Product design team interactions and peer feedback as indicators of team success

by

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B.S. Mechnical Engineering, Boston University (2011)

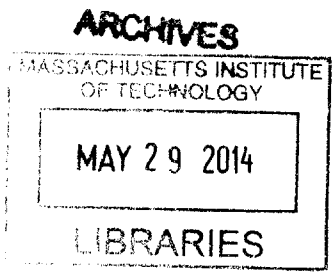
Submitted to the Engineering Systems Division
in partial fulfillment of the requirements for the degree of

Master of Science in Technology and Policy

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

June 2014



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Abstract

Teams have become ubiquitous. They are used at all levels of academia, government, and industry, and their use spans all sectors and fields. Much work has been done on the factors that affect a team's peformance and how and what type of interventions may be useful in improving a team's performance. One such type of intervention is peer review and feedback. In this study, team peer reviews completed during a semester-long product design project at MIT are coded into the categories of skills, effort, and performance strategies, and within those categories, whether comments are positive or negative, to attempt to determine a correlation between the way team members try to shape each other's behaviors and the eventual performance of the team. Results, although inconclusive, provide insights into potential directions of future research in this area.

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Acknowledgments

I would first and foremost like to thank my advisor, Professor Maria C. Yang, for her support throughout this process. She welcomed me into her lab with open arms, a caring smile, and a constructively furrowed brow, and then proceeded to guide, encourage, and mentor me at a level I would have dreamed was impossible. I would also like to thank my parents and family for instilling in me a sense of curiosity and work ethic so valuable to my time at MIT. A special thanks to Barbara DeLaBarre, whose generosity and humor have been daily joys over the past two years. I would finally like to thank my wonderful girlfriend, Rachel Hollander, and my friends Benjamin Michaels, Noah Steinhardt, and Matthew Tolchin for the support and balance they have always provided me. To my dog Kip, if I thanked you, you might get the idea that distracting me is always a good thing, so I'm afraid I must refrain.

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Chapter 1

Introduction

> "Although literally thousands of studies of group performance have been conducted over the last several decades, we still know very little about why some groups are more effective than others. We know even less about what to do to improve the performance of a given group working on a specific task" Hackman and Morris [22].

Teams are everywhere. They are ubiquitous in industry, pervasive in every level of government, and omnipresent in academia from kindergarten through the highest strata of higher education. Groups are favored over individuals because groups have been found to make better decisions than individuals, to be better at problem solving, and to be more creative and innovative [17].

Despite the extensive research conducted regarding the factors affecting team success, the literature in the field offers a complicated portrait of why some teams are more successful than others. This, of course, is not unusual given the complex nature of any study involving human factors. Diversity, cohesiveness, strategy, and cognitive ability, among others, have all been studied as components of team success, with varying levels of conclusiveness attached to each factor.

At the same time, significant research has also been conducted as to how to intervene in a group to improve its performance. Given any set of inputs–team size, skills, etc.–what conditions or tasks can be introduced to improve a team's processes, ability, and overall success? In a world where performance is intrinsically linked to financial growth and gain, unlocking the secrets to team success has potentially enormous implications for the betterment of the world.

One such intervention that has been proposed and utilized is peer feedback. Peer feedback, as considered here, is defined as a process by which a team's individual members give each other member assessments relating somehow to completion of a task. This study utilizes data collected from a semester-long product

design course during which three anonymized peer reviews were conducted over the course of the semester and seeks to answer the question of how peer reviews affects team success. Two hypotheses are proposed:

1. Teams that are more active in shaping individual team member's performances via peer reviews are more successful than teams who do not.

2. Teams whose peer reviews offer more positive, constructive feedback are more successful than teams whos peer reviews are negative and critical.

Beyond merely dividing the comments collected into positive and negative and investigating the correlation between constructive and negative feedback and team performance, this study also seeks to investigate whether the content of comments may be related to team success. The three content categories investigated–effort, skills and knowledge, and performance strategies–are three of the factors most often cited as having significant bearing on a team's success [22, 20]. By examining these categories of feedback, the study hopes to illuminate the kinds of comments most beneficial to a team's development and eventual success.

Chapter 2

Related Work

Significant research has been conducted regarding the performance of teams. For the purposes of framing this study, this research can be divided into two categories: the factors affecting team performance and the interventions that might be undertaken to improve a team's performance. Although product development teams are the subject of this study, teams of all kind and from all sectors, both in the lab and in the field, construct the basis of understanding regarding team effectiveness.

2.1 Factors affecting team performance

2.1.1 General themes

In one of the foundational articles regarding team performance, Hackman and Morris propose that group effectiveness is mediated by group interaction processes. They suggest that the "process criteria of effectiveness:" effort put forth by team members, the performance strategies employed by the team, and the knowledge and skill of the team's respective member affect the group interaction processes, and thusly, team performance [22]. As will be discussed below, theoretically, conditions can be introduced to improve the process criteria of effectiveness [20], which are the focus of this study.

Of course, other research exists. Many researchers have examined the idea of group cohesiveness, a characterisitc which itself is affected by numerous aspects of the group, as a key factor in a team's performance [48]. Results from project groups in an R&D organization to show that the factors group cohesiveness, physical distance, job satisfaction, and innovative orientation are correlated with project performance and that of the four factors, group cohesiveness was correlated with the most performance measures of the study [30]. Likert similarly argues that group cohesiveness is essential to team performance [37]. Computational

analysis of design team documents, including emails, presentations, and other documents, to show a positive correlation between the coherence and cohesivenes of a design team's design documents and their design's success [12]. Other research refutes the idea that cohesiveness is related to performance. This research proposes that cohesiveness within a group may mean conformity within a group, but that this conformity does not correlate with team outcomes [16].

Diversity is another element of interest within the field of team research. Research suggests that personality composition of teams affects performance [20, 39]. While functional and interpersonal diversity have implications for team process, performance, and effectiveness [8], Wilde describes a method for constructing successful design teams from a pool of individuals, based on survey responses, and which emphasizes combining juxtaposing attitudes [55]. Studies of product teams in technology companies showed that diversity of function on a team led to greater communication external to the team, but that this same diversity could impede the overall performance of the team, leading toward the conclusion that conflict resolution tools may be employed to mitigate the negative effects of team diversity [4].

2.1.2 Knowledge and performance strategies

Cognitive ability and strategy are not only two of the indicators essential to this study, but also two of the factors given considerable consideration within the field of performance research. Teamwork processes and planning processes are an indelible characteristic of effective teams [38, 52]. Studies have concluded that that group problem solving performance is related to a group's resources and its strategies to use those resources [7]. Woolley et al. study how team performance is affected by two things: the incorporation of experts into project teams and collaborative planning. Their study investigates the separate and joint effects of the two factors and finds that "task appropriate expertise" and collaborative planning work in tandem on successful analytic teams, and furthermore, that teams that engaged in planning more effectively integrated information into their problem-solving [57].

The strategy of goal-setting has been shown to have substantial impact on team performance [29]. Not only does team members' understanding of team goals affect team performance [41], but the process of setting goals as a group has been shown to have positive correlation with team performance [42, 52, 51, 53]. A study of a graduate engineering students divided into teams and given a simple design task showed that although single leader decision making was faster than consensus building, decisions by a single leader were not reported as faster by teams, indicating that perception of speed was more important than actual speed [59].

With respect to knowledge and skills, research not only suggests that teams with members of higher

cognitive ability adapt to difficulties better than teams with members of lower cognitive ability, but also that teams with learning-oriented members adapt better than teams with performance-oriented members [35]. Research by Ellis et al. corroborates this, finding that team cognitive ability correlated positively with team performance [14]. However, not all research about cognitive ability and team performance has been complementary. Although it has been demonstrated that that individual job performance is linked to cognitive ability [26, 43], other studies exhibit that cognitive ability is more linked to performance in teams in lab settings than in the field [11]. Research has demonstrated that team learning is negatively affected by high levels of agreeableness [14] and that high levels of agreement within a group can have disastrous consequences [28].

Additionally, explorations have been conducted about the negative and positive effects of habitual routines on group performance, as well as the ways routines can be changed or broken [15]. Studies have extended this discussion to the negotiation of norms within a group as they are affected by individual experience [6]. Also, the importance of communication in successful research and development teams is well known [1, 2]. Ancona and Caldwell show that successful teams have a comprehensive strategy of external communication and internal processes [3]. Stempfle and Badke-Schaub examine design team communications to show the interlinking of content- and process-oriented sequences in a project's lifecycle [46]. Research on the effect of interrelation between task interdependence, outcome interdependence, and team design and team performance has also been done [50]. Finally, opennes to change in a group is an important strategy for team performance [37].

2.2 Interventions

Interventions on a team can range from highly structured to very simple and can take on a variety of forms (surveys, consultants, etc.). For better or worse, the field of descriptive research on group behavior has not determined a generalized set of interventions to better team performances, but it has been proposed that group members should develop the skills to "manage their own development as a productive unit" and that group feedback should be considered as an effective tool for improving team performance [22, 20, 42]. Hackman and Wageman, after providing an overview on team coaching, suggest a model that of coaching that specifies under which conditions, specifically when, during a project lifecycle that different kinds of coaching–motivational, process, and educational–are most effective [23].

Other discussions center on the value of experiential learning in a design team as part of the design process, but focus on the design and not the design team's intra-team interactions and cohesiveness [47]. Studies have also explored the effect of timing of group development processes on group performance [15],

and even simple interventions improve information sharing and knowledge integration, which are essential to team performance [13].

Feedback interventions are an important segment of possible team interventions. Beyond merely proposing that strong interpersonal relationships are necessary for team cohesiveness and performance, Schein suggests that team members should be active in evaluating and bettering their relationships with each other [44]. In his model, however, a consultant is also engaged in improving group processes. Interventions promoting familiarity and evaluating team processes have also been shown to be positively correlated with team performance [40]. Gurtner et al. show that individual and group reflexivity are positively linked with team performance, empirically proving the theories of West [18, 54]. Results of studies by DeShon et al exhibit a correlation between feedback and team resource allocation and success [10]. The type of feedback given is also important. Studies of the effect of feedback show that positive reinforcement is correlated with higher performance [34]. Negative feedback may cause greater tension or conflict, negatively impacting performance [5, 25].

2.3 Opportunities for investigation

Despite the wealth of theory within the literature on team performance, the opportunities for further research in the field are many. Little work has been done on the performance of design teams specifically. In the same vein, no appreciable consideration been given to work products as a team task or metric of team success. Herein lies the potential boon to the field of team performance research.

Chapter 3

Methods

3.1 Design Course Overview

The data for this study was collected during a semester long, graduate level design course taught at an East Coast university in 2013. The class consisted of sixty mid-career professional students who were observed throughout the semester. All of the individuals in the class were enrolled as students, but all had 8-10 years of experience working in industry with some product development experience. A portion of the students were distance students, that is, they attended lectures and team meetings via videoconference technologies. The class in which the students were enrolled has been conducted in previous years and data from those classes has been the subject of other studies; however, no students enrolled in previous iterations of the course were enrolled in the 2013 interation of the course.

The students were divided into 11 teams ranging in size from four to seven members, with the average team size being 5.45 students and the median team size being five students. There were two teams of seven students and one team of four students; the remaing teams had either five or six members. Only one team was composed entirely of distance students; several teams had a single member who was a distance student. At the beginning of the course, the students were tasked with forming their own teams.

Over the course of the semester, each team was asked to create a functioning proof-of-concept prototype of a design idea that met the following guidelines:

1. Compelling, unmet user need
2. Market need
3. Tangible output

Submission Type	Description	Week of 1st Submission
Design Notebooks	Record of design notes, sketches, and ideas done in a design notebook or using Sketchbook Pro software.	3
Timesheets	Electronically submitted record of each student's individual time spent on each of thirteen activity categories.	3
User Interaction Forms	Detailed description of each instance of communication with product's potential users.	3
Prototype Questionnaire	Evaluation of each prototype created during the semester.	3
Product Contract	List of customer's key needs along with engineering values assigned each need.	7

Table 3.1: Weekly submissions

4. Simplicity

5. Low cost

6. Use of existing technologies

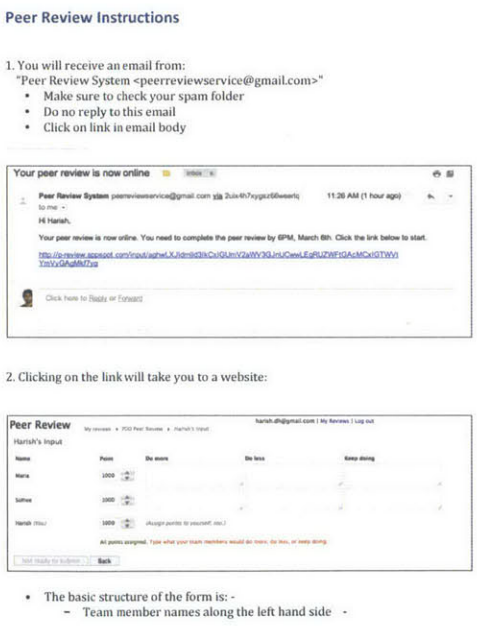
With regards to cost, each team was given $800 to use over the course of the semester for the development of the proof-of-concept prototype.

Data collected from previous iterations of the course examined several other factors relating to team performance, all more closely related to product design processes. Research conducted on data collected showed that teams that build prototypes early on in the design process and who performed additional rounds of benchmarking later on in the design process created more effective products than those that had not [24]. Other research suggested that the mere quantity of user interaction is not correlated with better design-outcomes, but that iterative interaction with potential users over the course of a design project is valuable to design performance [33]. With respect to team effectiveness measures, survey data regarding the social- and task-related dimensions of co-located and distributed teams suggest that the social-orientation common to co-located teams may impede team effectiveness, while conversely, distributed teams are more task-oriented and efficient [58].

3.2 Data Collected

As part of the class, each student was required to submit five weekly assignment that served as reports on each team's progress. The name, description, and week of the 14 week class during which weekly submission began are listed in table 3.1.

Timesheets collected in previous years have been the subject of other studies. The other piece of data collected was peer reviews. These were completed three times over the course of the semester and are the subject of this study. In each peer review, each student was asked to evaluate the other members of his/her team. The first section of the peer review gave the student points equaling 1000x the number of students in the group[1] and asked the student to distribute the points according to how he/she saw work being distributed on the team.[2] The second section of the peer review asked each student to give written feedback to each of the other team members. This feedback was divided into three subsections. These subsections were titled "Do more..."; "Do less..."; and "Keep doing...". Each subsection, thus, provided a prefix to each comment or set of comments given, suggesting a structure for the feedback. In the "Do more..." subsection, a respondent would generally comment on anything s/he would like to see more of from another team member, in the "Do less..." subsection, things s/he would like to see less of from another team member, and in the "Keep doing..." subsection, things about another team member that were pleasing to the respondent. Feedback was kept completely anonymous. In addition, neither the submission of feedback nor the receipt of positive or negative feedback from other team members had any bearing on the grade of a student. It is assumed that the declared noncorrelation of feedback with grade produced honest, unbiased results. Detailed instructions for the peer review can be found in figure 3-1, figure 3-2, and figure 3-3.



Peer Review Instructions

1. You will receive an email from:
"Peer Review System <peerreviewservice@gmail.com>"
- Make sure to check your spam folder
- Do no reply to this email
- Click on link in email body

Your peer review is now online

Peer Review System peerreviewservice@gmail.com via 2uix4h7xygzz66weerlq 11:26 AM (1 hour ago)

to me

Hi Harish,

Your peer review is now online. You need to complete the peer review by 6PM, March 6th. Click the link below to start.

http://p-review.appspot.com/input/aghwLXJkbmlidGlkCxIQUmV2aWV3GUnUCwwLEgRUZWFtQAcMCxIGTWVtYmVyQAuMM7yg

Click here to Reply or Forward

2. Clicking on the link will take you to a website:

Peer Review

harish.dh@gmail.com | My Reviews | Log out

Harish's Input

Name	Points	Do more	Do less	Keep doing
Maria	1000			
Sohee	1000			
Harish (You)	1000	(Assign points to yourself, too.)		

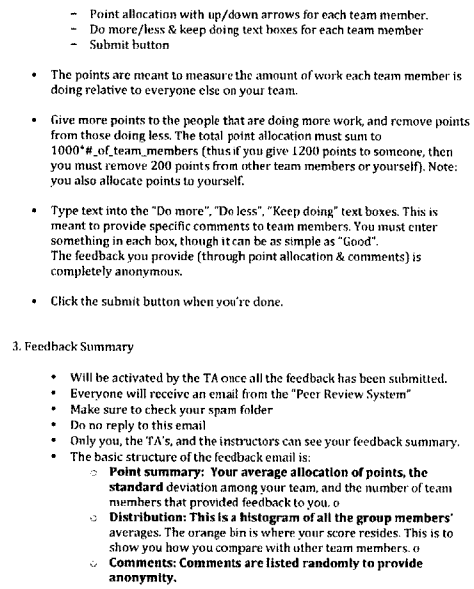
All points assigned. Type what your team members would do more, do less, or keep doing.

Not ready to submit | Back

- The basic structure of the form is: -
  - Team member names along the left hand side -

Figure 3-1: Student instructions for peer review-p.1

[1] Thus, a group of five students would mean the student completing the review would have 5000 points to distribute.
[2] Perfect work distribution would yield 1000 points awarded to each member of the team.



- Point allocation with up/down arrows for each team member.
- Do more/less & keep doing text boxes for each team member
- Submit button

- The points are meant to measure the amount of work each team member is doing relative to everyone else on your team.
- Give more points to the people that are doing more work, and remove points from those doing less. The total point allocation must sum to 1000*#_of_team_members (thus if you give 1200 points to someone, then you must remove 200 points from other team members or yourself). Note: you also allocate points to yourself.
- Type text into the "Do more", "Do less", "Keep doing" text boxes. This is meant to provide specific comments to team members. You must enter something in each box, though it can be as simple as "Good".
  The feedback you provide (through point allocation & comments) is completely anonymous.
- Click the submit button when you're done.

3. Feedback Summary

- Will be activated by the TA once all the feedback has been submitted.
- Everyone will receive an email from the "Peer Review System"
- Make sure to check your spam folder
- Do no reply to this email
- Only you, the TA's, and the instructors can see your feedback summary.
- The basic structure of the feedback email is:
  - **Point summary: Your average allocation of points, the standard** deviation among your team, and the number of team members that provided feedback to you. o
  - **Distribution: This is a histogram of all the group members'** averages. The orange bin is where your score resides. This is to show you how you compare with other team members. o
  - **Comments: Comments are listed randomly to provide anonymity.**

Figure 3-2: Student instructions for peer review-p.2

3.3 Design Outcome Measures

Few and far between are the instances in which team performance is easily evaluated. Outside the realm of sport, there are no comprehensive and widely-agreed-upon metrics for the evaluation of a team. In this study, the design success of each teach was evaluated by a panel of experts. The design performance grade was used as the primary metric of team success in this study.

At the end of the semester, each team presented their design and prototype to the entire class and to a panel of experts. For the 2013 iteration of the course, the panel was comprised of four representatives from academia and four representatives from industry. The representatives from academia were comprised of one professor, one postdoctoral associate, a doctoral candidate and research scientist, and a research assistant. All of the members of the panel were expert practitioners in the field of product design or development. Only the professor had followed the teams' progress over the course of the semester. However, analysis from previous studies of the course concluded that there was no grading bias based on familiarity for panel members who had followed teams' work throughout the semester compared to those that had not [24].

Each panel member awarded points on a 7-point Likert scale to the teams in the categories as listed in

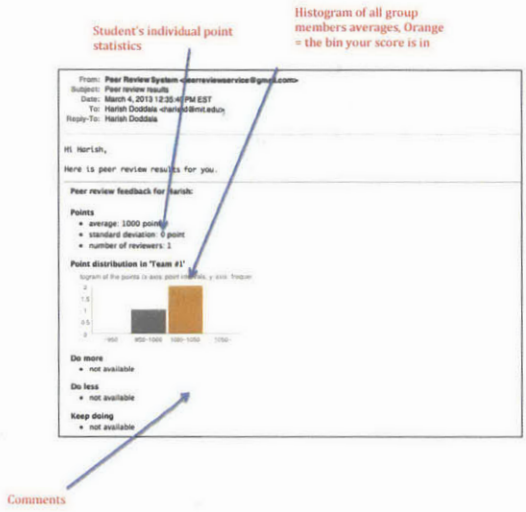


Figure 3-3: Student instructions for peer review-p.3

table 3.2. These categories built on the stated project goals of the class, which in turn built on the work of Ulrich and Eppinger [49].

Based on the scoring rubric, each team was given a score out of 70 by each reviewer. After the presentations, the reviewers gathered to compare the scores given and discuss final rankings. After these deliberations, the final rankings, as can be found in table 3.3, were determined. These rankings, unsurprisingly, mapped almost exactly with the averaged scores from the reviewers, the only exception being the tie for first place awarded to teams 9 and 10.

3.4 Peer Review Coding

This investigation was limited to the second section of the peer review, the written feedback. Each comment of every student in each period of feedback was coded into numerical data using the skills-effort-feedback framework described by Hackman and Morris [22, 20]. Also tabulated were non-responses and non-specific responses. Coding of each comment was defined according to the definitions in table 3.4. The definitions were constructed after extensive review of the feedback collected to ensure that the definitions fully accounted

Question		Topic	Question
1.	a)	User and Market Need	Do you think this user need is compelling, clearly defined, and unmet by existing products?
	b)		Does the team have an understanding of where the product fits in with its competition?
2.	a)	Product Concept	Does the concept the team has developed meet the user need?
	b)		Does the concept make a target user think, "I want this!"?
3.	a)	Prototype	Was the demonstration of the prototype's functionality convincing?
	b)		Does the prototype communicate the design concept well
	c)		Is the prototype's craftmanship of high quality?
4.	a)	Business Assessment	Do you agree that the team's business estimates for the first year are plausible?
5.	a)	Presentation	Was the presentation well structured and delivered?
6.			Overall Rating of the Project

Table 3.2: Final presentation review questionnaire

for each comment. A single comment could be span more than one category of comment if the content fell under multiple definitions. Each comment was coded, additionally, as positive feedback or negative feedback. Examples of comments and their associated coding can be found in Appendix A. The data was coded by a single researcher three times to ensure consistency of tabulation. After the comments were categorized and tallied as can be seen in table B.1 of Appendix B, the raw data was normalized by the number of team members per team, such that the data would reveal the number of comments in a particular category and period per team member, as can be seen in table B.2. The comments per team member data were normalized by the mean and standard deviation of the corresponding data, as can be seen in table B.3. Standardized totals of positive and negative comments per period and overall, of no feedback per period and overall, and total comments by category per period, can be found in Appendix B.

A Spearman rank correlation was used to correlate the coded, normalized peer review data with the final rankings, thus investigating how more active shaping (a higher volume of comments) and how positive, constructive feedback (any categorized, positive feedback) may be related to team success.

Team	Ranking
A	3
B	9
C	6
D	10
E	11
F	4
G	7
H	5
I	1
J	1
K	8

Table 3.3: Final rankings of teams

Category	Comment Content
Effort	Technical expertise
	Creativity
	Originality
	Innovative ideas
	Leadership skill
Skill	Meeting attendance
	Assisting with any work
	Meeting participation
	"Team player"
	Initiative
	Enthusiasm
Performance Strategies	Planning
	Delegation
	Organization
	Communication
	Openness to new ideas
	Time efficiency
	Patience
	Micromanagement
	Focus on objective

Table 3.4: Coding of written feedback-Definitions

Chapter 4

Results and Discussion

4.1 Spearman rank correlation results

The results of the Spearman rank correlations can be found below. Overall, analysis of the data showed no significant correlation of any indicator with final team performance (Spearman $p<0.05$). The only indicator that approached statistical significance was no feedback in period three, as can be seen in table 4.2. Although the p-value of the correlation is 0.233, it is significantly lower than the p-values calculated for the remainder of the data. This correlation may be attributed to the idea that more successful teams had less reason to give feedback to team members after the completion of the project, having already molded each other's behavior in earlier periods, while less successful teams may have had more to complain about with regards to other team members based on their (albeit accurate) feelings about their final product. No correlations exist to corroborate this assumption, but the conclusion is hardly a wild one.

4.2 Discussion

Interventions that induce discussions of performance strategy have been shown to improve team performance[21], but the peer review questionnaire did not specifically ask students to assess strategies of any sort, which may

Feedback Type	σ	p-val
Total Positive Feedback	0.100	0.769
Total Negative Feedback	-0.150	0.659
Total Feedback	-0.014	0.968
Total No Feedback	0.096	0.780

Table 4.1: Correlations of total feedback with final rank

Category	Period	σ	p-val
Skills	1	0.237	0.483
	2	0.094	0.784
	3	-0.337	0.311
Effort	1	-0.036	0.915
	2	-0.144	0.672
	3	-0.091	0.790
Perf. Strat.	1	0.066	0.847
	2	-0.050	0.884
	3	-0.161	0.637
No Feedback	1	0.205	0.545
	2	0.141	0.679
	3	0.392	0.233

Table 4.2: Correlations of total feedback by category and period with final rank

Category	Period	Feedback Type	σ	p-val
Skills	1	Positive Feedback	0.037	0.915
		Negative Feedback	0.110	0.747
	2	Positive Feedback	0.071	0.836
		Negative Feedback	-0.146	0.669
	3	Positive Feedback	-0.158	0.644
		Negative Feedback	-0.272	0.419
Effort	1	Positive Feedback	0.310	0.354
		Negative Feedback	-0.232	0.493
	2	Positive Feedback	0.267	0.428
		Negative Feedback	-0.254	0.451
	3	Positive Feedback	0.068	0.842
		Negative Feedback	-0.064	0.851
Perf. Strat.	1	Positive Feedback	0.326	0.327
		Negative Feedback	-0.175	0.607
	2	Positive Feedback	0.062	0.857
		Negative Feedback	-0.142	0.678
	3	Positive Feedback	-0.103	0.763
		Negative Feedback	-0.260	0.441

Table 4.3: Correlations of positive and negative feedback by category and period with final rank

Feedback Type	Period	σ	p-val
Total Positive Feedback	1	0.258	0.444
	2	0.208	0.540
	3	-0.032	0.926
Total Negative Feedback	1	0.112	0.743
	2	-0.173	0.611
	3	-0.343	0.301
Total Feedback	1	0.217	0.522
	2	-0.208	0.540
	3	-0.273	0.416

Table 4.4: Correlations of total feedback by period with final rank

have led to a higher correlation between performance strategy comments and team performance. Although other studies show a higher correlation of positive feedback with success versus negative feedback[34], no such correlation was exhibited in the data collected. Interestingly enough, one of the highest peforming teams, Team A, had more negative feedback than any other group. Other studies show the importance of familiarity with the work of individuals in prompting effective feedback[32], so it is possible that less-involved or distance members of groups were less likely to give appropriate feedback to other members to improve overall success. Other studies have exhibited that knowledge of performance affects team members' review of their work groups[45, 19], which may have positively or negatively shaded each team member's comments, as there were performance metrics evaluated throughout the semester, beyond the final ratings. Timing of the feedback may have also played a part. Immediate feedback may be more effective than delayed feedback in task issues[25], such that the time between the arising of an issue on a team and the peer review may have affected the honesty of the review. Other research has indicated that the existence of a low-performing group member, and acknowledgment of that existence by other group members, may have overall positive effects on group dynamics and performance, depending on the personalities of the remaining group members[36, 27]. This may explain why teams with high levels of negative feedback may have outperformed those with low levels of feedback. Finally, although team learning can improve team effectiveness, they can harm teams that were already performaing well[9], and beyond that, feedback does not always produce positive results and lose effectiveness as they change focus toward personal concerns away from task concerns[31]. The peer reviews may, in fact, have distracted teams from the task, resulting in negatively affected performances.

4.3 Study limitations

It is wholly unfortunate that the data did not produce conclusive results correlating specific aspects of team interactions with a team's overall success. This may be due to several causes, the first and most basic being the small sample size analyzed. With a total of 60 students divided over 11 teams, it is not surprising that the the correlations lacked statistical significance. Aggregating several years of reviews and teams' ranking would be required to achieve the statistical significance. Furthermore, with only three peer reviews conducted over the course of the semester, opportunities for honest, anonymous, peer coaching are, perhaps, too few to affect a final result. Also important to note is the inherent difficult in coding qualitative data into quantitative data, a task complicated by the structure of the survey and the demographics of the class. Despite the coding rubric created and the Do more-Do less-Keep doing structure of the survey combined to fairly comprehensively describe every comment analyzed and do so in terms of positivity and negativity, there is an assumptive leap from a commenter's intent and the researcher's interpretation. This leap to

denotative intent may have, and likely did, leave behind it the connotative intent of the comment. Although the denotation of the comment was the focus of this investigation, the necessary discounting of connotation may have adversely affected the results of the study. Anonymity, too, may have shaded the results of this investigation. On the one hand, the anonymity sought to promote and likely succeeded in promoting honestly from the respondents. On the other hand, anonymity may have led team members to put less thought and work into the peer review process. Moreover, a team member may be more responsive to the feedback of one teammate over the feedback of another. By masking the source of every comment, the anonymity of the peer review negates the weighting of comments a team member may do. It would, admittedly, be difficult to account for this weighting without significantly more extensive surveys, but the potential effect of anonymity on this study is certainly one worth mentioning.

Chapter 5

Conclusions and Future Work

This study sought to confirm two hypotheses. The first theory proposed was that teams more active in shaping the individuals from which it is composed would be more successful than teams that were less active. Based on correlations between the volume of comments given during peer review and team performance, this hypothesis can neither be considered soundly proven nor squarely disproven. The second hypothesis, which proposed that teams who gave each other more positive feedback and constructive criticism than negative feedback would be more successful than more negative teams was similarly neither confirmed nor denied.

The study also sought to illuminate whether certain categories of comments were more linked to successful team performance than others. Neither skills-focused, nor effort-focused, nor strategy-focused comments were found to have any significant correlation with team performance.

Despite the inconclusive nature of the study's results, this research does provide insight as to future work regarding peer reviews and team performance. Other research has indicated that the timing and content of interventions–task-focused versus interpersonal focused–affects a group's performance of a task[56]. In future years, the teams could be asked to submit peer reviews more often, either weekly or biweekly. By doing this, respondents may provide more specifc feedback and comments may be more accurate and less generalized. The peer review itself could be modified to more clearly understand the intent of every piece of feedback. Respondents would be asked whether or not each comment was aimed at a specific category of group performance or select comments from a predetermined list. Feedback would be standardized and would not be subject to the interpretative problems of coding. Great understanding could be gained from targeting each team member's real intent in each comment.

Although it would be incredible to discover the key to team success, it is unlikely that a generalizable intervention will ever be discovered. Such is the nature of a field in which the unpredicatability of human

nature is a significant component. With that in mind, however, this study's results–or lack thereof–should not be discouraging. This research is an opportunity, a jumping point. There is much compelling evidence that the road this type of research leads down should provide insights as to how to make teams more successful. One need only traverse it.

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Appendix A

Feedback and Coding Examples

<table>
<tr><th>Comment</th><th>Tabulation</th><th>Reasoning</th></tr>
<tr><td>"Do more...Be open to your team members... recommendations. Listen and let other team members to express the ideas. Accept help from your team..."</td><td><table><tr><th>Category</th><th>Positive</th><th>Negative</th></tr><tr><td>Skills</td><td>+0</td><td>+0</td></tr><tr><td>Effort</td><td>+0</td><td>+0</td></tr><tr><td>Performance Strategy</td><td>+0</td><td>+3</td></tr><tr><td>No Feedback</td><td colspan="2">+0</td></tr></table></td><td>The first sentence is a negative critique of the team member's openness to new ideas. The second sentence is a critique of communication. The third sentence is a critique of the team member's willingness to delegate.</td></tr>
<tr><td>"Do more... Showing... inspirational videos (just kidding!)"</td><td><table><tr><th>Category</th><th>Positive</th><th>Negative</th></tr><tr><td>Skills</td><td>+0</td><td>+0</td></tr><tr><td>Effort</td><td>+0</td><td>+0</td></tr><tr><td>Performance Strategy</td><td>+0</td><td>+0</td></tr><tr><td>No Feedback</td><td colspan="2">+1</td></tr></table></td><td>The comment contributes no actionable feedback to the team member receiving it.</td></tr>
<tr><td>"Keep doing...Doing a great job on the [skill redacted] aspect of the project. Continually updates the team with progress which is great..."</td><td><table><tr><th>Category</th><th>Positive</th><th>Negative</th></tr><tr><td>Skills</td><td>+1</td><td>+0</td></tr><tr><td>Effort</td><td>+0</td><td>+0</td></tr><tr><td>Performance Strategy</td><td>+1</td><td>+0</td></tr><tr><td>No Feedback</td><td colspan="2">+0</td></tr></table></td><td>The first sentence compliments a specific technical skill. The second sentence compliments the team member's communication.</td></tr>
<tr><td>"Keep doing...Very high engagement during the discussions. Very good comments and helpful guidences. Keep helping the team in finding the right solutions. Very good to have you in the team."</td><td><table><tr><th>Category</th><th>Positive</th><th>Negative</th></tr><tr><td>Skills</td><td>+1</td><td>+0</td></tr><tr><td>Effort</td><td>+1</td><td>+0</td></tr><tr><td>Performance Strategy</td><td>+1</td><td>+0</td></tr><tr><td>No Feedback</td><td colspan="2">+0</td></tr></table></td><td>The first sentence highlights the team member's participation during team meetings. The second sentence compliments the team member's ideas. The third sentence is a compliment of the team member's focus on the goal.</td></tr>
<tr><td>"Do more...Be more independent and proactive. Don't be afraid to be a leader."</td><td><table><tr><th>Category</th><th>Positive</th><th>Negative</th></tr><tr><td>Skills</td><td>+0</td><td>+1</td></tr><tr><td>Effort</td><td>+0</td><td>+1</td></tr><tr><td>Performance Strategy</td><td>+0</td><td>+0</td></tr><tr><td>No Feedback</td><td colspan="2">+0</td></tr></table></td><td>The first sentence critiques the team member's initiative. The second sentence critiques the team member's leadership skills.</td></tr>
</table>

Table A.1: Feedback, code, and associated reasoning

Appendix B

Data

Table B.1: Raw coding data

Team	Category	Period 1		Period 2		Period 3	
		Positive Feedback	Negative Feedback	Positive Feedback	Negative Feedback	Positive Feedback	Negative Feedback
A	Skills	47	21	27	18	18	17
	Effort	16	36	16	34	21	24
	Perf. Strat.	19	73	17	68	26	64
	Null	6		14		12	
B	Skills	8	6	6	4	5	2
	Effort	3	7	10	5	7	8
	Perf. Strat.	8	8	2	7	1	7
	Null	10		9		11	
C	Skills	35	8	30	7	29	0
	Effort	16	11	11	3	8	2
	Perf. Strat.	15	13	6	3	5	1
	Null	28		46		51	
D	Skills	16	13	15	12	10	1
	Effort	10	3	8	7	7	6
	Perf. Strat.	7	16	2	4	2	5
	Null	14		20		36	

Team	Category	Period 1		Period 2		Period 3	
		Positive Feedback	Negative Feedback	Positive Feedback	Negative Feedback	Positive Feedback	Negative Feedback
E	Skills	31	3	14	0	13	0
	Effort	18	10	15	1	17	5
	Perf. Strat.	21	21	6	5	7	3
	Null	11		28		30	
F	Skills	12	9	8	2	16	1
	Effort	21	3	16	4	13	3
	Perf. Strat.	6	7	7	11	7	11
	Null	24		24		26	
G	Skills	16	11	31	3	18	10
	Effort	12	4	5	5	1	1
	Perf. Strat.	1	16	7	5	3	7
	Null	10		22		23	
H	Skills	19	11	15	14	16	7
	Effort	19	21	12	12	21	12
	Perf. Strat.	14	26	10	19	8	15
	Null	10		17		29	
I	Skills	16	3	13	1	12	9
	Effort	3	4	8	2	2	4
	Perf. Strat.	4	16	1	2	4	2
	Null	18		38		28	
J	Skills	19	3	15	9	18	0
	Effort	7	11	8	10	14	10
	Perf. Strat.	7	18	2	6	2	8
	Null	9		19		22	
K	Skills	54	6	58	5	47	4
	Effort	31	14	20	7	20	16
	Perf. Strat.	17	20	16	12	11	5
	Null	49		60		68	

Table B.2: Raw data normalized by number of team members per team

Team	Category	Period 1		Period 2		Period 3	
		Positive Feedback	Negative Feedback	Positive Feedback	Negative Feedback	Positive Feedback	Negative Feedback
A	Skills	6.71	3.00	3.86	2.57	2.57	2.43
	Effort	2.29	5.14	2.29	4.86	3.00	3.43
	Perf. Strat.	2.71	10.43	2.43	9.71	3.71	9.14
	Null	0.86		2.00		1.71	
B	Skills	2.00	1.50	1.50	1.00	1.25	0.50
	Effort	0.75	1.75	2.50	1.25	1.75	2.00
	Perf. Strat.	2.00	2.00	0.50	1.75	0.25	1.75
	Null	2.50		2.25		2.75	
C	Skills	5.83	1.33	5.00	1.17	4.83	0.00
	Effort	2.67	1.83	1.83	0.50	1.33	0.33
	Perf. Strat.	2.50	2.17	1.00	0.50	0.83	0.17
	Null	4.67		7.67		8.50	
D	Skills	3.20	2.60	3.00	2.40	2.00	0.20
	Effort	2.00	0.60	1.60	1.40	1.40	1.20
	Perf. Strat.	1.40	3.20	0.40	0.80	0.40	1.00
	Null	2.80		4.00		7.20	
E	Skills	6.20	0.60	2.80	0.00	2.60	0.00
	Effort	3.60	2.00	3.00	0.20	3.40	1.00
	Perf. Strat.	4.20	4.20	1.20	1.00	1.40	0.60
	Null	2.20		5.60		6.00	
F	Skills	2.40	1.80	1.60	0.40	3.20	0.20
	Effort	4.20	0.60	3.20	0.80	2.60	0.60
	Perf. Strat.	1.20	1.40	1.40	2.20	1.40	2.20
	Null	4.80		4.80		5.20	

Team	Category	Period 1		Period 2		Period 3	
		Positive Feedback	Negative Feedback	Positive Feedback	Negative Feedback	Positive Feedback	Negative Feedback
G	Skills	3.20	2.20	6.20	0.60	3.60	2.00
	Effort	2.40	0.80	1.00	1.00	0.20	0.20
	Perf. Strat.	0.20	3.20	1.40	1.00	0.60	1.40
	Null	2.00		4.40		4.60	
H	Skills	3.17	1.83	2.50	2.33	2.67	1.17
	Effort	3.17	3.50	2.00	2.00	3.50	2.00
	Perf. Strat.	2.33	4.33	1.67	3.17	1.33	2.50
	Null	1.67		2.83		4.83	
I	Skills	3.20	0.60	2.60	0.20	2.40	1.80
	Effort	0.60	0.80	1.60	0.40	0.40	0.80
	Perf. Strat.	0.80	3.20	0.20	0.40	0.80	0.40
	Null	3.60		7.60		5.60	
J	Skills	3.80	0.60	3.00	1.80	3.60	0.00
	Effort	1.40	2.20	1.60	2.00	2.80	2.00
	Perf. Strat.	1.40	3.60	0.40	1.20	0.40	1.60
	Null	1.80		3.80		4.40	
K	Skills	7.71	0.86	8.29	0.71	6.71	0.57
	Effort	4.43	2.00	2.86	1.00	2.86	2.29
	Perf. Strat.	2.43	2.86	2.29	1.71	1.57	0.71
	Null	7.00		8.57		9.71	

Table B.3: Standard normalization of categorized data

Team	Category	Period 1		Period 2		Period 3	
		Positive Feedback	Negative Feedback	Positive Feedback	Negative Feedback	Positive Feedback	Negative Feedback
A	Skills	1.24	1.75	0.09	1.47	-0.44	1.81
	Effort	-0.17	2.33	0.22	2.68	0.76	2.01
	Perf. Strat.	0.72	2.80	1.65	2.87	2.64	2.88
B	Skills	-1.19	-0.05	-1.05	-0.21	-1.32	-0.34
	Effort	-1.36	-0.13	0.53	-0.12	-0.31	0.57
	Perf. Strat.	0.07	-0.70	-0.88	-0.14	-0.93	-0.08
C	Skills	0.79	-0.25	0.65	-0.03	1.08	-0.90
	Effort	0.13	-0.07	-0.43	-0.70	-0.67	-1.12
	Perf. Strat.	0.53	-0.63	-0.22	-0.62	-0.33	-0.71
D	Skills	-0.57	1.27	-0.32	1.29	-0.82	-0.68
	Effort	-0.39	-0.96	-0.77	-0.00	-0.61	-0.24
	Perf. Strat.	-0.48	-0.20	-1.01	-0.50	-0.78	-0.38
E	Skills	0.97	-1.12	-0.42	-1.29	-0.42	-0.90
	Effort	0.86	0.05	1.25	-0.93	1.11	-0.45
	Perf. Strat.	2.09	0.21	0.04	-0.43	0.25	-0.54
F	Skills	-0.99	0.31	-1.00	-0.86	-0.01	-0.68
	Effort	1.32	-0.96	1.54	-0.47	0.42	-0.85
	Perf. Strat.	-0.67	-0.95	0.30	0.03	0.25	0.10
G	Skills	-0.57	0.79	1.23	-0.64	0.25	1.33
	Effort	-0.08	-0.82	-1.63	-0.31	-1.65	-1.26
	Perf. Strat.	-1.58	-0.20	0.30	-0.43	-0.57	-0.22
H	Skills	-0.59	0.35	-0.57	1.22	-0.37	0.40
	Effort	0.52	1.14	-0.19	0.46	1.20	0.57
	Perf. Strat.	0.37	0.27	0.65	0.39	0.18	0.22

Team	Category	Period 1		Period 2		Period 3	
		Positive Feedback	Negative Feedback	Positive Feedback	Negative Feedback	Positive Feedback	Negative Feedback
I	Skills	-0.57	-1.12	-0.52	-1.07	-0.55	1.11
	Effort	-1.48	-0.82	-0.77	-0.78	-1.48	-0.65
	Perf. Strat.	-1.03	-0.20	-1.28	-0.66	-0.37	-0.62
J	Skills	-0.26	-1.12	-0.32	0.65	0.25	-0.90
	Effort	-0.86	0.20	-0.77	0.46	0.59	0.57
	Perf. Strat.	-0.48	-0.04	-1.01	-0.35	-0.78	-0.14
K	Skills	1.76	-0.81	2.24	-0.52	2.34	-0.26
	Effort	1.50	0.05	1.04	-0.31	0.64	0.86
	Perf. Strat.	0.46	-0.35	1.47	-0.16	0.43	-0.50

Table B.4: Total comments per period by category-Normalized

Team	Category	Period 1	Period 2	Period 3
		Total Feedback	Total Feedback	Total Feedback
A	Skills	1.92	0.72	0.60
	Effort	1.54	2.54	1.50
	Perf. Strat.	2.55	2.77	2.91
	Null	-1.24	-1.27	-1.62
B	Skills	-1.17	-1.08	-1.42
	Effort	-0.99	0.15	0.10
	Perf. Strat.	-0.55	-0.33	-0.33
	Null	-0.32	-1.16	-1.18
C	Skills	0.65	0.60	0.50
	Effort	0.04	-0.85	-0.98
	Perf. Strat.	-0.32	-0.56	-0.63
	Null	0.89	1.24	1.29
D	Skills	-0.02	0.24	-1.14
	Effort	-0.94	-0.38	-0.50
	Perf. Strat.	-0.34	-0.66	-0.51
	Null	-0.16	-0.38	0.73
E	Skills	0.47	-0.95	-0.89
	Effort	0.60	-0.24	0.44
	Perf. Strat.	0.94	-0.35	-0.33
	Null	-0.49	0.33	0.21
F	Skills	-0.82	-1.31	-0.39
	Effort	0.19	0.33	-0.18
	Perf. Strat.	-1.02	0.09	0.15
	Null	0.96	-0.03	-0.13

Team	Category	Period 1	Period 2	Period 3
		Total Feedback	Total Feedback	Total Feedback
G	Skills	-0.22	0.89	0.98
	Effort	-0.63	-1.08	-1.64
	Perf. Strat.	-0.75	-0.28	-0.33
	Null	-0.60	-0.21	-0.39
H	Skills	-0.42	-0.02	-0.12
	Effort	1.15	0.33	1.01
	Perf. Strat.	0.36	0.48	0.22
	Null	-0.79	-0.90	-0.29
I	Skills	-1.02	-0.95	0.11
	Effort	-1.55	-1.08	-1.22
	Perf. Strat.	-0.55	-0.85	-0.57
	Null	0.29	1.21	0.04
J	Skills	-0.72	-0.03	-0.27
	Effort	-0.43	0.05	0.65
	Perf. Strat.	-0.21	-0.53	-0.33
	Null	-0.72	-0.47	-0.47
K	Skills	1.35	1.89	2.02
	Effort	1.03	0.23	0.83
	Perf. Strat.	-0.11	0.22	-0.24
	Null	2.19	1.64	1.81

Team	Period 1	Period 2	Period 3	All Periods
A	0.83	0.61	1.12	0.91
B	-1.12	-0.94	-1.29	-1.20
C	0.63	0.33	0.20	0.45
D	-0.60	-0.75	-1.07	-0.84
E	1.47	0.01	0.36	0.77
F	-0.26	-0.29	0.28	-0.12
G	-0.82	0.62	-0.83	-0.42
H	-0.02	-0.31	0.40	0.02
I	-1.16	-0.98	-1.15	-1.19
J	-0.60	-0.75	0.12	-0.47
K	1.63	2.45	1.86	2.10

Table B.5: Normalized total positive feedback

Team	Period 1	Period 2	Period 3	All Periods
A	2.80	2.75	2.82	2.84
B	-0.47	-0.16	0.01	-0.21
C	-0.45	-0.57	-0.97	-0.66
D	-0.19	-0.03	-0.47	-0.22
E	-0.09	-0.78	-0.68	-0.53
F	-0.83	-0.30	-0.31	-0.48
G	-0.24	-0.47	-0.16	-0.30
H	0.62	0.61	0.38	0.55
I	-0.63	-0.83	-0.31	-0.61
J	-0.19	0.06	-0.16	-0.09
K	-0.35	-0.29	-0.16	-0.28

Table B.6: Normalized total negative feedback

Team	Period 1	Period 2	Period 3	All Periods
A	2.31	2.54	2.59	2.57
B	-0.95	-0.58	-0.61	-0.75
C	0.07	-0.31	-0.61	-0.27
D	-0.47	-0.38	-0.86	-0.58
E	0.79	-0.64	-0.32	-0.02
F	-0.69	-0.38	-0.09	-0.42
G	-0.63	-0.09	-0.51	-0.43
H	0.39	0.36	0.47	0.42
I	-1.08	-1.14	-0.78	-1.05
J	-0.47	-0.31	-0.05	-0.30
K	0.71	0.93	0.77	0.83

Table B.7: Normalized total feedback

Team	All Periods
A	-1.49
B	-1.00
C	1.24
D	0.09
E	0.06
F	0.23
G	-0.41
H	-0.69
I	0.56
J	-0.58
K	1.98

Table B.8: Total null feedback from all periods-Normalized

Appendix C

Graphs

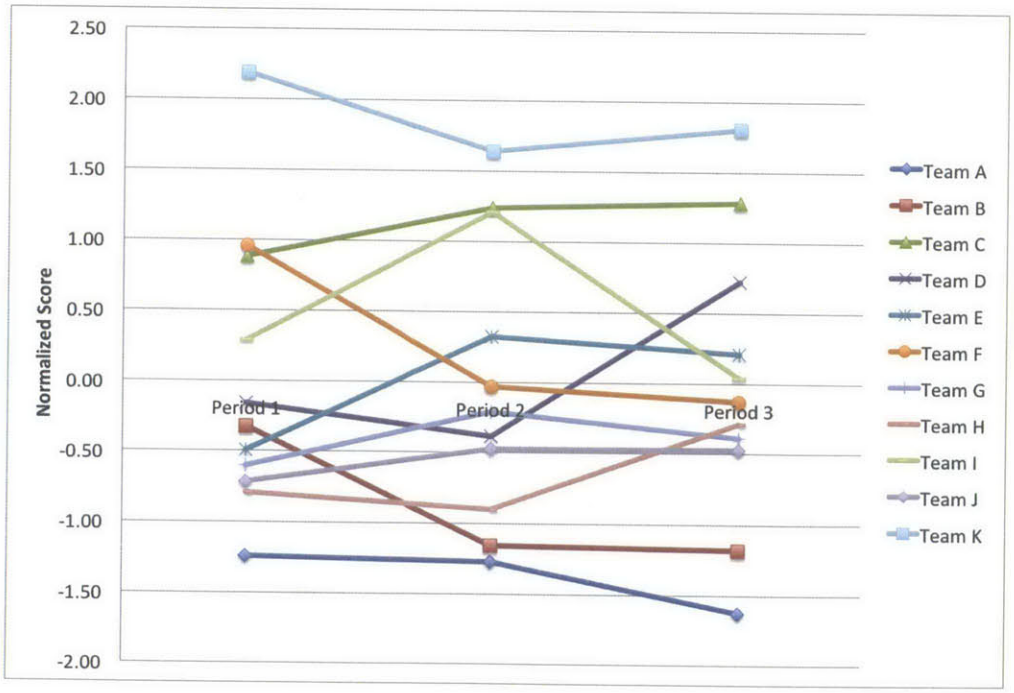

Figure C-1: No feedback per period

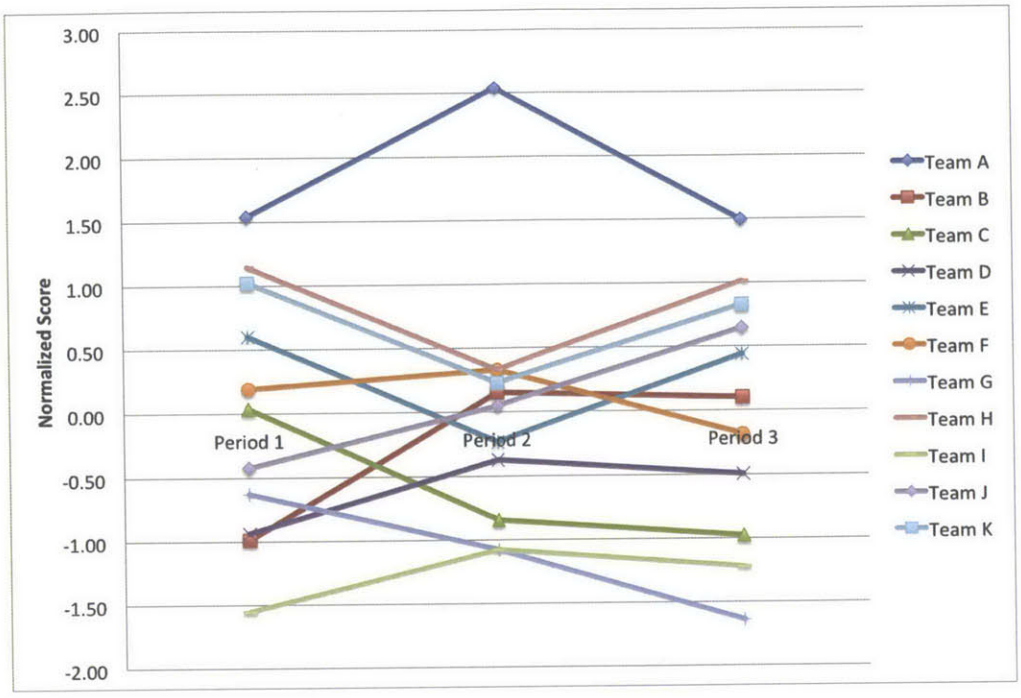

Figure C-2: Total effort feedback per period

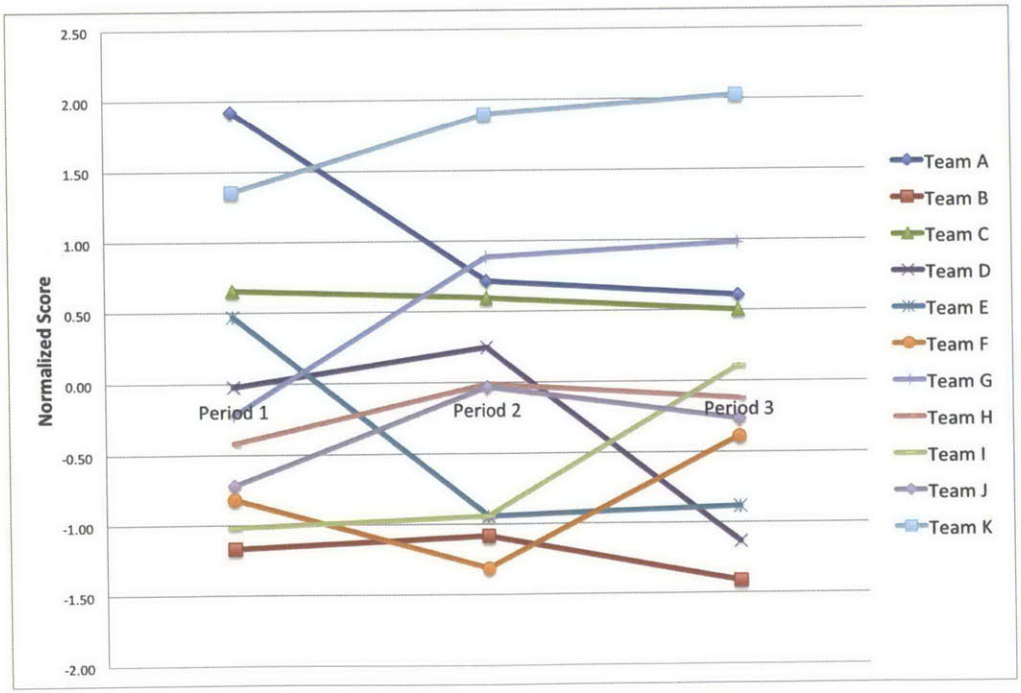

Figure C-3: Total skills feedback per period

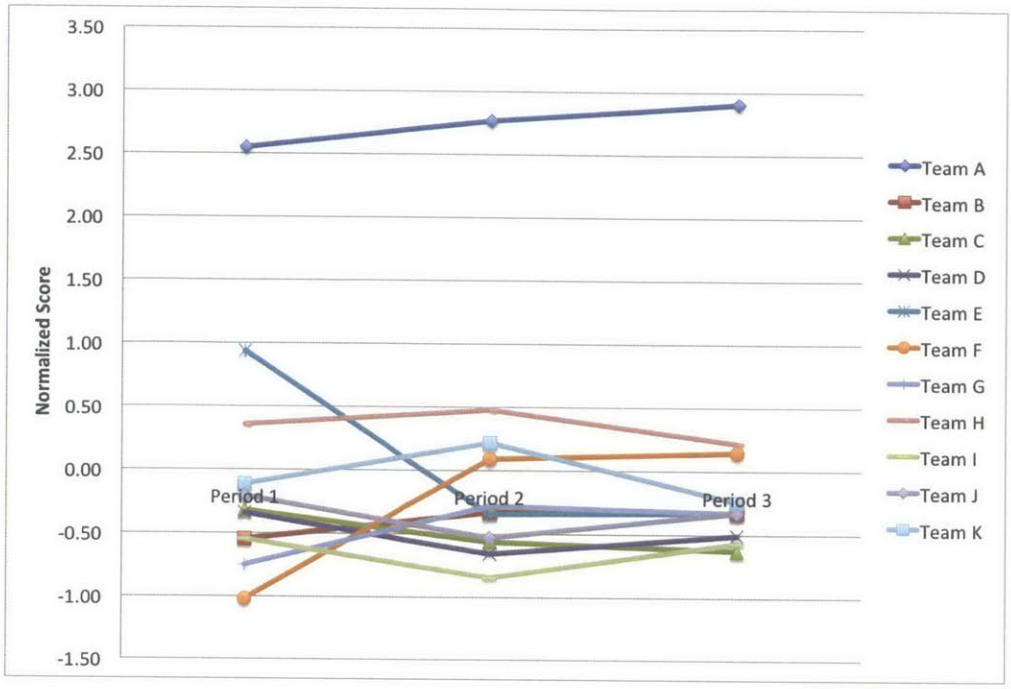

Figure C-4: Total performance strategy feedback per period

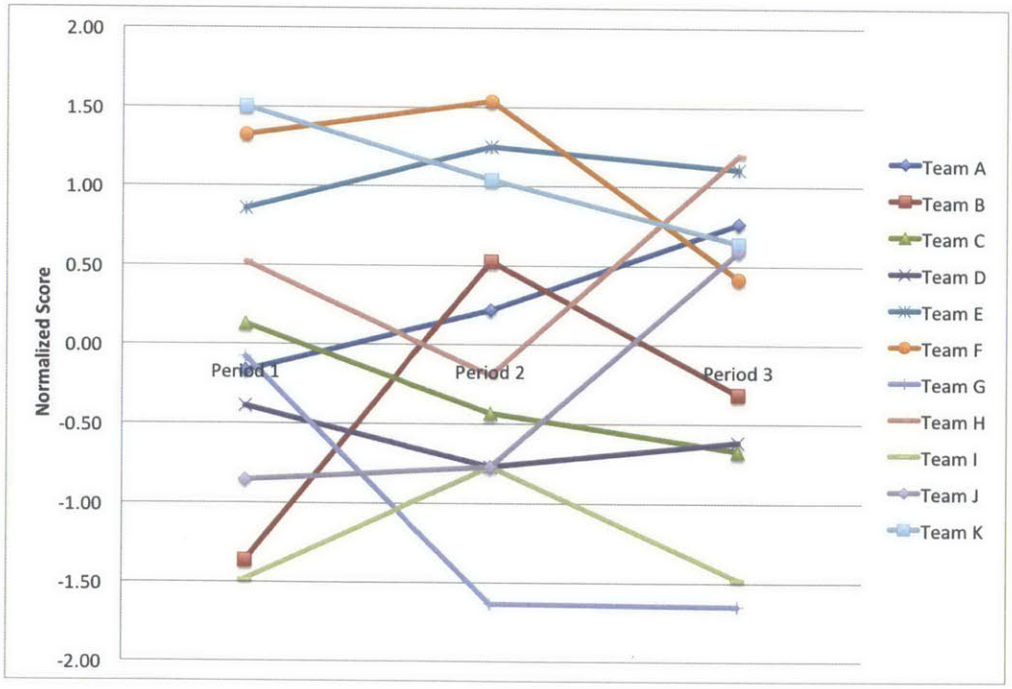

Figure C-5: Effort positive feedback per period

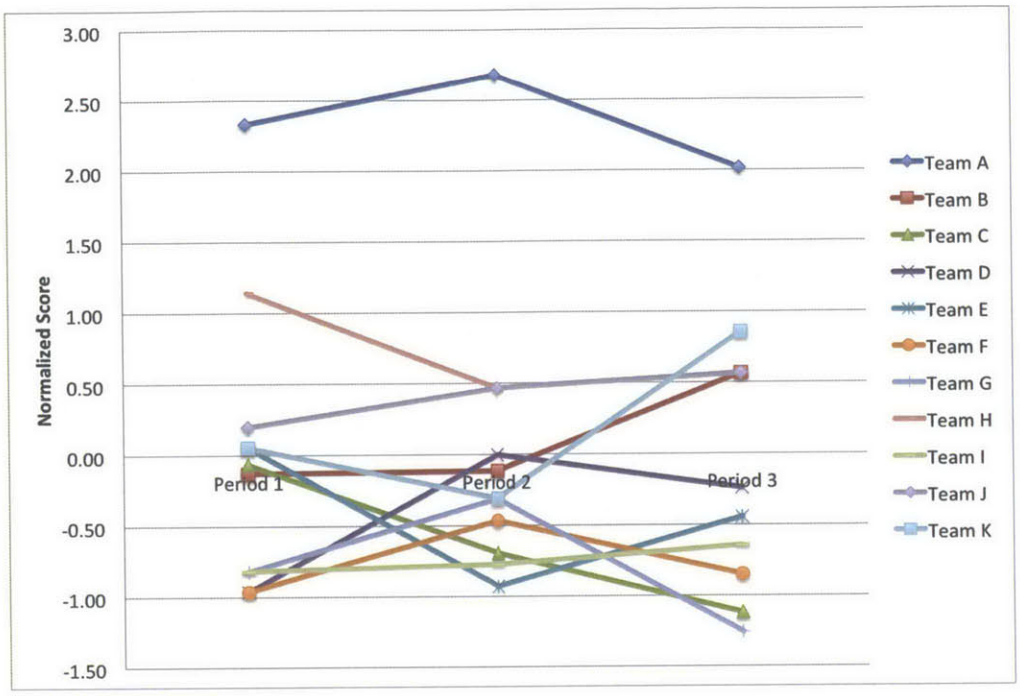

Figure C-6: Effort negative feedback per period

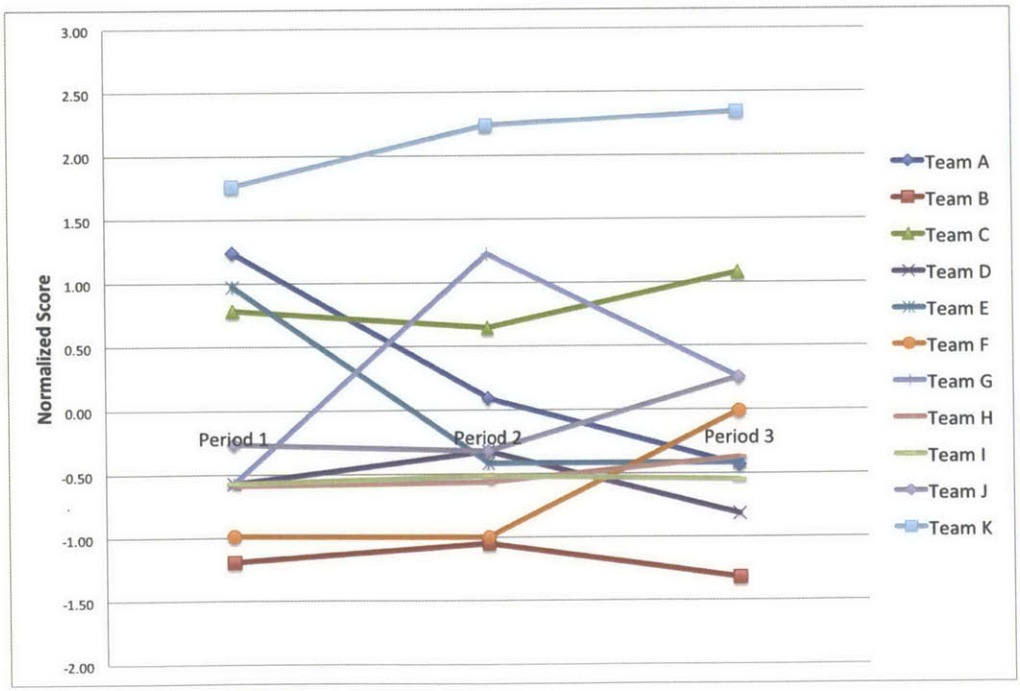

Figure C-7: Skills positive feedback per period

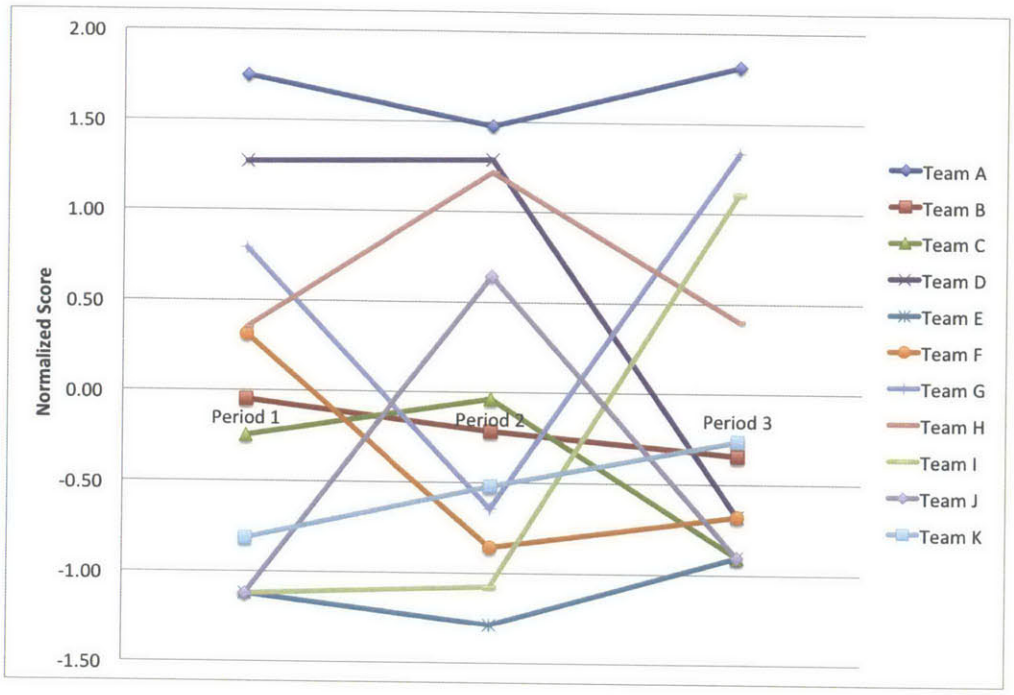

Figure C-8: Skills negative feedback per period

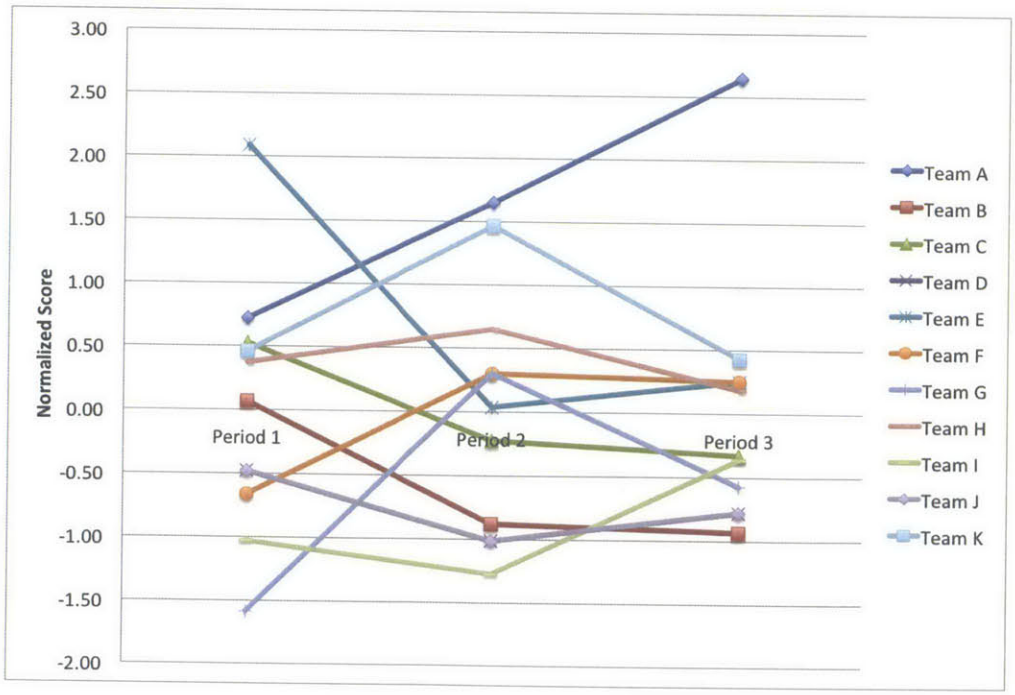

Figure C-9: Performance strategy positive feedback per period

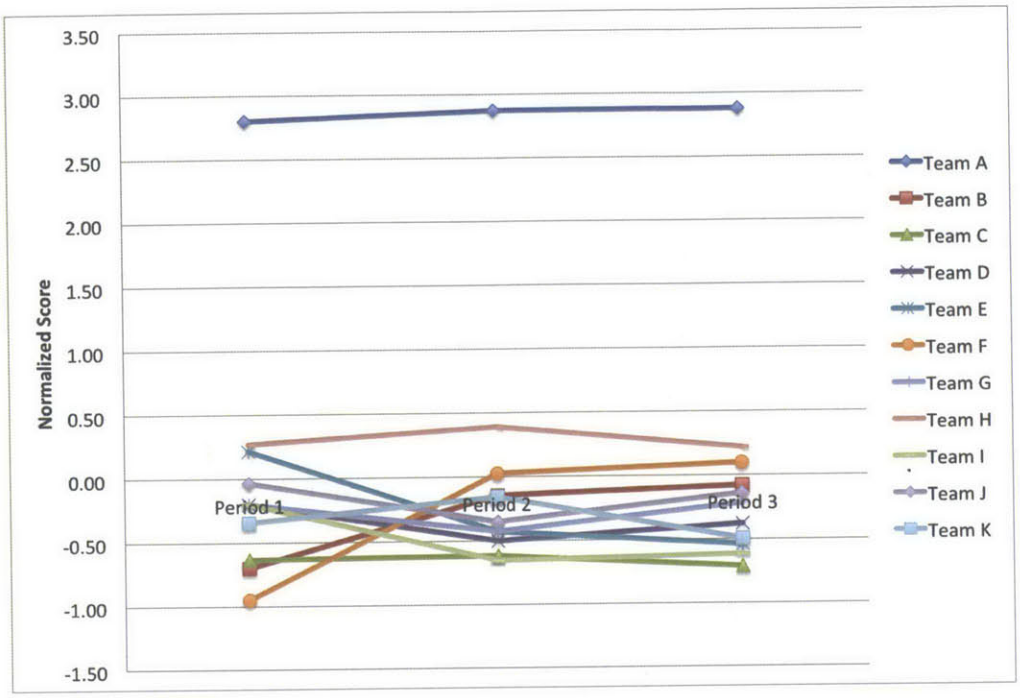

Figure C-10: Performance strategy negative feedback per period

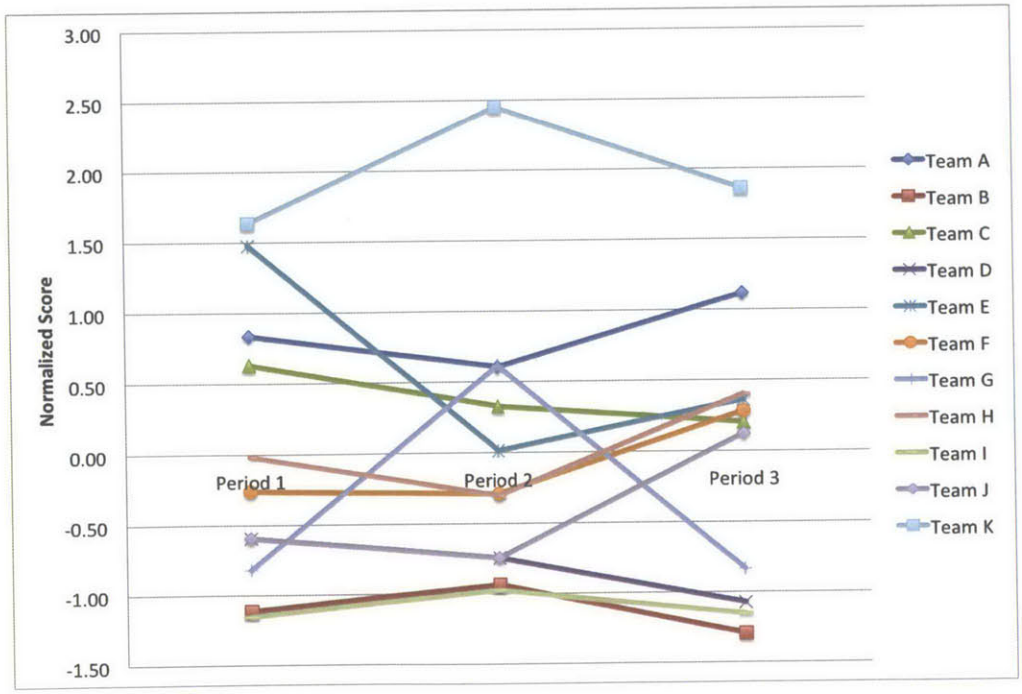

Figure C-11: Total positive feedback per period

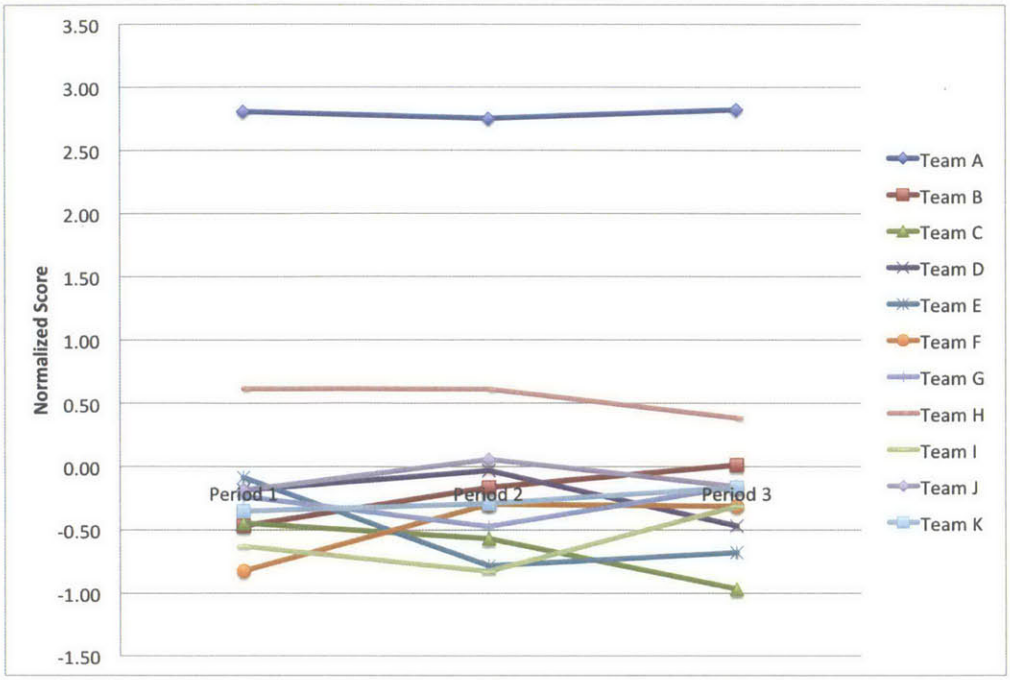

Figure C-12: Total negative feedback per period

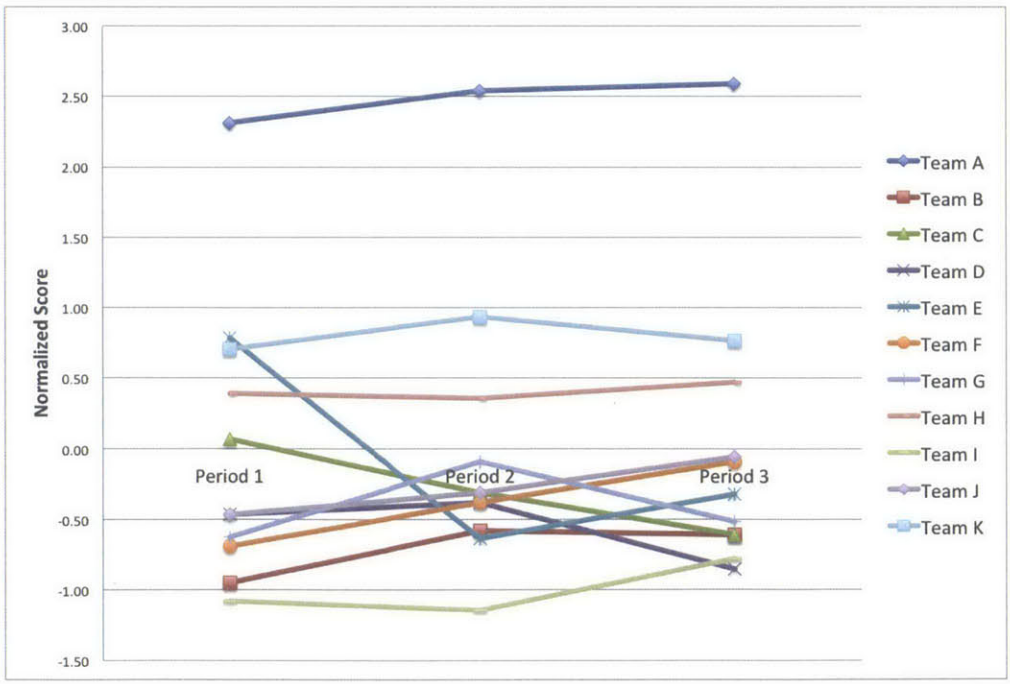

Figure C-13: Total feedback per period