How Do Engineering Students' Achievement Goals Relate to their Reflection Behaviors and Learning Outcomes?

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Abstract

This research study investigated the relationship between achievement goals, reflection behaviors, and learning outcomes of industrial engineering students. The study used Achievement Goal Questionnaire-Revised (AGQ-R) scale to measure engineering students' achievement goals. Six response variables for each student were included: the reflection quality score, total number of reflections, two exam scores, final exam score, and the total learning outcome based on course grading policy criteria. Both parametric bivariate regression analysis and regression analysis after transformation based on beta distribution were conducted. The results indicated that mastery approach had a significant effect on the total number of reflections, final exam, and the total learning outcome. Performance approach showed significances on the final exam and the total learning outcome. Mastery avoidance showed significances on the total number of reflections, exam2, and the total learning outcome. Performance avoidance had a significant effect on exam 2, final exam, and the total learning outcome. The findings of this study confirm previous research findings in other domains, which suggest that there is a positive relation between performance approach and learning outcome, and between mastery approach and students' learning style and strategies.

Keywords: *achievement goals, reflection, engineering education, mobile learning*

Introduction

Students' engagement in class depends on students' expectations about course content, classroom environment, their prior experiences, self-esteem, and interactions between faculty and other students[1]. Students form their achievement goals with the influence of both intrinsic and extrinsic motivation[1,2,3]. These achievement goals along with the instructional strategies affect students' decision making and their learning behavior[4,5]. This study explored the relationship among achievement goals, reflection, and learning outcomes of engineering students.

Achievement goal theory considers that an individual's motive is driven by a specific purpose[1,6]. The achievement goal theory explains the general orientation of students to the task and related beliefs such as effort, and competence[7]. In other words, achievement goals integrate not only goals but various related beliefs to achieve specific objectives. Accordingly, achievement goals can be considered as an integrating theory compared to other motivation theories. Mastery goal and performance goal are the key constructs of this theory. Mastery goal focuses on learning and understanding materials, whereas performance goal focuses on performing well compared to others as it involves individual's ego[6]. These different focuses influence students' achievement in a different way through their self-regulation strategies and learning process[6,7,8,9]. Studies have shown that self-regulation is strongly affected by mastery goal [10,11]. Bouffard and her colleagues argued that mastery goal is highly related to self-regulation and academic achievement for both boys and girls[10]. Similarly, performance goal was highly related to these two factors, however, only for boys[11,12,13].

Achievement goal theory adapted the 'approach versus avoidance distinction' to better explain performance goal related results[14]. Wolters emphasized the importance of the distinction between performance approach goal and performance avoidance goal[14]. He suggests that performance avoidance goals may be associated with negative academic outcomes, whereas performance approach goals are often considered as beneficial in some cases to enhance learning outcomes[14]. On the other hand, mastery approach is mostly associated with intrinsic motivation, higher engagement, and interest[1]. However, findings from research studies on these constructs are often not congruent[2,3,15,16,17]. The differences are due to the variables that researchers included as a measure of response or evaluation criteria that they used to categorize performance goal or mastery goal with approach and avoidance distinction[2,3,15,16,17]. Elliot and McGregor found that performance approach was a significant predictor of students' learning outcome[15]. Other studies found that mastery approach affected intrinsic motivation[3,18]. In addition, previous studies found the positive correlation between these elaborated achievement goal orientations and self-regulated learning (SRL) behaviors[16,19]. Elliot argues that mastery goal pursuit and performance avoidance goal pursuit use the same form of regulation since they both are supported by a single achievement motive and the focus of the goals conform to the affective state of motive[19]. On the contrary, performance approach goal uses more complex achievement motives and the focus of the goal does not conform to the affective state of motive. Elliot and Moller analyzed previous research studies regarding the relationship between SRL and performance approach[16]. They found that there was no significant relationship between SRL and performance approach. However, they also suggest the results might be affected by the different perspective about performance approach. That is, performance approach has been considered both positive and negative due to different focus by researchers when evaluating the goal orientation in their studies. The incongruent results about elaborated goal achievement constructs

and SRL justify the demand of more research studies to clarify the relationships among the constructs. Definitions of achievement goals were summarized in Table 1 below.

Table 1

Summary of Achievement Goals

Achievement goal	Definition
Mastery Approach	Focuses on learning and understanding materials
Performance Approach	Focuses on performing well compared to others, ego-involved
Mastery Avoidance	Focuses on avoiding failure of learning or understanding
Performance Avoidance	Focuses on avoiding performing worse than others

Reflections and Decision Making

Researchers have shown that achievement goals and reflection behaviors are essential components to understand their decision making and learning process[20,21,22,23]. In classrooms with the learner-centered approach, reflection is considered as one of the key learning strategies[20,21,22,23]. Boud, Keogh and Walker argue that reflection is the conscious statement of response to a learner experience which helps effective learning[20]. Our working definition considers reflection as a cognitive process of engagement where students actively conceptualize new information and consolidate existing information. Moreover, Zimmerman argues that reflection is one of the critical components of self-regulation[21].

The relationship between self-regulation and each achievement goal have been investigated by many educational psychologists to explain students' learning behavior regarding achievement goals. In the study of Ames and Archer, they found mastery goal had moderating effect between learning strategies and academic achievement[22]. Zimmerman argues that self-evaluation and self-reaction occur during the self-reflection phase of the SRL[21]. That is, students evaluate their performance by comparing them to others' performance or given standards. Through this process, students feel the sense of satisfaction and defend themselves from their current learning situation or adapt themselves to more effective learning strategies. Reflection strongly affects students' goal setting and decision-making process, and ultimately SRL[23]. The relationship between self-reflection and learning outcomes have been investigated by many researchers and proven that self-reflection significantly affects learning outcomes[22,24]. For example, Lee and Hutchinson examined the effect of self-reflection facilitated by questions on learning and found that the quality of the reflection positively related to students' learning[25].

Many research studies as mentioned above indicated the importance of students' achievement goals and reflection behaviors to understand their decision making and learning process. This implication justifies our research study on the relationship with achievement goals with these two constructs of engineering students. In this study, we investigated the relationship between engineering students' achievement goals on their reflection behaviors and learning

outcomes. We conducted a semester-long study in an Industrial Engineering class with 69 students to explore the relationship among achievement goals, reflection and learning outcomes of undergraduate engineering students. The research is particularly focused on answering two specific research questions: 1. How are achievement goals related to students' reflection behaviors? 2. What is the relationship between achievement goals and learning outcomes? The goal of this research is to provide evidence and the insight to key stakeholders in engineering education field such as instructors and administrators so that they can be better informed about engineering students' motivation and their learning process.

Method

Participants

The data were collected from 69 students (23 female and 46 male) from a fundamental statistics class for sophomore industrial engineering students at a public university in Turkey, where the official language of instruction is English. The age range of participants was 19-21. Three students were international and the rest of them were Turkish. The course was chosen since it was a required course for industrial engineering students and covers complex concepts such as demand forecasting and goodness of fit tests.

Instruments

The Achievement Goal Questionnaire-Revised (AGQ-R) survey consists of four subcategories; mastery approach goal, mastery avoidance goal, performance approach goal, and performance avoidance goal[18]. A total of twelve survey items were provided and a 5-point Likert scale was used for each item (i.e., 1: Strongly disagree, 5: Strongly Agree). Students' reflection behavior was collected through a mobile app called CourseMIRROR, which was developed by our research team for both iOS and Android smart devices[26,27]. CourseMIRROR combines the benefits of mobile application and reflections. In addition, it was designed to create an interactive environment between students and faculty in a large classroom. This innovative tool collects students' reflections and uses Natural Language Processing (NLP) algorithms to create phrase based text summaries of responses. Students' reflection quality score was measured based on a scoring rubric, which ranged from 0 to 4. The total number of reflections was also measured to find if students were consistently involved in reflection behavior throughout the semester.

Procedure

The survey data were collected at the beginning of the semester, prior to any collection of any data for reflection behavior or learning outcome. The data of students' reflection behavior were collected for 21 lectures throughout the academic semester. Students submitted their reflection via CourseMIRROR during the semester which lasted for 12 weeks. The two exams and the final exam score were used as learning outcome measures.

Analysis

To find the relationship between each achievement goal and participants' reflection behavior and learning outcome, six variables were included as response variables; the reflection

quality score, the total number of reflections, exam 1, exam 2, final exam, and the total learning outcome which added two exams and the final exam with different weights based on class grading criteria (exam 1*.3+ exam 2*.3 + final exam*.4). Multiple separate bivariate regression (with 0.05 as the level of significance) were conducted to find the relationship between each achievement goal and each response variable. Each achievement goal was included separately since Elliot and Murayama insist that achievement goals share same dimensions and thus there is correlation among achievement goals and each achievement goal should be assessed separately[18].

Normality and homoscedasticity check were conducted to find if any assumption was violated for regression analysis prior to regression analyses. SPSS was used for the statistical procedures. Shapiro- Wilk test was chosen to check the normality. We found that normality was violated for each model of mastery approach and exam 1 (SW = .930, p = .001), mastery approach and exam 2 (SW = .961, p = .045), mastery approach and the final exam (SW=.932, p = .002), and mastery approach and the total learning outcome (SW = .946, p = .010). Normality was violated for each model of performance approach and the total number of reflections (SW = .962 p = .041) and performance approach and exam 1 (SW = .931, p = .001). Normality was violated for each model of mastery avoidance and exam 1 (SW = .928, p = .001), mastery avoidance and exam 2 (SW = .955, p = .023), and mastery avoidance and the total learning outcome (SW = .952, p = .021). Normality was violated for each model of performance avoidance and the total number of reflections (SW = .048, p = .048), performance avoidance and exam 1 (SW = .932, p = .001), and performance avoidance and the final exam (SW = .960, p = .036). Homoscedasticity was checked with scatter plots using standardized residuals and standardized predicted responsive variable values. Heteroscedasticity was detected from each model of mastery approach and the reflection quality score, the final exam and the total learning outcome. Heteroscedasticity was detected from each model of performance approach and each reflection quality score, exam 1, exam 2 and the total learning outcome. Heteroscedasticity was detected from each model of mastery avoidance and exam 2. Heteroscedasticity was not detected from any model of performance avoidance and each response variable.

Results

The analysis results were from two different analysis procedures. One was parametric simple linear regression analysis and the other one was regression analysis after transformation. The results are summarized in Table 2 below.

Table 1

Regression Analysis Results for the Effects of Mastery Approach, Performance Approach, Mastery-Avoidance, and Performance Avoidance on Each Response Variables

Variable	F	p	η_p^2
Mastery approach			
reflection quality	$F(1,65) = .006$	.940	.000
total number of reflections	$F(1,65) = 5.268$	.025*	.075
exam1	$F(1,63) = 1.100$	.298	.017

exam2	$F(1,60) = 2.398$	.127	.038
final exam	$F(1,63) = 6.458$	.014*	.093
total learning outcome	$F(1,57) = 4.228$	.044*	.069
Performance approach			
reflection quality	$F(1,65) = .773$	.382	.012
total number of reflections	$F(1,65) = 1.148$	.288	.017
exam1	$F(1,65) = .303$	.584	.005
exam2	$F(1,60) = 2.126$	.150	.034
final exam	$F(1,63) = 11.409$	.001**	.153
total learning outcome	$F(1,57) = 5.299$	.025*	.085
Mastery avoidance			
reflection quality	$F(1,65) = .061$	.805	.001
total number of reflections	$F(1,65) = 23.605$	.000**	.266
exam1	$F(1,63) = 1.244$	.269	.019
exam2	$F(1,60) = 6.437$	.014*	.097
final exam	$F(1,63) = 8.573$	.005**	.120
total learning outcome	$F(1,57) = 3.382$	.071	.056
Performance Avoidance			
reflection quality	$F(1,65) = 1.115$	.295	.017
total number of reflections	$F(1,65) = 1.773$	.188	.027
exam1	$F(1,63) = .141$	.708	.002
exam2	$F(1,60) = 7.537$	.008**	.112
final exam	$F(1,63) = 5.861$	.018*	.085
total learning outcome	$F(1,57) = 5.638$	.021*	.090

*$p < .05$, **$p < .01$

Using JMP software, statistical program developed by SAS, transformation functions were explored[28]. The type of transformation was chosen based on the lowest log likelihood value and Akaike Information Criterion (AIC) value for response variables that were transformed[29]. AIC value is one of the measures to check the fit of a model to a given set of data[29]. Beta distribution fit the data of response variables and thus values of each response variable were transformed to within the range from 0 to 1[30]. Then, regression analyses were performed. Normality and homoscedasticity assumption check were conducted as well. The model of mastery approach and reflection quality score met normality and homoscedasticity assumptions.

However, significance and effect size remained same. The model of mastery approach and the final exam score still violated normality and homoscedasticity assumptions. The significance and effect size remained same for the model. The model of mastery approach and the total learning outcome still violated normality and homoscedasticity assumptions. Significance and effect size remained same as well.

The model of performance approach and reflection quality score met the normality and homoscedasticity assumptions. However, the significance and effect size remained same. The model of performance approach and the total number of reflections did not meet the normality assumption, however, p value was close to reject the null hypothesis ($p = .041$) and met the homoscedasticity assumption. Significance and effect size slightly improved ($p = .288$, $\eta_p^2 = .017$), however, still was not significant. The model of performance approach and exam1 still violated normality assumption, however, met the homoscedasticity assumption. Significance and effect size remained same. The model of performance approach and the total learning outcome met both normality and homoscedasticity assumptions. Significance and effect size remained same.

The model of mastery avoidance and exam 1 still violated normality assumption, however, met homoscedasticity assumption. Significance and effect size remained same. The model of mastery avoidance and exam 2 still violated both normality and homoscedasticity assumptions. Significance and effect size remained same. The model of mastery avoidance and the total learning outcome still violated normality assumption, however, met homoscedasticity assumption. Significance and effect size remained same.

The model of performance avoidance and the total number of reflections met both normality and homoscedasticity assumptions. However, significance and effect size remained same. The model of performance avoidance and exam 1 still violated normality assumption, however, met the homoscedasticity assumption. Significance and effect size remained same. The model of performance avoidance and the final exam score still violated normality assumption, however, p value was close to reject the null hypothesis ($p = .036$). Significance and effect size remained same.

Although beta distribution fit all distribution of response variables, the assumptions of some of the models as mentioned above were not improved. One possible explanation is that the data of both explanatory variables and response variables were clustered, meaning that students were clustered to a few score points. For instance, there were students who had similar score points for the reflection quality score and the final exam who had the same mastery approach score. In other words, the data distribution of exploratory variables and response variables were very similar. As a consequence, normality and homoscedasticity assumptions may not be appropriate to analyze the data.

Discussion

The overarching goal of this study was to investigate the relationship among achievement goals, reflection behavior and learning outcome of engineering students. The results indicate that there are significant effects of mastery approach on the number of reflections, final exam and total learning outcome. Performance approach had significant effects on the final exam and the total learning outcome. Although mastery approach and performance approach have limited significance on some of the response variables, the results align with some of the previous research studies on achievement goals, reflection behavior, and learning outcome[1,15,16,18,19]. That

is, performance approach is positively correlated with learning outcome and mastery approach is positively correlated with students' learning style and strategies. Our results indicated that mastery approach had the significance on learning outcomes such as final exam and the total learning outcome as well, however, performance approach had the stronger significance on the learning outcomes.

There are a few limitations in this study regarding the statistical analysis. For instance, since this is an exploratory research study, the impact of statistical significance of the analysis has limitations compared to the ones from the explanatory research study. Also, the sample size is limited due time constraints.

Conclusions and Implications for Future Research Studies

This research study addresses the necessity of research studies regarding achievement goal theory and engineering students' learning strategies and the outcome. Our findings support the numerous research studies in Educational Psychology field on achievement goals and their influence on students' reflection behavior and learning outcome.

A few potential directions for future research studies based on our research studies can be suggested. First, explanatory studies with the larger sample size can be performed to have a stronger impact on the statistical significance of the relationship among engineering students' achievement goals, learning strategies such as reflection behavior and learning outcome. Second, longitudinal research studies may be conducted to measure the effect of achievement goal and its long-term effect on students' learning strategies and learning outcomes. Third, more variables can be included to understand the relationship between achievement goals and reflection behavior and the learning outcome more thoroughly. Engagement, interest towards a course material or self-efficacy can be examples[31,32].

By addressing the influence of engineering students' achievement goals on reflection behavior and learning outcome in this study, not only researchers but also other stakeholders such as faculty members or administrators in engineering program can be benefited since they can have ideas on developing more effective intervention programs to facilitate students' motivation and learning outcomes. Therefore, more research studies on engineering students' achievement goals are required to provide these stakeholders with the research-based information.

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