

Basic Psychological Need Fulfillment by Gender in Team Environments

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Abstract— This Research Work in Progress seeks to assess to what extent students' genders are correlated with how they experience the satisfaction of their basic psychological needs (autonomy, competence, and relatedness) within engineering student project teams. In particular, it asks: are female students more likely to experience a deficit of any of these psychological needs compared to male students in the student project team environment?

This work is grounded in self-determination theory, which suggests that motivation exists not just in the binary (motivated or not), but rather in a continuum from extrinsic to intrinsic motivation. Intrinsic motivation, the type most associated with positive learning outcomes, is supported for an individual when their particular environment meets their basic psychological needs. Basic psychological need fulfillment is the extent to which an individual experiences autonomy, competence, and relatedness to others in a particular context. A survey tool from the literature (Basic Psychological Need Satisfaction Scale) was modified for this study to map students' basic psychological needs "profile" *within the team environment* to their genders. This 21-item scale gives students an interval score between 1 and 7 for each subscale: autonomy, competence, and relatedness. Data have been collected from 89 undergraduate students enrolled in a class involving a long-term group project component. To answer the research question, k-means clustering techniques and t-tests are used to explore the relationships between gender and motivation.

Keywords—Teamwork, gender, motivation

I. INTRODUCTION

Students participating in long-term team projects will inevitably be motivated in different ways. Some may be intrinsically interested in the topic, some may strive for a high grade point average (GPA), and still others may simply not see the connection between their own effort and desired outcomes at all. Instructors can support the extent to which individuals are motivated intrinsically by supporting students' autonomy, competence, and relatedness within the team environment. Still, students may experience these constructs at different levels due to their own identity. This study examines whether student gender correlates with the extent to which they experience these three constructs.

II. LITERATURE REVIEW

Group work is an essential component of engineering classrooms. Studies have shown that working in small groups

promotes greater academic achievement, more favorable attitudes toward learning, and increased persistence [1]. Group work is also thought to prepare students for the "real world" in engineering industry, where teamwork is prevalent. Graduates of engineering programs have reported that learning how to work in multidisciplinary teams was a key aspect of their post-graduate industry positions, spending 60-80% of their time working on a team with other engineers [2]. A key reason for this is that working on teams allows larger engineering challenges to be tackled than one engineer alone could have completed. Instructors may also want students to learn from one another – one student may have strengths, knowledge, or skills another does not – and thus the quality of the final product can be enhanced.

The theory of motivation underpinning this research is self-determination theory (SDT). SDT "views humans as inherently oriented toward actualizing their capabilities"[3]. Though colloquially people often express motivation as a binary state (either motivated or unmotivated), SDT describes a continuum of motivations according to the entity "determining" the activity: from complete lack of motivation (amotivation) to extrinsic motivation (determined by an external stimulus) to intrinsic motivation (determined by the self) (Figure 1). [4] **Intrinsic motivation** is the "inherent tendency to seek out novelty and challenges, to extend and exercise one's capacities, to explore, and to learn" [5]. Intrinsic motivation is linked with promoting creativity and improved performance on tasks, both of which relate directly to positive educational outcomes [6]. **Extrinsic motivation** occurs when an activity is performed to achieve some external outcome. For example, a student might take a class they find uninteresting because they believe it will improve their GPA or help them get a job. **Amotivation** describes a complete lack of motivation, typically due to an individual not seeing the connection between their actions and desired outcomes.

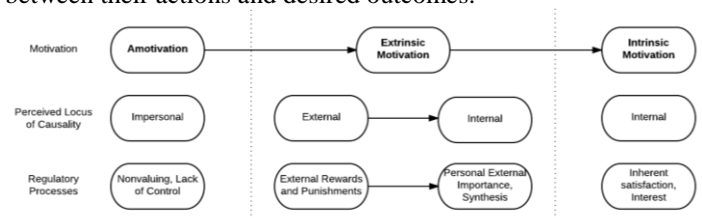


Figure 1: Simplified [5] Self-Determination Continuum

Processes like intrinsic motivation support the actualization of one's capabilities, but the environment a person is situated in can help or hinder this development. The "helping" aspects include the extent to which an individual feels autonomy, competence, and relatedness within that environment. **Autonomy** refers to the extent to which a person has the freedom to choose their own goals and activities. **Competence** is the extent to which a person feels capable of doing the things he or she has set out to achieve. **Relatedness** is how much a person feels connected to and cared for by others in their immediate reality. These three aspects are known as *basic psychological needs*, and account for variability in levels of intrinsic motivation. They have been shown to be innate and universal to all people (though in different amounts), regardless of gender, class, or whether people consciously rate these needs as being important to them [5]. The satisfaction of these needs is associated with positive outcomes such as adaptive psychological functioning and health behavior changes. Basic need satisfaction in all three arenas consistently predicts wellbeing and flow, a state of intrinsically-rewarding complete absorption in one's endeavors. [5], [7], [8] Subtheories of Self-Determination Theory, including Basic Psychological Needs Theory, suggest that psychological wellbeing and optimal functioning depend on an environment that supports each of these needs. Intrinsic motivation itself is predicated on these three factors being present in an environment. [5]

III. METHODS

The Basic Psychological Need Satisfaction Scale is a 21-item questionnaire based in self-determination theory that assesses the extent to which an individual's need for autonomy, competence, and relatedness to others is met within a particular context. The general scale has been modified to fit a variety of different contexts including but not limited to the work and relationship domains [9]-[11]. For the purposes of this study, the general scale was modified to fit the classroom team domain. Respondents answered each item on a scale from 1 (not at all true) to 7 (very true). Seven items correspond to the autonomy construct, six items to the competence construct, and eight items to the relatedness construct. A composite score for each subscale (i.e. autonomy, competence, relatedness) is obtained by first reverse scoring the items that are phrased negatively and then averaging the items on the relevant subscales. As such, the output of this questionnaire are three scores ranging from 1 to 7 for each subscale.

Upon review of the data, 100% of the participants answered more than half of the questions per construct (4 items for autonomy, 4 items for competence, and 5 items for relatedness). Given the pattern of missing values it was reasonable to assume that questions listed as missing were due to students agreeing with the preset custom start position of the slider. Thus, all missing values were recoded with the value corresponding to that question's custom start position. After recoding, there were assumed to be no missing values.

In total, 89 unique respondents completed the survey at a mid-sized southern university. These students had an average age of 21.07 (with five students not giving their age). Table 1 highlights the relative proportions of male and female participants by race, year in school, and major. In groups with higher n values (white students, fourth years, and students from biomedical or systems engineering), the percentage of students who are male and female are close to 50%. This gender parity was specific to the study, as the engineering school at the University of Virginia is 34% female as a whole. [12] Furthermore, the classes recruited for this study were specifically project design classes. The structure of students in each school year is a result of the curriculum. Most students do not take classes with long-term project components until their third or fourth year. ENGR 1420 is one of the few project classes offered to first years and is open only to a specific group of students from a scholar program.

Table 1: Participant demographic counts by gender

	n	Female	Male
OVERALL	89	50.6%	49.4%
RACE			
Other	3	66.7%	33.3%
Black	3	100%	0%
Asian	15	53.3%	46.7%
White	68	48.5%	51.5%
YEAR IN SCHOOL			
4+	3	100%	0%
Fourth year	60	45%	55%
Third year	20	65%	35%
Second year	0	0%	0%
First year	6	50%	50%
MAJOR			
Aerospace Engineering	4	25%	75%
Biomedical Engineering	37	48.6%	51.4%
Civil Engineering	6	100%	0%
Computer Engineering	3	33.3%	66.7%
Engineering Science	3	33.3%	66.7%
Mechanical Engineering	8	37.5%	62.5%
Systems Engineering	28	53.6%	46.4%

IV. RESULTS AND DISCUSSION

For each of the Basic Psychological Need Scale's three subscores, 2-sample t-tests examine differences between scores for males and females. The assumption of independent data is met. Using Levene's test and multiple comparisons, equal variances between men and women were ascertained for all three constructs. Anderson-Darling tests reveal a normal distribution for autonomy (AD=0.26, p=0.71) and competence (AD=0.49, p=0.22) and a non-normal distribution for relatedness (AD=1.3, p<0.01). However, the shape of the

histograms and skew and kurtosis values (<1.0) still suggest normality, and as this test is robust to minor departures from normality, the assumptions were considered met.

Autonomy scores for females had a mean of 4.91 and standard deviation of 0.81, while males had a mean of 4.94 and standard deviation of 0.79. 2-sample t-tests conducted using autonomy as the response and gender as the factor showed no statistically significant difference between the levels of autonomy experienced within the team context for males and females ($p=0.84$). Competence scores for females had a mean of 4.23 and standard deviation of 0.76, while males had a mean of 4.19 and standard deviation of 0.73. At a significance level of $\alpha=0.05$, t-tests did not show a statistically significant difference between levels of competence experienced within the team context for males and females ($p=0.80$). Relatedness scores for females had a mean of 5.17 and standard deviation of 0.84 while males reported a mean of 5.20 and standard deviation of 0.83. Similarly, no statistically significant difference between levels of relatedness to others on the team emerged for males and females ($p=0.88$).

Autonomy, competence, and relatedness scores are interrelated, however. To examine how these three measures might correspond to one another for the participants, k-means clustering was employed. While hierarchical clustering aims to achieve the optimal step at each cluster fusion, k-means seeks a global goal: optimization of the variance of the clusters. It was preferred to other hierarchical clustering methods because (1) greedy algorithms may result in a non-optimal solution by attaining a local versus global optimum, (2) hierarchical methods take comparatively more computing time, (3) k-means centroids are more easily interpretable than some hierarchical linkage methods like Ward's because it is space-conserving and (4) because data were continuous and numerical without need for further flexibility. [13]

After considering different numbers of clusters by examining the matrix scatterplots (Figure 2), six proved to most appropriately balance interpretability of the model with representative complexity of the associated basic psychological need profiles.

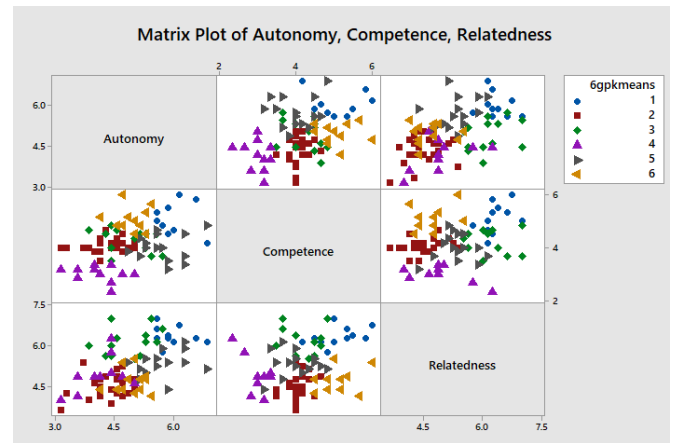


Figure 2: Matrix Plot of Six Clusters of Autonomy, Competence, and Relatedness

Qualitatively, these classes (Figure 3) can be defined as follows:

1. **Balanced, High** – High autonomy, High competence, High relatedness
2. **Balanced, Average** – Medium-low autonomy, Medium competence, Medium-low relatedness
3. **High Relatedness** – Medium autonomy, Medium competence, Medium-high relatedness
4. **Balanced, Low** – Medium-low autonomy, Low competence, Medium-low relatedness
5. **High Autonomy** – Medium-high autonomy, Medium competence, Medium relatedness
6. **High Competence** – Medium autonomy, Medium-high competence, Medium-low relatedness



Figure 3: Classes of basic psychological need profiles

Figure 3 is based on relative autonomy, competence, and relatedness scores among those surveyed. Overall, autonomy scores range [3.14,6.86], competence scores range [2.33,6.00], and relatedness scores range [3.63,7.00]. Cluster size and gender balance can be found in Table 2. The largest class of students assessed belong to the *Balanced, Average* class: 29.2% of students. The closest centroid to it was the *High Competence* class. As can be seen in Table 3, the main differentiator between these two classes was their disproportionate competence scores – autonomy and relatedness scores were largely similar. This was also the second tightest cluster, with an average distance from the centroid of just 0.63. The *Balanced, Low* class is characterized by consistently low psychological need fulfillment scores for all three constructs, relative to other study participants. This class houses 12.4% of participants. The average distance from the centroid is 0.73. The class with the closest centroid to this cluster is *Balanced, Average*. Similar autonomy and relatedness scores arise between these two groups, while lower competence scores set this class apart. This class has the lowest centroid values for autonomy and competence, but relatedness scores are the third lowest. The *Balanced, High* class encompasses 12.4% of participants. However, this group shows apparent equity between men and women. This suggests that, when all three psychological constructs are considered in conjunction with one another, men and women are equally likely to experience high levels of autonomy, competence, and relatedness. Furthermore, the highest centroid values for all three constructs are in this class, suggesting that when high levels of one construct is present it is likely that the other constructs will be similarly high. The class with the closest centroid to this one spatially is *High Relatedness*, and unsurprisingly the furthest class is *Balanced, Low*. The average distance from the centroid is 0.70.

The unbalanced classes are smaller than the balanced classes and are characterized by one construct measure that outweighs the other two. *High Autonomy* encompasses 18% of participant. The class with the closest centroid to this cluster was *Balanced, Average* and the average distance from the centroid is 0.76. The class with the centroid closest to the *High Competence* cluster's centroid is *Balanced, Average*. The defining feature of this class is having near average autonomy and relatedness scores alongside disproportionately high competence scores (though not reaching those in the *Balanced, High* class). The class with the centroid closest to the *High Relatedness* class's centroid is *High Autonomy*, apparently due to their similar competence scores.

Table 2: Cluster characteristics

Class	N	N female (% female)
1 - Balanced, High	11	5 (45.5%)
2 – Balanced, Average	26	10 (38.5%)
3 – High Relatedness	13	7 (53.8%)
4 – Balanced, Low	11	7 (63.6%)
5 – High Autonomy	16	10 (62.5%)
6 – High Competence	12	6 (50.0%)

Table 3: Cluster Centroids

Class	Autonomy Centroid	Competence Centroid	Relatedness Centroid
1 - Balanced, High	5.94	5.11	6.33
2 – Balanced, Average	4.39	4.05	4.50
3 – High Relatedness	4.88	4.26	6.14
4 – Balanced, Low	4.13	3.00	4.92
5 – High Autonomy	5.67	3.99	5.29
6 – High Competence	4.94	5.06	4.66

Though t-tests showed that on average males and females do not experience different levels of autonomy, competence, or relatedness in the project team context when each is considered individually, here these three constructs may be considered as a whole. Still, males and females do appear to belong to these classes in similar proportions. Of the “Balanced” classes (1,2, and 4), 54.2% of individuals belonging to one of these classes are men. The three unbalanced classes (3, 5, and 6) have a higher proportion of females than males (44% of participants belonging to these groups are male). When “Autonomy” is considered, *Balanced, Low* and *Balanced, Average* are the groups with the lowest centroid values and *Balanced, High* and *High Autonomy* have the highest centroid values. These groups are 54.1% and 44.4% male, respectively. When “Competence” is considered, *Balanced, Low* and *High Autonomy* are the groups with the lowest centroid values and *Balanced, High* and *High Competence* have the highest centroid values. These groups are 37.0% and 52.2% male, respectively. A test of proportions fails to reject the null hypothesis that the two proportions are the same. When “Relatedness” is considered, *Balanced, Average* and *High Competence* are the groups with the lowest centroid values and *Balanced, High* and *High Relatedness* have the highest centroid values. These groups are 57.9% male and 50% male, respectively.

It is also important to note what is *not* seen in this dataset: extreme imbalance. Individuals do not simultaneously have high autonomy scores relative to others surveyed while also having very low relatedness scores, for example. Having a very high score on one construct indicates at least average experience of the other constructs. By the same token, having a very low score on one construct indicates no more than average experience of the other constructs.

V. CONCLUSION

Instructors have the opportunity to support motivation that will lead to positive educational outcomes for students. In the classroom setting, the perception of controlling (i.e. giving students few choices) teaching behaviors was found to correlate positively with students' frustration and negatively with autonomous motivation levels. [14] In a study in which students were randomly assigned to either autonomy-supportive teachers or controlling teachers, students in the autonomy-supportive group reported higher intrinsic motivation, perceived competence, and self-esteem. [15] Students told to learn material either to teach it to others or to be tested themselves reported similar levels of rote memorization. However, the "teaching" group reported higher levels of intrinsic motivation, more conceptual learning, and more active engagement with the subject. [16] A study measuring autonomy, competence, and relatedness of teaching styles (measured through autonomy-support, structure of the classroom, and involvement, respectively) found that these three qualities influenced students' perceptions of their teachers as well as their engagement. [17]

Whether autonomy, competence, and relatedness are considered separately or in conjunction with one another, no significant differences exist between how males and females experience them on long-term project teams. Future studies may wish to examine any potential differences qualitatively by probing students' individual experiences on teams. Though quantitatively no differences emerged, still it is possible that the way these constructs are experienced varies between the genders. Understanding potential differences is key to facilitating student learning and growth through group work.

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