An Investigation of Gender Composition on Integrated Project Team Performance: Part III

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Abstract — This study presents the quantitative results of the investigation that measures the effects of gender composition in integrated project teams and the proportion of women in an organization on two dependent variables: 1) team performance, and 2) team cohesion. The duration of the study was 16 weeks during which two design projects were completed. Team performance was measured using: 1) team quizzes, 2) design demonstrations, 3) peer evaluations, and 4) blind evaluation of team reports. Criteria for project performance included thoroughness of the project report, submission timeliness, compliance to project requirements, and utilization of engineering problem solving skills. Team performance is also assessed through the Team Performance Questionnaire.

Index Terms — Integrated project teams, gender composition, and performance evaluation.

I. Introduction

Despite the widespread use of integrated project teams, they are not always effective [1]. This is true in both industrial and educational settings. One factor associated with team effectiveness is team composition [2]. Because of the increasing number of women joining the work force over the years; the gender effect on team performance has received attention. The results of previous studies have been conflicting because some researchers have found homogeneous teams to be more productive, whereas others have found the opposite to be true. Moreover, a recent study found the gender to be an insignificant variable for its effect on the performance of product design teams [3]. The duration of the design task included in this study was only 45 minutes.

The effect of the proportion of women in an organization has also been investigated, and found to be significant [4]-[6]. However, the effect of gender composition in teams and the effect of female/male ratio in organizations on the performance of product design teams have not been investigated simultaneously over an extensive period of time. This study fills that void. Furthermore, high performing team skills training is also included in the study as an independent

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variable to observe the effect it has on team performance. The results of this research can have important implications on project environment design, team formation and team performance evaluation. In an effort to extend the aforementioned studies, this study investigates team performance and cohesion over a 16-week period during which two engineering design tasks are performed by a set of homogeneous, mixed gender, and lone–female teams in three different environments with female to male ratios ranging from 15.6% to 48.5%.

II. Experimental Setting and Application

Three sections of the Introduction to Engineering Design and Graphics 100 course at the Pennsylvania State University during the Fall 2001 semester were included in the study. Each section consisted of eight, mostly four-person teams, representing an organization.

In a previous study, the effect of current average GPA (Grade Point Average) standing of the team on the team performance was found to be significant [1]. Thus, teams were formed with comparable GPAs. Scores on the mathematics portion of the SAT were used for first semester students who did not have a GPA. In all three sections homogeneous, mixed gender, and when necessary lone female teams were formed. Distribution of team compositions is given in Table I.

TABLE I
DISTRIBUTION OF TEAM COMPOSITIONS

Section	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Team 7	Team 8
1	All M	All M	All F	2 F* 2M**	2 F 2 M	All F	All M	Lone F
2	All M	2 F 2 M	All M	All M	All M	Lone F	2 F 2 M	All M
3	2 F 2 M	2 F 2M	2 F 2 M	2 F 2 M	2F 3M	All M	2 F 2 M	All M

*: Female
**: Male

Experimentation was conducted in two phases: design project 1, and design project 2. During the first phase, students experienced the pressure of working as a team for a deadline and a payoff. The first design project involved building a weighing system using strain gages and beams. After a series of guided, hands-on experiments with electrical resistors, strain gages and beams and lectures on the mechanical behavior of materials, teams were asked to build a weighing system that can accurately weigh objects within a specific weight range to a specified resolution. Team performance for this design project was measured using team quizzes, a design demonstration, and a blind evaluation of each team's design report. The grading weight of the team quiz is 15%, the weight of the design demonstration is 60% and that of the blind evaluation is 25%. 10% of the demonstration grade was awarded for early completion.

A team quiz is an assessment during which a set of questions is answered by a team of four in 15 minutes. Only one member would need 1 hour to solve the same set of questions. The time allowed for completion of the team quiz was adjusted based on the group size. However, for absent/late members, no time adjustment was permitted. The purpose of this phase was to give student designers an initial experience of product/solution design via teams. Also, the concept of team quizzes was established and practiced to help students learn to rely on other team members.

After this phase, students were asked to peer evaluate each other and comment on their contribution to the design task. Furthermore, they were asked if they wanted to keep their team for the second design project. All teams decided to keep their members. Due to this decision, results of the peer contribution reviews were not revealed to students at this point. Instead, a half an hour class period was dedicated for them to discuss their performance and how to improve performances individually and as a team.

Next, teams were presented with the second design project that same day. The design task along with several design requirements was conveyed to 24 design teams. Each team was given eight weeks to come up with their best solution. During this time, they were to act as companies that were competing to get Penn State Hazelton campus' business with their solution. This project involved the solution to a handicapped access at the Hazelton campus. This campus provides residence hall accommodations for 485 students. In addition, the hall's food court provides meals for resident students, faculty, staff, and visitors. The food court building and residence halls are located near the main entrance of campus, at an elevation ranging approximately 1575' to 1600' above sea level. All other campus facilities are located at an elevation of approximately 1710'. Getting from the lower portion of campus to the upper part is accomplished by either walking directly up a steep pathway, which is not compliant with the Americans with Disabilities Act Accessibility Guidelines (ADAAG) for slope and design—or directly on the main road, which is non-compliant for slope. Driving is an option but parking is limited. In order for the campus community to be able to access the facilities without having to drive, finding a solution that offers flexibility, convenience, ease of use, and accessibility for people with disabilities was the design task. Thus, teams were required to design a mechanical, manual, or service system that will provide access for people with disabilities and the non-disabled population.

Project deliverables were traffic analysis, CAD drawings, projected costs (construction and operation), a scale model prototype, and design documentation. For this project the performance was measured using team quizzes, peer design evaluations, and a blind review of the design reports. The weights of these grades were 5%, 23.75% and 71.25% respectively.

For both projects, the aforementioned grades were used to establish a project grade for each design team. Thoroughness of the project report, timeliness of the project report submission, compliance to project requirements, and utilization of engineering problem solving skills were used as criteria for project performance evaluations. The weight of the first and second design project grades relative to the overall course grade were 15% and 25% respectively.

Peer evaluations of contribution levels within teams during both design projects were also used as a dependent variable in the study. These peer evaluations were done after each project was completed. During these evaluations students were asked to rate their teammates performance based on 11 different items using a scale of 0-5. Each student's evaluations completed by his teammates' were then averaged to give his contribution value. Team cohesion is calculated as the average of these member contribution levels per team.

Team performance was also assessed through the Team Performance Questionnaire (TPQ) [7]. This instrument measures work group characteristics related to the level of team performance. The TPQ is widely regarded as a tool that is both reliable (i.e., meaning that it is consistent) and

valid (i.e., meaning that metrics used accurately reflect variables measured). The TPQ addresses six primary characteristics of teams: (1) goals and results, (2) collaboration and involvement, (3) competencies, (4) communication process, (5) emotional climate, and (6) leadership. Items (1) through (5) apply directly to level of team performance and are the focus here; item (6) applies to team leadership. At the end of the course, each student completed the TPQ. The instrument was completed privately by each student without the assistance of a team facilitator. Individual scores were then averaged to determine team scores for each characteristic. Then, each team's scores were averaged to determine an overall value for the first five characteristics that are relevant to the team performance. TPQ scores can be interpreted as: (1) 20 and up: Highly cohesive, high performing teams; (2) 14-19:Average cohesion, average performing teams; and (3) 13 or less: Low cohesion, below average teams.

Independent and dependent variables of the study are summarized in Table II.

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TABLE II
INDEPENDENT AND DEPENDENT VARIABLES
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Independent Variables	Levels
1. Gender composition of the team	All male, all female, 2 male and 2 female, lone female
2. Proportion of women in organization	15.6%, 37.5%, 48.5%
3. High performing team skills training	8 hours, 0 hours
Dependent Variables	**Explanations**
1.Team Performance for project 1	The weight of design project 1 grade is 15% of the overall grade.
• Team quizzes	3 team quizzes (15%)
• Design demonstration	Application of the weighing system (60%)
	(25%)
• Blind review of reports	
2.Team performance for project 2	The weight of design project 2 grade is 25% of the overall grade.
• Team quizzes	2 team quizzes (5%)
• Peer project evaluation	(23.75%)
• Blind review of reports	(71.25%)
3.Team cohesion	
• As an average of peer contribution evaluation	Done after each project
• Team Performance Questionnaire	Administered one time after design project 2.

During these projects, interventions relevant to high performing team skills training were conducted for two sections. The details of these high performing team skills training interventions are given in an earlier publication [8]. An alternative engineering lecture series was also presented to the third section. The alternative training included two lectures on design for society, one lecture on design for environment and one lecture on green engineering. Each intervention lasted approximately 2-hours. Teams were intervened 4-times for 2-hours each for a total of 8-hours. The timing and the duration of these training interventions were the same. They were conducted during the 6th, 9th, 11th and 14th week of the semester. Both high performing team skills training and alternate training were given by other faculty members than the course instructor.

V. Results

Team cohesion and design project performances measured for both design projects are given in Table III and Table IV respectively.

As can be seen in Table III, section 1's design project 1 performance is considerably lower than the other two sections. This is attributed to two possible causes: (1) the early meeting time for section 1(8:00 am) may be creating a disadvantage in performance when compared to that of section 3's; but no attempt was made to discern this effect in this study; and (2) the average semester standing in section 2 is higher, they were mostly sophomores and juniors; on the other hand section 1 included mostly freshmen students.

Average team cohesion values for all sections were about the same.

When similar design project performances are analyzed as in Table IV, a sharp decrease in the performances of sections 2 and 3 is noticed in comparison to their performance during the first design project. However, section 1's performance was stable. This may be attributed to the combined effect of high performing team skills training and the female to male ratio of the section.

When TPQ results are considered, it is seen that section 1 and 2 were highly cohesive and high performing whereas section 3 scored as an average performing team. This could be attributed to the positive effect of high performing team skills training interventions. However, the significance of the difference in TPQ results is not established. Two teams from section 3 were not present when the TPQ was administered, and hence, the associated data are missing.

Table V summarizes the same results by grouping the teams based on team composition only for design project 2. Teams of various gender compositions are listed in the table by section and team order.

TABLE III
DESIGN PROJECT I RESULTS

	Team Quizzes	Demo Grade	Report	Overall Project Grade	Team Cohesion
Section 1: meets 8:00 am for 2 hours, three times per week, received high performing team skills training, has a 37.5% female to male ratio.					
Team 1	61	100	88	91.20	0.89
Team 2	70	100	50	83.00	0.97
Team 3	49	100	87	89.05	1.00
Team 4	70	100	100	95.50	0.93
Team 5	66	110	97	100.15	0.95
Team 6	79	100	100	96.85	0.94
Team 7	75	100	80	91.20	0.97
Team 8	66	100	10	72.40	0.93
Average				**89.92**	**0.95**
Section 2: meets 10:10 am for 2 hours, three times per week, received high performing team skills training, has a 15.6% female to male ratio.					
Team 1	93	110	95	103.75	0.96
Team 2	73	100	85	92.15	0.96
Team 3	78	105	98	99.25	0.92
Team 4	88	100	100	98.15	0.98
Team 5	63	105	97	96.70	0.98
Team 6	93	105	100	102.00	0.96
Team 7	91	100	96	97.60	0.96
Team 8	91	110	99	104.35	0.97
Average				**99.24**	**0.96**
Section 3: meets 2:30 pm for 2 hours, three times per week, received alternate training, has a 48.5% female to male ratio.					
Team 1	62	110	88	97.25	0.98
Team 2	73	110	95	100.75	0.87
Team 3	82	110	95	102.10	0.99
Team 4	55	110	105	100.50	0.93
Team 5	81	110	90	100.60	0.97
Team 6	69	110	95	100.10	0.99
Team 7	94	110	80	100.15	0.97
Team 8	59	110	88	96.80	0.98
Average				**99.78**	**0.96**

TABLE IV
DESIGN PROJECT II RESULTS

	Team Quizzes	Peer Eval. Grade	Report	Overall Project Grade	Team Cohesion	TPQ
Section 1: meets 8:00 am for 2 hours, three times per week, received high performing team skills training, has a 37.5% female to male ratio.						
Team 1	87	99	91	92.6	0.92	21.00
Team 2	86	92	88	88.8	0.90	17.60
Team 3	83	95	85	87.3	0.91	19.40
Team 4	79	92	89	89.1	0.79	15.80
Team 5	90	96	86	88.5	0.95	21.65
Team 6	90	97	90	91.8	0.90	23.73
Team 7	93	94	93	93.2	0.97	19.07
Team 8	87	93	86	87.7	0.93	21.05
Average				**89.88**	**0.91**	**19.91**
Section 2: meets 10:10 am for 2 hours, three times per week, received high performing team skills training, has a 15.6% female to male ratio.						
Team 1	79	97	88	89.7	1.00	21.15
Team 2	97	85	89	88.5	0.90	20.10
Team 3	84	93	88	89.0	0.98	20.87
Team 4	94	95	94	94.1	0.98	21.25
Team 5	83	94	88	89.3	0.99	23.27
Team 6	81	91	56	65.6	0.97	19.80
Team 7	78	89	65	71.5	0.94	19.85
Team 8	85	97	83	86.3	0.97	21.87
Average				**84.25**	**0.97**	**21.02**
Section 3: meets 2:30 pm for 2 hours, three times per week, received alternate training, has a 48.5% female to male ratio.						
Team 1	87	94	84	86.5	0.93	22.55
Team 2	89	86	90	89.1	0.86	16.53
Team 3	91	97	58	69.0	1.00	No Data
Team 4	86	90	88	88.5	0.88	17.67
Team 5	85	95	89	90.2	0.90	No Data
Team 6	80	96	90	90.8	0.94	20.00
Team 7	90	95	87	89.0	0.90	15.65
Team 8	93	96	82	85.8	0.77	17.47
Average				**86.11**	**0.90**	**18.31**

TABLE V
TEAM COMPOSITION AND DESIGN
PROJECT II PERFORMANCE

Team Composition	Section	Team	Overall Project Grade	Team Cohesion	TPQ
All male	1	1	92.6	0.92	21.00
All male	1	2	88.8	0.90	17.60
All male	1	7	93.2	0.97	19.70
All male	2	1	89.9	1.00	21.15
All male	2	3	89.0	0.98	20.87
All male	2	4	94.1	0.98	21.25
All male	2	5	89.2	0.99	23.27
All male	2	8	86.4	0.97	21.87
All male	3	6	90.8	0.94	20.00
Average			**90.5**	**0.96**	**20.75**
All female	1	3	87.3	0.91	19.40
All female	1	6	91.8	0.90	23.73
All female	3	8	85.7	0.77	17.47
Average			**88.3**	**0.86**	**20.20**
2F, 2M	1	4	89.1	0.79	15.80
2F, 2M	1	5	88.5	0.95	21.65
2F, 2M	2	2	88.5	0.90	20.10
2F, 2M	2	7	71.5	0.94	19.85
2F, 2M	3	1	86.5	0.93	22.55
2F, 2M	3	2	89.1	0.86	16.53
2F, 2M	3	3	69.0	1.00	No Data
2F, 2M	3	4	88.5	0.88	17.67
2F, 2M	3	5	90.2	0.90	No Data
2F, 2M	3	7	88.8	0.90	15.65
Average			**85.00**	**0.91**	**18.73**
1 F, 4 M	1	8	87.7	0.93	21.05
1 F, 2 M	2	6	61.5	0.97	19.80
Average			**74.6**	**0.95**	**20.43**

Based on Table V, the following observations can be made:

1. Team cohesion values for all female teams are considerably lower than those of other types. This may mean that female students are more critical when evaluating each other. However, their team performances –measured as a composite project grade and using the TPQ- are not lower when compared to all male, lone female and 2 male- 2 female teams.

2. Average overall project grade of homogeneous teams is slightly better than that of heterogeneous teams.
3. When TPQ results are considered, overall 2 male- 2 female design teams had average performance while rest of the teams scored as high performing.

These observations, however, do not consider the effect of high performing team skills training, or that of female/male ratio in sections.

VI. Conclusions

This study was conducted to fill a void in the literature on the combined effect of gender composition within a team, organizational gender ratio, and the effect of high performing team skills training on the performance of IPTs. Tabulated preliminary results suggest that:
1. Design team's meeting time may affect their performance.
2. Female students tend to evaluate each other more critically when preparing peer evaluations for contributions to the design task even when their performance is not lacking.
3. The high performing team skills training may affect team performance especially when same teams work on consecutive projects over a long period of time (In this case, data is only established for a period of 16 weeks).
4. The average performance of homogeneous teams is slightly better than that of heterogeneous teams. However, statistically significance is not established. When TPQ results are considered, overall 2 male- 2 female design teams had average performance while rest of the teams scored as high performing.

A more detailed analysis of the project results will be presented in a forthcoming publication. However, more experimentation will be needed to establish the statistical significance of the findings.

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