The Effect of Goal Orientations and Belief Motivation on Undergraduate Engineering Students' Achievement

Olanrewaju P. Olaogun, Adurangba V. Oje, Nathaniel J. Hunsu, & Peter H. Carnell
University of Georgia
College of Engineering
Athens, United States
olanrewaju.olaogun@uga.edu

***Abstract* - This research full paper examines the relationship between achievement goal orientations, task value, self-efficacy for learning, and students' achievement. Participants were 171 undergraduate students from the college of engineering. The students completed measures that assessed achievement goal orientations, self-efficacy for learning performance, and task value. The results show that while mastery, performance approach, self-efficacy, and task value correlate significantly with the students' achievement, only self-efficacy for learning performance significantly predicts students' achievement when combined with prior knowledge and absence in a complete hierarchical regression model. The findings highlight the impact of objective measures (class attendance) on student achievement scores relative to their task or self-efficacy beliefs, and achievement goal orientations.**

Keywords- Self-efficacy, achievement goal theory, student achievement

I. INTRODUCTION

Statics is a foundational and gateway course to many advanced courses in undergraduate mechanical and civil engineering programs [1]. Students' performance in such courses is crucial in determining whether they could continue and finish their engineering majors [2]. However, Statics is challenging that many students find because of the abstract nature of the course contents [3]. As a result, having relevant prior knowledge in Newtonian Physics and Trigonometry is necessary for succeeding in the course. Failing in foundational engineering courses could prevent students from making academic progress, and make it impossible for them to continue in their intended undergraduate engineering program altogether.

Apart from domain prior knowledge, researchers have also consistently linked students' beliefs about themselves and the learning tasks they get assigned in class to academic achievement [4]-[6]. For example, students with high self-efficacy beliefs may adopt adaptive learning behaviors and academic achievement [5], [7], while those with low self-efficacy may disengage and underperform academically [8]. Similarly, students' perception of the value of their learning material and tasks, or how meaningful and enjoyable those tasks appear to them, affects the quality of their task engagements [9], [10]. Several studies have suggested that students' beliefs about themselves and their subjective tasks value beliefs affect their achievement motivations, self-regulated learning behaviors, and academic achievements (reviewed in [11]).

Although several studies have examined the relationships that exist between these affective variables and educational outcomes. Results about the causal relationships between self and task beliefs, achievement motivations, and students' academic achievement have been inconsistent across existing empirical literature [12]. For example, some studies report finding a small to moderate positive relationship between self-beliefs, achievement motivation and academic achievement. On the contrary, other studies reported finding no such effects at best, or negative correlations at worst [11]. Generally, more studies observe minimal to moderate effects in the relationship between students' self-efficacy belief, task value belief, achievement motivation belief, and their academic achievement. Furthermore, these relationships are less explored in engineering learning contexts.

While the relationships between some of these important variables have been highlighted in the past, they have not intentionally sought to examine the extent to which the effects of students' task-value, self-efficacy, and achievement goals on academic performance still hold when objective measures of prior knowledge and

absence are taken into consideration. In the current study, we examined the relationships among these variables by considering the following research questions:

- *First Research Question:* What is the nature of the relationship among task value, self-efficacy for learning performance, achievement goal orientations, and academic achievement?
- *Second Research Question:* How do the self-efficacy, task value, and achievement motivation beliefs predict students' achievement scores?
- *Third Research Question:* In what ways are these relationships affected when prior knowledge and class attendance are accounted for?

II. THEORETICAL FRAMEWORK

A. Self-efficacy beliefs and academic achievement

Bandura defined self-efficacy as "beliefs in one's capability to organize and execute the courses of action required to manage prospective situations" [16]. Research suggests that students with positive self-efficacy beliefs are better motivated to exert more effort at learning and persist longer on challenging tasks [9]. Self-efficacy is positively associated with academic performance in the literature [17], [18].

B. Achievement goal motivation and academic achievement

Achievement goals describe the competency-related goals that inform students achievement behaviors [19], [20]. They may be task or ego related. Task-related achievement goals are associated with striving to master tasks or gaining mastery on success-relevant skills solely because of an intention to attain mastery. While ego-related goals are driven by social comparisons. Different studies have related achievement goals to academic engagement, the use of learning strategies and achievement [10], [21].

C. Integrating self-efficacy, task value, and achievement motivation beliefs.

Students' achievement goals determine the self-regulated learning behaviors, and academic achievement [22], [23]. Students' self-efficacy play a significant role in instigating and sustaining achievement motivations [24]. For example, some studies have linked students' self-efficacy with their achievement motivations [25]-[28]. Ferla and his colleagues [27] found that students with low self-efficacy may be less motivated towards high achievement. By contrast, those with high achievement motivations believe in their abilities to adopt self-regulated learning behaviors that help them meet their achievement goals.

Apart from self-beliefs and achievement goals, expectations of success can also be influenced by subjective task values [4], [29]. Prior studies have shown that task value positively predicted mastery goal, while self-efficacy positively predicted mastery and performance approach goals and negatively predicted the performance avoidance goal, and that both task value and self-efficacy have positive relationships with self-regulation and academic achievement [5], [9], [10].

Having relevant prior knowledge is necessary to succeed in many foundational engineering courses, but so does self-efficacy, achievement goals and task-value beliefs. In this study, we examine the relative effects of students' task value, self-efficacy, achievement goal orientations on academic achievement in light of students' prior knowledge. Class attendance was included in the predictive model because it historically affected students' performance in the course focused on in this study.

III. METHODS

A. Participants

The subjects were 171 undergraduate students (32% female) who enrolled in Statics in the college of engineering of a public university in the United States. Undergraduate engineering students majoring in Environmental, Civil, Agricultural and Mechanical Engineering programs register Statics as a core course at the college. The sample consisted of 13.5% freshmen, 45.6% sophomores, 32.7% juniors, and 8.2% seniors. 74.9% were Caucasian, 9.4% were Asian or Pacific Island, 7.6% were Black or African American, and others were 8.1%. All the participants were full time students and their participation in this study was voluntary.

A. Procedure & Measures

An online survey was administered to participants using the Qualtrics survey platform. The survey included sections that assessed achievement goal orientations, self-efficacy for learning performance, and task value. All survey items were rated on a 5-point scale that ranged from 1 (Never or only rarely true of me) to 5 (Always or almost always true of me). Measures of student attendance and end-of-course performance were also obtained.

1) Achievement goal orientations: The students' achievement goal orientations were assessed using the 2 by 2 achievement goal questionnaire [30]. The

Achievement Goal Questionnaire (AGQ) comprises four sub-scales - mastery approach, mastery avoidance goal, performance approach, and performance avoidance goal orientations.

2) Self-Efficacy for learning and performance (SLP): The SLP was adapted from one of the subscales of the Motivated Learning Strategies for Learning Questionnaire (MSLQ) [31]. This subscale has been shown in literature to have good predictive validity [32], [33].

3) Task value: The students' task value was measured using 8-items also adopted from the Task Value sub-scale of the MSLQ. Items on the scale asked students to rate their perceptions about the usefulness and importance, and interest in the course content and material.

4) Prior Knowledge: The prior knowledge test consisted of 30 questions including: 14 physics questions from the Half-Force-Concept Inventory [34], four 3D visualization questions from the Purdue Visualization of Rotations Test [35], four questions from the Mechanics Baseline Test [36], and eight additional questions covering 3D visualization, 3D vectors, and trigonometry.

5) Absence: During each class, an attendance sheet was circulated so students could sign, and absences were noted and recorded. This record has 40 to 45 attendance checks, with an average of 2.43 (SD = 2.66) absences among students that took the final exams. We calculated the absence scores by taking the inverse of the students' presence score.

6) Performance: Students' end of course performance was composite of their scores on weekly homework assignments, three two-hour midterm exams at approximately four-week intervals and a three-hour final exam.

IV. RESULTS

We conducted a preliminary analysis to examine the validity and reliability of the instruments used, and to further test assumptions for conducting regression analysis. The assumptions of the normality of distribution of error terms and homoscedasticity were satisfied. There was no evidence of multicollinearity with our dataset (VIF < 2). Residual analysis results show there were no influential outliers in our dataset. And finally, the maximum Cook's distance was less than 1 – suggesting no such case existed in the dataset.

A. Reliability and Validity of Instruments

The measurements models for the self-report scales on the study participants were tested for reliability and validity using the Confirmatory factor analyses (CFA) with maximum likelihood estimation method. Statistically fit models would satisfy the following metrics: Comparative Fit Index (CFI) > 0.95, Tucker Lewis Index (TLI), > 0.95, Root Mean Square Error of Approximation (RMSEA) < 0.06 [37].

Our CFA analysis results for the AGQ showed a good model fit, $\chi2 = 34.42$, $df = 32$, $p < 0.353$, CFI = 0.997, TLI = 0.995, RMSEA = 0.021 (90% CI: 0.058, 0.102), after two redundant Mastery avoidance items were removed. Based on the Composite reliability, Average variance extracted (AVE), Maximum shared variance (MSV), no convergent or discriminant validity issues were observed with the trichotomous version of the achievement goal model used in the subsequent analyses (please see Table 1). Model fit statistics for the SLP scale was $\chi2 = 5.9$, $df = 5$, $p < 0.320$, CFI = 0.998; and Task Value $\chi2 = 3.76$, $df = 2$, $p < 0.152$, CFI = 0.995. Coefficients of internal reliability for each of the scales used were good (See Table I).

TABLE I: Reliability, and validity coefficients for self-report data

	CR	AVE	MSV	Cronbach α	Mastery	Per App	Per Avd
Task Value	0.87	0.64	-	0.92			
SLP	0.91	0.66	-	0.92			
Mastery	0.84	0.58	0.16	0.86	**0.76**		
Performance Approach	0.77	0.53	0.45	0.78	0.40***	**0.73**	
Performance Avoidance	0.87	0.68	0.45	0.89	0.33***	0.67***	**0.83**

A. Correlation and Regression Analyses

For the first research question, a Pearson correlation analysis was conducted to determine the magnitude and directions of the relationships between students' achievement goal orientations, self-efficacy, task values, and three educational measures of prior knowledge, absence, and performance scores. Most notably, we observed small to moderate correlations between the different achievement goal orientations, self-efficacy, and students' academic performances. The Pearson's correlation coefficients among the variables of interest in this study are reported in Table II.

For the second research question, a hierarchical regression analysis was conducted to evaluate how the predictor variables predicted the achievement outcome. The results of the first block hierarchical regression analysis showed the model based on achievement goals was significant, $(F(3, 161) = 4.73, p = 0.003, R^2 = .08)$. The analysis showed that performance approach was a significant predictor ($\beta = 0.23$, $t(161) = 2.6$, $p < 0.01$), while performance avoidance ($\beta = 0.01$, $p < 0.90$) and mastery were not ($\beta = 0.10$, $p < 0.19$). The R^2 associated

TABLE II: Descriptive statistics, Cronbach alphas for scales and zero order correlation coefficients among variables.

Variable	M	SD	1	2	3	4	5	6	7	8
Achievement goal variables										
1 P Avoidance	3.84	1.01	1							
2 P Approach	3.97	0.81	0.47**	1						
3 Mastery	4.35	0.60	0.25**	0.31**	1					
Belief variables										
4 Self-efficacy for Learning Performance	3.38	0.89	0.17*	0.36**	0.34**	1				
5 Task Value	4.27	0.75	0.06	0.15	0.61**	0.31**	1			
Learning context Variables										
6 Prior knowledge	17.08	4.97	-0.01	0.01	0.03	0.20*	0.14	1		
7 Absence	1.96	2.89	-0.02	-0.12	-0.07	-0.10	-0.12	-.19*	1	
8 Acad. Performance	79.05	12.65	0.14	0.26**	0.17*	0.40**	0.28**	.33**	-.61**	1

Note. *<.05 **<.01

with the model indicated that achievement goals accounted for only 8% of the variation in participants' final performance in the course.

The second block in the analysis included self-efficacy and task value. The results of the second block analysis was statistically significant, *(*$F(5, 161) = 4.73$, $p < 0.001$, $R^2 = 0.20$). The R^2 associated with the second model indicated that the variables explained 20% of the variation in students' performance – the 12% change in the variance explained after adding the two belief variables to the first model was significant ($p < 0.01$). The analysis showed that only self-efficacy for learning performance ($\beta = 0.31$, $t(161) = 3.95$ $p < 0.01$) and Task value ($\beta = 0.22$, $t(161) = 2.4$, $p = 0.02$) were significant predictors. The achievement goal variables were not significant.

To form the full model, prior knowledge and absence scores were added to the second block. The results of the full model analysis was statistically significant, *(*$F(7, 161) = 25.02$, $p < 0.001$, $R^2 = 0.52$). It showed that 52% of the variation in students' performance was explained by including all the variables. Further, the 32% change in the variance explained after including prior knowledge and absence scores in the full model was significant ($p < 0.001$). The analysis showed that absence ($\beta = -0.53$, $t(161) = -9.40$ $p < 0.001$) and prior knowledge ($\beta = 0.15$, $t(161) = 2.71$ $p < 0.01$) were significant predictors. Self-efficacy remained a significant predictor ($\beta = 0.97$, $t(161) = 3.95$ $p < 0.01$), while task value was marginal ($\beta = 0.21$, $t(161) = 2.4$, $p = 0.02$) ($p = 0.05$). The achievement goal variables were not significant predictors in the full model.

V. SIGNIFICANCE OF THE STUDY

Some of the findings of this study validate the robust relationships between self-efficacy, task value beliefs, and achievement goal orientation that were reported in past empirical literature [38], [39]. Other findings from our analysis may have consequential implications for theory and practice, and for future research. For example, we noted the objective measures of students' cognitive ability (prior knowledge) and class engagement (e.g., attendance) were more precise at predicting academic achievement than those based on subjective measures. Some have called for the use of more objective measures in assessing student related outcomes because of limitations associated with subjective measures. Our findings suggest that objective measures could be used in conjunction with subjective measures when assessing student learning outcomes[40].

Our observations suggest that dismal class attendance will likely undermine a student's potential academic achievements, irrespective of what they believe about themselves, their tasks, and their achievement goals. Students who miss classes may, at best, have to play catch up [41]. Some may even become less cognitively, socially, and emotionally invested with the task assigned in class [42]. These ramifications of the points noted above are salient in foundational engineering courses, where teacher presence and agency may be particularly critical to students' success.

Another implication of our results is that instructional efforts that encourage task value and self-efficacy would promote engineering students' achievement especially when such instructional design addresses students' low prior knowledge. Students' high task value and self-efficacy can act as a buffer for students with low prior knowledge when they stimulate a positive learning environment and positive achievement emotions in students.

TABLE III: Summary of Hierarchical Regression Analysis: Using Absence, Prior Knowledge, Self-beliefs, Goal Orientations, as predictors of Academic Performance

Model		Unstandardized Coefficients B	*SE*	Standardized Coefficients β	*t*	*Sig.*	R2	Adjusted R2	ΔR2
1	Performance Avoidance	0.14	1.05	0.01	0.13	0.90	0.08	0.06	
	Mastery	1.29	0.98	0.10	1.31	0.19			
	P Approach	2.79	1.07	0.23	2.60	0.01*			
2	Performance Avoidance	0.51	0.99	0.04	0.51	0.61	0.20	0.18	0.12***
	Mastery	-1.40	1.17	-0.11	-1.20	0.23			
	Performance Approach	1.68	1.05	0.14	1.60	0.11			
	Self-Learning Performance	3.84	0.97	0.31	3.95	0.00**			
	Task Value	2.69	1.12	0.22	2.40	0.02*			
3	Performance Avoidance	0.77	0.77	0.06	0.99	0.32	0.52	0.50	0.32***
	Mastery	-0.95	0.91	-0.08	-1.05	0.30			
	Performance Approach	1.01	0.82	0.08	1.23	0.22			
	Self-Learning Performance	3.23	0.77	0.26	4.19	0.00***			
	Task Value	1.72	0.88	0.14	1.95	0.05			
	Prior Knowledge	1.92	0.71	0.15	2.71	0.01**			
	Absence	-6.55	0.70	-0.53	-9.40	0.00**			

Note. *<.05 **<.01 ***<0.001

Cognitive preparedness (e.g., prior knowledge) and the social and cognitive engagement associated with class attendance might have greater ramifications in some engineering courses than others in which students' success is less dependent on the agency that teacher and peer presence facilitate. Future studies may examine whether the effect of achievement motivations on academic achievements are more or less salient depending on the nature of the tasks. Similarly, future studies may also examine the impact of class attendance and classroom engagement on student beliefs, motivations, and achievement in other similar or disparate engineering courses.

Irrespective of participants' prior knowledge and class attendance scores, the effects of self-efficacy for learning performance and task value beliefs on academic achievement remained salient. In fact, the effects of both variables on the variances in our participants' achievement scores were comparable to those due to prior knowledge alone. These findings could imply that pedagogical efforts that accentuate the utility value of an engineering course and cultivate students' self-efficacy beliefs could have both a direct and indirect positive impact on their academic achievement. Drawing on these findings, we hypothesize that pedagogical efforts that influence students to set performance approach goals may be more successful than those aimed at influencing mastery goals in advancing task competence.

In conclusion, we investigated the relationships between undergraduate engineering students' achievement motivation and belief constructs, and how well they predict academic achievement when students' domain-relevant prior knowledge and class attendance are taken into consideration. We found that class attendance was a better predictor of achievement score than self-efficacy beliefs, task value beliefs, and achievement goal orientation. Self-efficacy for learning performance and task value beliefs were better at predicting achievement score than achievement goals.

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