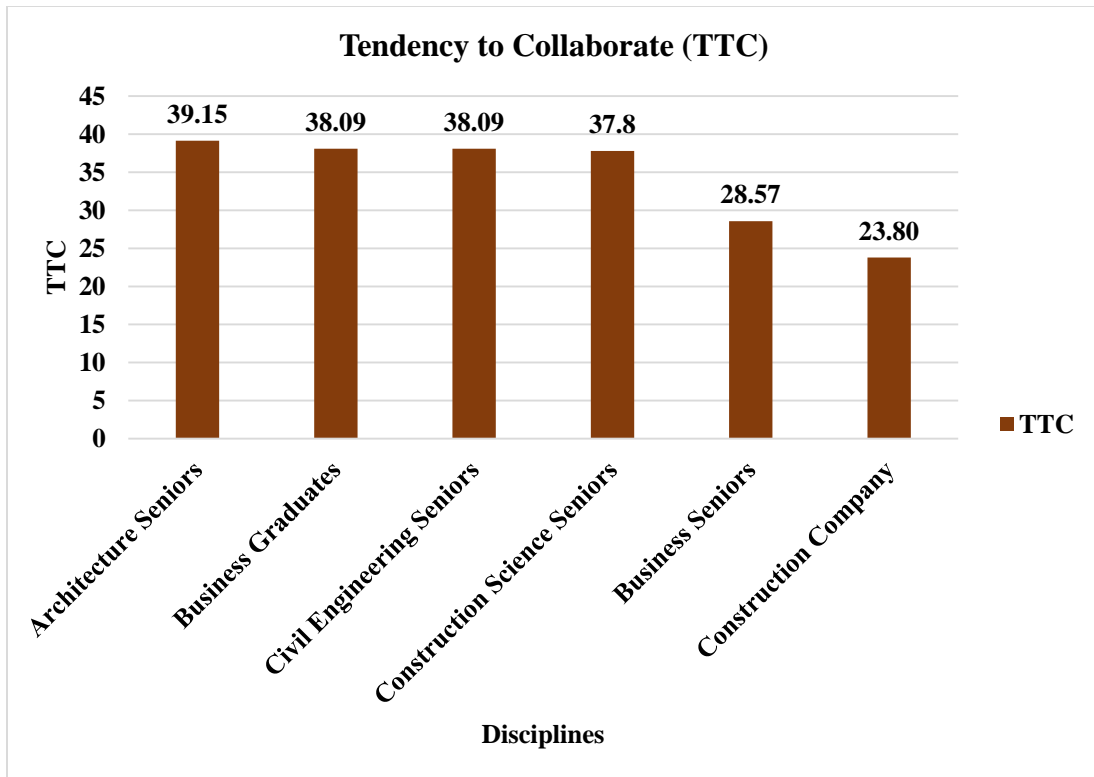


Figure 2: Disciplines and Their Average TTC

Comparing only the disciplines across Texas A&M University, it can be observed from the figure that the architecture senior students has the highest TTC with 39.15%. The business graduates and the civil engineering seniors had the second highest TTC with 38.09%. Construction Science seniors had the third highest TTC with 37.80%.

Interestingly, the business seniors had the lowest TTC when compared to all the other disciplines with TTC of 28.565%. However, there is no evidence of statistical significance that the level of collaboration is been influenced by the educational background. To verify whether the gender plays any role in the level of collaboration,

the percentage of women per team was calculated and their TTC was plotted in scatter plot. Figure 2 shows the scatter plot of percentage of women per team and their TTC.

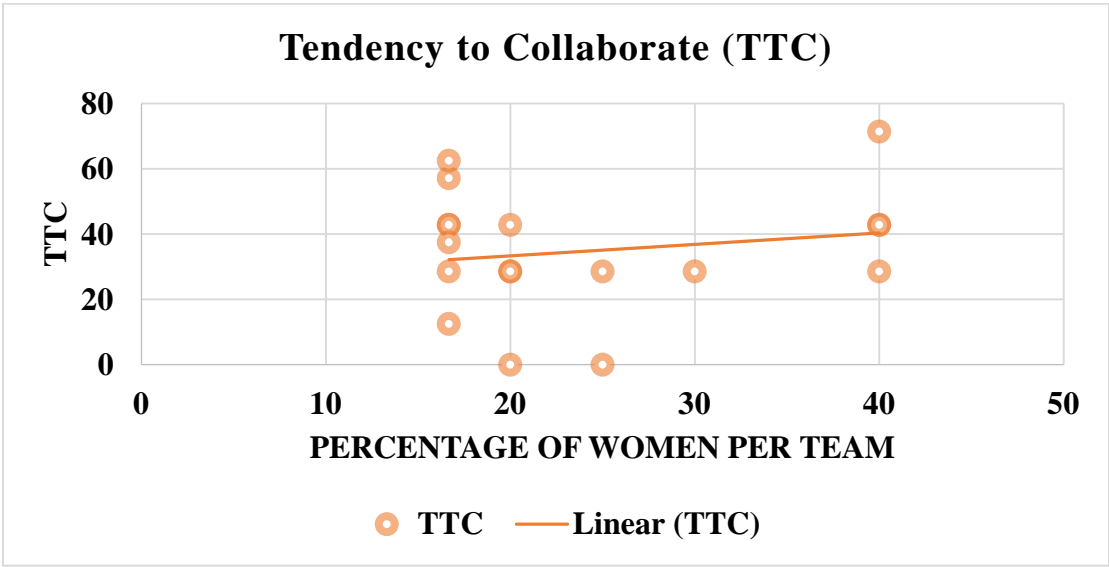


Figure 3: Percentage of Women per Team and Their TTC-Scatter Plot

Observing Figure 3 it can be seen that there is no statistical evidence to show that there is a difference in the level of collaboration based on the gender. However, it cannot be concluded that there is no difference in the level of collaboration based on the gender since there might have been other factors in the level of collaborating in the team. It can be seen from the percentage of women per team that they are not the dominant gender in the team. Hence, there are chances that even if the women of the teams had an intention

to collaborate there is a possibility of the men in the team to not collaborate because of their dominance in the team. For example as stated in section 4.2.3, the person who attempted to collaborate was a female student who was shut down by the team mates. We do not know whether the results would have been different had the teams been composed of only women. Hence, it is not evident that there is a difference in the level of collaboration based on the gender.

To verify whether the personality types play a role in the tendency to collaborate, the percentage of each personality types in each team was calculated and their TTC was plotted in a scatter plot.

Observing Figure 4, Figure 5, Figure 6, and Figure 7 it can be seen that there is no significant statistical evidence to show that extroverts, intuitives, feelers, and the judgers have a better tendency to collaborate when compared to the introverts, sensors, thinkers and feelers respectively. However, it cannot be concluded that personality types does not influence the tendency to collaborate. To validate the results, more research needs to be done on the personality traits and their influence on tendency to collaborate.

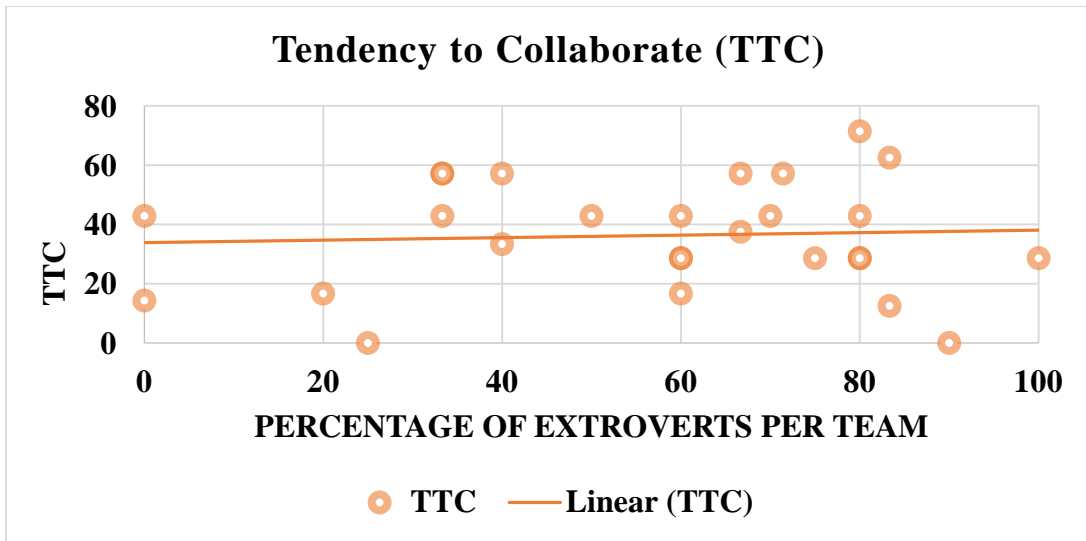


Figure 4: Percentage of Extroverts per Team and Their TTC

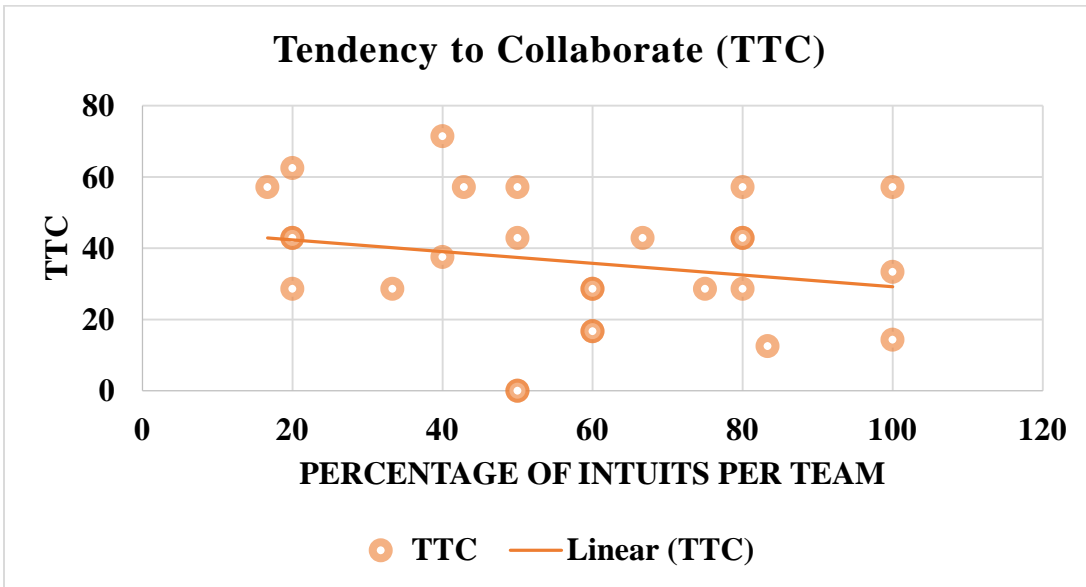


Figure 5 : Percentage of Intuits per Team and Their TTC

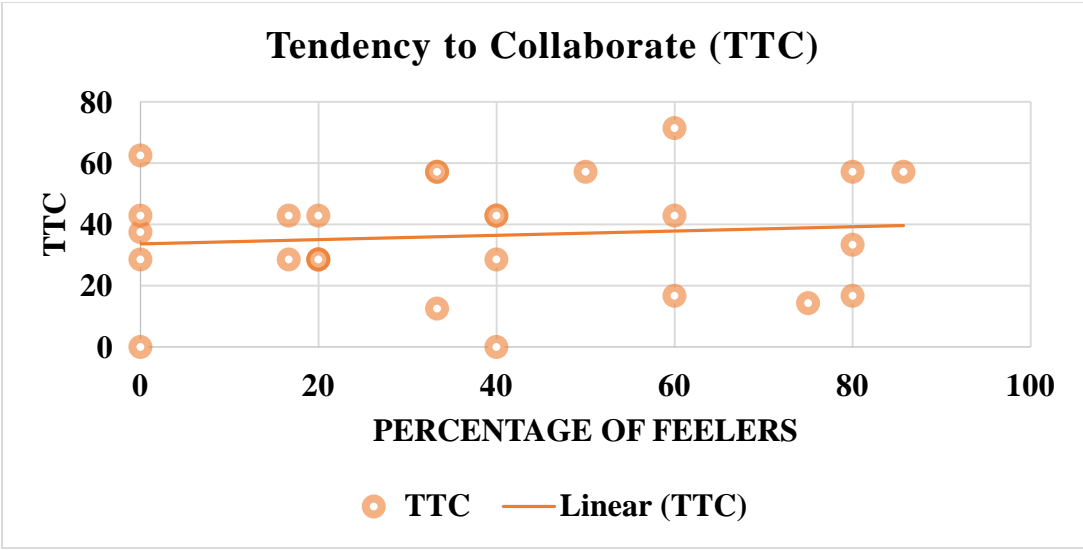


Figure 6: Percentage of Feelers per Team and Their TTC

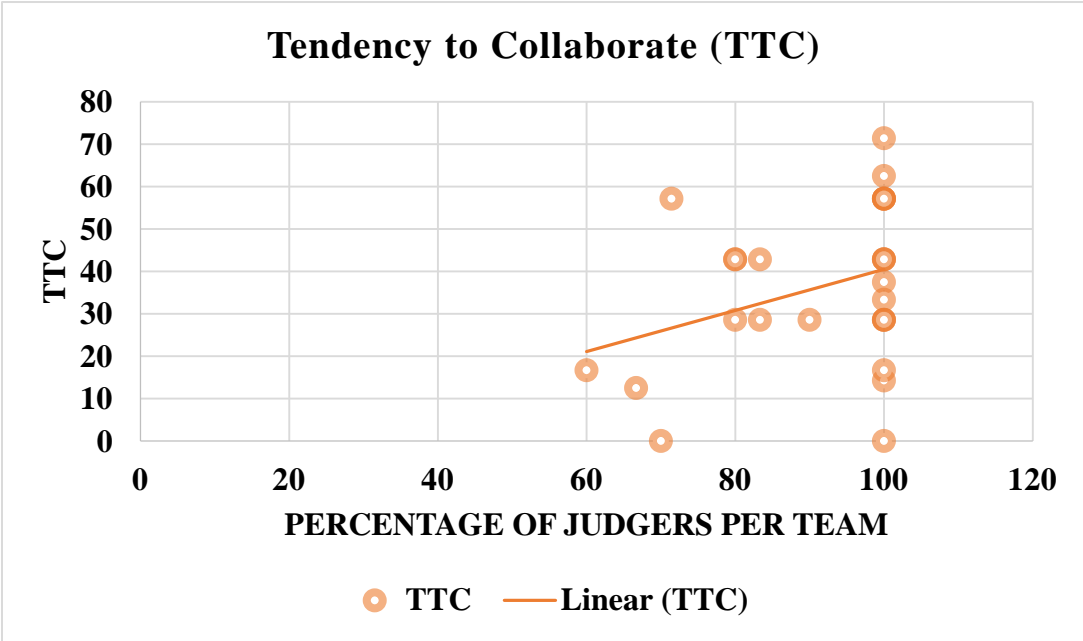


Figure 7: Percentage of Judges per Team and Their TTC

6. DISCUSSION

In conclusion, it might be observed that majority of the OAEC students from Texas A&M University were driven by competition during the initial rounds. It is observed they had an attitude of individualism over collectivism. It appears that natural competitive tendencies can often result in sub-optimization and long-term losses (Smith and Rybkowski 2012) and that these tendencies held true for the games administered. It was observed that the inability to collaborate with other teams prevented potential gains both in the short and long term. There seems to be a natural proclivity not to trust other teams in a competitive environment. The majority of the participants chose White as their first choice during the game. Also, it was seen that the tendency to betray is highest after gaining trust from other teams. In other words, one team would often betray the other two teams after agreeing that they would choose maroon. Consequently, the other two teams would refuse to place themselves in a situation where they might be taken advantage of again, ultimately reaching the point where all three teams select white every time and will even state their intentions of doing so indefinitely. In game theory, this is known as the Nash Equilibrium (Smith 2013). The Maroon- White Game can be used to teach participants how their natural tendencies to sub-optimize impacts long-term gains, trust, and collaboration.

Table 36 shows the results if the teams had a collaborative approach. It can be seen from the table that had the teams collaborated in each round, the maximum points that each team would have had would be 350 and the total team points would be 1050 points. By

comparing this table with any other result of the game administered, it can be concluded that collaborative approach maximizes both the individual points and the team points.

Table 36: Result- Teams With Collaborative Approach

	Team 1		Team 2		Team 3		Total Team Points
	Color Choice	Points	Color Choice	Points	Color Choice	Points	
Round 1	Maroon	50	Maroon	50	Maroon	50	150
Round 2	Maroon	50	Maroon	50	Maroon	50	150
Round 3	Maroon	50	Maroon	50	Maroon	50	150
Round 4	Maroon	50	Maroon	50	Maroon	50	150
Round 5	Maroon	50	Maroon	50	Maroon	50	150
Round 6	Maroon	50	Maroon	50	Maroon	50	150
Round 7	Maroon	50	Maroon	50	Maroon	50	150
Total Individual Points		350		350		350	1050

$$TTC = (21/21) * 100 = 100\%$$

7. VIEWS AND COUNTERMEASURES FOR BETTER COLLABORATION IN THE INDUSTRY

Although this game is not an exact simulation of the construction industry project deliveries or the processes, it does demonstrate the typical mindset of the people in the industry and depicts their typical decision processes. As discussed earlier, majority of the participants agreed that collaborating maximized the points and they were sub optimizing by not collaborating. The initial lack of trust and the betrayal impacted the future decisions. This aspect demonstrates the need to develop a sustained long-term relationship in the industry which forms the philosophy of lean construction. This game demonstrates the tendency to sub optimize acts against the thinking of developing a long-term sustained relationship.

The important lesson from the game is collaboration is important for sustaining long-term relationships. Hence, few of the factors affecting the tendency to collaborate that were mentioned by the participants are listed below:

- Lack of trust
- Lack of proper incentives
- Past experience
- Fear of betrayal
- Personality types
- Competitiveness
- Not seeing the long term benefit

- Cultural differences
- Not knowing people enough or lack of previous relationship
- Favoring capitalism

All these factors were collected from the participants of the game while discussing the importance of the game and lessons learned.

Few of the counter-measures that I believe improves collaboration in the construction industry are:

- Different project delivery method such as IPD which emphasizes collaboration
- Early and constant communication among all stakeholders
- Setting expectations among the stakeholders and informing them
- Change of Mindset
- Sustaining long term relationships
- Mutual Respect
- Early negotiations
- Better contract type emphasizing mutual respect and collaboration

8. OPPORTUNITIES FOR FUTURE RESEARCH

Collaboration in the construction industry needs more attention. As an industry that suffers from a generally poor reputation in this respect, both internally and externally, additional focus on the issue of collaboration will be a key component to changing the perceptions. The AIA claims IPD fails without collaboration. With this viewpoint, any work on collaboration will benefit the industry.

By identifying which disciplines have lower tendencies to collaborate, universities are better equipped to help OAEC students understand the importance of collaboration once they become professionals. Furthermore, collaboration is one of the key principles of lean construction thinking, and understanding it aids better implementation of lean principles in construction. With this in mind, the following are the few specific ideas recommended for future research:

- The game can be played across more disciplines to develop a stronger understanding of tendencies to collaborate in various disciplines including professions that are known to be more collaborative.
- The game should be played among construction industry professionals to see whether or not there is a correlation of TTC between OAEC students and OAEC professionals.
- The influence of culture and ethnicity on the tendency to collaborate can be analyzed.

- The game can be modified with better incentives for collaborating and with negative incentive for not collaborating to determine how the fear of losing also affects collaboration.
- Although this study reports the influence of gender on the tendency to collaborate, the research can be extended to see whether gender plays a major role in the tendency to collaborate. It can be tested for women in all teams, can be tested for women teams vs men teams to find whether there is any difference in the level of collaboration among genders.
- The study should be repeated enough times and at additional universities in order to achieve statistical significance and greater confidence in the result.

9. CONCLUSION

This research investigated the tendency to collaborate among different disciplines. The average TTC's for business seniors, architecture seniors, engineering seniors and the construction science seniors were found to be 28.57%, 39.15%, 38.09%, and 37.80% respectively. The average TTC of business graduates was found to be 38.09%. The architecture seniors had a higher TTC when compared to all other disciplines. However, overall differences in the TTC were not highly significant. To achieve statistical power to validate these results, further research needs to be done.

Of special interest is the observation that an actual construction company had a substantially lower TTC than the average student group tested. It would be helpful to study this phenomenon further to determine whether the outcome is generalizable to include most general contractors and if so, why this might be so.

This research also provided a platform to verify whether gender influenced the tendency to collaborate. By analyzing the results and neglecting the limitations, it is concluded that gender does not appear to have an influence on tendency to collaborate at least when women are operating together in groups with men. However, further research is required to statistically validate the results.

This research provided a better understanding on whether the personality types play a major role in the tendency to collaborate. By comparing the percentage of extroverts, intuitives, feelers, and judgers in each team to their TTC, we concluded that there is no

statistical evidence to conclude that personality types have an influence in the tendency to collaborate. However, further research is required to statistically validate the results.

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APPENDIX A

PLAYING THE MAROON-WHITE GAME[§]

GAME DESCRIPTION

The Maroon-White Game is derived from the Red-Black Game found on the College of St. Benedict website (CSB-SJU 2012).

The game is played as follows:

1. Write the following score chart (Table 1) on a chalkboard, flip chart, or dry-erase board for everyone to see (M = Maroon, W = White):

Table 1: Maroon-White Game Scoring Chart

Team Choice	Point Distribution		
M – M – M	50	50	50
W – M – M	100	0	0
All other Combinations	0	0	0

2. Divide the group into three teams: Each team should consist of a similar number of players. There is no maximum number of players but we have found that 3-5 per team provides for ideal participant involvement and overall better results. Each team should be allocated its own space to allow for private deliberations. This can be accomplished by having different rooms for each team, or by simply dividing the room so that each can have a discussion separate from the other teams.
3. Explain the following guidelines for the game:
 - a. Clearly and aloud, state the following: "The goal of the game is to score as many points as possible" (this direction to participants should be stated frequently throughout the game).

[§] The research game is reprinted with permission from "The Maroon and White Game: A simulation of trust and long-term gains and losses" by Smith, J. P. and Rybkowski, Z. K., 2013. *Proceedings of the 21th annual conference for the International Group for Lean Construction*; July 31-August 2, 2013: Fortaleza, Brazil.

- b. For each round, each team picks a color, either maroon or white, and then reports to the facilitator their selection when asked.
 - c. Scores are then distributed to each team based on the point distribution included above.
4. The facilitator can manipulate the game if desired by adjusting or introducing any of the following aspects of the game:
- a. Order of decision reporting by the teams.
 - b. Whether a team can change its choice during reporting.
 - c. Number of rounds, although 4-7 is recommended (the facilitator can also decide whether or not to let participants know from the start of the game how many rounds they will be playing).
 - d. Level of interaction between the teams (i.e., pick a representative from each team to negotiate with the other team representatives). Allowing the teams to try to come up with ways to structure the reporting or the negotiating can also provide valuable insight.
5. Reflections between rounds
- a. Literature suggests that students may learn better when they are given the chance to choose improvement methods for the next round as opposed to being told what to do (Dukovska-Popovska et al. 2008). The list of adjustments included in step 4 are potential options.
6. Keep score following each round on the white board/flip chart as shown below

	Team 1		Team 2		Team 3	
	Color Choice	Points	Color Choice	Points	Color Choice	Points
Round 1						
Round 2						
Round 3						

(Smith and Rybkowski 2013)

APPENDIX B

EMAIL TO PROFESSORS

Respected Professor,

I am Vishnu Ramanath, a graduate student doing my masters in Construction Management in the College of Architecture, Texas A&M University. For my master's degree I am doing a thesis research on "Exploratory investigation of the influence of educational background of owners, architects, engineers, and contractors on the level of collaboration in the construction industry". This research requires me to interact with the students present in your class. I am sending you this email requesting you to grant me permission to administer the Research game (Maroon White Game) during one of your classes, preferably during the month of March. I will also have to request the students to take a Human Metrics test before the day of administering the game and also have to request them to bring the printed copy of their result to the class on the day of administering the game. I kindly request you to forward my recruitment email to all the students of your class.

I would highly appreciate if you would grant me permission for administering the game in one of your class, helping me in my research study.

Awaiting your reply.

Regards,

Vishnu Ramanath
Graduate Student
Department of Construction Science
Texas A&M University

APPENDIX C

RECRUITMENT EMAIL

Hello,

I am Vishnu Ramanath, a graduate student doing my masters in Construction Management. Presently, for my master's degree, I am doing my research on the topic "Exploratory investigation of the influence of educational background of owners, architects, engineers, and contractors on the level of collaboration in the construction industry". The purpose of the study is to understand the role education in a particular field influences the students thinking. This research requires me to administer a game (Maroon White Game) with you all. I kindly request to play the game with me. The results obtained from the game will be analyzed and used in my research. The duration to administer the game will be approximately 30 minutes and the procedure of the game will be explained before the game starts. All the data obtained from the game will be kept confidential and will be destroyed after the completion of my study. Only the results of the teams as a whole will be published and no personal information linking you to my research will ever be published. Also, the result of the human metric test will not be published. Your willingness to participate in the game will help me in my research. If you agree to play the game, please take the Human metrics test before the day of administering the game. It will take an additional 15 minutes approximately to take the human metrics test. The link for the test is <http://www.humanmetrics.com/cgi-win/JTypes2.asp>. I also request you to get the printed copy of the test result to class on the day the game is being administered and hand it over to me.

In case of any queries feel free to contact me at any point of time via phone or email. Also, you can as well contact the IRB for any queries. The IRB could be reached via phone at 1-979-458-4117 or email at irb@tamu.edu.

Finally, I would like to inform you that your participation is totally voluntary and any refusal to participate will not involve any penalty. You can always withdraw your participation at any point of time.

I really appreciate your cooperation.

Regards,

Vishnu Ramanath
Graduate Student
Department of Construction Science
Texas A&M University
Email: vishnu2012@neo.tamu.edu
Phone: 812-390-6271

APPENDIX D

HUMAN METRICS

Reprinted from "Human Metrics." <<http://www.humanmetrics.com/cgi-win/JTypes2.asp>> (Nov.10 2013)

1. You are almost never late for your appointments
 YES NO
2. You like to be engaged in an active and fast-paced job
 YES NO
3. You enjoy having a wide circle of acquaintances
 YES NO
4. You feel involved when watching TV soaps
 YES NO
5. You are usually the first to react to a sudden event, such as the telephone ringing or unexpected question
 YES NO
6. You are more interested in a general idea than in the details of its realization
 YES NO
7. You tend to be unbiased even if this might endanger your good relations with people
 YES NO
8. Strict observance of the established rules is likely to prevent a good outcome
 YES NO
9. It's difficult to get you excited
 YES NO
10. It is in your nature to assume responsibility
 YES NO
11. You often think about humankind and its destiny
 YES NO
12. You believe the best decision is one that can be easily changed
 YES NO
13. Objective criticism is always useful in any activity
 YES NO

14. You prefer to act immediately rather than speculate about various options
 YES NO
15. You trust reason rather than feelings
 YES NO
16. You are inclined to rely more on improvisation than on prior planning
 YES NO
17. You spend your leisure time actively socializing with a group of people, attending parties, shopping, etc.
 YES NO
18. You usually plan your actions in advance
 YES NO
19. Your actions are frequently influenced by emotions
 YES NO
20. You are a person somewhat reserved and distant in communication
 YES NO
21. You know how to put every minute of your time to good purpose
 YES NO
22. You readily help people while asking nothing in return
 YES NO
23. You often contemplate the complexity of life
 YES NO
24. After prolonged socializing you feel you need to get away and be alone
 YES NO
25. You often do jobs in a hurry
 YES NO
26. You easily see the general principle behind specific occurrences
 YES NO
27. You frequently and easily express your feelings and emotions
 YES NO
28. You find it difficult to speak loudly
 YES NO
29. You get bored if you have to read theoretical books
 YES NO
30. You tend to sympathize with other people
 YES NO

31. You value justice higher than mercy
 YES NO
32. You rapidly get involved in the social life of a new workplace
 YES NO
33. The more people with whom you speak, the better you feel
 YES NO
34. You tend to rely on your experience rather than on theoretical alternatives
 YES NO
35. You like to keep a check on how things are progressing
 YES NO
36. You easily empathize with the concerns of other people
 YES NO
37. You often prefer to read a book than go to a party
 YES NO
38. You enjoy being at the center of events in which other people are directly involved
 YES NO
39. You are more inclined to experiment than to follow familiar approaches
 YES NO
40. You avoid being bound by obligations
 YES NO
41. You are strongly touched by stories about people's troubles
 YES NO
42. Deadlines seem to you to be of relative, rather than absolute, importance
 YES NO
43. You prefer to isolate yourself from outside noises
 YES NO
44. It's essential for you to try things with your own hands
 YES NO
45. You think that almost everything can be analyzed
 YES NO
46. Failing to complete your task on time makes you rather uncomfortable
 YES NO
47. You take pleasure in putting things in order
 YES NO

48. You feel at ease in a crowd
 YES NO
49. You have good control over your desires and temptations
 YES NO
50. You easily understand new theoretical principles
 YES NO
51. The process of searching for a solution is more important to you than the solution itself
 YES NO
52. You usually place yourself nearer to the side than in the center of a room
 YES NO
53. When solving a problem you would rather follow a familiar approach than seek a new one
 YES NO
54. You try to stand firmly by your principles
 YES NO
55. A thirst for adventure is close to your heart
 YES NO
56. You prefer meeting in small groups over interaction with lots of people
 YES NO
57. When considering a situation you pay more attention to the current situation and less to a possible sequence of events
 YES NO
58. When solving a problem you consider the rational approach to be the best
 YES NO
59. You find it difficult to talk about your feelings
 YES NO
60. You often spend time thinking of how things could be improved
 YES NO
61. Your decisions are based more on the feelings of a moment than on the thorough planning
 YES NO
62. You prefer to spend your leisure time alone or relaxing in a tranquil atmosphere
 YES NO
63. You feel more comfortable sticking to conventional ways
 YES NO

64. You are easily affected by strong emotions
 YES NO
65. You are always looking for opportunities
 YES NO
66. Your desk, workbench, etc. is usually neat and orderly
 YES NO
67. As a rule, current preoccupations worry you more than your future plans
 YES NO
68. You get pleasure from solitary walks
 YES NO
69. It is easy for you to communicate in social situations
 YES NO
70. You are consistent in your habits
 YES NO
71. You willingly involve yourself in matters which engage your sympathies
 YES NO
72. You easily perceive various ways in which events could develop
 YES NO