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Influence of Personality on a Senior Project Combining Innovation and Entrepreneurship*

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A pilot multidisciplinary engineering senior design project incorporating innovation and entrepreneurship was undertaken at San José State University in the 2010–2011 academic year. The influence of personality domains described by the Big-Five (extraversion, agreeableness, conscientiousness, emotional stability, and openness) on individual student performance, group experience, and attitudes towards multidisciplinarity, after the conclusion of the first semester of a two semester experience, are explored in this paper.

Keywords: multidisciplinary capstone project; Big-Five; Five-Factor model

1. Background

As the technical and non-technical fields become increasingly interdependent in society, multidisciplinary education becomes more relevant in higher education. Multidisciplinary group projects and teamwork support innovation by exposing students and faculty to ideas, values, and perspectives outside of their own discipline. Curricula designed with an understanding of multidisciplinary groups, their interactions, and educational effectiveness in groups will be required, in addition to the current curricula focusing on largely on individual performance.

Personality is hypothesized to be an important variable in group dynamics and performance, and hence should be a consideration in the study of multidisciplinary group projects. There are many personality tests in existence, but a commonly accepted empirical model in the social sciences is called the Big-Five, or equivalently the Five-Factor Model [1]. The Big-Five describe a taxonomy of five personality domains which map traits that statistically go together. The five domains are: extraversion (outgoing, social), agreeableness (sympathetic, warm), conscientiousness (organized, dependable), emotional stability (calm, not easily upset), and openness (adventurous, creative). The five factor models are considered more viable as a model of personality than the well-known Myers-Briggs personality test. The former is based upon extensive, systematic, and rigorous empirical work.

Ozer [2] summarized meta-analysis to show that the Big-Five are well accepted personality traits used to study how personality affects relationships. In all fields, the degree of conscientiousness can be used to predict performance. Agreeableness is highly correlated to working successfully on teams. Extraversion and emotional stability positively influence how a person feels about a work role.

Zhao [3, 4] conducted a meta-analysis on the big five personality traits and found a moderate effect between personality and the career choice of manager or entrepreneur. While the effects individual personality traits where shown to be minimal, the combined factors has a moderate effect size (R = 0.37). Agreeableness was found to have no relationship to being an entrepreneur.

Cunningham [5] presented a case study on the use of personality type in self reported success in managing an engineering undergraduate research group. Another case study [6] involving first time freshman engineering students reported the use of personality tests when communicating with other students.

Peeters [7, 8] reported that satisfaction of a team member with the team's performance depends upon personality. The researchers also found that satisfaction with the team goes down if everyone on the team is extraverted, but these results seemed to be contradicted by another study published later by the same author. They also discovered that team members who rated highly in conscientiousness felt dissatisfied with the team's performance if the team was composed of a varying level of conscientiousness. Team members, who were at a low level of conscientiousness, were not affected by those team members who were more conscientiousness.

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Felder [9] reported success in using personality data and active learning methods to motivate students who did not have strong engineering preparation backgrounds to increase graduation rates. Personality was not a factor for students who had strong academic preparation for engineering.

This work measured the five personality traits with a short ten item instruments developed by Gosling [10]. This instrument was reported to have a high degree of correlation with other instruments with significantly more items. Reducing the number of items a subject has to answer should increase the response rate.

Chen [11] used personality tests in the formation of successful intra-company, multidisciplinary design teams. It was suggested in this work, that the use of personality was useful is breaking down communication barriers, but that personality instruments should not be used for hiring purposes.

Morgeson [12] found that to make sure that team members exhibit the helping behaviors that team members need to demonstrate to have a successful team, that the required helping behaviors are perceived as 'part of the job' when working on a team.

Shen [13] found that there are some personality types that are better at the dual roles of engineering and design, but that a team should not be formed with more than one strong leadership type personality. Other personality traits that were suggested to be part of a successful team were, creative, problem solving and resourceful. It was also suggested that when forming teams to not let the students select their own teams, because it reduces the diversity required to have a successful team.

Some studies [14–17] found that diversity in a team does not always increase a team's performance, and as a result, diversity has to be managed carefully when selecting team members for a project. Other studies [18, 19] have shown that since team projects increase the workload of the students, students need to be motivated to work in team the benefits of working on teams must be carefully explained.

Dowling [20] reported that faculty felt that working on multidisciplinary research projects was rewarding, but that the faculty involved have to be willing to meet the deadlines of other researchers on the team, and have to be willing to learn the basics of the other team members' fields of expertise.

2. Project description and methodology

A pilot multidisciplinary senior project was undertaken at San José State University in the 2010–2011 academic year. Presumably, innovation will be fostered by a combination of individual performance, group dynamics, and attitudes towards multidisciplinarity, and the aim was to positively influence these areas in the pilot effort. The senior project challenge was to design, build, and test a 100-square-foot house that emits no greenhouse gas or pollutants during operation, hence the name 'zero-emissions' house, or ZEM house. The project was motivated by the current significant energy consumption by commercial and residential buildings (for example, buildings consumed 73% of electricity generated and emitted 39% of carbon dioxide in the US in 2009 [21]). There were 28 students and five faculty members working on the project, with one faculty member and approximately five students from each of the following disciplines: mechanical engineering, electrical engineering, industrial design, political science, and business. The five disciplines were responsible for the subprojects listed in Table 1, and for interacting and communicating with the other disciplines as required to accomplish their objectives.

Expectations of innovation on this particular project were high, both of the educational experience and of the project itself. The educational experience was innovative compared to traditional senior design projects, and would undoubtedly involve a much greater requirement for teamwork and collaboration. The students were instructed and encouraged to 'think outside the box', and would hopefully be influenced by their multidisciplinary peers. In addition, entrepreneurship was explicitly covered in the business project class, and it was the expectation that their subproject would influence the project as a whole in a positive manner.

During the first semester, all five disciplines participated in the design phase of the ZEM House. The 28 students attended a series of joint lectures given by the five faculty members, each describing contributions to sustainable design from the perspective of their discipline. Each dis-

Table 1. Subprojects by discipline for the SJSU ZEM House, 2010–2011

Mechanical engineering	HVAC, structure
Electrical engineering	Solar PV and electrical system, lighting
Industrial design	Human factors, material selection, aesthetics
Political science	Public policy, energy policy, and global warming
Business	Economic analysis, entrepreneurial opportunities

ciplinary student team then nominated a team liaison, who met with the other liaisons once a week to share information, report progress, and collaborate. Although the contributions from the individual teams varied, the overall achievement of the group as a whole was very positive. They staged an event for the 350.org global work party intended to make a political statement on 10/10/10 [22], which was covered by the San José Mercury News [23]. They won second place for social innovation at the Silicon Valley Neat Ideas Fair (a SJSU-wide entrepreneurship contest) and consequently presented their project at the Annual State of the Valley Conference in February 2011, attended by over 1000 civic and business leaders. A design emerged incorporating a solar photovoltaic and battery storage system, heat pump and air conditioning, LED lighting with automatic dimming and motion control, passive lighting, and solar heating, among other features. Lastly, over $15K of donations were solicited from local companies to support the project, including solar photovoltaic panels, batteries, an inverter, charge controller, lumber, and windows.

The reasons to undertake such multidisciplinary projects, in addition to fostering innovation, are multifold. Strong educational benefits are consistently reported in the literature, such as increased teamwork and communication skills [24], lifelong learning [25], and better project outcomes as judged by outside experts [26]. It strongly supports ABET Criterion 3, which specifies learning outcomes required of all accredited engineering programs. Faculty members, who are typically products of their own disciplinary training, also receive exposure to multidisciplinary perspectives, and can then better offer effective multidisciplinary experiences for students. Lastly, it was the hope that pooled resources, expertise, and skills would result in the ability to tackle more ambitious and significant projects in a resource-effective manner.

Although there are many facets to the educational aspects of this project, we hypothesize that personality type is an important factor and needs to be considered in the design of effective multidisciplinary educational experiences. To determine the influence of personality type on student performance, group experience, and attitudes towards multidisciplinarity, data were collected on the 115 students enrolled in the senior project classes of the participating faculty members on this project during the fall semester of 2010. Of this set, 28 students participated on the ZEM house project as described previously. The remaining students were instructed in the traditional manner. All 115 students were given the ten-item personality inventory [10] at the start of the semester to determine their attributes on the Big-Five personality dimensions. They took pre- and post-semester quizzes on the sustainability topics covered by the joint lectures attended by the ZEM House students. At the end of the semester, they were also asked about their attitudes towards multidisciplinarity and their assessment of the teamwork they experienced. Student identification numbers were collected, and information such as GPA, major, and gender were available to the analysis.

Comparisons of means are presented to illustrate differences in results between groups in the study. Statistical significance is determined by examination of the effect size and/or the probability value (p) as appropriate. Correlations between two variables and probability value are also reported for various groups in the study. The statistics used are defined as follows:

$$\text{Effect size} = \frac{\bar{X}_A - \bar{X}_B}{SD_{AB}} \tag{1}$$

$$\text{p(difference of means)} = f\left(t = \frac{|\bar{X}_A - \bar{X}_B|}{SD_{AB}\sqrt{\frac{1}{n_A} + \frac{1}{n_B}}}, DF = n_A + n_B - 2\right) \tag{2}$$

$$\text{correlation} = r = \frac{\sum X_A X_B - \frac{\sum X_A \sum X_B}{N}}{\sqrt{\left(\sum X_A^2 - \frac{\left(\sum X_A\right)^2}{N}\right) - \left(\sum X_B^2 - \frac{\left(\sum X_B\right)^2}{N}\right)}} \tag{3}$$

$$\text{p(correlation)} = f\left(t = \frac{r\sqrt{N-2}}{\sqrt{1-r^2}}, DF = N - 2\right) \tag{4}$$

In these equations, X_A and X_B are the samples for populations A and B, respectively, in a comparison of means. For correlations, they represent the samples for variables A and B, respectively. The variables SD and DF refer to standard deviation and degrees of freedom, respectively. The variables n and N are used to indicate the size of the population used in the comparison of means and correlation tests, respectively. The probability value, p, is obtained using function *f*, which is used to indicate the area above the t value for the degrees of freedom according to the two-tailed Student-t statistic. In general, a probability value less than 0.05 indicating a 5% chance of the null hypothesis was deemed statistically significant as is conventionally interpreted.

The formative assessment presented in this paper is based on data obtained after the first semester of the senior design project. Informed consent and confidentiality of the participants were implemented, and this assessment qualified for an exemption from full review by the Institutional Review Board (IRB) at SJSU. The planned second semester tasks and future studies are described in Future Work.

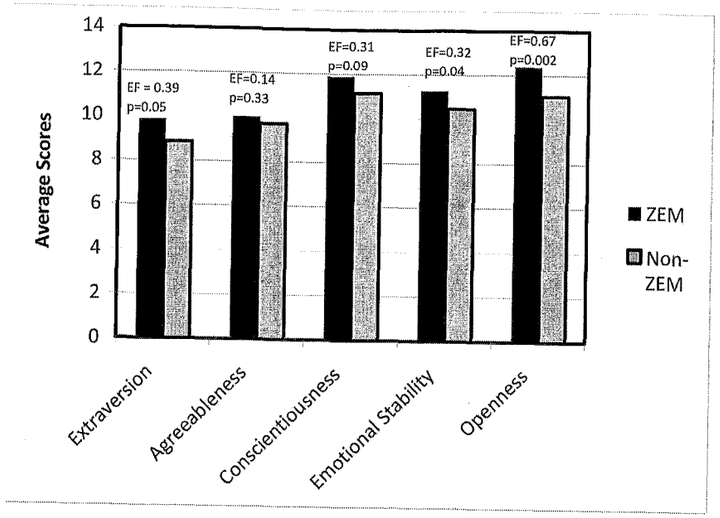

Fig. 1. Personality Characteristics Compared for ZEM and Non-ZEM Students.

3. Characteristics of current students

Characteristics of the current students in the five senior project classes are described in this section. The subset of students from each class participating on the ZEM House volunteered for the project. Although the demand was greater than the number of students we could accommodate in some classes, the ZEM students were for the most part a self-selecting group.

The Big-Five personality domains were each scored from 1 to 14, with 14 indicating the maximum score for that attribute. The mean values of each personality domain for the ZEM and non-ZEM students are shown in Fig. 1. The effect sizes and p-values are indicated above each comparison.

The ZEM students outscored the non-ZEM students in all five personality domains, although not with statistical significance for agreeableness and conscientiousness. For the other three domains, moderate differences are seen for extraversion and emotional stability (effect sizes are 0.39 and 0.32, respectively), and a moderately large difference is seen for openness (effect size is 0.67). It is logical that students who chose to participate in an experimental pilot of an educational experiment would be more open to new experiences than students who chose to do a traditional project. In addition, extraverted students are more likely to be excited about working in a large, diverse team, and emotionally stable students are less likely to feel anxious about the ambiguity inherent in an untested opportunity.

Personality means were also compared by discipline. Generally speaking, business students were the most extraverted of the group, and the industrial design students rated themselves to be the most open to new experiences. The differences, however, were not statistically significant due to relatively small sample sizes, and are not reported here. It would be interesting to see if these trends persist in a larger sample.

Differences in GPA exist between the ZEM and non-ZEM groups. The average GPA of the ZEM students was 3.2, whereas for the non-ZEM group it was 2.8. The effect size and probability value were 0.72 and 0.002, respectively, indicating that this is a moderately large effect, and that it is statistically significant. GPA is one indication of ability, and needs to be considered in the interpretation of performance results.

The gender composition for the various groups in the study is shown in Table 2. It is interesting to note

Table 2. Gender Composition for Various Groups in Study

	Female	Male
ZEM	22%	78%
Non-ZEM	29%	71%
Mechanical Engineering	4%	96%
Electrical Engineering	29%	71%
Industrial Design	18%	82%
Business	13%	87%
Political Science	62%	38%

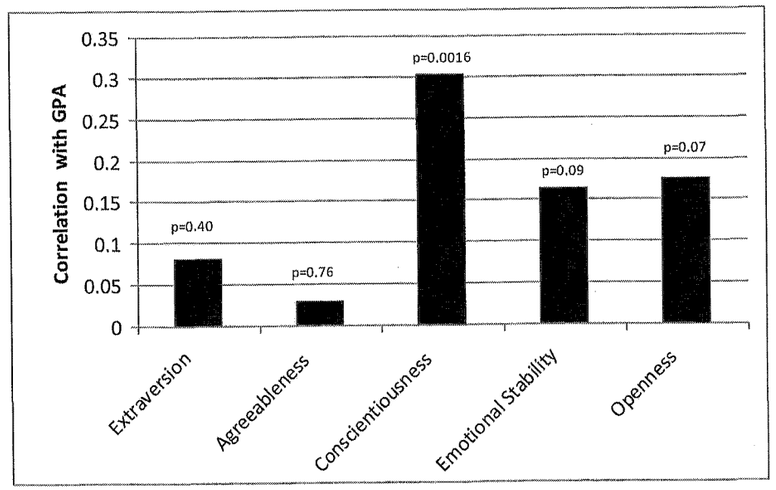

Fig. 2. Correlations of Personality Domains and GPA for All Students.

that the participating courses are largely male-dominated, except for political science. The engineering and industrial design courses are required of all seniors in their programs; hence we can infer that the percentages for these courses are fairly representative of those in the discipline. The ZEM team, consequently, is male-dominated, in similar proportion to the non-ZEM group. The influence of gender bias in collaborative projects is outside the scope of this paper, and is simply noted for now.

4. Results

The results of our analysis can be categorized into three areas: individual performance, group work experiences, and attitudes. Although the final assessment of innovation and entrepreneurship evident in the ZEM House is deferred to the end of the project conclusion, we build upon the premise that innovation is supported by positive performance, groups, and attitudes, and that personality could be an important influence in these areas. Some personality correlations from the prior literature are corroborated in our study. However, we do also find some counter-intuitive results that defy obvious explanation and merit further study through targeted data collection. Our results are not at a stage for forming broad scale recommendations, but rather for identifying factors important for more detailed further study and continuous improvement.

Because the multidisciplinary joint project has not undergone its implementation phase at this point in the study, assessment of student performance is limited to individual performance in this paper. GPA is one obvious measure of student performance, and its correlation to the personality domains for all students in our study is shown in Fig. 2.

A statistically significant and moderate correlation between conscientiousness and GPA is observed ($r = 0.30$, $p = 0.0016$). The positive correlation between conscientiousness and individual performance is well-supported by the literature [2]. In addition, mild positive correlations with GPA to emotional stability and openness are observed, albeit with less statistical significance ($p = 0.09$ and 0.07, respectively). There was no correlation found between GPA to extraversion or agreeableness.

A multiple choice quiz was administered to all the students in the study before and after fall semester. The quiz covered concepts taught during the disciplinary lectures on sustainability, delivered to the ZEM students over the course of the semester. The quiz was scored out of a total of 25 points, with five points in each of the five subjects covered.

The average improvement on the quiz was two points higher for the ZEM students compared to the non-ZEM students, although not with statistical significance. A closer examination of the individual responses from the post-semester quiz indicate that some students in both ZEM and non-ZEM groups appeared to leave items blank or mark them arbitrarily, resulting in some students exhibiting very large 'reduction of knowledge' and large standard deviations for both groups. The quiz was intended to study the effectiveness of the lectures only, and did not count towards the class grade. We speculate that pressures at the end of the semester and the desire to 'get it over with' led some students to not take the quiz seriously. Nevertheless, the use of the non-ZEM group as a control group provided evidence that the lectures delivered to the ZEM group did increase content learning and retention of the five disciplines and their relevance to sustainability, beyond what is obtained in traditional instruction.

A correlation between conscientiousness and improvement on the quiz was seen in the ZEM students ($r = 0.32$, $p = 0.14$). Although not statistically significant due to small sample size, the moderate positive correlation is in line with the GPA correlation in this study and the prior literature.

There appears to be very little difference in group work experience between the ZEM and non-ZEM students. All students were asked questions pertaining to their project groups at the end of the semester. The average responses for both groups are summarized in Table 3.

Statistically significant correlations were found for the first question (to what degree did all members share in the team's responsibilities) to the personality domains, extraversion and emotional stability, as summarized in Table 4. Higher extraversion was correlated with a greater feeling that group members shared team responsibilities for the student group as a whole, as well as for the non-ZEM students. Extraversion is positively correlated with positive feelings towards work roles in prior literature [2]. This correlation was not shared with the ZEM group for some reason, but the result is not statistically significant for this small group. In a surprising and inexplicable result, students with higher emotional stability (i.e. calm and less easily upset students) reported less feeling that group members shared team responsibilities. The negative correlation was moderate and consistent for all groups ($r = -0.25$ to -0.26) and statistically significant for the students as a whole and the non-ZEM students ($p < 0.05$ in both cases). The ZEM group reported the same trend, although not statistically significantly due to small sample size. This result is not consistent with prior literature correlating emotional stability to positive team experiences and performance [2, 7–8]. However, the result is statistically significant in our population, and bears further study to determine causal explanations.

There also appears to be very little difference in attitudes towards multidisciplinarity between the ZEM and non-ZEM groups. Both groups were asked a series of questions at the end of the semester, and the average responses summarized in Table 5. Correlations between responses to these questions and the personality domains were computed. Statistically significant trends for the fourth question

Table 3. Self-reported Group Work Experiences for the ZEM and Non-ZEM Students

	ZEM average	Non-ZEM average
To what degree did all members of the group share in the team's responsibilities? (*1-some members did no work at all, 2-a few members did most of the work, 3-the work was generally shared by all members, 4-everyone did an equal share of the work*)	2.86	2.92
Which of the following best describes the level of conflict at group meetings? (*1-no conflict, everyone agreed on what to do, 2-there were disagreements but they were easily resolved, 3-disagreements were resolved with considerable difficulty, 4-open warfare: still unresolved*)	1.77	1.88
How productive was the group overall? (*1-accomplished some but not all of the requirements, 2-met the requirements, but could have done much better, 3-efficiently accomplished goals that we set for ourselves, 4-went way beyond what we had to do, exceeding our goals*)	2.45	2.83

Table 4. Correlation between Reported Feeling that Group Members Shared Team Responsibilities with Personality Domains Extraversion and Emotional Stability

	All Students	ZEM Students	Non-ZEM Students
Extraversion	$r = 0.18$ $p = 0.08$	$r = 0.007$ $p = 0.97$	$r = 0.23$ $p = 0.05$
Emotional Stability	$r = -0.25$ $p = 0.013$	$r = -0.26$ $p = 0.25$	$r = -0.25$ $p = 0.028$

Table 5. Self-reported Attitudes towards Multidisciplinarity for the ZEM and Non-ZEM Students

(Scale for responses: 1-strongly disagree, 5-strongly agree)	ZEM average	Non-ZEM average
I understand the role of my discipline in society better as a result of this experience.	3.86	3.91
I understand the role of other disciplines in society better as a result of this experience.	3.77	3.76
I am more enthusiastic about my discipline as a result of this experience.	3.68	3.87
I am more interested in learning about other disciplines as a result of this experience.	3.90	3.70

Table 6. Correlation between Interest in Learning about Other Disciplines with Emotional Stability

	All Students	ZEM Students	Non-ZEM Students
Emotional Stability	r = –0.24 p < 0.05	r = –0.43 p = 0.05	r = –0.23 p < 0.05

(i.e. interest in learning about other disciplines as a result of this experience) correlated with emotional stability and are reported in Table 6.

In all groups examined, higher emotional stability is correlated to less interest in learning about other disciplines outside of their own. The effect is moderate in the non-ZEM group, and moderately strong in the ZEM students. It is statistically significant in all groups. The authors are unsure as to an explanation of these results, and can only speculate that they might be related to the previous result showing a correlation between high emotional stability and less feeling that group members contributed equally.

5. Conclusions

In this analysis, personality domains from the Big-Five were examined for possible influences on student performance, group experiences, and attitudes towards multidisciplinarity in a pilot implementation of a multidisciplinary senior project combining sustainability, innovation, and entrepreneurship. Twenty-eight students participated in the pilot multidisciplinary project group, the ZEM team. The remaining students out of 115, the non-ZEM students, were instructed on their senior projects in the traditional manner. The conclusions from this study include the following:

- The self-selecting ZEM students were more extraverted, emotionally stable, and open compared to their non-ZEM counterparts.
- Correlations between conscientiousness and individual performance were found in this study, corroborating prior results in the literature.
- There were very little differences in reported group experiences between the ZEM and non-ZEM students. However, extraverted students in both groups were more likely to report that group members shared in the team's responsibilities. More emotionally stable students were less likely to report that group members shared in the team's responsibilities. Emotional stability is often correlated with positive group outcomes, and the explanation for this result is presently unclear.
- There were very little differences in attitudes towards multidisciplinarity between the ZEM and non-ZEM students. Emotionally stable students were less likely to be interested in learning about disciplines outside of their own.

6. Future work

We plan to build a full-scale prototype of the ZEM House designed by the multidisciplinary student team during the second semester of this project. The mechanical engineering, electrical engineering, and industrial design students participate in a two-semester senior project, and will be doing the bulk of the construction. The business and political science students participate in a one-semester project, but will be welcome to continue contributing to the project.

Future studies include the assessment of project outcomes and educational effectiveness of the co-instruction model. We plan to assess student team and sub-team performance considering personality and other factors, as well as the innovation and entrepreneurship evident in the final project in comparison to more traditional senior projects. Targeted focus groups will be conducted to probe some of the counter-intuitive correlations obtained in the present study, and to obtain more in-depth information from the students' perspectives. In addition, studies of team effectiveness, communication skills, and attitudes towards multidisciplinarity will be conducted after the second semester during which the students will have had a very engaged and intense working period. Lastly, any benefits to faculty from this effort will be determined through interviews and recorded for the study.

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