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What Motivates Engineering Students? A Study in Taiwan*

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This study investigates the factors motivating learning among engineering students. A questionnaire based research framework that addresses the learning motivating factors and their links to students' motivation was employed. Statistical analyses are applied to investigate the factors that motivate engineering students to learn. The findings provide insight into the development of teaching inventories for engineering students. To enable students to learn effectively, a supportive setting with enabling factors and a cooperative learning environment is appreciated. Based on the study of the motivating factors and their impact on the learning motivation of engineering students, suggestions are made as to what can be developed to promote students' motivation.

Keywords: learning motivation; influencing factors; engineering students; Taiwan

INTRODUCTION

STUDENTS FROM THE TECHNOLOGY AND ENGINEERING FIELD are future professionals or the academia of the future and are vital to any prospering society. In the high-tech industries where high-tech professionals are vital assets, universities are talent pools providing a continuous workforce to the industry. To enhance the competitiveness, employers in the industry are expecting well-trained graduates with advanced skills and specific job-related knowledge. Not only are the companies looking for well-trained knowledgeable talent, they are also looking for individuals with a set of positive attributes. These attributes include the ability to operate in a dynamic environment, a positive working attitude, the ability to manage and handle multiple issues, the ability to apply learnt knowledge to perform analysis for decision making, etc.

The learning pathway that the candidate has gone through is thus critical. However, most of the courses offered at engineering schools are for explicit knowledge enhancement; there has been lack of consideration about the key features of a facilitative learning environment for engineering students. To enhance students' motivation, educators in higher education are urged to consider providing a better learning setting based on a variety of motivational constructs.

Based on this, the learning motivation may have motivating effects on student learning performance [1]; but what learning setting should educators develop to provide students with a facilitative environment to grow, learn, and develop.

Motivation and learning

Learning and motivation are highly complex facets of human behavior. The relationship between motivating factors and learning has been a prominent research topic in both educational and organizational studies [2]. This study investigates the factors that motivate learning among engineering students and the relationships between motivating factors and learning motivation.

Motivation is an enabler for learning and academic success [2, 3]. The importance of motivation for knowledge transfer has been advocated by researchers [4]. Therefore, an aim of every learning oriented entity is to explore the factors that enable and motivate individuals to learn. Motivational theories, such as motives and needs [5–7], Expectancy Theory [8], Adam's Equity Theory [9, 10], Cognitive Theory [11], Reinforcement Theory [12], and Goal Setting Theory [13] have been widely studied. Recent research primarily focuses on the need for achievement, which interacts with other variables to influence performance, and examined its relationship with work behavior [14]. Meanwhile, cognitive ability is found to moderate the relationship between the need for achievement and performance [15].

Expectancy theory [8] suggests that motivation is a multiplicative function of three constructs:

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expectancy (*people have different expectations and levels of confidence about what they are capable of doing*), instrumentality (*the perceptions of individuals as to whether they will actually get what they desire*) and valence (*valence refers to the emotional orientations hat people hold with respect to outcomes or rewards*). Rasch and Tosi [16] proved the significant relationships between performance and the elements such as expectancy, goal setting (*the notion that individuals have a drive to reach a clearly defined end state*) and the need for achievement of an individual.

Equity [9] was primarily proposed as a way of understanding how people respond to situations in which they are treated more or less favorably compared with a referent "other". This theory attempts to explain relational satisfaction in terms of perceptions of fair/unfair distributions of resources within interpersonal relationships.

Reinforcement Theory and Cognitive Evaluation Theory have also been two of the key theories within the mainstream of the motivation field. Reinforcement theory emphasizes the relationship between behavior and its consequences [12]. Cognitive Evaluation Theory suggests two motivational subsystems: an extrinsic subsystem and an intrinsic subsystem [11], in which situational variables and impacts from external sources could significantly affect the cognition and hence the motivation of an individual. This theory argues that intrinsic motivation is maintained only when the actors feel competent and self-determined.

The above mentioned theories are commonly used to explain how individuals are motivated intrinsically, it has long been believed that individual motivation greatly affects human behavior and determines their learning.

Personal goals

Personal goals are important in determining performance. The positive relationship between efficacy and performance has been addressed [17, 18]. The mediating roles of self-efficacies of students towards academic achievements have been proved [19–21].

Research that focused on several important issues related to the theory of goal setting was carried out in the 1990s. This includes the study of the goal difficulty–performance relationship, goal commitment in goal setting [13], personal goals and self-efficacy and effectiveness of goal setting. Self-efficacy generally refers to what a person believes he or she can do in a particular task. Wofford's study examined the role of self-efficacy in the goal setting process and self-efficacy has been proven to correlate with the intrinsic motivation and commitment to goal attainment [13]. People with a high-level of self-efficacy are likely to set high goals and to perform well [22]. Self-set goals are often more desirable than assigned goals because they automatically engender a higher-level of commitment [23]. Klein and Mulvey [24] further suggested that cohesiveness within teams also positively relates to goal commitment.

Learning in with peers

Not surprisingly, team learning has been proven to be gaining importance in education [25–27]. Team performance improvement is a result of the collective-intelligence of a team, which exceeds the sum of the intelligences of the individuals [28–30]. Knowledge gained by teams has been associated with realizable benefits in the form of improved performance [31–33]. This aligns well and is similar to the Core Group Theory, which explains how the power, knowledge, and influence of core groups interacts with opportunities of gaining learning and creativity for the groups concerned [34].

Engineering students and learning in teams

The learning motivation of the engineering education students is essential to their success. Besides in-class learning, engineering students also have opportunities to learn by performing experiments and to learn through team-based activities. Engineering students are experiencing team learning frequently. Learning does not take place solely within groups. Team learning therefore allows effective learning to take place at both individual and team levels, emphasizing the importance of the empowerment of individuals to take action [35–37].

THE STUDY AND RESEARCH FRAMEWORK

In this study, while searching for grounds for learning success, a better understanding of the determinants of learning effectiveness will improve the likelihood of achieving the preferred outcome.

We divided the learning factors into two main categories: intrinsic factors and extrinsic factors. Intrinsic factors refer to those factors focusing on the individual, such as individual attitude, expectation of outcomes and goal-setting. Extrinsic factors refer to those focusing on the environmental setting, such as the challenging tasks, social pressure and competition with peers, rewards and punishments.

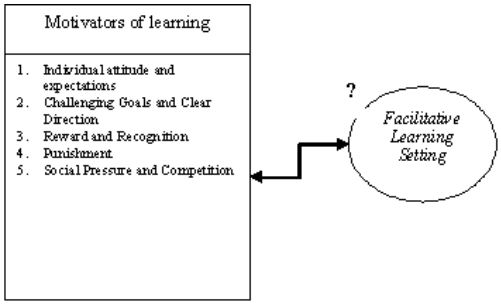

Fig. 1. Research framework.

METHODOLOGY

Questionnaire design

To investigate the learning motivating factors of selected groups of students, a questionnaire for studying the motivating factors is developed. Key motivating constructs are evolved from a questionnaire that has already been used in student learning motivation study [38, 39].

Pilot study and finalized questionnaire

A pilot study was carried out, prior to the data collection, to check the validity of the questionnaire and the appropriateness of the statement sets and as well to locate possible areas for refinement. The pilot study was carried in early 2007 (samples were collected from Norway, Hong Kong and Taiwan to also check for differences related to culture and study strategies [40, 41]). These results provided a preliminary basis for a pilot instrument for further tests. The questionnaire was then refined for data collection in Taiwan.

The final questionnaire comprised four parts. The first part asked for demographic information, such as level of study (postgraduate or undergraduate) and gender. The second part enables the identification of the factors that had a positive motivating effect on learning. There are 23 statements of six motivating factor dimensions and their perceived learning motivation.

A 1–6 Likert-scale scoring system is adopted, starting from 'disagree very much' to 'agree very much'. The high score represents a strong positive motivating effect on learning. The discerning point is set as 3.5, the middle of scale.

Participants

Data collection in Taiwan was divided into two rounds, the first round was conducted in May 2008 (just before the summer break), 35 postgraduate students from National Taiwan University were invited and 33 successful samples were received. To secure the significant sample size from undergraduate level, another round of data collection in Taiwan was carried out in early November (during the autumn term). An additional 47 samples were received from the 100 invitations. Generally, the students were contacted during the class time to secure a high response rate. They were invited to participate in the survey study on a voluntary basis. The data were manually entered into spreadsheets that were later imported into SPSS for statistical analysis.

Statistical approach

Reliability and factor analysis

The reliability is tested based on the average inter-item correlation (i.e. Cronbach alpha). The high value of α (0.86) suggests a high level of internal data consistency. Factor analysis is also applied to check if the motivating factors are properly categorized. The high value of Kaiser–Meyer–Olkin Measure of Sampling Adequacy (0.613) indicates that the variance in variables might be caused by underlying factors, thus a factor analysis may be useful. Very small values of significance (i.e. 0.00) indicate that there are probably significant relationships among variables. The factor analysis suggests a better categorization of the motivating factors. The list of factors is shown in Table 2.

Discriminant validity is checked using the multitrait matrix presented in Table 3. The diagonal figures of the matrix are the reliability coefficients for each latent variable identified. The remainder of the table is a correlation matrix between the pairs of variables. The correlation coefficients within each column are less than the Cronbach's alphas found in the diagonal (Table 3). This indicates that the internal reliability is much higher than the inter-item reliability [42] that, in turn, shows strong empirical support for discriminant validity.

Table 1. Demographic details of participants

	Postgraduate	Undergraduate
Invitations	35	100
Male	25 (76%)	42 (89%)
Female	8 (24%)	5 (11%)
Subtotal of responses	33	47
Response rate %	94%	47%

Table 2. List of factors

Items	Factor loadings*
Expectation and attitude	
1. Expectation of good grades	*0.80*
2. Positive attitude towards learning	*0.66*
3. Expectation of high marks	*0.85*
4. Expectation of achievements	*0.72*
Challenging goals	
5. Difficult tasks	*0.70*
6. Challenging deadline	*0.55*
7. Challenging goals	*0.50*
Clear direction	
8. Clear course objectives	*0.70*
9. Specific goals in learning	*0.71*
10. Clear target of achievement	*0.53*
Reward and recognition	
12. Positive appraisals by others	*0.50*
13. Appropriate reward is applied.	*0.77*
14. The instructor's encouragement and good comment	*0.62*
Punishment	
16. Punishment is applied	*0.90*
17. Mistakes avoidance	*0.90*
18. Good works to avoid mistakes	*0.88*
Social pressure and competition	
19. Social pressure from peers	*0.55*
20. Motivation from peers	*0.66*
11. Competition from peers	*0.51*
Team learning	
22. Motivation by the team learning	*n.a.*

Items are deleted due to too small factor loadings.
** Factor loadings are the rotated component matrix by factor analysis. Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.*

Table 3. Multi-traits matrix

Constructs	Individual attitudes and expectation	Challenging goals	Clear direction	Reward and recognition	Punishment	Social pressure and competition
Individual attitudes and expectation	*0.84*	/	/	/	/	/
Challenging goals	0.27*	*0.72*	/	/	/	/
Clear direction	0.67**	0.02	*0.77*	/	/	
Reward and recognition	0.57**	0.26*	0.58**	*0.70*	/	/
Punishment	–0.1	0.04	0.04	0.06	*0.85*	/
Social pressure and competition	0.36**	0.60**	0.36**	0.28*	0.30*	*0.74*
Learning motivation	0.31**	0.42**	0.31**	0.28*	0.30**	0.58**

*Pearson correlation, listwise, N= 80, 1-tailed. The diagonal is the Cronbach's alphas for each latent variable. The remainder of the table is a correlation matrix between the pairs of latent variables. *P < 0.05, **P < 0.01*

Table 4. Summary of findings

Constructs	All (n = 80) $\bar{X}$	s	Post-graduate (n = 33)	Under graduate (n = 47)	Male (n = 67)	Female (n = 13)
Individual attitudes and expectation	**4.88**	0.67	5.14	4.70	4.85	5.02
Challenging goals	4.21	0.69	4.44	4.05	4.19	4.33
Clear direction	**4.85**	0.68	5.10	4.67	4.85	4.82
Reward and recognition	**4.78**	0.64	5.00	4.62	4.76	4.87
Punishment	3.57	0.98	3.76	3.43	3.52	3.79
Social pressure and competition	4.38	0.74	4.72	4.13	4.35	4.52
Learning motivation	4.31	1.01	4.79	3.98	4.27	4.54

FINDINGS

Summary of findings

T-TEST TO JUSTIFY THE MOTIVATING EFFECTS

The data obtained from the survey study are derived from interval measurements (Likert scale on continuous basis). It is assumed that the measurement scales are intervals so that the arithmetic operations can be used while observations are independent. Parametric techniques are thus used as the test of hypotheses setting [43]. The one-sample t-test procedure tests whether the mean of a single variable differs from a specified constant. The significance level is set as $\alpha = 0.05$. It is hypothesized that the mean score above 3.5 is of a positive motivating effect, thus the hypotheses can be set as follows:

$$H1: \mu > 3.5$$

The critical value is set as a reference; it can be found from the t-table according to the degree of freedom. The t-value of each motivating factor construct provides the evidence to indicate its motivating effect on learning. If $t >$ critical value, we reject H0; if t = critical value, we do not reject H0. The degree of freedom (df) of this data set is n –1= 79. From the t-table, the critical value at 95% confidence interval is 1.96. So we compare the t-value with 1.96. The results from the t-test are summarized in Table 5.

Independent sample t-test

An independent sample t-test was used to compare the mean scores of the factors between sample groups from different levels (postgraduate and undergraduate). Results from the independent sample t-test are presented in Table 6.

Discussions on the findings

MOTIVATING EFFECTS OF THE FACTORS

Some interesting implications are seen from the above analysis. Both intrinsic and extrinsic factors have motivating effects on learning motivation. From Table 5, the results confirm that most of

Table 5. Results from the one-tailed t-test

Factors	Critical value	Test value = 3.5	
		t	sig.
Individual attitudes and expectation	1.96	25.9	0.00
Challenging goals	1.96	14.4	0.00
Clear direction	1.96	24.3	0.00
Reward and recognition	1.96	23.8	0.00
Punishment	1.96	**0.32**	**0.75**
Social pressure	1.96	15.5	0.00
Learning motivation	1.96	11.7	0.00

Table 6. Comparison of means of postgraduate and undergraduate students

Constructs	*F*	*t*	*Sig.*	Significant different between two groups
Individual attitudes and expectation	1.48	3.02	0.003	Y
Challenging goals	0.099	2.61	0.011	Y
Clear direction	0.40	2.79	0.007	Y
Reward and recognition	2.88	2.73	0.008	Y
Punishment	1.71	1.46	0.15	N
Social pressure	0.11	3.72	0.00	Y
Learning motivation	0.28	3.80	0.00	Y

Table 7. Ranking of motivating factors

	Postgraduate (n = 33)	Undergraduate (n = 47)
Most motivating factors	Individual attitude and expectation (5.14) Clear direction (5.10); Reward and recognition (5.00)	Individual attitude and expectation (4.70) Clear direction (4.67); Reward and recognition (4.62)
Least motivating factor	Punishment (3.76)	Punishment (3.43)
Learning motivation	4.79	3.98

the factors have a strong positive motivating effect on learning motivation, except 'Punishment'. The finding supports that 'individual attitudes and expectation', 'clear direction' and 'reward and recognition' are perceived as the most motivating factors. This suggests that effective learning is determined by multiple factors: both the intrinsic factors of the students and environmental factors will affect learning.

Differences between postgraduate and undergraduate groups

From Table 6, the small significance values (< 0.05) of the motivating factors, except 'Punishment', suggest the significant differences between the mean values of 'Punishment' of the two groups. Table 7 summarises the most motivating factors and least motivating factors as rated by participants. There is no difference in the ranking of the factors but we can note that 'individual attitude and expectation' shows significant difference in mean value (5.14 and 4.70). Meanwhile, the perceived learning motivation is also worth noting (4.79 and 3.98). The significant and obvious differences are justified by the independent t-test (Table 6). Postgraduates perceive the stronger motivating effect of 'individual attitude and expectation' on learning motivation. They are more self-confident, and they show higher level of motivation in learning. For undergraduates, 'individual attitude and expectation', 'clear direction' and 'reward and recognition' have similar impacts on learning motivation.

Insights on teaching engineering graduate students

The study provides a means of examining how these factors influence engineering students' learning. Some of the factors are correlated, for example, for some of the factors like challenging work/job or punishment, we look at how they influence, and to what extent are greatly dependent on, the individual attitude and expectation. The findings from the study also give insight into the development of teaching inventories for engineering education. To enable students to learn effectively, a supportive environment with enabling factors (i.e. rewards and clear goals) and a learning environment (i.e. group pressure) should be provided. Having found 'What' the influencing factors are, the study leaves with the question of 'How' to identify the factors that could motivate learning effectively.

As educators in higher education strive to provide good education, facilitating learning frameworks and approaches are designed and put into place in an attempt to achieve this goal. Educators thus need to be aware that providing the best course content and structures are not enough. The learning settings for engineering students at different levels require different features.

The motivation and learning setting affect the success of course designed to ensure learning. Academics need to be aware of and account for the effects of student motivation. If student motivation is lacking, the effectiveness of any designed intervention will be reduced. They also need to ensure that continuing facilitation and guidance is given to ensuring that students are motivation at both individual and collective levels and have a clear vision of the subject being studied.

CONCLUDING REMARKS AND FUTURE WORK

The study showed that the investigated factors provide positive motivating effect to certain degrees, whereas the extrinsic factor "Punishment" is quite weak in its positive motivating effect. The subjects pay greater importance to the intrinsic

factors (i.e. individual attitude and expectations), though this preference is hard to measure and control. The extrinsic factors are seen to have a clearer trend to motivating effects for the team-based learning, while the intrinsic factors play an important psychological role for the individual members in the learning teams of engineering students.

Unlike individual learning, team learning requires a better understanding of people, not only as individuals but regarding the team dynamics as well. The environment, that is all the extrinsic factors when 'applied appropriately', will have a great positive motivating effect on their learning.

Education is frequently believed to be the end result rather than the process of enlightening, opening of eyes and changing of mindsets. With the notion that the motivating factors may have a motivating effect on learning, this study made a first step in the investigation of how these factors have an effect on engineering students' learning. By knowing what the key motivators of learning are, learning can be motivated within a facilitative learning setting, and this will enhance the learning effectiveness. This survey was confined to the learning environment for engineering students in a graduate institute in Taiwan. A further study will be aimed at increasing the validity of our results by continuing this study with larger samples and a broader scope. It will be worth extending such a study to obtain a better and wider understanding of whether such a conclusion also hold true for other disciplines.

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