JET
The Journal of Effective Teaching
an online journal devoted to teaching excellence

# The Role of Intrinsic Goal Orientation, Self-Efficacy, and E-Learning Practice in Engineering Education

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**Abstract**

Research on academic self-regulation suggests that students who are successful in academic settings tend to possess and use effective self-regulative learning characteristics such as intrinsic goal orientation and self-efficacy. Social-cognitive theories also emphasize that learning occurs through interactions between learners and the learning environment. For example, it is possible that students' learning is partially influenced by the interaction between their intrinsic motivation and self-efficacy levels and their performance in a self-paced e-learning environment. This study was conducted to explore the role that students' intrinsic goal orientation, self-efficacy, and e-learning practice have on learning in an introductory engineering class. The results showed that students significantly improved learning by the end of the course and that students' intrinsic goal orientation and e-learning practice made significant contributions to their learning. Implications of the results, limitations of the study, and recommendations for future research are discussed at the end.

**Keywords:** Academic self-regulation, intrinsic goal orientation, self-efficacy, e-learning, engineering education.

Many different models and perspectives describe college students' motivation and learning (Pintrich, 2004). *Academic self-regulation* is one of the perspectives built upon social-cognitive theoretical foundations that addresses the development and impact of self-regulatory characteristics of learners on their success or failure in academic settings (Schunk, 1989). Academic self-regulation is defined as "a way of approaching academic tasks that students learn through experience and self-reflection" (Pintrich, 1995, p. 7). Research on academic self-regulation has shown that learners who are successful in academic settings tend to possess and use effective self-regulative learning (SRL) characteristics. Some of the characteristics address cognitive and affective components of motivational profiles of the learners such as their intrinsic goal orientations, self-efficacy, or task values, whereas other characteristics are related to specific strategies that learners use during the learning process, such as rehearsal, elaboration, organization, management

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of time and study environment, or help seeking (Pintrich, Smith, Garcia, & McKeachie, 1991). SRL theory and research over the last 40 years has promoted adoption of the belief that student achievement is not solely based on their cognitive skills and abilities, but also based on such factors as self-regulative, motivational profiles of the learners (Schunk, 2005).

The understanding of the interplay between cognition and motivation in learning based on the social-cognitive theoretical framework of SRL has also broadened the scope of instructional approaches in academic settings. SRL theorists and researchers argue that self-regulative characteristics are not in-born, fixed traits of individuals; therefore, students can improve their motivation and learning strategies, especially when effective teaching strategies and environments are provided. SRL research has also demonstrated that motivational orientations and learning strategies are dynamic and context-bound; that is, students may have different levels of motivational orientations in different courses and they can learn to use effective SRL strategies for specific courses (Duncan & McKeachie, 2005). Numerous SRL-related studies have been conducted in various fields of postsecondary education such as Engineering (Hutchison, Follman, Sumpter, & Bodner, 2006), Marketing (Young, 2005), Math (Pereis, Dignath, & Schmitz, 2009), Nursing (Kuiper & Pesut, 2005), and Teacher Education (Perry, Phillips, & Dowler, 2004), to name a few.

### *Intrinsic Goal Orientation and Self-Efficacy for Academic Self-Regulation*

Self-regulation involves students being proactive with regard to their learning behavior or strategies to achieve self-set goals (Cleary & Zimmerman, 2004). Such self-regulative processes can be affected by students' goal orientations, intrinsic or extrinsic. *Intrinsic goal orientation* is motivation that stems from primarily internal reasons (e.g., being curious, wanting to challenge, wanting to master the content) whereas extrinsic goal orientation is caused by primarily external reasons (e.g., getting good grades, competing with others, and seeking approval or rewards). Research shows that students with an intrinsic goal orientation tend to value a deeper level of understanding of tasks than those with an extrinsic goal orientation, and that conversely, those with an extrinsic goal orientation tend to use more surface-level processing strategies such as memorization or guessing (Lyke & Kelaher Young, 2006). Intrinsic goal orientation, compared to extrinsic goal orientation, would also likely promote both short-term and long-term persistence toward the learning subject (Vansteenkiste, Lens, & Deci, 2006). Therefore, development of intrinsic goal orientation is more desirable for improving academic self-regulation.

Students' *self-efficacy* is also an important SRL characteristic that influences academic self-regulation and performance. Self-efficacy, defined as a "belief in one's capabilities to organize and execute the courses of action required to manage prospective situations" (Bandura, 1995, p. 2), affects both cognitive and affective dimensions of learning processes. Students can construct their self-efficacy beliefs through four different sources of experiences: mastery experiences, vicarious experiences, verbal persuasion, and physiological and affective states (Bandura, 1997). Among the four sources, mastery experiences of successfully solving problems are considered the most effective source for developing self-efficacy, because they help students build cognitive foundations for determining the level of efforts necessary for a success. High self-efficacy helps students become persistent in pursuing intrinsic goals and willing to attempt difficult tasks. Research has shown that self-efficacy among engineering students is a precursor of their outcome expectations, interests, and goals (Lent et al., 2008). Self-efficacy is not only a means for successful outcomes, but also a product of successful learning experiences. Research has shown that high achieving college students have significant higher self-efficacy than low achieving students (Al-Alwan, 2008).

### *Self-Regulative Learning Characteristics in Engineering Education*

Research indicates that around middle school age, students start to lose self-esteem, task values, and intrinsic motivation in academic tasks (Cleary & Zimmerman, 2004). By the time students graduate from high school, decisions on their academic and professional career goals are influenced by their intrinsic goals, self-efficacy, and perceived values toward certain subject matters. This leads to a question as to what levels of self-regulative characteristics, such as intrinsic goal orientation and self-efficacy, students possess and use in their introductory engineering course. Attrition rates are particularly high in the first and second years of the undergraduate engineering curriculum, due to various factors such as low GPA and self-rated abilities of success, a gender-biased atmosphere, and a lack of sense of community (Bernold, Spurlin, & Anson, 2007; Goodman et al., 2002; Hartman & Hartman, 2006). The percentage of engineering students who change majors or drop out of engineering altogether ranges from 40 to 70 percent (Hartman & Hartman, 2006). Therefore, understanding engineering students' self-regulative characteristics during one of their first introductory engineering courses would provide beneficial information on how to adjust instructional methods to improve their academic performance and to help them continue on with their engineering careers.

### *E-Learning for Self-Regulative and Mastery Learning Experiences*

The social-cognitive view and the Vygotskian view of SRL emphasize the importance of interaction between the characteristics of learners and the learning environment (Zimmerman, 1989). Mastery learning experiences can be facilitated via self-paced *e-learning environments* designed with interactive instructional contents and immediate feedback. Self-paced e-learning programs can allow students to make numerous attempts to produce successful outcomes, and this positive self-image of 'becoming' successful learners can help them build continuous motivation and persistence. When students were guided to use self-regulative learning techniques within e-learning context, they produce significantly higher learning outcomes, compared to when they were not persuaded to use self-regulative learning techniques (Santhanam, Sasidharan, & Webster, 2008).

Incorporation of e-learning strategies can benefit traditional engineering education techniques. Internationally, the engineering education community has been conducting educational research on how adopting e-learning strategies affects student learning. E-learning is often implemented in blended (hybrid) learning approaches that combine traditional education and e-learning (e.g., Ku & Fulcher, 2007; Lee & Low, 2004;

Sommaruga & De Angelis, 2007). The Sloan Consortium, a leading academic organization in the U.S., also advocates augmenting several of the ABET engineering competencies through online learning (Bourne, Harris, & Mayadas, 2005). However, adoption of e-learning in engineering education is still in its infant stage, and both positive and negative impacts of e-learning require continued studies (Kamp, De Jong, & Ravesteijn, 2008). Especially, it is possible that students' learning is partially influenced by the interaction between their self-regulatory characteristics such as intrinsic motivation and self-efficacy levels and their performance in a self-paced e-learning environment. This study examined this notion and reports the findings in the following sections.

## Method

### *Research Question and Participants*

This study was conducted to answer two questions: 1) What levels of intrinsic motivation and self-efficacy do students have in an introductory engineering class? and 2) What role do students' intrinsic goal orientation, self-efficacy and e-learning practice play in their learning? The target population of this research is college students who are taking an introductory engineering class. Students who enrolled in the Introduction to Materials Science and Engineering class offered at a mid-size university in the northwestern region of the United States during the spring semester of 2008 were used as a convenience sample. The sixty-seven students enrolled in the course were invited to voluntarily participate in the study in the beginning of the course, and 59 students agreed to do so by signing an informed consent form. Students who initially agreed to participate in the study were free to decline their participation in the research anytime during the course (meaning that their data would be excluded from the research analyses).

### *Instruments and Procedure*

**E-Learning Practice Modules**. Nine self-paced e-learning modules were used in this study. The nine e-learning modules covered the following topics of the course: mechanical properties of metals (2 modules), crystal defects, phase diagrams, eutectic phase diagrams, the iron-carbon phase diagram, and diffusion (3 modules). The development of the e-learning modules was partially supported by a National Science Foundation grant awarded to the institution in 2006. Each e-learning module was designed with multimedia (text, images, animation, video, and audio), using Gagne's nine events of instruction (Gagne & Mesker, 1996) and Cisco's guidelines for designing e-learning content (2003) as the design framework (see Table 1). E-learning development software, Articulate®, was used. Each e-learning module consisted of a module overview, instructional topics with practice, and a module test including multiple-choice, true-false, drag-and-drop matching, drag-and-drop sequencing, and short-answer questions. Each module ended with a module test, and the number of questions in the module tests ranged from 5 to 25 depending on the complexity of the content. The expected length of each module varied from 15 to 40 minutes. The instruction with audio narration was presented at a pre-set pace. However, students were allowed to control the sequence by using the navigation menu on the screen.

During the course, the nine self-paced e-learning modules were provided via Blackboard to the students as a homework assignment, regardless of their consent or dissent to participate in the study. Each e-learning module was assigned to be completed before the topic was covered in the classroom. Students were allowed to use the e-learning modules as many times as they want. Students' module test scores were automatically recorded on the gradebook of Blackboard. The average of the 9 module test scores was used to indicate the level of e-learning practice. If a student used a module multiple times, the score of the last attempt was used. Figures 1 and 2 are screen shots of the e-learning module on crystal defects.

**Table 1. The Framework for Designing E-Learning Modules.**

| Gagne's nine events of instruction | Cisco's e-learning content structure | An e-learning module on crystal defects |
|---|---|---|
| 1. Gain attention<br>2. Inform learners of objective<br>3. Stimulate recall of prior knowledge | Introduction, relevance, objectives, prerequisites, scenario or outline | Title<br>Module overview<br>Module objectives |
| 4. Present new content<br>5. Provide learning guidance<br>6. Elicit performance<br>7. Provide feedback | A series of topics with practices: e.g.,<br>Topic 1 + practice<br>Topic 2 + practice<br>Topic 3 + practice<br>etc. | Topic 1: Point defects<br>Topic 2: Dislocations<br>Topic 3: Planar defects<br>Topic 4: Pores, voids, and precipitates |
| 8. Assess performance | Assessment | Module test – 15 questions |
| 9. Enhance retention and transfer | Summary review | Module review |

**A Pre-Test and a Post-Test**. A written test of 30 objective questions measuring students' knowledge in the topics (that were covered in the e-learning modules) was administered in the classroom during the 1$^{st}$ week of the course, in order to check students' entry-level knowledge. The same test was administered again at the end of the course as a post-test to measure changes in students' knowledge levels specific to the topics covered in the e-learning modules. Each question in the tests included a confidence measure, asking students to rate how confident they thought their answers were correct. The confidence levels were measured on a 7-point scale, 1 being 'not confident at all' and 7 being 'very confident.' Below is an example. The pre-test and the post-test were administered for a research purpose, and the scores were not included in calculating the total points that determined the final letter grades of the course.

Q. A structure deforms or strains based on the magnitude of stress. In most cases, when metals are stressed in tension at a relatively low level, stress is directly proportional to strain. This is called __________.

a. Hooke's Law b. Poison's Ratio

How confident are you that your answer is correct?
Not confident at all 1 2 3 4 5 6 7 Very confident

**Figure 1. A screen shot of instructional steps.**

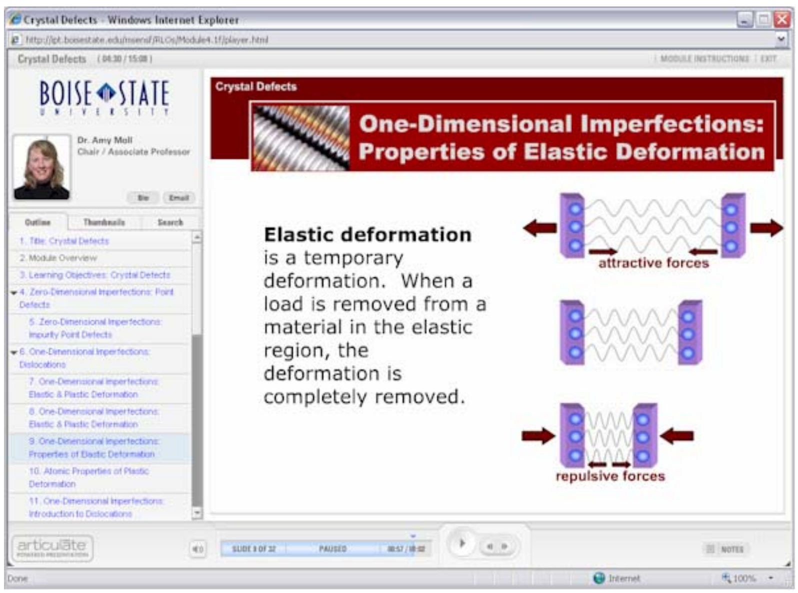
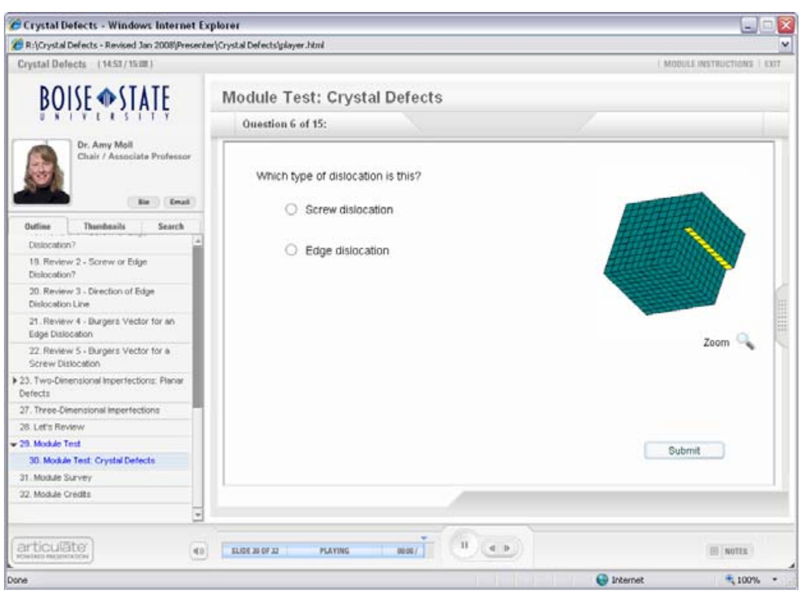


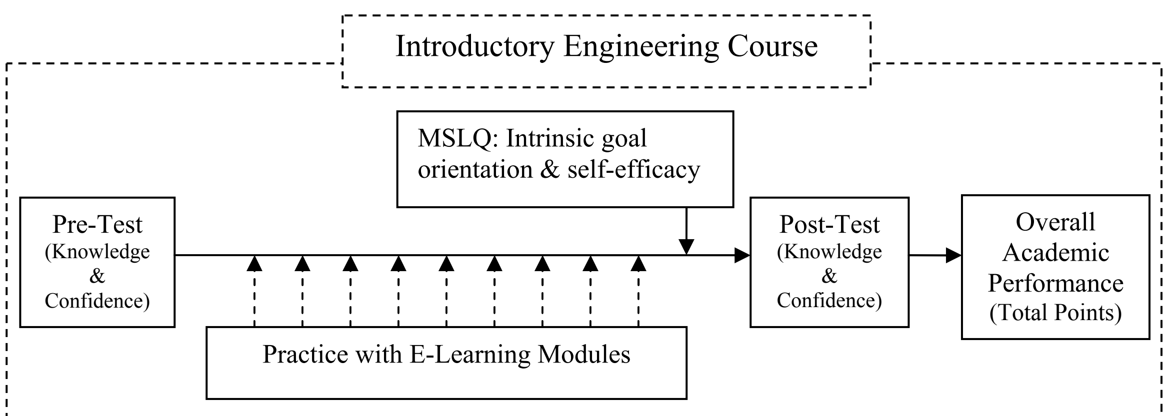

**Figure 2. A screen shot of a module test item.**



**Intrinsic Goal Orientation and Self-Efficacy**. Students' intrinsic goal orientation and self-efficacy levels were measured with two sub-scales of the Motivational Strategies for Learning Questionnaire (MSLQ) at the end of the semester. The MSLQ was developed by a group of researchers in the University of Michigan in the early 1990s to improve postsecondary teaching and learning (Duncan & McKeachie, 2005). It is designed to measure college students' motivational orientations and their use of learning strategies for a college course. The complete MSLQ contains 15 different sub-scales, which can be used together or singly (Pintrich et al., 1991). In the MSLQ, students' intrinsic goal orientation, defined as perceiving themselves "to be participating in a task for reasons such as challenge, curiosity, and mastery" (p. 9), was measured with four questions. The self-efficacy for learning and performance subscale of the MSLQ, consisting of eight questions, measured students' expectancy for success and self-efficacy, defined as "a self-appraisal of one's ability to accomplish a task as well as one's confidence in having skills to perform that task" (p. 13). The 12 questions used in the two subscales (intrinsic goal orientation and self-efficacy) are presented in Appendix A. The entire questionnaire and the reliability and confirmatory factor analyses results are available in the manual (see Pintrich et al., 1991).

**Overall Academic Performance**. Students' overall academic performance in the course was measured by the total points earned from five criteria including weekly homework (25%), weekly in-class quizzes (25%), two exams (20%), project (10%), and final exam (20%). Although different weighting was applied to the five criteria when determining final letter grades, unweighted total points were used as an indicator of overall academic performance in this study. Figure 3 presents the overall research procedure used in this study.

**Figure 3. The overall research procedure.**




## Results

### *Demographic Information*

One participant withdrew from the course during the semester, leaving 58 participants. Due to the voluntary nature of participation, 50 out of 58 participants provided complete sets of data. Among the 50 students, 43 (86%) of them were male and 7 (14%) were female. The average age of the participants was 25, ranging from 18 to 45 years of age (see Table 2). Six students were 18 or 19 years old, 30 students were in their 20s, 12 students were in their 30s and 2 students were in their 40s. The median age was 23.

**Table 2. Descriptive Statistics of Participants' Age.**

| Variable | *N* | *Min.* | *Max.* | *M* | *SD* |
|---|---|---|---|---|---|
| Age | 50 | 18 | 45 | 25.26 | 6.17 |

### *Overall Improvement in Knowledge and Confidence Levels*

To better understand student learning outcomes, the differences in knowledge scores and confidence levels between the pre-test and the post-test were analyzed. To make fair comparisons of data obtained from the pre- and post-test questions and confidence measures, percentages of the raw scores were used in analysis. The pre-test scores ($M$ = 54.60, $SD$ = 10.63) were not normally distributed (*Shapiro-Wilk* = .94, $p$ = .009) and negatively skewed (Skewness = -.894), possibly due to the fact that it was a convenience sample, rather than a sample randomly selected from its population. The mean value of the post-test scores was 79.40 ($SD$ = 9.10), which is an increase of 24.80 from the pre-test. A Wilcoxon Signed Ranks test (Green & Salkind, 2008) revealed that this difference was significant ($Z$ = -6.06, $p$ < .001). Thus, it was concluded that students achieved a significant level of learning during the course. Student learning was also confirmed by the changes in their confidence levels from 37.96 ($SD$ = 14.60) to 80.79 ($SD$ = 11.68). It should be noted that students' pre-test confidence levels ($M$ = 37.96) were significantly lower than their actual pre-test scores ($M$ = 54.60), $Z$ = -5.24, $p$ < .001, reasonably so considering the possibility that in some cases in the pre-test they selected correct answers by chance. However, students' confidence levels significantly improved from the pre-test to the post-test ($Z$ = -6.14, $p$ < .001), and no significant difference existed between their post-knowledge and post-confidence levels as measured by the post-test ($M$ = 79.40 and $M$ = 80.79, respectively, $Z$ = -1.39, $p$ > .05). This result indicates that students' post-test scores likely reflect their true knowledge. See Table 3.

**Table 3. Descriptive Statistics of Overall Learning Outcomes.**

| | *Pre-Test* | | *Post-Test* | | *Difference* | |
|---|---|---|---|---|---|---|
| Variable | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Knowledge | 54.60 | 10.63 | 79.40 | 9.10 | 24.80 | 14.05 |
| Confidence Levels | 37.96 | 14.60 | 80.79 | 11.68 | 42.83 | 16.89 |

Listwise $N$ = 50

### *Intrinsic Goal Orientation and Self-Efficacy Levels*

Students' intrinsic goal orientation and self-efficacy scores were analyzed to answer the first research question: What levels of intrinsic motivation and self-efficacy do students have in an introductory engineering class? The sample of students used in this study had above average levels of intrinsic motivation and self-efficacy (*M* = 4.96 and *M* = 5.50, respectively, on a 7-point scale). The results including the instrument reliability measured by Cronbach Alpha (α) levels were similar to the benchmark established by Pintrich and his colleagues' research (1991). Table 4 presents the comparisons.

**Table 4. Comparing Descriptive Statistics from Pintrich at al. (1991) and This Study.**

| | | *Pintrich et al.* | | | *This Study* | | |
|---|---|---|---|---|---|---|---|
| Variable | | *M* | *SD* | *α* | *M* | *SD* | *α* |
| Intrinsic Goal | Q1 | 5.05 | 1.41 | | 4.94 | 1.25 | |
| | Q2 | 5.68 | 1.38 | | 5.62 | 1.26 | |
| | Q3 | 5.23 | 1.41 | .74 | 4.94 | 1.16 | .70 |
| | Q4 | 4.14 | 1.58 | | 4.28 | 1.17 | |
| | Average | 5.03 | 1.09 | | 4.96 | .87 | |
| Self-Efficacy | Q1 | 4.95 | 1.59 | | 5.42 | 1.27 | |
| | Q2 | 5.18 | 1.62 | | 4.78 | 1.44 | |
| | Q3 | 6.36 | .96 | | 6.34 | .93 | |
| | Q4 | 5.36 | 1.48 | | 5.08 | 1.35 | |
| | Q5 | 5.24 | 1.47 | .93 | 5.18 | .96 | .88 |
| | Q6 | 5.55 | 1.39 | | 5.64 | 1.29 | |
| | Q7 | 5.57 | 1.30 | | 5.28 | 1.24 | |
| | Q8 | 5.55 | 1.34 | | 5.74 | 1.12 | |
| | Average | 5.47 | 1.14 | | 5.50 | .80 | |

Listwise *N* = 50

### ***The Role of Intrinsic Goal Orientation, Self-Efficacy and E-Learning Practice on Learning***

A simultaneous multiple regression analysis was conducted to answer the second research question: What role do students' intrinsic goal orientation, self-efficacy and e-learning practice play in their learning in an introductory engineering class? During pre-analysis data screening, two outliers were observed and removed. After removing the outliers, the normality, linearity and homoscedasticity assumptions (except for non-normality of post-test scores) were met for conducting a multiple regression study (Leech, Barrett, & Morgan, 2005; Mertler & Vannatta, 2005) (see Table 5).

As shown in Table 6, the combination of three variables (intrinsic goal orientation, self-efficacy, and e-learning practice) was found to play a substantial role in predicting students' learning, $F$ (3, 44) = 4.59, $p$ = .007. The *R squared* value was .24 and the *adjusted R squared* value ($R^2_{adj}$) was .19, indicating that 19% of the variance in the post-test scores was accounted for by the combination of the three variables. Their intrinsic goal orientation and e-learning practice were significant contributors ($p$ = .027 and $p$ = .040, respectively). The contribution of self-efficacy to the prediction was not significant. Two tolerance values (.70 and .68) were below .81 (= 1 - $R^2_{adj}$ = 1 - .19), but the variance inflation factors (VIF) were close to 1, which confirmed that multicollinearity was not a concern.

**Table 5. Normality and Intercorrelations.**

| | *Descriptive* | | *Test of Normality* | | *Intercorrelations* | | | |
|---|---|---|---|---|---|---|---|---|
| Variable | *M* | *SD* | *Shapiro-Wilk* | *p* | *1* | *2* | *3* | *4* |
| 1. Intrinsic Goal | 4.96 | .87 | .96 | .139 | - | .53 | .08 | .39 |
| 2. Self-Efficacy | 5.50 | .80 | .95 | .052 | - | - | .21 | .27 |
| 3. E-Learning | 91.74 | 5.21 | .95 | .081 | - | - | - | .32 |
| 4. Post-Test Score | 79.79 | 9.08 | .92 | .003 | - | - | - | - |

Listwise $N = 48$

**Table 6. A Simultaneous Multiple Regression Analysis Summary**.

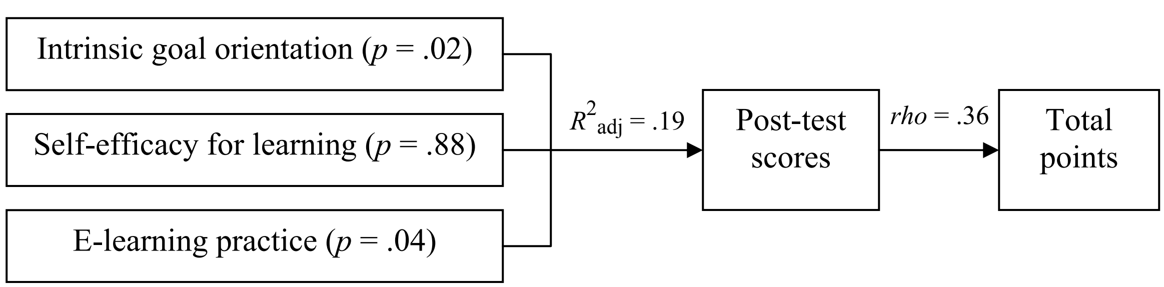
| | *Unstandardized Coefficients* | | *Standardized Coefficients* | | | *Collinearity Statistics* | |
|---|---|---|---|---|---|---|---|
| Model | *B* | *Std. Error* | *Beta (β)* | *t* | *Sig.* | *Tolerance* | *VIF* |
| (Constant) | 14.58 | 21.64 | - | .67 | .50 | - | - |
| 1. Intrinsic Goal | 3.68 | 1.61 | .35 | 2.28 | .02 | .70 | 1.41 |
| 2. Self-Efficacy | .26 | 1.80 | .02 | .14 | .88 | .68 | 1.46 |
| 4. E-Learning | .49 | .23 | .28 | 2.11 | .04 | .95 | 1.04 |

Dependent Variable: Post-Test Scores
$R = .49$, $R^2 = .24$, $R^2_{adj} = .19$; $F(3, 44) = 4.59$, $p = .007$; Listwise $N = 48$

### *Correlation between Post-Test Scores and Overall Academic Performance*

Overall academic performance was measured with the total points earned from the course. A nonparametric correlation analysis revealed that the post-test scores and the total points earned from the course had a moderate level of positive correlationship (*rho* = .36, $N = 48$). Figure 4 illustrates the overall relationships among variables found from the multiple regression and correlation analyses.

**Figure 4. Overall relationships among variables.**



## Discussion

The intrinsic motivation and self-efficacy levels measured by the sample of students used in this study were similar to the benchmark established by Pintrich and his colleagues' earlier research. Students' intrinsic motivation and self-efficacy levels were reasonably high, and they learned at a significant level by the end of the course. This study further explored the role that students' intrinsic goal orientation, self-efficacy and e-learning practice played in their learning in an introductory engineering course, and revealed that students' intrinsic goal orientation and e-learning practice were significant contributors to the prediction of learning.

### *The Role of Intrinsic Goal Orientation and Self-Efficacy in Engineering Education*

It is not surprising that intrinsic goal orientation ($\beta$ = .35) is a significant contributor to the prediction of learning in this engineering course. This result supports the existing literature that intrinsic goal orientation is one of the important determinants for academic self-regulation and helps to produce higher academic performance. As pointed out earlier, research shows that about 40 percent to 70 percent of students who start an engineering program end up changing their initial decisions and move to another engineering major, or drop out of an engineering major altogether (Hartman & Hartman, 2006). Therefore, it cannot be assumed that all students who start an engineering major and enroll in an introductory engineering course would have high levels of intrinsic goal orientation or maintain the levels throughout the course or program. To increase retention, the engineering education community should find ways to help students improve and maintain their intrinsic goal orientations toward engineering subject matters. For example, intrinsic goal orientation can be promoted by a certain learning environment such as problem-based learning (PBL). Research has shown that high school students who participated in PBL had higher levels of intrinsic goal orientation, metacognitive self-regulation, and peer learning, compared to students in a traditional instructional setting (Sungur & Tekkaya, 2006). PBL approaches have been incorporated into college-level engineering classrooms as well. Research shows that engineering students view PBL approaches favorably (Mitchell & Smith, 2008; Ribeiro, 2008), and that engineering students taught via PBL outperform those who were taught via subject-based learning (Nasr & Ramadan, 2008). PBL can also be effectively facilitated via e-learning. Middle-school students' attitudes toward science and their intrinsic goal orientation significantly increased after using an e-learning application (Liu, 2005).

Self-efficacy was not found to be a significant contributor to the prediction model in this study ($\beta$ = .02). Although the exact reasons for this result are unknown, a couple of plausible explanations exist. In this sample, students' self-efficacy scores were already relatively high ($M$ = 5.50 on a 7-point scale) and hence the variance in students' self-efficacy levels might have not been very sensitive for predicting post-test scores. Also, the self-efficacy data barely met the normality assumption (the $p$ value was .052). More normally distributed data from a larger sample may produce different results. Nonetheless, the non-significant contribution of self-efficacy to the multiple regression model found in this study does not disprove the important role that self-efficacy plays in academic self-regulation and performance. The intercorrelation between self-efficacy and post-test scores was .27 (Spearman's *rho* was .30), indicating a low-medium level of strength of a positive relationship.

### *The Role of E-Learning in Engineering Education*

Similar to the role of intrinsic goal orientation in predicting engineering students' academic performance, e-learning practice was found to be another significant contributor to the prediction of learning ($\beta = .28$). The higher the students' e-learning module test scores, the higher their post-test scores. This result confirms the benefits of using e-learning modules as learning activities to help improve students' understanding of specific content in an introductory engineering class. This result supports the fundamental learning principle that practice is an effective way to reach mastery learning. For example, individualized exercises improved calculating skills of engineering students in a fundamental mathematics class (Yoshiok, Nishizawa, & Tsukamoto, 2001).

E-learning also has economic benefits, and it provides engineering students with a convenient venue to practice during their learning processes. E-learning can support mastery learning experiences through repeated practice without incurring much burden on the instructor. Current learning management systems (e.g., Blackboard) are equipped to automate most of the 'management processes' such as authenticating, scoring, and record-keeping. As an example, the Blackboard's gradebook records in this study showed that on average, students used each e-learning module 1.5 times and accessed the e-learning modules for about 4 hours and 16 minutes. Because the records were not produced from a controlled research lab environment, it is difficult to verify the accuracy of these results as students may not have been solely focused on the module while it was open on their computer. Nonetheless, there is no doubt that provision of the e-learning modules created structured study hours outside the classroom, and that students received learning guidance from the e-learning modules without an instructor's presence.

### *Limitations of the Study and Recommendations for Future Research*

The findings of this study support that higher levels of intrinsic goal orientation and e-learning practice are associated with higher academic achievement. However, the small size of the convenience sample used in this study was the main limitation of the study. In addition, due to the nature of voluntary participation in educational research, data obtained from only 50 out of 66 students who completed the course were made available for analysis, and two datasets were excluded from analysis to ensure that multiple assumptions for conducting a multiple regression analysis were met. This actual sample size used in this study was smaller than desirable. A larger sample size would yield more reliable results from a multiple regression study. It is suggested that future researchers who wish to replicate this study secure a large sample size for their studies, for example using this formula: $N > 50+8K$ when $K$ = the number of predictor variables (Warner, 2008). Another limitation of the study was that the nine e-learning modules implemented in the study were for about 70% of the topics covered in the course. Had a complete set of e-learning modules for all of the topics covered in the course been used, more comprehensive data could have been obtained to correlate the results with the overall academic performance of the course. The non-normality of the post-test scores and the less-than-perfect linearity among variables were also limitations of the study.

For future researchers who are interested in studying the effectiveness of e-learning, it is recommended to use a learning management system to administer the modules which enables researchers to track students' online behavior. Depending on the research design, researchers could design the e-learning modules and set the system to allow participants to make only one attempt or a certain number of attempts or unlimited attempts on each e-learning module. However, as noted earlier, it would be important to administer the e-learning modules in a controlled environment in order to obtain reliable data from e-learning modules. Also, educational researchers often develop research treatments that also provide educational benefits. When designing e-learning modules for research and instructional purposes, the current e-learning practice suggests following the principle of granularity. A recommended size for small chunks of e-learning modules is to be completed in 15-20 minutes, allowing students to engage in self-paced learning, anytime from anywhere.

## Acknowledgements

This work was supported in part by the National Science Foundation under Grant No. 0530139. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. The authors appreciate co-principal investigators of the grant, Drs. Callahan, Knowlton, and Müllner, for their contributions to this project.

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# Appendix A

**The Intrinsic Goal Orientation and Self-Efficacy Questions in the MSLQ.**
(Pintrich et al., 1991)

| Sub-Scale | Question Item |
|---|---|
| Intrinsic Goal Orientation | 1. In a class like this, I prefer course material that really challenges me so I can learn new things.<br>2. In a class like this, I prefer course materials that arouse my curiosity, even if it is difficult to learn.<br>3. The most satisfying thing for me in this course is trying to understand the content as thoroughly as possible.<br>4. When I have the opportunity in this class, I choose course assignments that I can learn from even if they don't guarantee a good grade. |
| Self-Efficacy for Learning and Performance | 1. I believe I will receive an excellent grade in this class.<br>2. I'm certain I can understand the most difficult material presented in the readings for this course.<br>3. I'm confident I can understand the basic concepts taught in this course.<br>4. I'm confident I can understand the most complex material presented by the instructor in this course.<br>5. I'm confident I can do an excellent job on the assignments and tests in this course.<br>6. I expect to do well in this class.<br>7. I'm certain I can master the skills being taught in this class.<br>8. Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this class. |