Students' Grit Level as a Predictor of Their Academic Achievement in Engineering Design Courses

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Abstract *The primary purpose of this study is to explore the relationship between engineering students' year of study, gender and grit level. This study also aims to assess whether there is any relationship between students' peer assessment scores in a collaborative project-based learning course and their goal orientation — either towards performance goals or learning goals — and their grit level. The study design is a quasi-experimental design, and the methods used in this study are quantitative. Student grit level was measured using a 12-item scale. The questionnaire was administered in three engineering design courses at different levels of study. The first course is an introduction to engineering design course for first-year engineering and computer sciences students; the second is an introduction to engineering design course for second-year engineering and computer science students; and the third is a computer-aided design/computer-aided-manufacturing (CAD/CAM) engineering design capstone course for fourth-year mechanical engineering students. Data collection occurred during the fall semester of 2018-2019 academic year. Students' grit level was not found to be a predictor of students' peer assessment scores, although their goal orientation predicted their level of contribution to their team project.*

Keywords: Perseverance, Grit, Peer Assessment

1. INTRODUCTION

Recent meta-analysis studies have brought attention to several non-cognitive variables as potential predictors of academic performance, such as personality traits, conscientiousness, anxiety, study skills and habits, emotional intelligence, learning strategies and grit [1].

Grit, a relatively new construct in the behavioural sciences that has received a lot of attention recently [2], is defined as perseverance and passion for long-term goals [3].

Grit as defined by Duckworth et al. “is rooted in the ideas of self-control and conscientiousness” [4]. Costa, McCrae and Dye [5] conceptualized conscientiousness as an individual's need for achievement and moral scrupulousness and cautiousness (p. 889) and suggested that its facets are competence, order, dutifulness, achievement striving, self-discipline and deliberation. The difference between grit and the Big Five personality trait of conscientiousness is that grit entails the capacity to sustain both effort and interest in long-term projects [4].

Duckworth et al. [3] found that grit was a better predictor for success outcomes than IQ and a better predictor of retention for the first summer semester at the United States Military Academy at West Point than the school's cadet quality measure of self-control; they also found that grittier individuals had higher levels of education than those of similar age (p. 1098). Studies on grit have found that grit predicted a wide array of both academic and non-academic outcomes and that grittier individuals had a greater sense of belonging, were more engaged in co-curricular activities [6] and more likely to demonstrate an increased level of self-control, mental well-being, life satisfaction, feelings of worth, resilience and growth mindset [7]. Also, grit was found to predict high school students' grades, while only the grit scale's perseverance of effort factor predicted both high school and college students' grades [8]. Studies have consistently found that perseverance of effort is a stronger factor than the consistency of interest factor of the grit scale, as it has been found to predict increases in GPA over time [6] and motivation for self-regulated learning [9]. Studies on engineering students' grit have found that female engineering students are grittier than male engineering students and that grit fluctuates as students progress through engineering school [10].

Advocates for grit as a predictor of success are in line with proponents of the importance the role that deliberate practice plays in the development of expertise. Ericsson, Krampe and Tesch-Römer [11] argued that high levels of deliberate practice are necessary to attain expert-level performance (p. 392) and that the reason for the difference in performance between higher performers in a certain domain and normal adults is a “life-long period of

deliberate effort to improve performance in a specific domain” (p. 400).

It should be noted that grit as a distinct valid construct has been challenged [1]. Credé, Tynan and Harms [1] criticized the distinction between grit and conscientiousness and emphasized there is no empirical evidence that points to a difference between grit and other attributes such as willpower, tenacity, determination and persistence of motives. Muenks et al. [8] found that grit did not predict high school students’ grades when personality variables were controlled and also noted that in their study of high school students, grit was not predictive of long-term goals. Moreover, more research is required to understand if grit is a predictor of academic success in various groups at different developmental stages [8].

The primary purpose of this study is to explore the relationship between engineering students’ year of study, gender and grit level. This study also aims to assess whether there is any relationship between students’ peer assessment scores in a collaborative project-based learning course and their goal orientation — either towards performance goals or learning goals — and their grit level.

2. MAIN BODY

2.1 Research Questions

This study aims to answer the following research questions:

RQ1: Are there any statistically significant differences in the mean scores of grit based on gender or year of study?

RQ2: Is there any statistically significant relationship between students’ grit levels and their peer assessment scores?

RQ3: Does students’ goal orientation predict their level of contribution to the project as measured by their peer assessment marks?

RQ4: Is there any relationship between students’ grit scores and their goal orientation?

2.2 Methods

2.2.1. Participants

Participants in this study ($n = 198$) were engineering students enrolled at the university of X, X. Participants responded to an online questionnaire during the fall term of

2018. Students’ participation was strictly voluntary. In terms of gender, 77.9% of the participants identified as male, and 22.1% identified as female.

2.2.2. Measures

The variables in this study included students’ grit level, year of study, peer assessment score, course grade and cumulative GPA. Their cumulative GPA and grades were on a 10.0 scale, while their grit level was measured using a 12-item scale developed by Duckworth et al. [3]. The scale consists of two factors: the first factor measures consistency of interest, and the second factor measures perseverance of effort. The first factor contains 6 items that indicate consistency of interest, and the second factor contains 6 items that indicate perseverance of effort. Respondents indicated their extent of agreement with each item on a 5-point scale, with responses ranging from 1 = *not at all like me* to 5 = *very much like me*. A high score indicates a high grit level.

After completing the grit-level questionnaire, students were presented with a question to assess their goal orientation. The question is part of a larger questionnaire developed by Carol Dweck [12] that aims to assess respondents’ learning and performance goals. The question presented to the students was the following: If I had to choose between getting a good grade and being challenged in class, I would choose ... (Circle one) “good grade” or “being challenged.” The answer was converted to a dichotomous variable that indicates the respondent’s goal choice. If the students’ response was “good grade,” then their goal orientation is a performance goal; and if they responded with “being challenged,” then their goal orientation is a learning goal.

Students’ contribution to project work was measured only at the second-year level collaborative project-based learning course. The students had to rate their contribution and their teammates’ contribution to the project. The assessment was done using the peer feedback online tool developed by the Individual and Team Metrics Lab at the University of Calgary. The tool — which is based on Ohland’s et al. [13] Comprehensive Assessment of Team Member Effectiveness [14] dimensions: communication, commitment, knowledge, skills and abilities, standards, and keeping the team on track — invites students to rate each other on a five-point Likert scale and provide personal feedback. The tool produces a mark for each students’ contribution to the project based on the student’s self-assessment and the teammates’ assessment of the student’s

contribution to the project. Students are also able to provide feedback on each other's strengths and weaknesses and where they need to develop. This feedback was used during a team meeting mid-course as a team debrief to discuss each member's performance and potential areas of improvement.

2.2.3. Procedure

Students responded to the questionnaire in an online format. The questionnaire was administered in three engineering design courses at different levels of study. The first course is an introduction to engineering design course for first-year engineering and computer science students; the second is an introduction to engineering design course for second-year engineering and computer science students; and the third is a computer-aided design (CAD) capstone course for fourth-year mechanical engineering students. Ethical review was passed, and students' informed consent was obtained. The questionnaire was administered during the second week of the fall semester of the 2018–2019 academic year. Students' responded to the questionnaire through a link that directed them to the questionnaire's page on SurveyMonkey.ca.

3. RESULTS AND DISCUSSION

A total of 198 students responded to the questionnaire out of 225 students registered for the three courses in which participants were recruited for the study. Table 1 outlines the descriptive statistics in for the students' grit, perseverance and passion scores.

Table 1 Descriptive Stats

Variable	Number	Mean	Standard Deviation
Grit	198	3.31	.51
Passion	198	2.83	.71
Perseverance	198	3.79	.61

The students' mean score for grit was consistent with similar studies done on engineering students. Choi [15] measured students' grit level using a shorter version of Duckworth's grit scale for a sample of 1,443 first-year engineering students and reported a mean grit score of 3.63 for female students ($n = 273$) and 3.54 for male students ($n = 553$). Jaeger et al. [10] administered the grit survey to 374 first-year engineering students and reported a mean grit score of 3.55 with a standard deviation of 0.49.

Figure 1 - Means Plot of Students' Grit Score Based on Their Year of Study

To assess if there was any statistically significant difference in the mean scores of grit between students at different years of study, a one-way between subjects analysis of variance (ANOVA) test was conducted. Participants were classified into four groups: first-year students ($n = 39$), second-year students ($n = 43$), third year students ($n = 7$) and fourth-year students ($n = 109$). There was a significant effect for students' year of study on their grit score at the $p < .05$ level [$F(3, 194) = 3.5, p = 0.017$]. Post hoc comparisons using the Scheffe test indicated that the mean score for students in their second year of study ($M = 3.15, SD = 0.078$) was significantly lower than that of students in their fourth year ($M = 3.39, SD = 0.05$). However, first- and third-year students' mean grit scores did not differ significantly from second- and fourth-year students' grit scores.

A one-way ANOVA test was used to understand which component of the grit score was causing the drop in students' grit scores by the end of their first year. It found that the students' passion scores dropped by .339. Perseverance scores increased slightly from first year to second year, by .025. These results indicate that further investigation is required to understand what is causing the decrease in students' passion scores by the end of the first-year program. These results also indicate that students' grit scores fluctuate as they progress through their engineering program, a finding that is supported by a Jaeger et al. [10] study. These results also suggest that students' grit level is not significantly different in their last year of study from when they first started their engineering program.

A one-way ANOVA was also conducted to determine if the students' grit scores were different based on the students' gender. The students' grit scores were higher for female students ($M = 3.28$, $SD = .54$) than for male students ($M = 3.31$, $SD = .50$), but the differences between gender groups was not statistically significant, $F(1, 196) = .85$, $p = .771$. Research on gender and grit has presented mixed results [16]. Our results are consistent with studies that have found gender does not play a role in determining individuals' grit level [17], [16].

A Pearson's product-moment correlation was run to assess the relationship between the students' peer assessment marks and their grit scores. There was no statistically significant correlation between the two variables, $r(71) = .048$, $p = .690$, a finding that indicates that students' grit level does not predict the level of contribution they put into their team projects as measured by their peer assessment marks. This finding draws more attention to the role of grit in predicting performance in an engineering setting and suggests that although grit might be relevant for predicting retention in a military academy [3] or performance in well-defined tasks, it might not be as strong of a predictor in ill-defined tasks that require creativity [1] such as an engineering design project.

A one-way ANOVA was conducted to determine if the students' peer assessment mark was different for groups with different goal orientation. Participants were classified into two groups: students with a learning goal ($n = 28$) and students with a performance goal ($n = 43$). There were no outliers; data were normally distributed for each group, as assessed by a Shapiro-Wilk test ($p > .05$); and there was homogeneity of variances, as assessed by Levene's test of homogeneity of variances ($p = .105$). Data are presented as mean $\pm$ standard deviation. The peer assessment marks were statistically significantly different between the two student groups with different goal orientations, $F(1, 69) = 8.680$, $p = .004$, $\omega^2 = 0.112$. Peer assessment marks were lower for students who wanted to achieve a good grade — performance goal — ($M = 4.469$, $SD = .368$) than for students who wanted to be challenged — learning goal — ($M = 4.708$, $SD = .274$). These results indicate that grittier students tend to adopt a learning goal rather than a performance goal.

A Spearman's rank-order correlation was also run to assess the relationship between the students' goal orientation and their grit scores. There was no statistically significant correlation between the students' grit scores and their goal orientation, $r_s(198) = -.074$, $p = .303$.

4. CONCLUSIONS

This study explored if students' grit, defined as perseverance and passion for long-term goals, can be used to predict their contribution to and achievement in a project in an engineering design course. Moreover, the study aimed to understand if the students' objectives had any relationship with their performance in collaborative project-based learning courses. The results indicate that grit is not a statistically significant predictor of students' contribution to their teamwork in collaborative project-based learning engineering courses. However, their objective upon entering the course was found to have an impact on their level of contribution to the project. Students who described themselves as challenge-seekers received higher peer assessment marks than those who noted that their objective was to get a high grade.

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