Investigation of Team Dynamics and Group Performance in the Product Engineering Process

by

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STEPHANIE K. LEE

Submitted to the Department of Mechanical Engineering on May 12, 2006 in partial fulfillment of the requirements for the Degree of Bachelor of Science in Mechanical Engineering

ABSTRACT

The cultural traits of a project engineering team can strongly influence the performance of its members and the quality of the product. The 2.009 Product Engineering Processes class provides an opportunity for investigating the relationships between group dynamics and performance as the student groups work with customers and advisors on brainstorming, designing, testing and construction a fully-functional mechanical prototype over the course of a semester. Performance was measured as a function of time using information from the class ranking system while each team’s cultural traits were measured using two surveys that all students were required to complete.

Results of this study revealed that the most influential traits on group performance were task understanding, organization and creativity. Analysis of the survey data showed that feedback and professional communication increased while flexibility decreased as the student groups matured from their initial formative stages into fully defined teams. A comparison of teams with sections that reported polar opposite team dynamics revealed that sections with negative group dynamics performed worse than their positive counterparts, though this trend did not hold in the context of the entire class. Investigation of the dynamic profiles of these teams revealed that organization, task understanding, creativity and efficient use of resources had the greatest influence on performance. The results of a direct comparison of high and low performing teams for each assignment confirmed this trend.

Thesis Supervisor: Henry S. Marcus
Title: Professor of Marine Systems
1. Introduction

Culture is a system of values widely accepted and intensely shared in an organization. For example, some groups may emphasize teamwork and constructive criticism, while others may promote constant personal growth. The culture of an organization can heavily influence the overall achievement of the group and the individual employees. The 2.009 Product Engineering Processes class provides a close simulation of an engineering company for undergraduates in the MIT Mechanical Engineering Department. Within this class, students must work in teams to design, build and test a working prototype of a new product by meeting a predetermined schedule of milestones. The goal of this thesis is to study the values and characteristics of the evolving group dynamics within the 2.009 design teams to determine their affect on group performance.

2. Background

Past studies on teamwork and performance have revealed that team performance is dependent on a variety of factors and qualities within the group. Several models have been developed to understand the relationships between these qualities and a team's output. This thesis will attempt to add to the current body of research in this area by studying teams within an academic environment instead of a corporate one.

When a team is initially formed, the team dynamics, values and cultural traits of the group have not been established yet. A study by Tuckman (1965) developed a model that describes group behavior during four formative stages before it reaches its full performance potential. During the initial Forming stage, team members are highly dependent on the leader for guidance and direction, have unclear individual roles and responsibilities, and have little agreement on the team's purpose, objectives and external relationships. The team members fight to establish themselves in relation to one another during the Storming stage, resulting in power struggles and factions that must be controlled and focused to prevent the team from being distracted from its goals. The Norming stage is when consensus is formed within the group and the roles and responsibilities of each team member are clear and accepted. Commitment, unity and consensus are strong as the team develops its working style to reach the Performing stage. This final state sees the team reach its full performance potential: all of the members share a single vision, allowing a high degree of autonomy within the group and the efficient achievement of the team's goals.

In 1995, Margerison & McCann performed a study on high-performing teams to determine the most effective way to improve work output and quality. By studying critical success factors used by individuals and teams in a variety of industries, they developed a model of nine universal work functions that must be present for any team to optimize its performance. Some of these functions are Advising, which involves the gathering and giving of information, Innovating, which is the generation of new ideas, and Organizing, which includes the creation of a structure and resources for the team to work with.

A study by McCann & Anderson (1997) used the Margerison & McCann model of team dynamics to improve team performance at a chemical factory. The researchers
distributed a 64-item questionnaire that was divided to measure eight defined work functions. The employees were asked to rate each activity based on its importance for success in their job. A second questionnaire was distributed to participants to objectively measure team performance in terms of the nine factors identified by Margerison & McCann (1995) that were associated with high-performing teams. The resulting team profiles were then used to provide a common starting point for improving performance by serving as a catalyst for team development and citing specific areas that required improvement.

The team profiles revealed an average low rating in Producing, which includes efficiently delivering a high quality product, and Inspecting, which involves the regular inspection of work activities and quality audits of produces and services. The work teams developed new vision and purpose statements, and a subsequent effort to improve the deficient areas resulted in the discovery of quality issues in intermediate chemicals that the employees had previous been unaware of. McCann & Anderson concluded that successfully managing team performance requires identifying in what areas teams are performing well and what areas require improvement.

Team performance in an academic environment was studied by Coleman & Craig (2004) in the 16.03 Unified Engineering class offered by the MIT Department of Aeronautics and Astronautics. Initial work found a relationship between the teams' design performance and written communication scores. There was a quantitative correlation between poor performance and low communication scores, but high communication scores did not necessarily result in successful performance. The faculty also observed that high performing teams had good teamwork skills and technical understanding in addition to generally high communication skills. Low performing teams exhibited difficulty in meeting milestones, weak technical understanding, and frequent teamwork problems. The study concluded that the teams' performances were the likely results of their ability to learn, work together, make decisions and use resources. The effectiveness of these capabilities was then reflected in the quality of their communication assignments.

This thesis will be similar to prior studies by using team dynamic profiles to track the performance of student product development teams as they transition from their initial formative stages into maturity. The 2.009 Product Engineering Processes class provides an ideal environment to conduct this study. The class presents an opportunity to study performance and team dynamics because it lacks the inequalities in facilities and resources between teams often found in other organizations. All of the teams are given the same amount of reserved laboratory and lecture time and have access to the same machining facilities, equipment, supplies, budgets, computers, servers, electronic materials, research assistance and advisors.

By measuring the evolution of different traits and comparing them to team rankings in 2.009, this thesis will be able to study the relationship between culture and performance and track their progress over the course of the semester.
3. Methods

Two separate means were used to measure performance and cultural traits: team rankings and anonymous surveys. A statistical analysis was conducted on the data collected to determine if there was a correlation between these two factors.

3.1 Performance

Data from the 2.009 grading system measured the performance of the student teams during the entire length of the course. The teams were all required to meet a series of milestones that represented the typical product design process, from initial brainstorming for ideas to final prototype. The class had six teams: Red, Yellow, Orange, Green, Blue and Purple. Every team had two sections of approximately seven to eight students, with the exception of Yellow, whose sections converged into a single team only a few weeks into the class due to the lack of students in its laboratory section. Though initial class assignments and milestones were graded based on the sections, both sections were required to meet together and share the same lab time and advisors. As the development of the product reached completion, the sections merged together to work as a single team of approximately 15 people. During this entire time, the students received individual grades every two weeks on their design notebooks, which represent their personal contributions to the team.

The three milestones that were used to analyze team performance were the information treasure hunt, sketch model review and mockup review. Each team was ranked on their deliverables for each of these milestones, which represented different stages in the product design process. The treasure hunt was designed so the sections could learn how to gather and research market and product information, handle problems under a time constraint and delegate tasks according to the different skills and schedules of each member. Sections were evaluated according to the accuracy of their answers and quality of their citations.

The sketch model review was a continuation of the brainstorming process as the students focused their ideas into developing two design concepts while getting experience working in the laboratory and machining facilities. In addition to creating a physical representation of their ideas, the sections had to find and present market, customer and technical data to support their design decisions. The grading criteria for this milestone involved the usefulness of sketches and CAD models, the quality and thoughtfulness of the designs, and the quality and relevance of the data presented. The course instructors then discussed among themselves all of the ideas and ranked each section on a scale from 1 to 4 in the categories of the sketch model and research, with 1 being the highest rank. This milestone can represent the period during which the sections began establishing ground rules, individual responsibilities and leadership roles as section members were required to work together and use their personal skills to finish the wide variety of tasks required to complete the sketch model presentation.

The last ranked milestone used for this study was the mockup review. The primary purpose of this assignment was for the student sections to not only further develop their design concepts but to also address key challenges associated with their concepts, learn how to present technical problems and solutions and to receive feedback.
and suggestions from others. Each section was required to present mockups of their designs, with an emphasis on technical feasibility, user interaction with the product, and operational principles. Course instructed consulted with one another and ranked sections on a scale of 1 to 5 based on the following criteria: overall progress from the sketch model review, effectiveness of the mockups, and solutions for critical issues.

3.2 Team Dynamics

Every 2.009 student was required to complete two surveys during the semester, called team reviews. These surveys were intended to allow the students to analyze specific traits within the group and diagnose any issues the group may have. The surveys were administered anonymously using a form published in a restricted section of the class website. The surveys asked the students to rate 15 characteristics on a scale of 1 to 5. These qualities included adaptation, creativity, commitment, respect, organization, communication, flexibility, leadership and conflict resolution.

The first survey, designated Review A, was conducted after the sketch model milestone was due. Review B was administered after the sections merged together and were graded by their team color. The results of these surveys were compiled into section profiles by the course instructors and published online for all class participants to view. The results of both surveys were discussed by the sections after they were published to address their strengths and weaknesses. The timeline for the class was as follows:

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treasure Hunt</td>
<td>Sept. 12</td>
</tr>
<tr>
<td>Sketch Model Review</td>
<td>Oct. 5</td>
</tr>
<tr>
<td>Review A</td>
<td>Oct. 14</td>
</tr>
<tr>
<td>Mockup Review</td>
<td>Oct. 20</td>
</tr>
<tr>
<td>Review B</td>
<td>Nov. 9</td>
</tr>
</tbody>
</table>

For this study, the culture of the 2.009 class itself was accounted for by averaging the results of all teams for all of the characteristics. The cultural strength and traits of each team were distinguished using a t-test to determine their statistical significance. The specific traits emphasized within each team were found by determining if a team’s average score for a trait is statistically different from the class average. The statistically significant traits of the high performing teams were then compared with the traits of the low performing teams to determine if there were distinguishing qualities that could be correlated with performance. Teams that reported below-average levels in more than approximately 75% of their traits were designated “negative cultures” while teams exhibiting the opposite trend were designated “positive cultures.” Teams with negative cultures were compared with positive ones to determine if there was a corresponding affect on their milestone rankings. Similarly, teams that exhibited consistent improvement or decline in the rankings were also compared to see if they had corresponding traits that could be attributed to the changes in performance.
3.3 Analysis

The comparisons were conducted using a t-test, which calculated the probability that the difference between two means was caused by chance. The t-test uses the equation

\[ t = \frac{\bar{X}_2 - \bar{X}_1}{SE(\bar{X}_2 - \bar{X}_1)} \]

(1)

where \( \bar{X}_1 \) is the mean of group 1, \( \bar{X}_2 \) is the mean of group 2 and \( SE(\bar{X}_2 - \bar{X}_1) \) is the standard error of difference between \( \bar{X}_1 \) and \( \bar{X}_2 \). The denominator of Equation 1 can be calculated with the variances, \( \nu_2 \) and \( \nu_1 \), and the number of samples, \( n_2 \) and \( n_1 \), of the two groups using the formula,

\[ SE(\bar{X}_2 - \bar{X}_1) = \sqrt{\frac{\nu_2 + \nu_1}{n_2}} \]

(2)

The variance \( \nu \) is defined as

\[ \nu = \sigma^2 \]

(3)

where the standard deviation \( \sigma \) is

\[ \sigma = \sqrt{\frac{\sum(X - \bar{X})^2}{n-1}} \]

(4)

In Equation 4, \( \bar{X} \) is the mean of the sample group, \( X \) is the value of each sample, and \( n \) is the total number of values in the sample group.

Since this study does not have a control group, a null hypothesis will be used to analyze the results. This hypothesis will assume that the difference \( \Delta \) between the means \( \bar{X}_1 \) and \( \bar{X}_2 \) is equal to zero. For this study, the minimum risk level of \( p=0.10 \) will be used. This level represents that there is a 90% probability that the statistical significance in the findings did not occur by chance. The degree of freedom \( df \), which is equal to

\[ df = n_1 + n_2 - 2 \]

(5)

was used in conjunction with the t-test \( t \) and risk level \( p \) to determine if the results of the data and comparisons were statistically significant.

4. Results

A comparison between the overall results of Review A and Review B revealed general changes in team dynamics as the student groups matured from the initial stages of defining individual roles, establishing leadership positions and determining each member's specific personality, schedule and skills. General changes involved improvement in communication but a reduction in overall flexibility. The only statistically significant difference between the two surveys was improvement among team members in receiving feedback on their progress (\( p<0.05 \)). This change could be attributed to the increasing emphasis on feedback associated with the milestones, with the mockup review including a one hour question and answer session with class instructors. The difference may also be due to increased familiarity and comfort among team members, instructors and advisors with providing constructive criticism and helpful
suggestions to one another. The increase in feedback was also accompanied by a rise in professional communication and self-awareness.

The development of clearly defined goals and set agendas, most notably with the creation of the product contract shortly before Review B, may have resulted in the noticeable drop in goal adaptation. Teams also improved in the efficient use of resources, suggesting that the teams had begun to focus their efforts towards their final product instead of pursuing multiple ideas that were eventually abandoned. A higher rating in the shared leadership category indicates that the students had learned to delegate tasks more appropriately based on members' skills and experience. Self-Assessed effectiveness, which was how well a team member believed he or she could work in a team dropped, possibly caused by the similar reduction in conflict resolution, organization, commitment and helpfulness within the teams.

4.1 Relationship between Dynamic Traits and Performance

Teams Orange, Green and Purple reported sections of opposing cultures in Review A. The rankings of these teams for the treasure hunt and sketch model were compared to determine if there was a relationship between positive cultures and high performance. Sections of the same team were used because of their homogeneity:
officially designated as a single team, the two sections shared the same workspace and reserved lab time.

The other teams were not included in this analysis because their sections were not culturally distinctive from one another. The sections of Yellow had already merged into a single, smaller sized team, and so the dynamic traits of the original separate sections could not be reliably measured. Both sections of Blue exhibited 100% positive cultures. The survey indicated that a negative culture existed in Red A, with 73% of its levels reported below average, but Red B did not have a distinctively positive or negative culture, and therefore was not used for this comparison.

There were several possible reasons for how sections of the same team that frequently worked together in the same environment could have such radically different group dynamics. The personalities, skills and experiences of the members in each section certainly influenced the dynamics of each section. Students were assigned to teams based on which lab times fit their personal schedules, so it was possible for some sections to have more students experienced in leadership and engineering projects than others. With the advantage of having prior experience working in groups or similar undertakings, these students may have been able to form a better initial group dynamic than their less fortunate counterparts. In all three teams with opposing cultures, students in sections with positive cultures reported higher self-assessed effectiveness working in teams than students working in the other sections, though the difference was not statistically significant.

Another cause for the extreme difference in team dynamics may be the section instructors. During the initial month prior to Review A, each section had different instructors assigned to them and did not always meet with one another, though they shared the same conference room during the same lab time. This arrangement gave the instructors a high degree of influence over their respective sections. Some sections may have had instructors who were better at answering questions, providing advice and guiding their students than their counterparts. These instructors would then give some sections an advantage over the others, resulting in the formation of a positive team dynamic within their sections.

A possibility that may have caused such a large reported difference between scores may have been the proximity sections of the same team may have had with one another. Since the teams did meet together for at least some amount of time during their designated laboratory periods, students in different sections were aware of one another’s progress. The students may have reported the difference between the team sections because they were comparing their own work to the other’s to deduce whether their traits were better or worse than the other section’s. This possibility does not fully explain why such different cultures coexisted together in the same environment, but it may be a reason why such a large gap was reported.

A statistical comparison of survey results between sections of Orange, Green and Purple revealed several traits that all of the positive cultures reported significantly higher than their negative counterparts. These categories were commitment, organization, professional communication, creativity and task understanding. These traits were not necessarily higher than the class average, as shown in Figure 2. Negative sections were statistically significant opposites from positive cultures in creativity, commitment and use
of resources. Negative cultures also reported low levels of professional communication and organization.

![Comparison of Sections with Positive Cultures with the Class](image)

![Comparison of Sections with Negative Cultures with the Class](image)

**Figure 2:** An analysis of sections with positive and negative cultures belonging were statistically significant opposites in creativity, commitment and use of resources.
The findings on team dynamics in positive cultures were compared to a qualitative assessment conducted on the performance data. The number of ranking data points was too low to conduct a reliable statistical analysis.

**Table 1: Rankings of Sections of Opposing Cultures of Milestones Before Review A**

<table>
<thead>
<tr>
<th>Section</th>
<th>Percentage of positively reported traits</th>
<th>Treasure Hunt Rank</th>
<th>Average Sketch Model Rank</th>
<th>Average rank before Review A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange A</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Orange B</td>
<td>100</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Purple A</td>
<td>86.67</td>
<td>3</td>
<td>2</td>
<td>2.5</td>
</tr>
<tr>
<td>Purple B</td>
<td>13.33</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Green A</td>
<td>0</td>
<td>1</td>
<td>2.5</td>
<td>1.75</td>
</tr>
<tr>
<td>Green B</td>
<td>86.67</td>
<td>1</td>
<td>2.25</td>
<td>1.625</td>
</tr>
</tbody>
</table>

The comparison showed teams with positive cultures did perform better than their negative counterparts, though the difference is not large. These findings also indicated that sections with more positive cultures in general did not always perform better than negative cultures. For example, Green A reported all of its dynamic traits as below class average, yet it ranked higher in the sketch model review than Orange B, which reported all of its traits above average. These results support the possibility that students were directly comparing their sections to their team counterparts when they responded to the surveys. If this situation were the case, then students in sections with negative cultures may have believed their group dynamic was dysfunctional when in actuality they could have been doing better than many other sections in the class.

Despite this possibility, negative cultures still reported themselves as significantly lower than the class in creativity, commitment and the use of resources. These traits may be the reason why many students believed their sections had poor team dynamics. They may have thought their ideas were inferior to the other section’s because of their lower rank, which resulted in a low reported level of creativity even though they may have been coming up with just as many ideas as the other section. The significantly low levels of commitment within negative sections therefore suggest that the students believed they were not spending as much time on their class assignments as the students in the positive section. Their reportedly inefficient use of resources could also be explained in this way.

4.2 Effects of the Convergence of Two Opposing Cultures on Performance

Teams Blue and Green were selected to determine how performance was affected when sections of opposing cultures merged into a single culture because these two teams had the least amount of noise in their performance data. Blue consistently dropped in the rankings and Purple consistently improved, while all other teams fluctuated up and down.
Figure 3: Team Purple consistently rose in the rankings while Green fell. Scores from different milestones were appropriately scaled to a ranking of 1-4, with 1 being the highest and 4 being the lowest. Scores for sections A and B converge because sections of the same color received the same scores for the technical review and final presentation.

The results of Review A reveal a negative culture in Green A, with reported levels in all 15 categories below class average and 46% of the categories significantly low (p<0.10). Most notably, Green A had extremely low levels of efficient resource use (p<0.05) and commitment (p<0.05). Green B initially had a positive culture, with 87% of the traits reported above average and 40% significantly higher (p<0.05). The positive culture in Green B can be attributed to the section’s slightly better performance in the sketch model review than Green A, though both sections received a rank of 3 for the mockup.

After convergence into a single team, Green reported a negative culture compared to the rest of the class in Review B, with significantly low task understanding (p<0.05), organization (p<0.05) and creativity (p<0.10). Comparing the results with Review B, Green A improved in self-awareness and its use of resources. The added self-awareness may have been the result of heightened consciousness as both sections redefined individual roles and responsibilities and members became acquainted with the personal skills and experiences of people from the other section. Despite the improvement in resource allocation, Green team was still well below the class average in the same category, though not significantly so.

The merging of two opposing sections resulted in an overall positive culture in Purple team. Purple A had a positive culture with significantly high levels of good resource use (p<0.01), commitment (p<0.01) and organization (p<0.05). Purple B had borderline negative culture with 73% of reported traits reported as below average and only one, professional communication, was statistically below (p<0.05). After the
sections converged, Purple retained a positive culture, with high levels of organization (p<0.01) and self-assessed effectiveness (p<0.05). The increase in the latter trait may have been caused by increased confidence and self-esteem among members of Purple as a result of the sections’ continuous rise in the rankings.

**Review B Results of Purple and Green Compared to the Class**

![Bar chart showing comparisons between Purple, Green, and Class on various traits]

**Figure 4:** Both Purple and Blue had sections of opposing cultures that merged into a single team shortly before Review B. Purple reported a resultant positive culture with significantly strong organizational skills, while Green’s combined culture was pervasively negative with significantly low organization.

As Purple’s culture became more positive over time, so did their improvement in the rankings. Purple B’s culture was also not as negative as Green A’s, with only 73% of the categories below average, as opposed to 100%. In this case, a group with a positive dynamic performed better overall than a group with a negative dynamic, even though the previous comparison found no distinct relationship between positive cultures and good performance in the class. It must be noted that students completed Review B after the ranking results of the mockup review were published. Based on these rankings, they may have rated the traits of their team as either better or worse than their responses to Review A. Therefore, the reported positive and negative dynamics may have been the result of the team’s performance, and not the other way around.

The statistically significant traits measured in Review B suggest a correlation between organization, creativity and task understanding with performance: Green’s decline in performance was mirrored by a significant decrease in these traits, while Purple’s improvement saw an increase, though it must be noted that Purple did not have
statistically higher levels of task understanding in Review B. These results are consistent with the trend found in the previous comparison between positive and negative cultures.

Another trait with possible links to performance was the use of resources. Both sections of Purple exhibited unusually efficient resource allocation in both surveys, with Purple A reporting significantly high levels in Review A (p<0.01). In comparison, Green had the exactly opposite trend. This finding suggests that the use of resources may have been the most important factor affecting performance. Purple’s efficiency in using their time, personnel and materials may have given them the advantage to quickly improve the quality of their deliverables and to eventually overtake the other teams in the rankings. The relationship between the use of resources and performance may also be indirect: well prepared team members with a good comprehension of their goals would presumably use their resources more wisely, preventing excessive waste or effort in areas that did not contribute to their objectives. In this case, organization and task understanding would directly affect performance.

4.3 Comparison of High and Low Performing Sections

The third aspect of this study was to compare high and low performers for each milestone to investigate trends in their team dynamics. The best and worst ranked sections for the treasure hunt milestone were Green B and Purple B, respectively. Green B had a reported a positive culture and Purple B had a negative culture. The earlier comparison between positive and negative cultured teams indicated that teams with positive cultures do not necessarily perform better than sections with negative cultures overall, yet Green B does in this particular case.

**Figure 5:** Green B had the largest advantage over Purple B in professional communication. Other traits reported significantly higher than class average were creativity, organization and task understanding.
Green B reported significantly high levels of creativity, organization and task understanding, which were all traits that had potential connections to performance. Purple B was far from being the worst of all the negative sections, with only one trait, professional communication, reported significantly lower than the rest of the class. Perhaps for this assignment, this lack of professional communication resulted in the worst overall performance, because the treasure hunt involved a collaborative effort to collect information from various sources. Due to the heavy emphasis on research for this assignment, communication may have been particularly critical to success. Green B reported a significantly high level of professional communication (p<0.01), which may have contributed to their top rank. A comparison of the two sections revealed the greatest advantage Green B over Purple B was indeed professional communication (p<0.001).

Interestingly, students in Purple B indicated they had high self-assessed effectiveness and frequently provided help when needed. These results could have been caused if Purple B had too many natural leaders who believed they were very capable at working in a group. This possibility is supported by the low level of shared leadership indicated by Purple B in the survey. The large amounts of help the members gave one another may have occurred to make up for the deficiencies in other dynamic areas.

Purple B was also the lowest performer on the sketch model, with both of its presented ideas receiving a rank of 4 in both the model and research categories. The highest performer was Purple A, which received the rank of 1 in both categories for its manioc shredder idea.

![Sketch Model Review Comparison of Best (Purple A) and Worst (Purple B) Performers](image)

**Figure 6:** Purple B was the worst performer for both the treasure hunt and the sketch model review, yet its students indicated they provided more help and worked better in teams than the top ranked sections for both milestones.
A comparison of their team dynamic profiles was done to determine how sections belonging to the same team, who shared the same work space and meeting times, could have such radically different performance results. Figure 6 showed that students in Purple B still reported they helped each other when needed and believed they worked well in teams more than the best performer for the milestone. Purple A had significantly higher creativity (p<0.10), commitment (p<0.001), task understanding (p<0.05) and efficient use of resources (p<0.01) than the rest of the class. These four traits appeared to be consistent for high performers and positive cultures in all of the comparisons conducted for this study. This consistency suggested some degree of interrelation between these traits. Good understanding of the group’s goals allowed for the appropriate allocation of work and materials. A high degree of creativity allowed the team to adapt its ideas to new obstacles and commitment among members helped to tackle problems well and ensure the tasks get done quickly and effectively.

The best and worst ranked sections for the mockup review were also a confirmation of prior trends. On average, team Orange ranked the highest with its tree barrow and rice planter concepts, while team Red ranked the lowest with its orange and banana harvesters. Review B compiled the responses of both sections into one team, so the dynamic profile of individual sections cannot be accurately ascertained from the data. Their levels can be inferred from the overall responses provided from the entire team. Separation of the sections’ profiles for team Orange was further complicated because half of the members of each section were exchanged, effectively changing the membership of each section.

**Comparison of Mockup Review Best (Orange) and Worst Performers (Red)**

![Comparison of Mockup Review Best (Orange) and Worst Performers (Red)](image)

**Figure 7:** Previous comparisons indicated having a negative culture is not necessarily indicative of performance in the class, which is further indicated by teams Orange and Red.
Students in Orange and Red both reported negative dynamic profiles in Review B. This finding fit with the conclusion that negative cultures do not necessarily perform worse than positive ones. Red’s profile was very similar to Purple B in Review A, with professional communication being the only trait that was significantly below class average (p<0.10). This finding suggested that the ability to separate personal and professional communication has an affect on performance. Orange also had a below-average level of professional communication, but it was not statistically significant. Orange also reported low significantly low levels of organization (p<0.001) and task understanding (p<0.001) compared to the rest of the class.

The negative culture may have been the result of the merger that occurred in Orange for the mockup review. Orange originally had a polar dynamic, with Orange A exhibiting a negative culture and Orange B exhibiting a positive culture. The decision for some Orange B members to work with Orange A and vice versa may have caused some confusion and disorganization as students had to redefine their individual responsibilities and accommodate others’ schedules. Because the members of Orange B had not worked on the tree barrow concept before, they may not have known what work needed to be done or how to do it, resulting in the low reported level of task understanding. As a result, members of Orange B may have indicated particularly low levels in all categories for Review B because they believed their new situation was substandard to the one they previous had.

5. Summary

This study tracked the rankings and dynamic profiles of the student groups through their initial formative stages as they learned about the product development process. A comparison of the overall class results for the two surveys revealed that as the teams developed and students developed a common vision and learned to work with one another, feedback and professional communication increased among members. Flexibility and goal adaptability simultaneously decreased as the project became more defined and individual responsibilities were established.

An investigation of teams that had one section report a negative culture and one with a positive culture suggested that students were comparing themselves to the other section within their team when they completed the surveys, creating the large difference between the group dynamics of the two sections. Possible causes for the disparity in group dynamics between the two sections were the number of experienced and technically qualified students per section and the teaching abilities of the instructors. The comparison also showed that sections reporting positive cultures performed better than the other section within their own team, but did not necessarily rank higher in the context of the entire class. Common traits among positive group dynamics were high levels of commitment, organization, professional communication, creativity and task understanding. Negative group dynamics were characterized by significantly low levels of commitment, creativity and efficient use of resources. The large difference in reported commitment and creativity between the two dynamic types may be the reason why students may have considered their group to be superior or inferior to the other.

The resulting team dynamic after sections of opposing cultures merged into a single team also highly affected that team’s performance in their assignments. The team...
that consistently rose in the rankings had a final group dynamic that was positive, while the team that consistently fell in the rankings exhibited the opposite dynamic. These dynamic profiles may have been the result of the teams’ rankings in the mockup, and not vice versa. Despite this possibility, the team showed improvement had significantly high levels of organization, creativity, task understanding and resources. An analysis of the high and low performing teams for each milestone also suggested these traits were linked with good accomplishment.

The recurrence of above-average levels of organization, task understanding, creativity and the use of resources among high-ranked sections marked these particular traits as the most influential on group performance. Special emphasis should be given to developing these behaviors to improve overall work quality within the class. Teaching students how to effectively organize their goals, delegate tasks, manage their budgets and use their materials may help them to improve their overall performance. Class instructors and section leaders should clarify milestone requirements and expectations so students have a good understanding of the tasks at hand so they can accomplish them in the most effective and efficient manner. The survey results should also be used to address disparate group dynamics within a team to prevent later difficulties when the two sections are required to work together.

7. Future Research

Though this study provided a comprehensive investigation into the effects of group dynamics on performance, further studies should be conducted to determine the exact relationship between these two factors. If future classes do choose to teach organization and resource management skills, the resulting effect on the team’s dynamic profiles can be compared to the ones derived from this study to determine their degree of influence on performance. A third review could also be conducted at the very end of the class to increase the scope of the study to include the entirety of the course, since this study was limited to only observing the first two months of the semester. Interviews with students and observations taken by instructors throughout the product engineering process could also assist future studies by providing insight into the internal group dynamics of each team. This knowledge could then be used to explain the occurrence of different dynamic profiles, accurately interpret the analysis results and pinpoint incidents or factors that may have caused specific changes within a team’s dynamics over time.

Additional research could also be conducted on the effects of group dynamics on individual performance. All students in the 2.009 class are required to document their personal contributions to the team in notebooks that are submitted for grading on a weekly basis. This aspect of the course could be used to document individual performance over time without affecting class logistics too adversely. Though difficulties may arise from confidentiality issues and different grading standards among laboratory instructors, the effect of group dynamics on individual performance could be investigated by comparing changes in notebook grades and survey results over time.
8. References


