Exploration of Engineering Students' Values with Respect to Behaviors in Group Work

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Abstract

In order to train young professionals, instructional methodologies in engineering need not only teach students knowledge, but must also instill the values and teach the behaviors—*competencies* students can demonstrate—required of professional practice. Herein, we focus on understanding the values and behaviors of students with respect to working as a member of an engineering group as a part of a course project. *Our hypotheses are (1) that the students' values with respect to the behavior of individuals in a group will remain stable through the academic year and (2) there will be behavioral predictors to group-based values.* Our findings agree with the literature on societal groups which indicate that values should remain constant over time; we see here with our cohort of students that values not only remain stable, but also, students maintain high agreement through the academic year. With respect to behavior predictors, the behaviors that repeatedly correlated or predicted positive group values were related to interpersonal skills rather than knowledge or learning. This finding is important as it points to a noted necessity to foster strong interpersonal skills among students. Students need to recognize that how they interact with their group is just as important as the skills being brought to the group. The results presented herein are a first step toward creating a "personalized" instructional approach that focuses on aligning individual values and behaviors when working in an engineering group.

Keywords: Engineering, Values, Behavior, Group, Team, Individual sustainability

1. Introduction

It is important for effective instructional methodologies in engineering to teach behaviors—*competencies* students can demonstrate—rather than simply the acquisition of knowledge of, or attitudes towards, a topic. Pappas and Pappas (2015) describe that one's "individual behavior creates the foundation for action in social, economic, and environmental sustainability and potentially guides our ability to work with one another to make life-affirming decisions. In short, it is a matter of aligning our day-to-day behaviors with our well-stated values that will result in greater sustainable community action" (p. 12). Consequently, not only must we teach students about sustainability, we must also instill sustainability-focused values with matching sustainable behaviors in our students.

In order for engineering students to understand the breadth of sustainability and how our behaviors affect our society and people, it is critical to understand sustainability across a variety of contexts, especially the role of individuals. It is an individual's demonstrated *behavior and skills*, not simply his or her *knowledge* of sustainability, that supports and promotes sustainability. We recognize that developing an individual's values may provide motivation to behave in a manner more congruent with sustainability principles (Shields, Solar, & Martin, 2002). This transformative process employs instructional theory and methodologies that offer students greater insight into, and understanding of, sustainability problems—far greater than traditional instruction that focuses on increasing "student knowledge" or learning basic laboratory skills. *Creating a "cognitive dissonance" between an individual's stated values and demonstrated behaviors tends to encourage individuals to balance more effectively the self-knowledge that informs decision making and problem solving.*

The overarching premise for our research is that *students generally embrace admirable values related to sustainability, but often encounter a "cognitive dissonance" when asked to explain whether their actions accurately reflect their values* (Ballantyne & Bain, 1995). In other words, students often do not act according to their values and beliefs. Earlier research addressing this issue indicated that students themselves believe there was a "disconnect" between what they believe about sustainability and how they act (E. C. Pappas, 2013). This inconsistency motivated students to more actively align their behavior with their values. In the current study, the values and behaviors of students with respect toward working as a member of an engineering group are explored. This falls under the categories of individual and social sustainability where individual sustainability is defined as,

> *"Sustainable individuals are characterized by creating harmony, interconnection, and relatively high levels of self-awareness in their values, thoughts, behaviors, and actions as well as cultivating continued individual growth in their physical, emotional, social, philosophical, and intellectual abilities. Individual sustainability includes possessing a well-developed and demonstrated value system that acknowledges the importance and interconnectedness of all global biological and social systems, and our appropriate place within them" (J. B. Pappas & Pappas, 2015),*

and social sustainability is defined as,

> *"Social sustainability includes the role of individuals, relationships among social groups, the family, collective behavior, social class, race and ethnicity, medicine, education, and the role of institutions in society. This includes cultural factors related to the shared values, attitudes, beliefs, behaviors, and social practices that characterize human knowledge and behavior (e.g., fine arts, humanities, the transmission of knowledge, shared everyday way of life)" (E. Pappas & Pierrakos, 2010).*

Students participating in the study presented herein were asked to rate their values toward the behaviors of individuals working in engineering groups as well as to rate their own behaviors as a member of an engineering group. The survey instruments (one for values and another for behaviors) as well as the results from survey deployments are presented in this paper. The goal of the study presented in this paper was to gain insight into four different research questions:

1. Are there correlations between group-based values,
2. Do students' values with respect to group behaviors change while working on a group-based design project,
3. Do self-reported, group-based behaviors predict group-based values, and
4. How do student's self-reported behaviors correlate to their values?

Our hypotheses are (1) that the students' values with respect to the behavior of individuals in a group will remain stable through the academic year and (2) there will be behavioral predictors to group-based values. Literature on the values of societal groups seems to support the idea that values tend to remain quite stable (M. Rokeach, 1973; Milton Rokeach & Ball-Rokeach, 1989). It should be noted, however, that individual values can change over time due to external influences and personal growth (e.g., business ideology and socio-cultural influences (David A. Ralston, 2008; D. A. Ralston et al., 2006). For this study, we have adopted the definition of value change proposed by Bardi and Goodwin (2011):

> *"…Value change is a change in the importance of a value, evident in a change in the rating or ranking of a value on a questionnaire. This can be a short-term (temporary) change, such as in the response to an experimental manipulation, or a long-term change" (p. 272).*

2. Background

Collaborative practices among students create a culture that influences how teams work, how much work they complete, and the quality of work they produce. In addition, how well teams are aligned with respect to individual values and collaborative work values dictates students' level of satisfaction and productivity.

The underlying principle for learning sustainability or exhibiting sustainable behavior is values (Leiserowitz, Kates, & Parris, 2006), which we define as beliefs in, or demonstrations of, the significance and meaning of objects, qualities, or human behaviors. When solving sustainability problems, we are confronted by a decision we must make according to our values related to human well-being. As individuals and as a society, we must understand the value-related ramifications of our actions on a host of factors that determine sustainable practices, whether they be corporate, community, or individual. This is the central unifying factor in our research: Students generally embrace admirable values related to sustainability, but often encounter a "cognitive dissonance" when asked to explain whether their actions accurately reflect their values (Ballantyne & Bain, 1995). In short, students often do not act according to their values and beliefs. Earlier research addressing this issue indicated that students themselves believe there was a "disconnect" between what they believe about sustainability and how they act (E. C. Pappas, 2013). This inconsistency motivated students to more actively align their behaviors with their values.

Theories on successful team composition and functioning are many; most tend to focus upon organizational structure, team goals, individual skills, or personality. Chen and Lin (2004) report that engineering knowledge, teamwork capability, and communications skills are the foundational requirements for a successful engineering team. Forming multi-functional engineering teams, according to Zakarian and Kusiak (1999), requires an analytical alignment among members, the effective transmission of information, and organizational rewards. Others have relied on personality skills such as flexibility and empowerment, interpersonal skills, as well as technical skills (Fitzpatrick & Askin, 2005). Too often, however, teams are haphazardly constructed. Theories and practice in industry inform university practice, of course, and we see the influences in countless engineering programs.

When working collaboratively, students are significantly influenced by each other's values and attitudes, factors that influence project outcomes (George & Jones, 1997). Katzenbach and Smith (1993) suggest that through collective values and purpose, "teams develop direction, momentum, and commitment by working to shape a meaningful purpose" (p. 112). Similarly, Jones and George (1998) note that collaborative experiences and productivity are determined by "the interplay of people's values, attitudes, and moods and emotions" (p. 531) and that "one's value system determines which types of behaviors, events, situations, or people are desirable or undesirable" (p. 532).

The values held in common, those that determine the productivity and "culture" of a team, depend upon shared values *and* behaviors. In particular, common beliefs and complementary knowledge, as well as social, cultural, and physical concepts provide the collaborative foundation for teams (Mohammed & Dumville, 2001). Kotter (1992) maintains that shared values create a culture that persists over time and is difficult to change; on the other hand, a change in collaboratively agreed upon values undermines the effort and productivity of a team. The centrality of shared values is a major contributing factor to team culture (the ease and pleasure of working together) as well as productivity and longevity. The dependence between values and behaviors is nowhere more important than in situations in which knowledge sharing, problem solving, and idea generation are goals. Our research focuses quite specifically upon collaborative values and behaviors in small groups.

While instruction in sustainability that increases students' knowledge appears to have an influence on their behaviors (Courtenay-Hall & Rogers, 2002), there is research to support that instruction that tends to change students' behaviors is longer lasting (J. B. Pappas & Pappas, 2015). Encouraging environmental (or other) ideas and actions offers "opportunities" to be more sustainable, but increasing knowledge does not necessarily change values or help change behavior. We acknowledge the idea that productive change often starts with the individual and is reflected then in professional and community behavior.

Beyond knowledge retention, outcomes assessment should also focus on the values, attitudes, and behaviors of students (Shephard, 2008). Education in sustainability must engender the values and behaviors in students that allow them to make educated, sustainability informed decisions. To do this, ethics and values must be a key part of any course related to sustainability (Parkin, Johnston, Buckland, Brookes, & White, 2004). Mulder (2010) suggests that a "university education is about sharpening critical minds that are able to make balanced appraisals of their subjects of choice, and the norms and values to use in this appraisal" (p. 77). Similarly, Barth (2007) stresses the importance of instilling ownership of learning so that students can not only generate and acquire new knowledge but also reflect on their own behavior and values. To engender sustainability based individual values and behaviors, a hands-on learning module is being developed by Hayles and Holdsworth (2008) that allows students "to foster values and behaviors, deepening their understanding of the issues, and help them recognize the importance and complexity of the decisions they will be asked to make in their professional lives" (p. 29). Arbuthnott (2009) warns, however, that changed values and behaviors do not always result in an intentional change. He further stresses the importance of providing an environment that fosters individual change, and that programs should "plan education aimed at helping people translate their intentions into action" (p. 154).

2.1 Cognitive Dissonance

As early as 1957, Festinger (1957, 1962)—the first to advance this theory of motivation—noted: "The theory of cognitive dissonance centers around the idea that if a person knows various things that are not psychologically consistent with one another, he [sic] will, in a variety of ways, try to make them more consistent" (p. 1). Cognitive dissonance is noted for its controversy and simplicity, and numerous other authors have experimented with the theory (Festinger & Aronson, 1960; Festinger & Freedman, 1964; Gawronski & Strack, 2004; J. B. Pappas & Pappas, 2015).

Aronson (1969) suggests that humans are not rationale animals, but rationalizing ones who seek to *appear* rational. He further suggests that while cognitive dissonance appears to be a simple concept (and is perhaps suspicious simple for that matter), one seriously complicating matter is the *degree* of dissonance. Aronson and Mills (1959) suggest that to reduce cognitive dissonance, an individual may distort perceptions in a positive manner. While telling one's self stories may reduce cognitive dissonance, more recent research supports Festinger: "…dissonance was experienced as psychological discomfort and that this psychological discomfort was alleviated on implementation of a dissonance-reduction strategy attitude change" (Elliot & Devine, 1994, p. 382).

Stone and Cooper (Stone & Cooper, 2001) found that dissonance motivation played a part in changed behavior based on individuals' self standards in a particular social setting. The authors' research suggests it is possible to "predict the conditions under which each of the contemporary views of the self in dissonance is the most accurate explanation of the process of dissonance arousal and reduction" (p. 1).

In 2005, Matz and Wood (2005) reported on cognitive dissonance in groups. In this case, they found that disagreements with others in a group creates a discomfort which is a motivating factor in reducing dissonance in the individual group members. In a related study, Mckimmie, et al. (2003) predicted successfully that those group members who received the least support from other group members experienced greater degrees of individual dissonance, which they resolved though attitude change and reduced levels of group identification.

2.2 Values and Behaviors Collaborative Work

Hall (2005) notes that professional cultures characterize most professions and are influenced by teamwork and collaborative practices, especially values and problem solving approaches. Schwartz (1999), in a study of how national differences in cultural values influence work-related variables, found it possible to predict "risk-taking and innovation in work; managers' behaviour towards workers; decision making styles of reliance on own judgement, rules, [and] consultation with superiors or subordinates, etc." (p. 45). In an international study, Chou et al. (Chou, Wang, Wang, Huang, & Cheng, 2008) found that shared work values increased interpersonal trust among work team members and increased team member performance. In addition, the authors found that "higher levels of interpersonal trust…leads to better team members' work quality and efficiency in the workplace" (p. 1735).

Ruiz Ulloa (Ruiz Ulloa & Adams, 2004) found that student team members' attitudes were responsible for the productivity of a team, and "when mature communication, accountable interdependence, psychological safety, common purpose, role clarity, and clear goals are present during the process of teaming, the experience will have a positive effect on individuals' attitude toward teamwork" (p. 145).

In a fascinating study of four generations of workers, Twenge, et al. (2010) found that the current generation of college students does not highly value the social rewards related to team work, and that "structuring work and organizational culture around teams in an effort to recruit and retain younger workers may not be fruitful" (p. 1137).

3. Methodology

Our research focuses quite specifically upon collaborative values and behaviors in small groups. The following subsections describe the identification of value and behavior statements, the value and behavior survey, survey deployment, and population statistics.

3.1 Value and Behavior Identification

A review of the literature revealed constructive and destructive behaviors but not specific values. To identify a set of values related to the behaviors of individuals when working as a part of an engineering group, the research group utilized existing surveys and literature in the area of group roles. Key sources used during this process included the *Groups in Context: Leadership and Participation in Decision Making Groups* text which provides task roles, social/maintenance roles, and dysfunctional roles for members of the group (Wilson & Hanna, 1986), the CATME Team-Maker Instrument ("The Team-Maker / CATME website,") which uses a behavior-based rating system to assess the contributions of group members (Ohland et al., 2012), de Bono's *Six Thinking Hats* (1999) which provides idealistic group behaviors based on individual roles to drive success, and Tuckman and Jensen's "Stages of Small-Group Development Revisited," (1977) which is covered by the course text (Dym and Little's *Engineering Design: A Project-based Introduction* (2009)). It should be noted that the CATME Team-Maker Instrument is used during the junior and senior capstone design courses for self and peer evaluation purposes. The list of behaviors was generated to capture the breadth of behaviors seen in the aforementioned literature. The resultant list of behaviors was then independently evaluated by faculty in the Psychology, Integrated Science and Technology, Engineering, and Education Departments at James Madison University. This process resulted in 36 behavior statements which follow.

1) I attend group meetings.
2) I am willing to acquire the knowledge necessary to complete group tasks.
3) I always correct other people's positions.

4) I get bored easily.
5) I let the group know as soon as I know I can't keep a commitment.
6) I want to know what everyone else in my group is doing.
7) I pay attention when other people are talking.
8) I provide more information than is necessary to complete group tasks.
9) I would rather work alone.
10) I use my knowledge of group dynamics to help lead the group to success.
11) I prefer to get work done as quickly as possible.
12) I am one of the hardest workers in my group.
13) I am unable to restate other people's positions.
14) I complete group assignments for which I'm responsible on time.
15) I frequently ask questions to help clarify ideas.
16) I rely on others to provide the knowledge necessary to accomplish tasks.
17) I take the time to get to know others.
18) I rarely stand-up for my own opinions.
19) I don't like it when I am asked to clarify my positions or ideas.
20) I engage group members in my portion of the group work.
21) I am good at summarizing progress.
22) I interact with the group.
23) I don't like meeting with my small group.
24) I rarely complete my portion of the work.
25) I like to make others feel good about their contributions.
26) I respect other people's opinions.
27) I arrive prepared with the necessary materials for group meetings.
28) I do not help group mates when they are having difficulty.
29) I express myself well verbally.
30) I volunteer to take on tasks necessary to complete group work.
31) I do not verbally participate.
32) I produce high quality work.
33) I am able to suggest the next steps the group should take to complete our task.
34) I encourage the group towards success.
35) I like to solve problems in groups.
36) I listen to alternative points of view.

Behavior statements were sorted based on affinity by the research group. For each grouping of behaviors, a value was assigned. The affinity sort, not being the students' perception of how the behaviors and values map together, was then disregarded as it is students' perception of correlations between values and behaviors that is desired for the creation of personalized instructional activities. Like with the behavior statements, the list of values was independently evaluated by faculty in the Psychology, Integrated Science and Technology, Engineering, and Education departments at James Madison University. The resultant 13 value statements follow.

1) It is important for every group member to complete a fair share of the work.
2) It is important for every group member to do quality work.
3) It is important for every group member to accept responsibility for tasks required to complete work.
4) It is important for every group member to keep commitments to the group.

5) It is important for every group member to assist members who are having difficulty.

6) It is important for every group member to respect feedback from other members.

7) It is important for every group member to provide constructive feedback to other members.

8) It is important for every group member to respect and listen to the ideas and viewpoints of other members.

9) It is important for every group member to participate in group meetings.

10) It is important for every group member to communicate with other group members outside of meetings.

11) It is important for every group member to monitor and be aware of the progress of the group.

12) It is important for every group member to believe that the group will be successful.

13) It is important for every group member to acquire the knowledge necessary for the group to be successful.

3.2 Values & Behaviors Surveys

The value and behavior statements became the basis for the value and behavior surveys. Two survey instruments, one based on the 13 values and the other based on the 36 behaviors, were developed. For the value survey, students were provided the following prompt asking to rate their agreement with each value statement on a seven-point Likert scale from 1 "Strongly Disagree" to 7 "Strongly Agree."

> *Below is a listing of the group values that were discussed during ENGR ###. Please read each sentence below and indicate how much you agree with the value now that you have completed a full academic year of group work in the sophomore engineering design sequence. There are no right or wrong answers, and it is fine if your values have changed from last semester. All answers will be kept confidential.*

For the behavior survey, students were prompted to self-report on their own behaviors over the course of the prior semester on a seven-point Likert scale from 1 "Strongly Disagree" to 7 "Strongly Agree." The prompt given to the students follows.

> *This is a checklist to find out more about your specific behaviors during group situations you were placed in during ENGR ### with the human-powered vehicle design project. Some sentences will describe you better than others. Read each sentence and indicate how much it is like you by clicking on the appropriate response. There are no right or wrong answers. Your answers will be kept confidential. Remember all of the statements are meant to be a reflection on how you have acted in your group for the course.*

For each survey, the ### was changed to reflect the course in which the survey was administered. Students were not told that correlations may or may not exist between behaviors and values. Students were told in class that their answers would be anonymous and could not be used to impact their grades. Completion of the survey instruments was voluntary with no compensation or recognition provided for completion.

3.3 Survey Administration & Population Statistics

Administration of the value survey and behavior survey occurred over two years—termed AY1 and AY2 from here forward. The value survey was administered three times during the AY1 and once during AY2 to sophomore engineering students. Students given the value survey were asked to rate on a scale from one to seven how strongly he or she regards the value. The Behavior Survey was only administered with the Value Survey, which occurred twice during AY1 and once during AY2 to sophomore engineering students. Students given the behavior survey of 36 questions were asked to rank each item based on their behavior as a member of an engineering team.

In total, there were four survey deployments. The first survey deployment, which occurred during week 3 of AY1-Fall, contained only the values survey and was deployed as a baseline on the students' values since the students had not yet begun to work in their engineering groups. The second and third survey deployments (once during Week 16 of AY1-Fall semester and again during Week 16 of AY-Spring) contained the behavior survey in addition to the value survey. An additional deployment of both the value and behavior surveys occurred during AY2 to increase the sample size with a similar population as the first deployment.

All students who participated in the survey were enrolled in Engineering Design I and/or Engineering Design II and were declared engineering majors. Details on the administration times and survey participants follow in Table 1.

Table 1. Details on Administration and Participants

Time Point	Week during the semester	Course	Administration Method	N	Survey
1	Week 3 Fall-AY1	ENGR Design I	Paper in-class	74	Value
2	Week 16 Fall-AY1	ENGR Design I	Online out-of-class	52	Value & Behavior
3	Week 16 Spring-AY1	ENGR Design II	Online out-of-class	28	Value & Behavior
4	Week 16 Spring-AY2	ENGR Design II	Online out-of-class	44	Value & Behavior

During the AY1 academic year, the survey was administered twice during Engineering Design I—once when students were placed on their course groups and a second time at the conclusion of the course. For both Spring-AY1 and Spring-AY2, during Engineering Design II, the survey was administered only once—at the conclusion of the course. The second administration of the survey during Engineering Design I was intended as a mid-academic year data point. All presented results are based on the four survey deployments.

Engineering Design I and Engineering Design II are the first two classes in the six-course engineering design sequence at James Madison University. The relatively new James Madison University (JMU) engineering program was designed to train the Engineer of 2020 (National Academy of Engineering, 2004, 2005). The program was developed from the ground up to not be an engineering discipline-specific program, but instead to provide students training with an emphasis on engineering design, systems thinking, and sustainability while also providing a strong foundation in engineering science (O. Pierrakos, Kander, Pappas, & Prins, 2008). The vision of the program is to produce cross-disciplinary engineer "versatilists."

At the heart of the program is the aforementioned six-course engineering design sequence which provides instruction on design theory (e.g., thinking, process, methods, tools, etc.), sustainability, ethics, group management, and technical communication (both oral and written), while incorporating elements of engineering science and analysis (R. L. Nagel, Pierrakos, Pappas, & Nagel, 2012; O. Pierrakos, Pappas, Nagel, & Nagel, 2012). Students apply design instruction in the context of two projects during the six-course sequence—the sophomore design project spanning both the fall and spring semesters of the sophomore year (which is where the values survey was administered) and the capstone project spanning the junior and senior academic years. Following the sophomore design experience, students have the opportunity to "specialize" their degree through the selection of their two-year capstone project and their technical electives. Some students choose a very specific path with the desire to enter a particular field of study in graduate school, while others choose to remain non-discipline specific.

It is during the sophomore design experience where student's paths are most common, and consequently, the sophomore experience is the ideal time in our students' academic careers to study their values related to individual behavior on groups. Students have two different group experiences during the sophomore design sequence (J. Nagel, Nagel, Pappas, & Pierrakos, 2012; R. L. Nagel et al., 2012). During Engineering Design I, students work in groups of three and four, which tends to be most similar to prior group experiences (if the students report having prior group experiences). During Engineering Design II, however, students work in groups of eight or nine, which pushes the group to adopt project and group management tools to continue working toward a successful project. Those groups that fail to manage their group along with the project, tend to struggle to balance the two and have difficulty completing the course project.

SAS 9.3 was used to analyze all data collected from this study.

4. Results

This study sought to answer four research questions. With respect to question one, factor analysis indicates that a single value related to individual behavior with respect to group work is most probable, and with respect to question two, results indicate that for the AY1 academic year student cohort, students' values placed on the behavior of individuals in engineering groups likely remained stable through the academic year.

The third and fourth research questions focused on the correlations between values and behaviors. Based on the second Fall-AY1 survey deployment, five behaviors correlate to this single group-work value: I attend group meetings, I am willing to acquire the knowledge necessary to complete group tasks, I complete group assignments for which I'm responsible on time, I frequently ask questions to help clarify ideas, I like to make others feel good about their contributions. Four behaviors correlated to the single group-work value when looking at the Spring-AY1 and Spring-AY2 combined data: I provide more information than is necessary to complete group tasks, I interact with the group, I like to make others feel good about their contributions, and I respect other people's opinions. With respect to research question four, all behaviors have either low or moderate correlations. No high correlations were identified.

The following four subsections describe the analysis and results for each of these four research questions.

4.1 Research Question 1: Are there correlations between group-based values?

Table 2 contains the descriptive statistics for the 13 value items averaging across all three time points. In evaluating univariate normality, all items are notably negatively skewed, and some item distributions were highly leptokurtic. Because non-normal items can affect the factor solutions obtained from Pearson correlations, polychoric correlations were estimated. Polychoric correlations assume a continuous, normal distribution underlies the non-continuous or non-normal observed variables (Muthén & Kaplan, 1985).

Due to the nature in which the value scale used in the value survey was generated, there are no grounds to assume any number of factors underlie the observed variables. It is, however, probable that the students conceptualize these items supposing to measure a "group work value" as one or a few different dimensions rather than 13 different dimensions arrived at by the research group.

First, Time Point 1 data (N = 74) were evaluated to determine the amenability of the items to a factor analysis. This sample was used to assess factor structure as it was the largest sample of the three and would provide the most stable solution. The Factor 8.1 program (Lorezo-Seva & Ferrando, 2012) was used to calculate Bartlett's test and the Kaiser-Meyer-Olkin (KMO). The null hypothesis of Bartlett's test states that the variables are unrelated in that no factor solution can reduce the data. This null was rejected (χ^2 (78) = 596.1, $p < .001$), supporting the notion that these data can be reduced. The KMO for these data was 0.964 which is considered to be "marvelous" according to Kaiser (Kaiser, 1974). Both of these tests indicate that the data are amenable to factoring; the decision now is how many factors to extract.

Table 2. Descriptive Statistics for Value Scale Items

	Mean	SD	Skewness	Kurtosis
Value 1	6.20	1.09	-3.01	13.06
Value 2	6.70	0.88	-6.10	42.95
Value 3	6.53	0.92	-4.96	32.10
Value 4	6.50	0.90	-5.06	33.68
Value 5	5.91	1.06	-2.61	11.75
Value 6	6.24	1.02	-3.34	16.83
Value 7	5.95	1.13	-2.43	9.40
Value 8	6.51	0.96	-4.52	26.58
Value 9	6.28	1.02	-3.46	17.65
Value 10	5.85	1.32	-2.66	8.91
Value 11	6.00	1.05	-2.89	13.04
Value 12	6.35	1.05	-3.41	16.65
Value 13	6.30	0.95	-3.94	23.29

Note. Students responded to each item on a 7-point Likert scale from 1 "Strongly Disagree" to 7 "Strongly Agree."

A parallel analysis (Horn, 1965) and a scree plot evaluation were conducted to determine the number of factors to extract from the data. In a parallel analysis, the observed eigenvalues of the data are compared to randomly generated eigenvalues from several matrices of the same structure. If the observed eigenvalues are greater than those obtained randomly, then the number of factors for that eigenvalue should be extracted. The parallel analysis was conducted using the Factor 8.1 program (Lorezo-Seva & Ferrando, 2012). The observed eigenvalue for one factor is greater than the mean eigenvalue in the randomly generated data and the 95th percentile of these randomly generated eigenvalues. The second eigenvalue, however, is not different from a random series of eigenvalues which means that a one-factor solution is most tenable (i.e., the students do indeed conceptualize that all of the values measure a single "group work value"). The results from the parallel analysis indicate that a one-factor solution is most probable due to the difference between the observed eigenvalues for the first and second roots are provided in Table 3. This first factor accounted for 60.6% of the variance in the value items.

Table 3. Parallel Analysis Results

		Random Eigenvalues	
Root	Observed Eigenvalues	Means	95th %ile
1	7.877	1.770	1.957
2	0.676	1.551	1.684
3	0.630	1.397	1.505
4	0.569	1.272	1.366
5	0.491	1.156	1.238
6	0.478	1.049	1.124
7	0.418	0.954	1.026
8	0.379	0.862	0.931
9	0.366	0.774	0.848
10	0.318	0.686	0.761
11	0.296	0.599	0.670
12	0.269	0.512	0.590
13	0.231	0.417	0.499

The finding that a single group work value likely results from the factor analysis provides some validity for the value statements when used with this population of engineering students. Also, knowing that a single group work value is probable allows the remaining research questions related to correlating values and behaviors to focus on identifying correlations to the single resultant group work value.

4.2 Research Question 2: Do students' values with respect to group behavior's change while working on a group-based design project?

Total value scores were calculated for each student during each time point. Descriptive statistics for the value scores are found in Table 4. Total value score at each time point appear normally distributed and resulted in satisfactory internal consistency (α = .85). One student at Time Point 2 was identified as an outlier and removed as the student clearly did not pay attention to the polarity of the scale. An Analysis of Variance (ANOVA) was run on the total value scores across the three time points (Fall-AY1 – Week 3, Fall-AY1 – Week 16, and Spring-AY1 – Week 16) with the data from the 74 students who completed items at time point one, the 52 students at time point two, and the 28 students at time point three. From this analysis, it was found that the homogeneity of variances assumption was upheld (F (151) = 2.42, p = 0.09), and the mean value scores did not differ significantly across time (F (2, 151) = 0.73, p = 0.48). These results indicate that for this AY1 student cohort, students' values placed on the behavior of individuals in engineering groups likely remained stable through the academic year.

Table 4. Total Values Scores by Time Point

Time Point	*N*	Mean	SD	Skewness	Kurtosis
1	74	82.34	5.52	-0.339	-0.626
2	52	81.75	7.04	-0.451	-0.162
3	28	83.50	6.18	-0.320	-1.301

4.3 Research Question 3: Do self-reported, group-based behaviors predict group-based values?

In order to evaluate what behaviors provide the best relative contribution to values, a multiple regression model was run with student value scores as the dependent variable and the 36 behaviors statements as the independent variables. Two students did not finish the behavior survey, so 51 students were used in the regression analysis. The omnibus F-test for the model was significant (F (36, 14) = 5.25, p < .001) and explained a large portion of the variance in values scores (R^2 = 0.93). Not all variables in the model were significant in predicting variance in student value scores. After examining the tests of the unstandardized regression weights for each variable, only eight of them were significant, producing an R^2 of 0.66. After fitting this reduced model to the data again, three behaviors were no longer significant, leaving five behavior statements that predicted value scores well (F (5, 45) = 14.75, $p < .001$, R^2 = 0.62). Table 5 provides the model and the five behaviors noted as correlating to the single group-work value identified as a result of Research Question 2.

Table 5. Regression Model for Fall-AY1 ENGR 231 Sample

Variable	b	SE (b)	β	t	p	sr^2
Intercept	8.73	10.42	0	0.84	0.406	--
1. I attend group meetings.	5.30	1.74	0.35	3.05	0.004	0.253
2. I am willing to acquire the knowledge necessary to complete group tasks.	4.27	1.99	0.29	2.14	0.038	0.039
14. I complete group assignments for which I'm responsible on time.	-2.85	1.05	-0.32	-2.71	0.010	0.033
15. I frequently ask questions to help clarify ideas.	2.34	0.64	0.36	3.65	0.001	0.117
25. I like to make others feel good about their contributions.	2.36	0.71	0.34	3.33	0.002	0.180

Note. b = unstandardized regression weight, β = standardized regression weight, sr^2 = semi-partial squared correlation.

The semi-partial squared correlation (sr^2) is the amount of unique variance that each predictor explains in value scale scores. Note that most behaviors relate positively with values scores, holding all other variables in the model constant. Interestingly, one behavior statement (14) related negatively with value scores after controlling for the other variables in the model. This may be due to a suppression effect given that behavior statement 14 is correlated only slightly with the value scores (r = 0.12) but moderately with the other predictors (e.g., r = .54).

A total of 28 students completed the values and behaviors survey in the spring. With only 28 students completing the 36 behavior items, the regression model predicting values scores did not converge. To increase the sample size, students enrolled in ENGR 232 during the AY2 academic year were asked to complete the values and behavior survey at the same time point in the semester as the prior year's cohort. The combined sample was 76 students who attempted the values and behaviors survey in the spring. As in the fall, the primary research question concerns what behaviors relate with a student's values. Another multiple regression model was run with student value scores as the dependent variable and the 36 behaviors statements as the independent variables. Six students (combined between Spring-AY1 and Spring-AY2) did not finish their survey, so 69 students were used in the regression analysis. The omnibus F-test for the model was significant (F (36, 32) = 2.24, p = .011) and explained a large portion of the variance in values scores (R^2 = 0.72).

As in the fall sample, not all variables in the model were significant in predicting variance in student value scores for the spring sample. After examining the tests of the unstandardized regression weights for each variable, only six of them were significant, producing an R^2 of 0.50. After fitting this reduced model to the data again, two behaviors were no longer significant, leaving four behavior statements that predicted value scores well (F (4, 64) = 14.23, $p < .001$, R^2 = 0.47). This model is presented in Table 6 with column one listing the four behaviors noted as correlating with the single group work value identified as a result of Research Question 1. Consequently, with respect to research question three, five behaviors have been identified which contribute significantly to the "group work value" for the fall-AY1 small group dataset while four behaviors have been identified for the spring-AY1/AY2 large group dataset.

Table 6. Regression Model for Spring-AY1 and Spring-AY2 Samples

Variable	b	SE (b)	β	t	p	sr^2
Intercept	27.70	8.05	0	3.44	0.001	--
8. I provide more information than is necessary to complete group tasks.	1.39	0.46	0.30	3.01	0.004	0.120
22. I interact with the group.	2.76	1.05	0.27	2.64	0.011	0.182
25. I like to make others feel good about their contributions.	2.02	0.79	0.27	2.55	0.013	0.055
26. I respect other people's opinions.	3.04	1.13	0.28	2.69	0.009	0.129

Note. b = unstandardized regression weight, β = standardized regression weight, sr^2 = semi-partial squared correlation.

4.4 Research Question 4: How do student's self-reported behaviors correlate to their values?

In order to understand the correlations between behaviors and values, Pearson's correlations were calculated between each behavior item, and the single value related to individual behavior with respect to group work was identified as a result of research question 2. Pearson's correlations were calculated using the Fall-AY1 data set with 51 students and with the combined Spring-AY1 and Spring AY2 data sets with 66 students. Table 7 provides calculated Pearson's correlations.

Table 7. Pearson Correlations with Value Scale by Sample

Behavior Item	Fall-AY1 (N=51)	Spring-AY1 & Spring-AY2 (N = 69)
1. I attend group meetings.	**0.503**	0.220
2. I am willing to acquire the knowledge necessary to complete group tasks.	**0.510**	0.332
3. I always correct other people's positions.	0.027	0.022
4. I get bored easily.	-0.243	-0.297
5. I let the group know as soon as I know I can't keep a commitment.	-0.032	0.171
6. I want to know what everyone else in my group is doing.	0.321	0.182
7. I pay attention when other people are talking.	0.373	0.357
8. I provide more information than is necessary to complete group tasks.	0.273	0.341
9. I would rather work alone.	-0.278	-0.074
10. I use my knowledge of group dynamics to help lead the group to success.	**0.459**	0.359
11. I prefer to get work done as quickly as possible.	-0.290	0.128
12. I am one of the hardest workers in my group.	0.063	0.347
13. I am unable to restate other people's positions.	-0.080	-0.204
14. I complete group assignments for which I'm responsible on time.	0.118	0.277
15. I frequently ask questions to help clarify ideas.	**0.425**	0.266
16. I rely on others to provide the knowledge necessary to accomplish tasks.	-0.063	-0.233
17. I take the time to get to know others.	0.326	0.127
18. I rarely stand-up for my own opinions.	-0.092	-0.283
19. I don't like it when I am asked to clarify my positions or ideas.	-0.242	-0.168
20. I engage group members in my portion of the group work.	0.169	0.057
21. I am good at summarizing progress.	0.292	0.074
22. I interact with the group.	0.249	**0.497**
23. I don't like meeting with my small group.	-0.302	-0.145
24. I rarely complete my portion of the work.	-0.119	-0.294
25. I like to make others feel good about their contributions.	**0.526**	0.498
26. I respect other people's opinions.	**0.457**	0.372
27. I arrive prepared with the necessary materials for group meetings.	0.398	0.244
28. I do not help group mates when they are having difficulty.	-0.382	-0.367
29. I express myself well verbally.	0.201	0.187
30. I volunteer to take on tasks necessary to complete group work.	0.270	0.351
31. I do not verbally participate.	-0.267	-0.296
32. I produce high quality work.	0.329	0.152
33. I am able to suggest the next steps the group should take to complete our task.	0.079	0.264
34. I encourage the group towards success.	0.356	0.393
35. I like to solve problems in groups.	0.206	0.256
36. I listen to alternative points of view.	**0.453**	0.403

In Table 7, eight correlations, denoted with bold text, were noted to be at a moderate level (0.4 to 0.6). Of those with moderate correlations, just two, *I like to make others feel good about their contributions* and *I listen to alternative points of view*, correlated during both the fall and spring semesters. None of the behaviors correlated at a high level.

5. Discussion & Implications

As stated in the Introduction, developing sustainable individuals is a crucial component of this research. Through self-awareness and the development of an engineering identity, we hope to educate students who can work and function as productive members of their engineering group. Specifically, in this paper, the results of research related to student values and behaviors with respect to engineering groups were explored, and four key research questions were posed.

5.1 Research Questions

With respect to research question one, *Are there correlations between each of the value statements,* based on both the scree plot and parallel analysis performed, a single value related to individual behavior with respect to group work is the most tenable. In other words, all of the value statements correlate to a single group-work based value. As stated in the Results, this finding indicates that for the student population who completed the values survey, all of the values correlated to a single group work value. This result is as anticipated, and consequently, provides some content validity (Kerlinger, 1964) that all of the value statements do indeed relate to group work values when used with this particular population of students.

Further, with respect to research question two, *Do students' values with respect to group behaviors change while working on a group-based design project,* the analysis indicates that for this student population, students' values placed on the behavior of individuals in engineering groups likely remained stable through the academic year. *This result supports our first hypothesis that the students' values with respect to the behavior of individuals on a group will remain stable through the academic year.* This is a positive finding, as we see that students seem to maintain their values even when their group environment changes (i.e., transitioning from a group of three or four in the fall semester to a group of nine or ten in the spring semester). Consistency in values will be important as students are placed in dissonance as this indicates that students will be less likely to change their values when confronted with their won incongruent behaviors.

We also can note that the students' self-report having strong values with respect to the values statements. The average score for all values, all students, all survey deployments is 6.25 with a high value of 6.7 and a low of 5.85. This seems to support the starting premise for our research: *Students generally embrace admirable values, but often encounter a "cognitive dissonance" when asked to explain whether their actions accurately reflect their values* (Ballantyne & Bain, 1995).

During the two semesters when this study was being performed, students were also asked to self-report on their behaviors based on the 36 aforementioned behavior statements. The third research question asked if these *self-reported, group-based behaviors predict group-based values.* Knowing if there is correlation between the group-based behaviors and the group-based values will provide insight into where there might be behavioral weaknesses, and consequently, which behaviors to target with course interventions. From the fall semester data, five behaviors were identified which predicted the student values. Those behaviors include: I attend group meetings, I am willing to acquire the knowledge necessary to complete group tasks, I complete group assignments for which I'm responsible on time, I frequently ask questions to help clarify ideas, and I like to make others feel good about their contributions. As stated above, four behavior statements correlate positively, while one behavior statement, *I complete group assignments for which I'm responsible on time*, unexpectedly correlates negatively. It is speculated that this negative correlation may be due to a suppression effect given that behavior statement is correlated only slightly with the value scores but moderately with the other predictors. From the spring semester data, four behaviors were identified which predict the student values. Those behaviors include: I provide more information than is necessary to complete group tasks, I interact with the group, I like to make others feel good about their contributions, and I respect other people's opinions. In the spring data set, all behaviors had positive correlation.

With respect to our second hypothesis, *there will be behavioral predictors to group-based values,* behavioral predictors to group-based values are noted in the data, but since only one behavior remains consistent between semester one and two, there seems to be other factors influencing student behaviors and the behaviors' relationships to values. It is speculated, that this change in the behaviors noted by the group as important could be a result of the transition from a small group of three or four students to a larger group of nine or ten students. In end-of-year reflection statements, students often comment that managing the larger group is more difficult and more time consuming than maintaining the small group. With the larger group, students must spend more time keeping the group dynamic positive versus in the smaller group. The behavior correlations noted in the analysis seem to support these statements noted in the student reflections.

Research question four sought to understand the correlations *between student's self-reported behaviors and their values.* Pearson correlations are provided for fall (small group) and spring (large group) data sets. Assuming an absolute scale where 0 to 0.3 are small correlations, 0.4 to 0.6 moderate correlations, and 0.7 to 1.0 high correlations, high correlations are not noted between behaviors and values in the data set. Medium correlations are noted for the following behaviors during the fall semester: I attend group meetings, I am willing to acquire the knowledge necessary to complete group tasks, I use my knowledge of group dynamics to help lead the group to success, I frequently ask questions to help clarify ideas, I like to make others feel good about their contributions, I respect other people's opinions, and I listen to alternative points of view. Three behaviors have medium correlations for the spring semester dataset; those are: I interact with the group, I like to make others feel good about their contributions, and I listen to alternative points of view. Finally, two behaviors correlate at a medium level during both fall and spring: I like to make others feel good about their contributions and I listen to alternative points of view. Interestingly the behavior, *I like to make others feel good about their contributions*, was also noted as a predictor.

5.2 Implications & Future Directions

A critical component of the Engineering Design 1 and Engineering Design 2 courses where this study was carried out is the development of identity and community among a cohort of students. The sophomore design course sequence contains a year-long, immersive, design/build course project that exposes the students to an experience that transcends the classroom, and in the process, teaches the students that they are part of a larger complex system. Through this very-real project students, as representatives of the University and the Department, see first-hand how their decisions and actions as engineers can (and likely will) influence individuals as members of society (i.e., they are a member of a system of systems). For many students, this project is their first realization of social systems and their future role as a member of a social system as a practicing engineer.

Interestingly, in this study, the behaviors that repeatedly correlated or predicted positive group values were related to interpersonal skills rather than knowledge or learning. Students' data correlate behaviors related to listening, attending meetings, valuing group member correlations, and respecting opinions as the most important behaviors with respect to the group values—all key characteristics of both individual and social sustainability as defined in the Introduction. These skills, however, are not normally those skills taught in an engineering program where the emphasis is typically the knowledge and content. This finding is important as it points to a necessity to foster strong interpersonal skills among students. Students need to recognize that how they interact with their group is just as important as the skills being brought to the group, and knowledge of behavior and value mappings will allow for development of course instructional activities that target group-based behavioral weaknesses. Course activities will be developed around this concept of dissonance and will be used to foster positive group behaviors and build group cohesion among students with the overarching goal of teaching students to function as a member of a multidisciplinary group (i.e., allowing us to more effectively meet ABET Outcome D (2010) during design courses).

It is important that instruction teaches not only knowledge and skills, but also instills behaviors in students. This is especially true in social sustainability and individual sustainability, as one's behavior—both individually and as a member of a group—is a critical component of each. Beyond self-assessment and reflection, students must recognize the alignment or lack of alignment between values and behavior. This lack of alignment, termed cognitive dissonance, has not yet been explored, and consequently, two areas of future work will next be explored. The first will be to investigate the impact of cohesion on an engineering group. The second will focus on making students aware of dissonance and encouraging them to balance more effectively the self-knowledge that informs decision making and problem solving.

Toward these future research directions, our overarching goal is to create personalized learning to encourage students toward intentional change fostering a positive, harmonious community environment among each engineering cohort. Pedagogical models have been trialed by the research team using the PersonalityPad.org framework (E. Pappas, Pappas, Benton, & Keith, 2015). Using Personality Pad, individuals can receive multi-source feedback for a "Big Five" personality dimension: (1) Real Self: How conscientious you think you are, (2) Ideal Self: How conscientious you would like to be, (3) Friends and Family Average: How conscientious your friends and family think you are, (4) Peer Real: How conscientious your peers think they are, and (5) Peer Ideal: How conscientious your peers would like to be (E. Pappas et al., 2015). As a pedagogical tool incorporated into the classroom, the multi-source framework used by PersonalityPad.org creates an immersive learning approach that places students directly in cognitive dissonance, not only with where they would like to be with their conscientiousness, but also, how others see they with respect to their conscientiousness. Students use this dissonance as motivation toward creating and following through on action plans to improve their conscientiousness with the overarching goal of increasing students individual sustainability.

Following the model explored using Personality Pad, students in Engineering Design 1 and Engineering Design 2 will record their values toward the behaviors of individuals working on an engineering group (demonstrated by this study to remain constant through the academic year) at the start of the academic year. Periodically through the year, students will be asked to self-rate their behaviors as well as the behaviors of the team members. Reports will be generated based on these ratings showing students their value ratings, their self-report behavior ratings, and their group-report (as an average) behavior ratings. Students will be asked to reflect on the discrepancies and to develop a strategy for improvement. It is anticipated that this process will cause cognitive dissonance for many of the students, and consequently, students will need to be guided through the process of reflecting and strategizing improvement. Without guiding the students, it is hypothesized that students may develop distrust of their peers, and with respect to group dynamics, more harm than benefit may result. Knowing that the students inherently understood that the behaviors mapped to the values is the first step toward developing this pedagogical approach.

Toward this goal, it is also then important that teams have strong, well-develop team dynamics prior to engaging in the multi-source feedback from group members—especially since group members are often assigned and not chosen in engineering classes. For example, consider that the Personality Pad framework uses friends and family as sources for multi-source feedback (E. Pappas et al., 2015). Consequently, development of group cohesion becomes an important next step prior to implementing the aforementioned multi-source feedback tool. Castaño et al. (2013), drawing from Festinger (1950) and Mudrack (1989), defines cohesion as "the 'field of forces interacting to keep a group intact" (p. 209) which may be "represented by a group that is *bonded* and *sticks* together" (p. 209). Cohesion is defined by three variables, (1) Interpersonal Attraction which may be defined as "a shared liking for or attachment to the members of the group" (Beal, Cohen, Burke, & McLendon, 2003, p. 995), (2) Task Commitment which may be defined as "the extent to which the task allows the group to attain important goals or the extent to which a shared commitment to the group's task exists" (Beal et al., 2003, p. 995), and (3) Group Pride which may be defined as "the extent to which group members exhibit liking for the status or the ideologies that the group supports or represents or the shared importance of being a member of the group" (Beal et al., 2003, p. 995). With respect to social sustainability, we consider Interpersonal Attraction and Group Pride as being directly correlated, and future studies will explore this linking.

6. Conclusions

This paper has presented the results of a study toward understanding how students value the behavior of individuals when acting as a member of an engineering group. To support the results presented, two survey instruments are provided: one for exploration of student values toward small group behaviors and a second for self-assessment of the behaviors.

Our findings agree with literature on societal groups which indicates that values should remain constant; we see here with our cohort of students that values not only remain stable, but also, students maintain high agreement with the 13 values through the academic year. Further, we identified five behaviors which correlate to the "group work value" for the fall-AY1 small group dataset and four for the spring-AY1/AY2 large group dataset. More trials would be required to understand if this is related to team size or not. Additional key limitations of this study include: sample size, a single institution sample, engineering-only cohort, and self-reporting without external validation.

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