Capstone Design and Psychology: Teams, Traits, and Competencies Measured in Student Surveys

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Abstract

Aerospace engineering students at the Florida Institute of Technology are required to complete a 3-semester capstone design project. In their junior year students propose topics, form teams, and write a proposal for their senior project, then as seniors they complete preliminary and detailed design, then fabricate and test their system. Their efforts culminate in a Student Design Showcase, where industry participants judge the final projects. Many students identify the capstone design project as the most significant event in their academic career. In this paper we describe changes made in the aerospace engineering capstone curriculum during the 2016-2017 season and report results from surveys administered by the School of Psychology during that period. The course modification goals were to improve project quality, increase student engagement, and emphasize "real-world" professional skills like self-management, teamwork, and communication. Students took individual difference and process surveys hosted by the School of Psychology to capture these professional skills. The first student survey measured individual differences that are generally considered relatively stable over time and are predictive of performance; these individual differences include personality traits (e.g., introversion, conscientiousness) and competencies (e.g., political skills, adaptability). Students then completed a series of process surveys designed to gain insight on team behavior and performance over the life of the project. Average student scores on personality traits and competencies were compared to see if there was a change before and after the completion of capstone design.
Introduction

Aerospace engineering capstone design at the Florida Institute of Technology (Florida Tech) is a three-semester course sequence that begins in spring of the junior year. In the 1-credit Junior Design course, students identify topics, form teams, and develop a project proposal. Two three-credit classes follow in the fall and spring of the senior year. In Senior Design 1, students develop detailed requirements, complete a Preliminary Design Review, and present their final designs at a Critical Design Review. In Senior Design 2, students purchase components, fabricate their system, and test it against requirements. The highlight of the spring semester occurs in April, where students from all majors present their projects in a large Student Design Showcase to industry, the university community, and the public. Industry representatives judge the projects and award top prizes for different categories.

In prior years, a different instructor would teach aerospace capstone design for each graduating class. One instructor would teach the same students from Junior Design through Senior Design 2, and then a new instructor would start with a new class of juniors the following spring. Interaction between the College of Engineering and the School of Psychology was limited, and the processes for surveying capstone teams were not yet well established. In 2016, two changes occurred— a new instructor was permanently assigned to teach the aerospace capstone classes (i.e., the first author), and collaboration began on research with the School of Psychology’s Relationship and Interaction Optimization in Teams (RIOT) Lab (which include the second and third authors).

In this paper we report changes made to the capstone courses during the 2016-2017 academic cycle and explore potential student development outcomes in response to the course design elements as a part of the broader RIOT research effort. Though the capstone program is considered highly successful at Florida Tech, previous instructors have noted that some teams struggled with leadership and teamwork issues, and not all students on every team were fully engaged and contributing their best efforts. (These student teams are self-organized and appoint their own leaders.) Due to the complexity and cost of the aerospace engineering projects, teams tend to be large—between 6-12 students per team. Large teams contribute to the potential for some students "coasting" on the work of others, possibly due to a lack of commitment to the project or poor leadership and delegation skills within the team. The course was modified to give
students increased choice in topic selection, increase emphasis on self-management and professional/political skills in course lectures and assignments, include coaching of student leaders on how to deal with management issues within their team, and to introduce team time cards in conjunction with an instructor evaluation and peer feedback to increase individual accountability. Our goals were to improve the capstone design experience for the aerospace engineering students, and to better understand the evolution of students as individuals and in their team relationships.

Changes to the Aerospace Capstone Design Course during the 2016-2017 Program.

Increased Student Choice in Topic Selection.

Marin et.al. identified student ownership as one part of designing an optimal experience for capstone design [1], and we hypothesized that if students were allowed a chance to research possible topic areas, propose projects to their peers, and have an element of choice in which topics went forward, it would broaden the base of possible creative ideas, increase student enthusiasm for the class, and deepen their level of commitment to their specific project. This approach is also consistent with Florida Tech’s participation in the Kern Entrepreneurial Engineering Network (KEEN), which seeks to develop an entrepreneurial mindset in students [2].

In the aerospace capstone program, some topics are predefined by industry or research sponsors, but many can be defined by the instructor. In previous years, some effort was made to obtain student input, but approaches varied with the instructor and minimal class time was used to explore options. With the new approach, the instructor defined boundaries of what was considered an acceptable topic in the first week of class, and then students identified their ideas for a capstone project in a writing assignment. The instructor presented the general themes of interest to the class and provided private feedback on ideas considered too risky or ambitious. Students were allowed in-class time to network with others and to present acceptable topics to the entire class. The class voted on the topics, and the favorites were approved for implementation. Next students identified their top three project choices and how strongly they felt about each choice, and the instructor made team assignments based on their requests. As
part of the topic assignment request, students were asked to rate their own ability in areas such working in teams, creating technical drawings, conducting engineering analysis, fabrication and machine shop skills, and writing, but student preference was prioritized over balancing skills across teams. This approach described worked well in Spring 2016 and was also implemented the next time the class was offered in 2017.

**Emphasis on Self-Management and Professional /Political Skills**

Though the practice of engineering requires a highly technical skill set, most in the field would agree that self-management and the ability to work with others are also very important. Contrary to popular stereotypes, engineers spend a surprisingly large amount of time interacting with other people to coordinate and complete work [3]. Industry representatives have identified that desirable attributes of an engineer include good communication skills, high ethical standards, the ability and self-confidence to adapt to rapid or major change, the ability to work in interdisciplinary teams and a profound understanding of the importance of teamwork [4]. In the RIOT team surveys, "Political Skill" (described in the next section) measures these competencies in the individual differences surveys.

We hypothesized that explicitly addressing these "soft topics" before the capstone teams were formed would increase student awareness of their importance and provide specific tools to help with self-management and team cohesion. Florida Tech students come from over 50 countries with diverse cultures and international students made up 39% of the class, so we also believed that presenting common terms and implied norms of behavior would be helpful.

Though the NASA Systems Engineering Handbook [5] is used as the primary design reference for the class, in previous years there was no course text identified for the capstone sequence. In 2016-2017, one was added: *The 7 Habits of Highly Effective People* [6]. The Air Force and NASA have used this book in their professional development programs, and Time magazine identified it in 2011 as one of the 25 most influential business books [7]. Concepts first made popular in *7 Habits* are now part of the management vernacular, including the importance of "proactivity" and seeking a "win-win" solution; these have been referenced in other capstone programs [8].
In the 2016-2017 season, selected topics from *The 7 Habits* were introduced in two Junior Design lectures prior to team formation and reinforced by instructor throughout the course. These included proactivity and using the "circle of influence" as a specific tool to promote adaptability; building trust by making "deposits" in the "Emotional Bank account"; thinking about desired outcomes (and requirements) through each step of the capstone program, i.e., to "Begin with the End in Mind"; and the importance of self-management as a prerequisite for managing others [6]. In 2017-2018, short writing assignments were added to encourage students to reflect on the relevance of these concepts to their work as an engineering team.

**Emphasizing Peer Feedback and Individual Accountability**

Because most of the real work of capstone design occurs within the team, instructors often rely on peer feedback and logs of student activities (i.e., “time cards”) as a tool to assess individual contribution to the overall effort and to adjust grades accordingly. Though capstone peer feedback and time cards were used at Florida Tech in past years, implementation approaches varied. In some cases the students received peer feedback too late for them to change behavior that semester. Time cards were often handmade forms filled out by students and signed by the student leaders, which could be cumbersome to manage. We hypothesized that individual and team performance would improve if a peer feedback and timecard system could be developed that was predictable, transparent, and based on quantifiable data (i.e., perceived to be "fair"). Increasing the amount and timeliness of peer feedback, reducing student temptation to falsify time card reporting, and making the process efficient for the instructor and the team were also important.

The Comprehensive Assessment of Team Member Effectiveness (CATME) online peer feedback system [9] was first used in 2016-2017 capstone cycle. In Junior Design, peer feedback from two surveys provided 15% of the grade; in Senior Design 1 and 2, four surveys were used to determine 20% of the total grade. The CATME system enables students to provide anonymous feedback and comments to the instructor, provides qualitative feedback directly to the students immediately after the survey, and gives the instructor a peer adjustment score that can be used in grading. As part of the capstone design class, instructor would then convert the CATME peer adjustment score into a grade for the course's online grade book. This structured approach
allowed the students to see peer feedback within a week of each survey, allowing them to make adjustments in how they interacted with their team.

<table>
<thead>
<tr>
<th>TEAM NAME: Team Awesome</th>
<th>WEEK: WEEK 1 - Jan 9th-15th</th>
<th>WEEKLY STATUS FOR: Your Name Here (JOHN DOE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td>Location(s) &amp; Time</td>
<td>Activities, Contributions</td>
</tr>
<tr>
<td>Mon</td>
<td>Class Lecture (3-4); Team meeting-Library (4-5); At home (9-9:30pm)</td>
<td>Lecture: Required attendance. Team Meeting: agreed to get drawing feedback from Mr Jones &amp; look at CDR feedback for my section. At home, reviewed CDR feedback; fixed edits…</td>
</tr>
<tr>
<td>Tues</td>
<td>Machine shop (2-230); Computer lab 4-5</td>
<td>Mr Jones drawing feedback. Fixed dimensions on page 2, texted Madeline about her subsystem dimensions.</td>
</tr>
<tr>
<td>Wed</td>
<td>GDT Lecture 3-5</td>
<td>Required lecture, follow-on meeting</td>
</tr>
<tr>
<td>Thurs</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Fri</td>
<td>0</td>
<td>Missed mandatory lecture- FIT Soccer &quot;away game&quot;. Coach sent emails to all instructors</td>
</tr>
<tr>
<td>Sat</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Sun</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>WEEKLY TOTAL</strong></td>
<td><strong>2.5</strong></td>
<td><strong>1.5</strong></td>
</tr>
</tbody>
</table>

Figure 1. Student Time Card Template: Individual Tab (one per student)

Time cards were not used until Senior Design 2. The instructor created a time card template in a spreadsheet with a team summary tab and a tab for each team member. At the end of each week, each team member completed their own tab to report hours worked, the time and place of the work, and what was accomplished (Figure 1). Team leaders reviewed and consolidated individual team tabs each week, entered weekly totals into the summary tab (Figure 2), and uploaded it into the online grade book as a team assignment that all team members could see. By combining the summary tab for all teams and sorting on hours worked, it was easy to compare relative work effort across the class. The instructor used information on hours worked along with personal observations and feedback from advisors, faculty and staff, and team leaders to produce a mid-term and final "individual evaluation" assessment worth a total of 15% of the course grade.
RIOT Lab Surveys of Aerospace Capstone Students

Procedure

The RIOT Lab surveyed the 2016-2017 capstone teams nine times over the course of three semesters (Junior Design 1, Senior Design 1, and Senior Design 2). The initial survey (Time 1) measured students’ individual differences, including personality traits and competencies. The initial Time 1 survey occurred during team formation, before much work had begun with their projects. At subsequent time points (Time 2 to Time 8), processes (e.g., leadership, teamwork) and states (e.g., trust) associated with working together were measured. At the final time point in mid-April 2017 (Time 9), the same individual differences were measured again and compared with the initial survey (Time 1) to see whether students’ competencies were developed after going through the capstone experience.

Table 1 Survey Dates

<table>
<thead>
<tr>
<th>Survey</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
<th>T6</th>
<th>T7</th>
<th>T8</th>
<th>T9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>2/25/16</td>
<td>3/2/16</td>
<td>4/5/16</td>
<td>10/17/16</td>
<td>11/7/16</td>
<td>11/28/16</td>
<td>1/16/17</td>
<td>2/27/17</td>
<td>4/10/17</td>
</tr>
</tbody>
</table>

Individual differences in our research include both competencies and personality traits that were found to predict desirable outcomes in previous studies [11],[12]. Therefore, we assumed them to have a role in students’ capstone experience, and possibly have a positive impact. Competencies included in our paper were political skill and adaptability, and personality traits included
personalized power motivation, socialized power motivation, extroversion, conscientiousness, propensity to trust, and collective orientation. Overall, we expected that students’ competencies would be improved at the end of their capstone projects because they needed these competencies in interacting with their teammates and working on the projects. Competencies can change over time more easily than personality traits, which are relatively more stable, but we also explored whether their personality traits changed (i.e., increased, decreased, or remained stable) before and after completing their projects.

We were also interested in how trust changed in teams over the course of the projects (i.e., from Time 2 to Time 8). This is because team members need to first trust each other and interact effectively to achieve the outcomes they want [13], and teams with high trust are indeed found to come together and better coordinate among themselves [14].

**Traits and Competencies Measured**

**Political skill.** Political skill is defined as “the ability to effectively understand others at work, and to use such knowledge to influence others to act in ways that enhance one’s personal and/or organizational objectives” [15]. Those with high political skill know when and how to adjust their social behaviors depending on the environment and people they are interacting with to influence others and achieve what they want. It is considered a positive characteristic, as it focuses on a balance in self-confidence and self-awareness, not in self-absorption. For instance, it was found to be related to self-monitoring and emotional intelligence [11]. It was measured by the Political Skill Inventory on a 5-point Likert scale (1 = “Strongly Disagree” to 5 = “Strongly Agree”) [11]. A sample item was “I spend a lot of time and effort at work networking with others.” Seventeen questions on the individual differences survey related to political skill.

**Adaptability.** Adaptability is defined as the ability to adapt to uncertainty, unpredictability, and changes in work situations and to resolve new problems [16]. In the study of Charbonnier-Voirin and Roussel [16], adaptive performance was positively correlated with transformational leadership, which is characterized by providing followers vision and inspiration and motivating them through influence, growth, and consideration. It was measured by the Adaptive Performance Scale developed by those authors [16], which used a 5-point Likert scale (1 =
“Strongly Disagree” to 5 = “Strongly Agree”). A sample item was “I quickly decide on the actions to take to resolve problems.” Nineteen questions on the survey related to adaptability.

**Personalized power motivation.** There are two types of power motivation in leadership: personalized power motivation and socialized power motivation. Personalized power motivation concerns with an egoistic desire to promote one’s interest and status while having an impact on others and disregarding others’ interests and goals; it is considered the negative side of leadership [17]. For example, personalized power motivation was related to aggressive behaviors [18] and antisocial decision making in conflict situations (e.g., criminal behaviors [19]). It was measured by the Personalized and Socialized Power Scale [20] on a 7-point Likert scale (1 = “Strongly Disagree” to 7 = “Strongly Agree”). A sample item was “Being seen as superior to others is important to me.” Twelve questions on the survey related to personalized power motivation.

**Socialized power motivation.** Socialized power motivation concerns with a prosocial desire to help and support others and is considered the positive side of leadership [17]. For instance, those with high socialized power motivation tended to form positive communication and trust with others [21]. It was also measured by the Personalized and Socialized Power Scale [20] on a 7-point Likert scale (1 = “Strongly Disagree” to 7 = “Strongly Agree”). A sample item was “Attaining power for oneself is important in order to empower others.” Twelve questions on the survey related to socialized power motivation.

**Extroversion-Introversion.** Big Five personality dimensions are one of the most studied personality traits in psychology, and one of the dimensions, extraversion, is about “activity and sociability” [22]. Extraversion, which is the conceptual opposite of introversion (i.e., lower social engagement) was previously found to be the strongest and most consistent predictor of transformational leadership [23]. It was also a predictor of extra-role performance (i.e., going above and beyond required duties) [12]. It was measured by the shortened version of the Mini-IPIP [24] where students reported the extent to which the given statements accurately described them on a 5-point Likert scale (1 = “Very Inaccurate” to 5 = “Very Accurate”). A sample item was “I am the life of the party.” Four questions on the survey addressed this category.
Conscientiousness. Another dimension of Big Five, conscientiousness, is about “dependability and will to achieve” [22]. Conscientiousness was positively related to academic performance [22] and in fact, it was consistently found to be a good predictor of performance across different occupational groups [25]. It was also measured by the shortened version of the Mini-IPIP [24]. A sample item was “I get chores done right away.” Four questions on the survey addressed conscientiousness.

Propensity to trust. Propensity to trust is the dispositional tendency to trust other individuals. Previously, it was found that those with high propensity to trust tended to be more sensitive to another individual [26] and more committed to their organizations [27]. Propensity to trust was measured using the scale from Mayer and Davis [28]. It was measured on a 5-point Likert scale (1 = “Strongly Disagree” to 5 = “Strongly Agree”). A sample item was “Most experts tell the truth about the limits of their knowledge.” Five questions addressed propensity to trust.

Collective orientation. Collective orientation or team orientation is defined by Mohammed and Angell as “an individual’s propensity for functioning as part of a team and the degree to which individuals prefer to work in group settings for task accomplishment” [29]. It has two dimensions: affiliation and dominance, so high collective orientation means high affiliation and low dominance [30]. In their study, collective orientation was found to be related to social and interpersonal competence and team effectiveness [30]. It was measured using the scale developed by Driskell et al. on a 5-point Likert scale (1 = “Strongly Disagree” to 5 = “Strongly Agree”) [30]. A sample item was “I find working on team projects to be very satisfying.” A total of fifteen questions addressed the two dimensions of collective orientation.

Trust in teams over time. Trust in teams includes positive expectations towards all team members and willingness to be vulnerable to the team as a whole [31]. Trust was measured by using social network approach, which takes interdependent nature of the teams into consideration and captures the interaction patterns of dyadic relationships within the teams [32]. In this approach, everyone in the team rated every member of the team except himself or herself on the extent to which they trusted each of their teammates. It was measured on a 5-point Likert scale (1 = “Distrust Very Much” to 5 = “Trust Very Much). The density score of trust network within each team was calculated, and it reflects the extent to which each member trusts the team
members collectively. The density score ranges from 0 to 1 with 0 being no trust and 1 being full trust.

**Participants**

In our sample, we had a total of 69 participants, with an average team size of 9. More than half of the sample was male (\(N = 46\)), and the average participants’ age was 21.39 years (\(SD = 2.20\)). Twenty-seven participants were international students and reported English as the second language. Most students identified themselves as Caucasian (40.8%) and Asian (23.9%), and various ethnicities were also represented: 8.5% African American, 12.7% Hispanic or Latino, 1.4% Pacific Islander, 2.8% American Indian, 5.6% Middle Eastern, and 1.4% other. In all our surveys, we included three attention check items, and the purpose of including them was to see if students were paying attention and carefully reading the instructions and statements while taking the surveys. A sample attention check item was “For this item, please choose Strongly Agree.” One student at Time 1 and two students at Time 9 failed all three attention check items, and therefore, were excluded from the analysis.

**Survey Results**

We conducted a dependent-samples t-test where each student’s individual differences in the pre-test (Time 1) were compared to those in the post-test (Time 9). We did not find any significant difference between the pre- and post- tests, possibly due to a small sample size. However, except conscientiousness and collective orientation, the means of all other individual differences in the post-test were higher than those in the pre-test. In other words, there was an increase in students’ traits and competences after completing the projects, although the difference was not statistically significant. Table 1 summarizes the means and standard deviations of all individual differences in the pre- and post-tests.
Table 1 *Mean Pre- and Post-Test Scores on Personality Traits and Competences.*

<table>
<thead>
<tr>
<th></th>
<th>Pre-Test</th>
<th></th>
<th>Post-Test</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>M</em></td>
<td><em>SD</em></td>
<td><em>M</em></td>
<td><em>SD</em></td>
</tr>
<tr>
<td>Personality Measures:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personalized Power Motivation</td>
<td>3.29</td>
<td>1.48</td>
<td>3.41</td>
<td>1.43</td>
</tr>
<tr>
<td>Socialized Power Motivation</td>
<td>4.62</td>
<td>0.90</td>
<td>4.68</td>
<td>.99</td>
</tr>
<tr>
<td>Extroversion</td>
<td>3.05</td>
<td>0.93</td>
<td>3.11</td>
<td>.87</td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>3.81</td>
<td>0.64</td>
<td>3.77</td>
<td>.69</td>
</tr>
<tr>
<td>Propensity to Trust</td>
<td>2.78</td>
<td>0.64</td>
<td>2.85</td>
<td>.70</td>
</tr>
<tr>
<td>Collective Orientation</td>
<td>3.22</td>
<td>0.47</td>
<td>3.14</td>
<td>.44</td>
</tr>
<tr>
<td>Affiliation</td>
<td>3.19</td>
<td>0.51</td>
<td>3.18</td>
<td>.44</td>
</tr>
<tr>
<td>Dominance</td>
<td>2.69</td>
<td>0.72</td>
<td>2.92</td>
<td>.67</td>
</tr>
<tr>
<td>Competencies:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Political Skill</td>
<td>3.77</td>
<td>0.65</td>
<td>3.80</td>
<td>.65</td>
</tr>
<tr>
<td>Adaptability</td>
<td>3.86</td>
<td>0.47</td>
<td>3.93</td>
<td>.53</td>
</tr>
</tbody>
</table>

In addition, we were particularly interested in two competencies, political skills and adaptability, which can change over time more easily compared to other relatively stable personality traits. Both political skills and adaptability increased slightly across the class after completing the projects, but when these skills were considered at the team level, the data were less consistent. Table 2 breaks down the means and standard deviations of both competencies in the pre- and post-tests by teams, and Figures 3 and 4 show the mean scores of each team, where the teams were listed in order of average lowest class grade to highest class grade. Class grades included a mix of individual and team assignments. The data did not show consistent correlation between political skills, adaptability, and team grades.
### Table 2. Team-Level Pre- and Post-Test Scores on Competencies

<table>
<thead>
<tr>
<th></th>
<th>Political Skills</th>
<th></th>
<th>Adaptability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-Test</td>
<td>Post-Test</td>
<td>Pre-Test</td>
</tr>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
<td>$M$</td>
</tr>
<tr>
<td>Team 1</td>
<td>3.92</td>
<td>0.76</td>
<td>4.02</td>
</tr>
<tr>
<td>Team 2</td>
<td>3.56</td>
<td>0.74</td>
<td>3.46</td>
</tr>
<tr>
<td>Team 3</td>
<td>3.69</td>
<td>0.43</td>
<td>3.47</td>
</tr>
<tr>
<td>Team 4</td>
<td>3.61</td>
<td>0.74</td>
<td>3.40</td>
</tr>
<tr>
<td>Team 5</td>
<td>3.54</td>
<td>0.69</td>
<td>3.81</td>
</tr>
<tr>
<td>Team 6</td>
<td>3.99</td>
<td>0.57</td>
<td>4.13</td>
</tr>
<tr>
<td>Team 7</td>
<td>3.81</td>
<td>0.88</td>
<td>4.00</td>
</tr>
<tr>
<td>Team 8</td>
<td>4.12</td>
<td>0.43</td>
<td>3.82</td>
</tr>
<tr>
<td>Team 9</td>
<td>3.74</td>
<td>0.56</td>
<td>4.21</td>
</tr>
<tr>
<td>Overall</td>
<td>3.77</td>
<td>0.65</td>
<td>3.80</td>
</tr>
</tbody>
</table>

**Figure 3. Team Averages: Political Skills Scores (Teams listed in order of class grade)**
Finally, Table 3 shows the network density scores of trust within each team from Time 2 to Time 8, and although there were some fluctuations over time, the overall network density scores of trust in all the teams were high.

Table 3. Trust in Teams over Time

<table>
<thead>
<tr>
<th>Team</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
<th>T6</th>
<th>T7</th>
<th>T8</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team 1</td>
<td>0.86</td>
<td>0.82</td>
<td>0.92</td>
<td>0.91</td>
<td>0.9</td>
<td>0.91</td>
<td>0.94</td>
<td>0.89</td>
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*Note.* Team 9 was added in Fall 2016 so there is no T2 and T3 for the team as these time points were measured in Spring 2016. (The added team was a sponsored research project whose funding arrived later than expected).
Several teams showed decreases in trust scores after the Student Design Showcase, which occurs after Time T7 and before Time T8 (Figure 5). One possible reason for the change in scores may tie to the timing of the surveys. Work effort and commitment to the project typically peak in preparation for the showcase. Hopes are high among the students that their project will win an award. In the aftermath, most teams are not declared winners and their trust, conscientiousness, and collective orientation can suffer. Complicating this situation was that there are multiple class assignments due after the showcase when some students may have trouble with motivation. The post-test for political skills and adaptability was also administered after the showcase, and the teams that showed a decrease in trust also showed a drop in political skills (Figures 5 and 6).

![Figure 5. Trust in Teams over Time: Teams with Lower Trust at Project End](image1)

![Figure 6. Political Skills and Adaptability: Teams with lower trust at project end](image2)
Four teams managed to show stable or upward trust scores at Time T8 (Figure 7). Interestingly, these teams also showed improvements in their political skills scores at project end (Figure 8). Figures 4-7 suggest a correlation between growth in political skill and the ability to maintain trust through the end of the project.

![Figure 7. Trust in Teams over Time: Teams with higher trust at project end](image)

![Figure 8. Political Skills and Adaptability: Teams maintaining trust at project end](image)

It should be noted that the final individual difference scores were also collected after the Student Design Showcase. It is possible that the tendency to lose enthusiasm at the end of a project may
have also affected some individual difference results, and any future work in this area will consider that possibility.

Effect of Course Modifications on Project Quality

Though no baseline data were collected before the 2016-2017 capstone cycle, we believe that the course modifications led to improvements in the student’s capstone experience and the quality of their projects. Unlike in previous years, all teams had completed hardware fabrication and some systems-level testing. Though many teams had not accomplished everything that they had planned, even the weaker teams had some level of success to display, and feedback from industry judges and senior faculty members indicated that the teams were better prepared for the Student Design Showcase and the projects were more fully developed.

Of all the course modifications discussed in this paper, the use of team time cards provided the most visible benefits. When used as part of an instructor evaluation and in conjunction with peer feedback, it appears to reduce social loafing and improve accountability among team members [10]. Most students liked the system since it allowed the instructor and their team members to see the effort they were putting into the project, and some of their comments from an end-of-course "lessons learned" assignment were shown below. The enthusiastic response was of particular interest because these students had completed Senior Design 1 (MAE 4291) with the same teams without the time cards, so they had a sense of how the time card system affected team dynamics. The comments below are from a student writing assignment on their lessons learned during the class.

"The time cards really show who is doing what and why stuff is or isn’t getting done. Time cards were a brilliant idea and should have been implemented sooner in my opinion."

"Team members are more accountable and willing to put in work when their grade depends on it. This was seen through the implementation of timecards during the second semester."
"The implementation of timesheets ensured that team members were being held accountable for the work they were assigned, and also to ensure that team members were being recognized for the amount of time and effort they put into the project. I think that in future Capstone Design cycles the time sheets should be implemented at least by the start of the first Senior Design class, MAE 4291... This can also supplement the CATME surveys by providing more insight into whether team members are contributing fully and equally to the project."

Based on the successes seen in the 2016-2017 teams, time cards were implemented in the 2017-2018 season for MAE 4291, where they have encouraged low-effort students (i.e., “social loafers”) to increase the time spent on their capstone projects [10].

**Conclusion**

Changes to the 2016-2017 Aerospace Engineering capstone course included increased student choice in topic selection, increased emphasis on self-management and professional/political skills, and an increased emphasis on peer feedback and individual accountability. The RIOT survey data did not support the original hypothesis that personality traits and competencies for all participants in Senior Design would improve in a statistically significant way, possibly due to the small sample size. The following trends were noted:

- When the entire class was considered as a whole, personality traits and competencies did not change significantly before and after capstone design.
- Changes in political skill and adaptability varied at the team level.
- There was no uniform trend between changes in political skills and adaptability and the course grades of the team members.
- Some teams at Florida Tech had difficulty maintaining trust in the final phases of their project, possibly because some students lost enthusiasm and had difficulty honoring their team commitments after the Student Design Showcase in early April.
- Teams that had difficulty maintaining trust in the final phases of the project also showed a drop in their average political skills score; teams that maintained higher trust levels at the end of the project showed an increase in their average political skills score.
Although we did not find significant results based on survey data, qualitative feedback provided promising results and implications. End of course feedback was very positive. In response to the question, “Rate the overall value of the course as it contributed your learning,” students rated the course as 4.5 of 5, where 5 is “Very Effective”. Of the 42 surveys, two contained complaints about the instructor being unfair and another student felt their CATME peer feedback grade didn’t represent their work, but the remaining comments praised the instructor and the class. There were no complaints about the frequency of the surveys. Course comments included appreciation for both the engineering design knowledge and team experience gained:

- “I have never learned more. I learned as much in my senior design classes combined as in my four years of other undergraduate classes.”
- “Most valuable- the team experience gained.”
- “Most valuable- team management skills and the engineering process.”
- “Most valuable- learning to work well in a team with a scope as large as capstone design.”
- “Time Cards- Great Idea.”
- “Time sheets should be implemented sooner.”
- “Extremely valuable in providing an opportunity to experience the engineering design process.”
- “This is the most similar class to the real world, and so preparing for that is important.”

Feedback from industry judges and other neutral observers indicated that the 2017 projects were more complete and the teams were better prepared for the Student Design Showcase than in recent years. Though cause and effect cannot be proven in this paper, it is possible that changes to the course may have encouraged this improved performance. In particular, both the students and the instructor believed that the implementation of team time cards significantly improved individual accountability. This is a particularly important issue to address, since team trust can drop after the showcase for many teams. Capstone instructors should be aware of this tendency and provide plenty of motivation and pressure to encourage follow-through for all team members.

The collaboration at the Florida Institute of Technology between the Aerospace Capstone Design Program and the Psychology Department’s Relationship and Interaction Optimization in
Teams (RIOT) Lab provides a unique opportunity to look at capstone team dynamics in a fresh way. Lessons learned from the 2016-2017 collaboration will be used to guide further research and provide insight on how to improve the effectiveness of the capstone program.

References


