Teams Assessing Teams: How Assessment is Affected by Team Member Personality Traits

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ABSTRACT

In architectural and civil engineering design, effective team collaboration is critical to creating functional built environments. To prepare future engineers for careers involving collaboration, this research paired first year engineering students with similar extraversion Five Factor Model scores in dyads to complete an introductory bridge design project. To understand the benefits of this type of pairing, 29 teams were tasked with designing and constructing Popsicle stick bridges, with data collected over several semesters. During the project, students completed a peer review activity in which one team would attempt to build, and subsequently generate feedback about another team’s design. Every dyad had an opportunity to generate feedback for another design, as well as receive feedback about their design. The students completed pre- and post-test assessments to provide their perceptions about their own designs before and after this prototyping activity. The analysis focused on the dynamics of team agreement regarding perceptions of the design and documentation. The paper finds correlations of Openness and Agreeableness to shifts in perception of performance in the design. Correlations were also found related to these factors as well as conscientiousness for perception shifts related to documentation tasks. The findings of this research generally align with related prior works and illustrate how team personality traits can be tied to the way that the same type of formative feedback can be received differently by students.

INTRODUCTION

The process of engineering a building or civil infrastructure design is often performed via a team. Input is required from various types of engineers and designers with different levels of experience and expertise. To effectively support this process, team and interpersonal skills are needed to foster effective team interaction. This
research explores a dyad-based project in which students enrolled in a first year seminar course at large university must design, construct, and structurally test a Popsicle stick bridge. The holistic approach of the project encourages students to problem solve and think creatively while developing effective team skills.

In addition to the team skills that the design project was intended to foster, it also introduced students to the design process. During the design process, engineers often generate models to understand and evaluate particular design concepts. For new engineering students, the process of creating a mental model from 2D plans can be challenging and prone to errors (Johnson 1997). Situated Learning Theorists suggest the best way to learn content applied to a specific setting, is to learn in the same setting in which that knowledge will eventually be applied (Lave and Wenger 1991). In the context of design education, this means that students should be put in a position where they need to conceptualize and document their own designs and reflect on their work. Thus, a project containing these components would allow students to learn how to create effective 3D mental models and communicate them via 2D documentation.

To help students improve their design conceptualization and documentation skills, a Popsicle stick bridge prototyping activity was incorporated into the first year seminar course. During this activity, students brought in copies of their design documents and traded them with another group. Each group then attempted to build a Popsicle stick prototype of the other group’s bridge design based on the documentation received. In building these prototypes, students identified design flaws and deficient aspects of their peers’ design concepts and documentation. The prototyping activity explored in this research allowed students to develop their design conceptualization skills by constructing a physical 3D model via 2D documentation. In addition, the activity provided an opportunity for students to give and receive formative feedback about their designs from their peers, which can help to improve learning (Sadler 1998).

To assess the value of this peer review activity, students completed pre- and post-tests that asked them to evaluate their own team’s design performance, which helped to capture how their perceptions had shifted after the prototyping activity. Prior work related to this course project explored the shift in perception among all students (Ayer et al. 2012). It was observed that students were more likely to identify flaws in both their own design concepts and their own design documentation after completing the prototyping activity (Ayer et al. 2012). The research presented in this follow-up paper paired students based on the results of Five Factor Model personality tests and explored how pairing team members based on extraversion affected their shift in performance perception. Specifically, the research sought answers to the following research questions: 1) how does personality affect students’ perceptions of their bridge design concepts? And 2) how does personality affect students’ perception of their bridge design documentation?

**BACKGROUND**

Students completed a Five Factor Model personality test to understand how team personality traits affect the teams’ perceived performance. The Five Factor Model (FFM) of personality has five main elements: Openness to experience (O), Conscientiousness (C), Extraversion (E), Agreeableness (A), and Neuroticism (N)
The FFM of personality’s effect on performance primarily focuses on the differences at an individual level (Rothstein and Goffin, 2006; Hough, 2001; Mount and Barrick, 1998). Although some links between individuals and teams have been established, this research explores the still limited empirical research on how personality relates to performance of teams as a whole (Morgeson et al., 2005; Kozlowski and Bell, 2003). However, the FFM literature does have research on how aggregation methods relate to team performance.

There are multiple methods of aggregation for understanding how individual FFM scores translate to team characteristics based on the type of task performed by the group (Demko, 2001; Neuman et al., 1999; Barrick et al., 1998; Driskell et al., 1987; Steiner, 1972). Driskell et al.’s (1987) basic group performance model, based on personality, states that there are different levels that feed into the group interaction process in which group performance is an outcome, such as context and environment. Context breaks down into six task types: mechanical/technical, intellectual/analytic, imaginative/aesthetic, social, manipulative/persuasive, and logical/precision. In general, engineers perform thinking, problem-solving, and decision-making exercises, which align with an intellectual/analytical task (Kwasitsu, 2003; Allen, 1966; Driskell et al., 1987; Lonergan et al., 2000). These key words are also used to describe intellectual teams, whose primary function is to think on intellectual/analytical tasks (Bell, S. 2007). However, within the context of the bridge design project, imagination must also be used to assist with problem-solving requirements. This raises the question, what happens if a task type is a combination of intellectual/analytical and imaginative/aesthetic tasks, such as task that requires design development?

According to Driskell et al. (1987) and Lonergan et al. (2000) there are certain aggregation methods that specifically help predict outcomes within certain contexts. However, a design and development task requires a team of individuals who are both problem-solvers and creative. This paper addresses the four methods of aggregation that align with Steiner’s (1972) definitions of task types: additive (e.g. summation or mean), compensatory (e.g. variance or standard deviation), conjunctive (e.g. minimum), or disjunctive (e.g. maximum). Both additive and compensatory tasks are the benefit of individuals coming together as a sum of their parts or the diversity with the team, respectively. Conjunctive and disjunctive tasks are more representative of the weakest and strongest individuals within the team, respectively (Barrick et al., 1998). Each of these task types can represent an entire task or combine for a single task (Barrick et al., 1998; Steiner, 1972). The project described in this research can be classified as both conjunctive and disjunctive with the potential to benefit from each individual, hence compensatory. Therefore average and each measure of spread from the FFM (i.e. standard deviation, minimum, and maximum) were assessed against team perception.

RESEARCH PROCESS

For the purposes of this research, a first year seminar that introduces students to the building discipline was examined. The course assists students in determining if their interests align with the major of Architectural Engineering. In order for students to experience a team-based design project, the Popsicle stick bridge project was incorporated into the class experience. The specific activities completed for both
student design and research data collection during the project are shown in Figure 1. This research focuses primarily on the Initial Design Documents phase of the project and the activities that are associated with that phase.

After students were paired via FFM, they were required to develop a bridge design and create a set of design drawings to illustrate their concept. Students compiled and brought a set of draft drawings to class for the peer review prototyping activity. Prior to the bridge prototyping design review activity, students individually completed pre-tests. Within the pre-test questionnaire, two 5-point Likert questions were examined in particular: 1) Our group did a good job of designing our bridge, and 2) Our group did a good job of documenting our bridge design.

The possible response choices ranged from “Strongly Agree” to “Strongly Disagree”. The responses received for these questions were used to establish the performance perceptions among the students.

On the day of the bridge prototyping activity, students attempted to assemble a prototype of another group’s design from only their given design drawings. During the prototyping task, students evaluated the other team’s documentation by filling out a provided evaluation rubric. Additionally, students were provided with an assessment form to interpret the qualities of the team’s design concept. Both the evaluation rubric and the assessment form were filled out as a group and returned to the original design group.

After the prototyping session, students were asked to individually complete an online post-test. The post-test sought responses to the same questions as the pre-test related to students’ perceptions of their work. This helped to identify any shifts in student perception after completing the prototyping review activity.

Measures

The student dyads were based on the Big Five Inventory (BFI) personality test, a version of the Five Factor Model (John et al., 2008). The output from the BFI was scaled based on age and gender through percentiles from 0-100 for each factor. For example, the highest level (i.e. score of 100) of Openness for an individual was
considered imaginative and curious, while the lowest score (i.e. 0) represented a more consistent and cautious person. The Extraversion characteristic had the highest score (i.e. 100) as extraverted and the lowest (i.e. 0) as the most introverted. These individual scores were then aggregated by mean, standard deviation (SD), minimum, and maximum to make a dyad score (see Table 1). These dyads’ scores were then used to make teams and evaluate students on a team-level.

Table 1. Example Aggregation Methods for Individuals into Teams for Personality

<table>
<thead>
<tr>
<th></th>
<th>O</th>
<th>C</th>
<th>E</th>
<th>A</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person 1</td>
<td>28</td>
<td>18</td>
<td>90</td>
<td>3</td>
<td>90</td>
</tr>
<tr>
<td>Person 2</td>
<td>88</td>
<td>13</td>
<td>87</td>
<td>78</td>
<td>56</td>
</tr>
<tr>
<td>Mean</td>
<td>58</td>
<td>15.5</td>
<td>88.5</td>
<td>40.5</td>
<td>73</td>
</tr>
<tr>
<td>Std Dev</td>
<td>42.43</td>
<td>3.54</td>
<td>2.12</td>
<td>53.03</td>
<td>24.04</td>
</tr>
<tr>
<td>Min</td>
<td>28</td>
<td>13</td>
<td>87</td>
<td>3</td>
<td>56</td>
</tr>
<tr>
<td>Max</td>
<td>88</td>
<td>18</td>
<td>90</td>
<td>78</td>
<td>90</td>
</tr>
</tbody>
</table>

To scale the responses for analysis, each team’s performance was based on their perception of their work. Team perception was created as the response variable through the difference in responses among the dyad from the pre- to post-tests for the two specific questions with respect to design and documentation (Table 2). Based on the 5-point Likert questions, the largest possible difference between each individual is four points in either a positive or negative direction. Thus for a dyad for either question, there is an acceptable interval of difference from -8 to +8. The sign represents the direction of change from the pre- to post-test. Hence, the negative is when the post-test is less than the pre-test and the positive value is a higher post-test score than pre-test. For example, in Table 2, both person 1 and 2 have lower perceptions of their design work by one from their post-test over their pre-test. Therefore, their team perception for design score is negative two. Also in Table 2, the team perception for documentation did increase for Person 1 by one and it did not change for Person 2. Therefore, their team perception shift for documentation is a positive one. For the purposes of the analysis, the team’s perception of design and documentation was tested as the dependent variable in all formats.

Table 2. Aggregation Methods for Individuals into Teams for Team Perception Response Variables

<table>
<thead>
<tr>
<th></th>
<th>Design Pre-</th>
<th>Post-</th>
<th>Δ</th>
<th>Documentation Pre-</th>
<th>Post-</th>
<th>Δ</th>
<th>Team Perception Design</th>
<th>Doc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person 1</td>
<td>3</td>
<td>2</td>
<td>-1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>-2</td>
<td>1</td>
</tr>
<tr>
<td>Person 2</td>
<td>2</td>
<td>1</td>
<td>-1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Teams

Over the Spring 2012, Fall 2012, and Spring 2013 semesters, dyads were paired based on the individuals’ FFM level of extraversion. The dyads were grouped
via sections of the course and by homogeneous levels of extraversion, which resulted in a less overall spread within a team. The overall distributions of the dyads are demonstrated in Figures 2a and 2b.

![Histogram of Dyad Extraversion (Mean)](image1)

![Histogram of Dyad Extraversion (SD)](image2)

**Figure 2a. Histogram of dyad’s extraversion (mean)**

**Figure 2b. Histogram of dyad’s extraversion (SD)**

During these three semesters, 179 students were enrolled in the course. Nearly all the students were of freshmen standing and less than 20 years of age. Most of the students (73.7%) were male. Because some of the students enrolled did not submit either the FFM results, perception data, or did not allow their responses to be used for this study, 29 dyads submitted complete data with both members giving permission to use their data.

**Analysis**

Before commencing data analysis, data cleaning and normalization of each of the variables occurred. If normality was not reasonable, transformations of the natural log, power, and inverse were utilized. The following variables were transformed: Maximum conscientiousness via power; Maximum agreeableness via power; and the minimum neuroticism via natural log.

To assess the impact between the student perceptions and their designs, hypothesis testing of the differences was performed for the pre- and post-test questions related to the project’s designs and documentation. The impact of this testing was to validate its similarity to the previous results from Ayer et al. (2012). For testing the influence of extraversion’s FFM on team perceptions of contribution to the design and documentation, statistical multiple linear regression modeling was used. The multiple linear regression models were run with the dependent variable as team perception with all four aggregation methods (i.e. mean, standard deviation, minimum, and maximum) for all five factors of the BFI as the independent variables. Two tests of the regression were used to test the difference between the complete data set of team perception for design and documentation.

**RESULTS AND DISCUSSION**
Tests were run to assess the pre- and post-test differences on individual student perceptions of design and documentation before examining the team level. There are statistical differences between the pre- to post-test answers for both the design and documentation questions within the survey. Not only was there a statistical difference between both the pre- and post-tests, but they were both statistically significant as an upper tail hypothesis test (Design: $p = 0.006$; Documents: $p = 0.000$). Thus, the pre-activity questions for confidence in design and documentation were rated higher than the post-activity questions. These results align with the previous findings in Ayer et al. (2012).

**Teams and perception**

The resulting stepwise multiple linear regression model for the dyads with respect to design was significant ($p$-value = 0.003; $R^2 = 0.4184$; $R^2_{adj} = 0.3487$), though it only found the FFM factors of openness and agreeableness as significant contributors towards team perception. This indicates that almost 42% of the shift in team perception of design performance from pre- to post-test is related to these differences in personality.

The second regression model for how FFM related to team perception of documentation was also significant ($p$-value = 0.003; $R^2 = 0.5121$; $R^2_{adj} = 0.406$). This indicated that roughly 51% of the differences in team perception of documentation before and after the activity were due to openness, conscientiousness, and agreeableness. Table 3 lists the results from both of these analyses and the signs for each significant result. For example, as the standard deviation of teams’ Openness scores decreased and standard deviation and mean of agreeableness increased, there tended to be more of a shift in perception of design performance after the prototyping activity. Conversely, as the mean of team Agreeableness scores increased, there tended to be more of a shift in perception of design performance after the activity.

**Table 3. Multiple Linear Regression Models of Team Perception**

<table>
<thead>
<tr>
<th>Design</th>
<th>Sign</th>
<th>Aggregation</th>
<th>FFM</th>
<th>Documentation</th>
<th>Sign</th>
<th>Aggregation</th>
<th>FFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>SD</td>
<td>Openness</td>
<td></td>
<td>+</td>
<td>Mean</td>
<td>Agreeableness</td>
<td>Conscientiousness</td>
</tr>
<tr>
<td>+</td>
<td>SD</td>
<td>Agreeableness</td>
<td></td>
<td>+</td>
<td>Min</td>
<td>Agreeableness</td>
<td></td>
</tr>
<tr>
<td>+</td>
<td>Mean</td>
<td>Agreeableness</td>
<td></td>
<td>-</td>
<td>Mean</td>
<td>Conscientiousness</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>Min</td>
<td>Conscientiousness</td>
<td></td>
<td>-</td>
<td>Min</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Discussion**

The focus of this analysis was not on student performance, but rather the shift in perception of the students on their own performance. Students within the same teams received the same feedback, but reacted in different ways to that feedback. The results of the analysis indicate that the shift in students’ perception of their own dyad’s design and documentation performance, after the prototyping activity is partly due to their team personality traits. The regression models suggest significant relationships of Openness and Agreeableness to shifts in perception of design performance. As team members had less diversity in Openness and higher mean and
While both openness and agreeableness are significant for both design and documentation performance perception, they aggregate differently in the different categories. For design performance perception, the significant results aggregated align with additive and compensatory tasks. Design tasks typically involve imagination and consideration of aesthetics, which can benefit from both team members working together and by raising a variety of thoughts and ideas for a design. Therefore, the finding that these types of aggregation methods align with shifts in design performance perception is logical.

For design documentation performance perception, the significant results aggregated align with additive and conjunctive tasks. While the process of conceptualizing a design requires creativity and imagination, the process of documenting that design concept is more of a mechanical or analytical task. In this way, the process of documenting a design can be enhanced with both team members’ actively contributing, but can also benefit from one highly capable individual carefully examining the developed documents. Therefore, the findings that these types of aggregation methods align with shifts in design documentation performance perception, again, seem logical for this type of task.

CONCLUSIONS

The presented research demonstrates how students’ perceptions of their own work can be affected through the process of generating formative assessment through a peer reviewing bridge prototyping activity. This research observed that the extent to which student perceptions of their own work is affected by their team personality traits. In particular two main components of self-assessment were examined. Students were asked about their opinion of their own design concepts as well as their opinions on the quality of their own design documentation. The results of this research indicated that the shift in student perception of their own performance in design can be partially affected by the levels of team Openness and Agreeableness. For design documentation quality perception, the results suggest that Openness, Agreeableness, and Conscientiousness can affect shifts in perception. This suggests that even though students completed the same design project and completed the same peer-reviewing prototyping activity, the feedback generated was frequently interpreted differently based on the personality traits of the students receiving the feedback. This finding lays the groundwork for future research to determine if there may be better approaches for creating formative feedback so that it may be appropriately received by teams of students with different personality traits.

There are a few limitations with this presented research that future studies may be able to address. There can be limitations in the use of a self-assessment tool for identifying the FFM traits and self-assessment feedback using custom developed scales, however the observed results do align with previous research. It would also be advantageous for future research to obtain a larger sample size for additional analysis,
potentially including teams that are created based on different FFM characteristics. Finally, this research only explored how students’ perceptions of their work shifted from the prototyping experience. Further analysis in future work will be performed to understand how the team perceptions may relate to actual performance among the cost and structural performance of the resulting bridge designs.

ACKNOWLEDGEMENTS
The authors of this work would like to thank Penn State’s Leonhard Center for enhancement of engineering education for their support for this research. Additionally, the authors would like to thank the students enrolled in AE124S who participated in this research project.

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