Int. J. Engng Ed. Vol. 25, No. 1, pp. 144–151, 2009
Printed in Great Britain.

0949-149X/91 $3.00+0.00

A Comparative Study of Learning Motivation among Engineering Students in South East Asia and Beyond*

KRIS M Y LAW,[1] FRODE EIKA SANDNES,[2] HUA-LI JIAN[3] and YO-PING HUANG[4]
[1] *Graduate Institute of Industrial Engineering, National Taiwan University, Taipei, Taiwan. Department of Manufacturing Engineering and Engineering Management, City University of Hong Kong, Kowloon Tong, Hong Kong. E-mail: mekris@cityu.edu.hk*
[2] *Faculty of Engineering, Oslo University College, Oslo, Norway.*
[3] *Department of Foreign Languages and Literature, National Cheng Kung University, Tainan, Taiwan.*
[4] *Department of Electrical Engineering, National Taipei University of Technology, Taipei, Taiwan.*

This investigation covers learning motivation among engineering students and the relationships between learning approaches and those motivating factors. A questionnaire-based research framework that addresses these motivating factors and their linkages with team learning and action-learning approaches was employed. The findings from the study provide insights into the development of teaching inventories for engineering students. To enable students to learn effectively, a supportive setting with pulling forces should be provided (i.e. rewards, achievement, clear goals) and a cooperative group-based learning environment should exist (i.e. group pressure). Based on this study, suggestions are offered regarding what can be developed to promote students' motivation.

Keywords: Learning motivation, influencing factors, team learning, action learning, engineering education

INTRODUCTION

ENGINEERS ARE VITAL to any prospering society and the effective training of the next generation of engineers is therefore crucial. Essential to the success of engineering education is the learning motivation among the students. Learning and motivation are highly complex facets of human behaviour. People do learn from their experiences, and their willingness to learn is affected by a set of determinants. Relationships between motivating factors and learning have been a prominent research topic in the field of higher education [1].

MOTIVATION AND LEARNING

Motivation is believed to be an enabler for learning and academic success [1, 2]. The importance of motivation for knowledge transfer has been advocated by several researchers [3, 4]. It isn't surprising, therefore, that the aim of every learning-orientated researcher is to explore the factors that enable and motivate individuals to learn.

Motivation in learning is described as the desire to use the knowledge and skills mastered in associated learning activities [5]. It constitutes a central force when going through process-of-learning activities. Motivational theories, such as motives and needs [6, 7, 8], Expectancy Theory [9], Adam's Equity Theory [10, 11] Cognitive Theory [12] and Reinforcement Theory [13], Goal Setting Theory [14], have been widely studied.

Recent research has primarily focused on the need for achievement, which interacts with other variables to influence performance, and it has examined its relationship with work behaviour [15]. Meanwhile, cognitive ability is found to moderate the relationship between need for achievement and performance [16].

Expectancy theory [9] suggests that motivation is a multiplicative function of three constructs:

1) expectancy (people have different expectations and levels of confidence about what they are capable of doing);
2) instrumentality (the perceptions of individuals whether they will actually get what they desire);
3) valence (valence refers to the emotional orientations people hold with respect to outcomes or rewards).

Rasch and Tosi [17] 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.

* Accepted 24 August 2008.

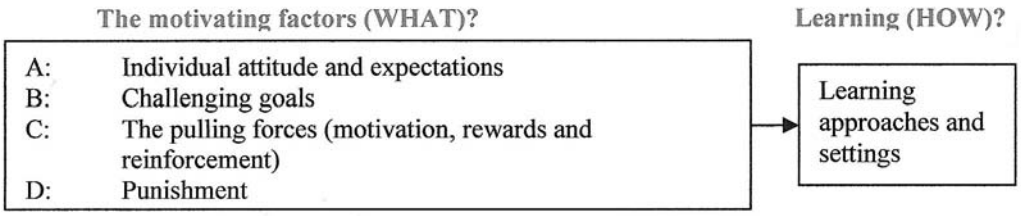

Fig. 1. The research framework.

Equity [10, 11, 18] was primarily proposed as a way of understanding how people respond to situations in which they are treated more or less favourably in comparison to 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 motivation field. Reinforcement theory emphasizes the relationship between behaviour and its consequences [13]. Cognitive Evaluation Theory suggests two motivational subsystems: extrinsic subsystem and intrinsic subsystem [12], 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 actors feel competent and self-determined.

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

Personal goals

Personal goals are important in determining performance. The positive relationship between efficacy and performance has been addressed [19, 20]. The mediating roles of self-efficacies of students towards academic achievements have been proved [21, 22, 23].

Research focused on several important issues related to the theory of goal setting was carried out in the 1990s. This included the study of goal difficulty-performance relationship, goal commitment in goal setting [14], 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 [14]. People with high-level self-efficacy are likely to set high goals and to perform well [24]. Self-set goals are often more desirable than assigned goals because they automatically engender higher-level commitment [25]. Klein and Mulvey [26] further suggested that cohesiveness within teams also positively relates to goal commitment.

Team learning

Not surprisingly, team learning has been proved to be gaining importance as a developmental strategy [27, 28, 29]. It has been well documented [30, 31] and extensively studied [32, 33, 34, 35, 36, 37, 38].

Peter Senge [37] explained that team performance improvement is a result of the collective intelligence of a team, which exceeds the sum of intelligence of individuals. Knowledge gained by teams has been associated with realizable benefits in the form of improved performance [35, 39, 40]. 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 to gain learning and creativity for the groups concerned [41].

Action learning

Action learning has been proposed as one of the effective approaches in learning [42] and a problem-solving approach when facing complex problems [43]. It was first elaborated by Revans [44] as a type of learning that comes from concrete problem-solving experience and critical reflection within a social environment, by encompassing a wide variety of management learning methods and activities of action and reflection with proper facilitation [45]. Learning does not take place solely within groups [46]. Emphasizing the importance of the empowerment of individuals to take action, action learning therefore allows effective learning to take place at both individual and organizational levels [47, 48, 49]. In this way, the goal-driven action learning through project teams can be applied as the learning approach.

STUDY AND RESEARCH FRAMEWORK

In this study, while searching for a ground for learning success, a better understanding of the determinants of learning effectiveness will thus improve the likelihood of achieving a preferred outcome. Figure 1 shows the research framework linking the motivating factors and learning approaches.

METHODOLOGY

Questionnaire design

To investigate the learning motivating factors of selected groups of students, a questionnaire for

student learning teams motivating factors study is developed by referring to the previous work of Yin et al [50]. The questionnaires comprised two parts. The first part solicits demographic information (program, mode of study). The second part addresses the motivating factors which may affect students' learning motivation.

Pilot study and finalized questionnaire

The preliminary questionnaire was used in the pilot study to help identify the key motivating factors and thus provide a basis for further refinements. The pilot study was carried in early 2007 (samples were collected from Norway, Hong Kong and Taiwan to check also for differences related to culture [53, 54]). This helped to check the validity of the questionnaire and appropriateness of the probing questions.

The questionnaires were in four parts. The first part asked for demographic information, such as level of study (undergraduate or postgraduate), mode of study (full time or part time), gender and the learning approach (if students are taking team-based/ action-based learning courses).

The second part enabled the identification of factors having positive motivating effect on learning. There are 23 statements of 6 motivating factor dimensions and their perception towards the learning approaches (team-based learning and action-based learning).

A 1–6 Likert-scale scoring system was adopted, ranging 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 the scale.

The finalized questionnaires were first authored in English. It was then translated into traditional Chinese by the author from Hong Kong.

Participants

The questionnaire was developed in two stages. First, the pilot group was asked to evaluate the appropriateness of the learning motivating factor questions. These results provided a preliminary basis for a pilot instrument for further tests. Another round of larger scale pilot study was carried out in early 2007 for further refinements, which further confirmed the appropriateness of the statements set.

Table 1 lists demographic details of the students participating, including the total number of students for each group (and university), the number of females, the mean age and its standard deviation.

Data collection

Data collection started in Hong Kong in January 2008. A total of 144 students from City University of Hong Kong were invited, and 79 returned the questionnaires. The data collected in Hong Kong included 67 undergraduate students, 12 postgraduate students, composing full time and part time students. The students were contacted during class time to secure a high response rate and some of them were e-mailed with their forms submitted electronically. Data were manually entered into Microsoft Excel spreadsheets which were later imported into SPSS for statistical analysis.

Statistical approach: reliability and factor analysis

Reliability testing was based on average inter-item correlation (i.e. Cronbach Alpha). The high value of α (0.9627) suggests a high level of internal data consistency.

Factor analysis was also applied to check if the motivating factors were properly categorized. The high value of Kaiser-Meyer-Olkin Measure of Sampling Adequacy (0.874) indicates 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 suggested a better categorization of the motivating factors. The results are shown in Table 2.

FINDINGS

Table 3. Summary of findings of six key constructs of motivating factors

T-Test

Data obtained from the survey are derived from interval measurements (Likert scale on continuous basis). It was assumed that the measurement scales are intervals so that arithmetic operations can be used while observations are independent. Parametric techniques are thus used as the test of hypotheses being set [52]. In this study, t-test was used; results are summarized in Table 4.

Statistical analysis was carried out using SPSS. Besides descriptive statistics, one-tailed t-test was adopted to test the hypotheses set. The significance level was set as $\alpha = 0.05$. It was hypothesized that the mean score above 3.5 was of positive motivating effect, thus the hypotheses can be set as follows:

H0: $\mu \leq 3.5$
H1: $\mu > 3.5$

Table 1. Demographic detail of the respondents

	Number of respondents		
	Master Level	Undergraduate Level	
		Full time	Part time
Invitations	48	59	41
Male	10	29	14
Female	2	21	3
Subtotal of responses	12	50	17
Response Rate %	25%	85%	41%

Table 2. Summary of results on factor analysis of the motivating factors

	Scale	Code	Factor Loadings*
1	Individuals attitudes and expectations		
	Expectation of benefits	A1	0.705
	Positive attitudes	A2	0.795
	High marks	B1	0.807
	Positive outcomes	B2	0.529
2	Challenging Goals		
	New challenges	C1	0.705
	Challenging deadline	C2	0.757
	Challenging goal	C3	0.584
3	The Pulling forces		
	Clear goal/vision and Competitive Objectives		
	Clear goal	D1	0.591
	Clear specifications	D2	0.763
	Championship	E1	0.554
	Reward & Reinforcement		
	Appraisal	F1	0.683
	Reward	F2	0.524
	Encouragement	G1	0.650
4	Punishment		
	Motivation w punishment	H1	0.906
	Team w punishment	H2	0.936
	Mistake avoidance w punishment	H3	0.898
5	Group Pressure		
	Competition in team	I2	0.641
	Motivation in team	I3	0.686

Remarks*:
- Factor loadings are the rotated component matrix by factor analysis, Extraction Method: Principal Component Analysis.
- Rotation Method: Varimax with Kaiser Normalization.

Table 3 summarizes the results of the six key motivating factors.

		Master Level		Undergraduate				Overall	
				Full time		Part time			
	Constructs	Mean	Std. D	Mean	Std. D	Mean	Std. D	Mean	Std. D
1.	Individual Attitudes and Expectation	4.92	1.008	5.01	0.682	4.78	0.586	5.00	0.734
2.	Challenging Goals	4.69	0.958	4.43	0.710	4.51	0.590	4.47	0.752
3.	The Pulling forces	4.94	1.038	4.89	0.647	4.86	0.550	4.89	0.712
4.	Punishment	3.36	1.077	3.51	1.273	3.41	1.205	3.49	1.241
5.	Group Pressure	4.67	1.073	4.60	0.775	4.53	0.800	4.61	0.819
6.	Learning Approach	4.54	1.033	4.61	0.861	4.76	0.664	4.60	0.882

Table 4. Results from the t-test

	Constructs	Critical Value	t	Sig.	Test Value= 3.5	
			df= 78		Mean	Std. D
1.	Individual Attitudes and Expectation	1.99	18.17	0.000	5.00	0.734
2.	Challenging Goals	2.53	11.45	0.000	4.47	0.752
3.	The Pulling forces	2.11	17.42	0.000	4.89	0.712
4.	Punishment	3.51	–0.08	0.940	3.49	1.241
5.	Group Pressure	2.39	17.42	0.000	4.61	0.819
6.	Learning Approach	3.41	11.10	0.000	4.60	0.882

Critical value can be found from the t-table according to the degree of freedom. The t-value of each motivating factor construct provides the evidence that indicates its motivating effect on learning. The results show that most of the constructs provide strong evidence that they have a positive motivating effect on learning, except for 'Punishment', which attracts our attention and concern.

Correlation of factors

Correlation of factors has also been testified.

The simple correlation analysis (Table 5) indicates that all motivating factors are significantly correlated with learning, except for 'Punishment'. The stepwise regression analysis was also carried out to help identify the predictors that most adequately predict responses on a dependent variable.

Linkage between team learning and motivating factors

Tables 6 and 7 summarize the stepwise regression model. They show that all five motivating factors entered into the regression model. The F change is significant at the 0.001 level. The R square value is sufficiently high (0.651) to show that the variation in this model accounted for most of the variance in the learning as perceived by students.

The 'Pulling forces' and 'Group Pressure' are significantly correlated with learning at 0.01 levels, and the standardized coefficients are rather large to indicate a significant correlation with learning. This implies that a change in these two components will definitely influence learning, and vice versa. The result supports the positive and corresponding relationship between these variables, thus justifying the assumptions on the influence of these components on learning while team- and action-based learning are facilitated.

DISCUSSION

Some interesting implications are seen from the above analysis (Table 3 and Table 4). In general, the extrinsic factors (i.e. 'Pulling forces', 'Group Pressure' and 'Learning approach) may usually have some motivating effect while the intrinsic factors (i.e. 'Individual attitudes and expectations') are dominating (μ= 5.00).

From the correlation (Table 5) and stepwise regression results (Table 6), it has been found that 'Pulling forces' and 'Group Pressures' are the two keys for motivating team-based and action-based learning. It can be easily understood that for the team-based action learning to be facilitated, a supportive environment with enabling extrinsic factors such as rewards and a group-based setting is essential.

Table 5. Correlation of factors and their linkage to learning approaches

	Constructs	Individual Attitudes and Expectation	Challenging Goals	The Pulling forces	Punishment	Group Pressure
1.	Individual Attitudes and Expectation	1	/	/	/	/
2.	Challenging Goals	0.554**	1	/	/	/
3.	The Pulling forces	0.726**	0.589**	1	/	/
4.	Punishment	0.202	0.137	0.146	1	/
5.	Group Pressure	0.613**	0.521**	0.733**	0.351**	1
6.	Learning Approach	0.557**	0.533**	0.746**	0.243*	0.748**

Pearson correlation, listwise, N= 79, 1-tailed, *P<0.05, **P<0.01.

Table 6. Model summary of the stepwise regression

Model	R square		Std error of the estimate		Change statistics
			R square change	F	Sig.
1	0.651	0.53827	0.080	27.293	0.000

Dependent variable: Learning approach.
Entering variables: Individual Attitudes and Expectation, Challenging Goals, The Pulling forces, Punishment, Group Pressure.

Table 7. Coefficients of independent variables

Model	Un-standardized coefficients		Standardized coefficients	t	Sig.
	B	Std error	Beta		
1 Constant	–0.244	0.474	/	–0.514	0.609
1. Individual Attitudes and Expectation	–0.0856	0.126	–0.071	–0.681	0.498
2. Challenging Goals	0.116	0.104	0.099	1.121	0.266
3. The Pulling forces	0.538	0.153	0.434	3.513	0.001
4. Punishment	0.0264	0.054	0.037	0.494	0.623
5. Group Pressure	0.440	0.119	0.409	3.688	0.000

Dependent variable: Learning approach.

In the meantime, the 'Individual attitude and expectation' still plays an important motivator role; what people expect and value in a task may be important in defining whether this factor is effective in motivating people in team learning.

INSIGHTS ON TEACHING ENGINEERING STUDENTS

There was a tendency for students in the study to choose some of the factors as having great motivating effect, such as high expectation of outcomes and group pressure. The consequence is that if the expectation is too high and the group is not capable of meeting it or the pressure is too large and causes some of the members in the group to lose confidence, the effect on overall team learning may be the reverse. In order to overcome this problem, to have a good understanding among the group members is very important. With good communication, desired cooperation and team commitment could often be realized, which would in turn help to motivate the learning team members.

The study also provides a means to examine how these factors influence learning among engineering students. Some of the extrinsic factors are closely related to personality. For example, factors such as challenging work/job or punishment, how do they influence and to what extent are they dependent on the personality of the group members and their individual value? Such questions underline the importance of proper settings for team-based learning.

Additionally, the findings from the study give insights into the development of teaching inventories for engineering students. Both the learning group setting and learning objectives should be taken into consideration when a course is being developed. To enable students to learn effectively, a supportive setting with enabling pulling forces (i.e. rewards, achievement, clear goals) and a cooperative group-based learning environment (i.e. group pressure) should be provided. Knowing 'What' the influencing factors are prompts the question of 'How' to find the factors that could motivate team learning effectively. One way is to try to correlate the factors identified with the team performance [57].

As educators in higher education we strive to provide a good education, facilitating learning frameworks; approaches are designed and put into place in an attempt to achieve this goal [56]. Educators thus need to be aware that the best course contents and structures are not enough. The motivation and setting for learning affect the success of courses designed to ensure learning. Learning will not happen without motivation and a supportive environment. Academics need to be aware of and account for the effects of student motivation in any studies [55]. If student motivation is lacking, the effectiveness of any intervention will be reduced. They also need to make sure that continuing attention is paid to ensuring that students are motivated at both individual and collective levels and have a clear vision of the subject being studied, to increase the effectiveness of learning and achieve a higher level of performance.

CONCLUDING REMARKS AND FUTURE WORK

The study showed that the investigated factors have certain degrees of positive motivating effect whereas the extrinsic factor "Punishment" is quite weak in this.

Intrinsic factors (i.e. individual attitude and expectations) scored higher, although they are hard to measure and control. Extrinsic factors have a positive motivating effect on team-based learning while intrinsic factors play an important role in motivating individual members in the learning teams.

We have put the focus on team learning; unlike individual learning, this requires better understanding of people not only as individuals but as team dynamics as well. The environment, which is all the extrinsic factors when 'applied appropriately', will have a considerable positive motivating effect on team learning.

The survey is confined to the university's learning environment for engineering students in a Hong Kong university. Its scope could be widened by taking a larger sample of subjects from different countries.

REFERENCES

1. D. J. Lynch, Motivational factors, learning strategies and resources management as predictors of course grades. *College Student J*. 2006, **40**(2), pp. 423–428.
2. E. A. Linnenbrink and P. R. Pintrich, Motivation as an enabler for academic success. *School Psych. Rev*. 2002, **31**(3), pp. 313–327.
3. S. S. Naquin and E. F. Holton III, The effects of personality, affectivity, and work commitment on motivation to improve work through learning. *Hum. Res. Dev. Quart*. 2002, **13**(4), pp. 357–376.
4. T. M. Egan, B. Yang and K. R. Bartlett, The effects of organizational learning culture and job satisfaction on motivation to transfer learning and turnover intention. *Hum. Res. Dev. Quart*. 2004, **15**(3), pp. 279–301.

5. R. A. Noe and N. Schmitt, The influence of trainee attitudes on training effectiveness: test of a model. *Pers. Psych*. 1986, **39**, pp. 497–523.
6. C. P. Alderfer, *Existence, relatedness and growth human needs in organizational settings*, Free Press, New York. (1972).
7. A. H. Maslow, *Motivation and Personality*, Harper & Row, New York. (1954, 1970).
8. D. C. McClelland, *The Achieving Society,* Free Press, New York; Collier Macmillan, London (1967).
9. V. Vroom, *Work and Motivation*, John Wiley & Sons, New York. (1964).
10. J. S. Adams, Toward an understanding of inequity. *J. Abnormal Soc. Psych.* 1963, 67, pp. 422–436.
11. J. S. Adams, Inequity in social exchange. in Berkowitz, Leonard (Ed), *Advances in Experimental Social Psychology, 2*, Academic Press, New York, (1965), pp. 267–299.
12. E. L. Deci, *The Psychology of Self-determination*. Lexington Books, Lexington, Mass, (1980).
13. B. F. Skinner, *Contingencies of Reinforcement: a Theoretical Analysis.* Prentice-Hall, Englewood Cliffs, N.J. (1969).
14. J. C. Wofford, V. L. Goodwin and S. Premack, Meta-analysis of the antecedents of personal goal level. *J. Management*, 1992, **18**(3), pp. 595–615.
15. G. Hofstede, B. Neuijen, D. D. Ohayv and G. Sanders, Measuring organizational cultures: a qualitative and quantitative study across twenty cases. *Admin. Sci. Quart*. 1990, **35**, pp. 286–316.
16. K. Wright, M. Kacmar, G. C. McMahan and K. Deleeuw, P|=f(M X A): Cognitive ability as a moderator of the relationship between personality and job performance. *J. Management*, 1995, 21(6), pp. 1129–1139.
17. R. H. Rasch and H. L. Tosi, Factors Affecting Software Developers' Performance: An Integrated Approach. *MIS Quart*., 1992, **13**(3), pp. 395–413.
18. M. L. Ambrose and C. T. Kulik, Old friends, new faces: motivation research in the 1990s. *J. Management*, 1999, **25**(3), pp. 231–292.
19. C. C. Durham, D. Knight and E. A. Locke, Effects of leader role, team-set goal difficulty, efficacy, and tactics on team effectiveness. *Org. Behav. and Hum. Decision Proc*. 1997, **72**(2), pp. 203–231.
20. G. E. Prussia and A. J. Kinicki, A motivational investigation of group effectiveness using social-cognitive theory. *J. App. Psych*., 1996, **81**(2), pp. 187–198.
21. H. Margolis and P. P. McCabe, Self- efficacy, A key to improving the motivation of struggling learners. *The Clearing House*. 2004, **77**(6), pp. 241–249.
22. M. Bong, Academic motivation in self-efficacy, task value, achievement goal orientations, and attributional beliefs. *J. Educ. Res*. 2004. **97**(6), pp. 287–298.
23. B. J. Zimmerman and A. Kitsantas, Homework practices and academic achievement: The mediating role of self-efficacy and perceived responsibility beliefs. *Contemp. Educ. Psych*. 2005, **30**, pp. 397–417.
24. E. A. Locke and G. P Latham, *A Theory of goal setting & task performance.* Prentice Hall. Englewood Cliffs, N J. (1990).
25. V. B. Hinz, L. R. Kalnbach and N. R. Lorentz, Using judgmental anchors to establish challenging self-set goals without jeopardizing commitment. *Org. Behav. & Hum. Dec. Proc.* 1997, **71**(3), pp. 287–308.
26. H. J. Klein and P. W. Mulvey, Two investigations of the relationships among group goals, goal commitment, cohesion, and performance. *Org. Behav. & Hum. Dec. Proc*. 1995, **61**(1), pp. 44–53.
27. P. Osterman, How common is workplace transformation and who adopts it? *Ind. Lab. Rel. Rev*. 1994, **47**(2), pp. 173–188.
28. C. C. A. Chan, C. Pearson and L. Entrekin, Examining the effects of internal and external team learning on team performance. *Team Performance Management, 2003,* **9**(7/8), pp. 174–181.
29. A. Rassuli and J. P. Manzer, Teach to learn: multivariate analysis of perception of success in team learning. *J. Educ. Bus*. 2005. **81**(1), pp. 21–27.
30. T. Kotnour, Organizational learning practices in the project management environment. *Int. J. Qual. Rel. Man*. 2000, **17**(4/5), pp. 393–406.
31. R. F. Poell and F. J. Van der Krogt, Project-based learning in organizations: towards a methodology for learning in groups. *J. Workplace Learning*, 2003, **15**(5), pp. 217–228.
32. L. Cavaluzzo, Enhancing team performance. *Healthcare Forum J*. 1996, **39**(5), pp. 57–59.
33. P. Flood, S. MacCurtain and M. West, *Effective top management teams: an international perspective.* Blackhall publishing, Dublin. (2001).
34. J. R. Katzenbach and D. K. Smith, The discipline of teams. *Harvard Bus. Rev.* 1993, March/April, pp. 111–20.
35. M. A. Meyer, The dynamics of learning with team production implications for task assignment. *Quart. J. Econ*. 1994. **109**(4), pp. 1157–84.
36. E. Roberts, Team training: When is enough . . . enough? *J. Qual. & Participation*, 1997, **39**(5), pp. 16–20.
37. P. Senge, *The fifth discipline: the art and practice of the learning organization,* Doubleday, New York, NY. (1990, 1992).
38. R. Teare, H. Ingram, G. Prestoungrange and E. Sandelands, High performance learning at work. *Int. J. Contemp. Hosp. Man*., 2002, **14**(7), pp. 375–381.
39. R. S. Wellins, W. C. Byham and J. M. Wilson, *Empowered teams: creating self-directed work groups that improve quality, productivity, and participation,* Jossey-Bass, San Francisco, CA. (1991).
40. Y. Lee and P. A. Ertmer, Examining the effect of small group discussions and question prompts on vicarious learning outcomes. *J. Res. Technol. Educ*. 2006, **39**(1), pp. 66–80.
41. A. Kleiner, Core Groups: a theory of power and influence for 'learning' organizations. *J. Org. Change Man*. 2003, **16**(6), pp. 666–683.
42. J. Clarke, R. Thorpe, L. Anderson and J. Gold. It's all action, it's all learning: action learning in SMEs. *J. Eur. Ind. Training*, 2006, **30**(6), pp. 441–455.
43. I. D. Loo, Action and organizational learning in an elevator company. *Learning Org*. 2006. **13**(3), pp. 204–214.

44. R. W. Revans, Developing Effective Managers: *A new approach to business education.* Praegar, New York. (1971).
45. I. McGrill and L. Beaty. *Action Learning*, Kogan Page, London. (1995).
46. G. Lee, D. Bennett and I. Oakes, Technological and organisational change in small- to medium-sized manufacturing companies- A learning organisation perspective. *Int. J. Op. Prod. Man*. 2000, **20**(5), pp. 549–572.[47].
R. W. Revans. *The Origins and Growth of Action Learning,* Chartwell Bratt, Bromley. (1982).
48. R. W. Revans. *ABC of Action Learning*, 3rd ed., Lemos & Crane, London. (1998).
49. D. A. Garvin, Building a learning organization. *Business Credit*. 1993, **71**(4), pp. 78–91.
50. Y. T. Yin, M. Y. K. Law & K. B. Chuah, Investigation of the Motivating Factors Influencing Team Learning, *Proceedings of the 5th International Symposium on Management of Technology*, ISMOT, Hangzhou, China. (2007).
51. W. G. Zikmund, *Business Research Methods*, 5th ed. The Dryden Press, Harcourt Brace College Publishers. (1997).
52. D. R. Cooper and P. S. Schindler, *Business Research Methods*. 8th ed. McGraw-Hill. (2003).
53. H.-L. Jian, F. E. Sandnes, Y.-P. Huang, C. Li and M. Y. K. Law, On Students' Strategy-Preferences for Managing Difficult Coursework. *IEEE Transact. Educ*. **51**(2), pp. 157–165. (2008).
54. F. E. Sandnes, Y.-P. Huang and H.-L. Jian, Experiences of Teaching Engineering Students in Taiwan from a Western Perspective. *Int. J. Eng. Educ*. 2006, **22**(5), pp. 1013–1022.
55. N. J. Delson, Increasing Team Motivation in Engineering Design Courses. *Int. J. Eng. Educ.* 2001, **17**(4/5), pp 359–366.
56. G. Lim, K. S. Chua and K. Y. Wee, Effects of Instructional Intervention Strategies on Students at Risk in Engineering Education. *Int. J. Eng. Educ*. 2003, **19**(4), pp 525–531.
57. N. Moskalski, Factors that Enhance or Constrain Implementation of Team Activities in Engineering Courses. *Int. J. Eng. Educ.,* **18**(3), pp. 264–274.

Kris M. Y. Law received a Ph.D. in the discipline of organizational learning and development. She is currently a fellow at the Graduate Institute of Industrial Engineering of National Taiwan University. Her research interests include organizational learning and development, sustainability development, supply chain in high-tech industries and engineering education. She had extensive consultancy and training experience from the commercial sector before joining academia.

Frode Eika Sandnes received a B.Sc. in computer science from the University of Newcastle upon Tyne, U.K., and a Ph.D. in computer science from the University of Reading, U.K. He is currently a Professor in the department of Computer Science at Oslo University College, Norway. His research interests include parallel processing, error-correction, human computer interaction, and university level pedagogy. He is the International Coordinator in the Faculty of Engineering.

Hua-Li Jian received a B.A. in foreign languages and literature in Taiwan, a M.A. in TESOL from the University of Newcastle upon Tyne, U.K., and a Ph.D. in linguistic science from the University of Reading, U.K. She is currently an Associate Professor in the Department of Foreign Languages and Literature at National Cheng Kung University, Tainan, Taiwan. Her research interests include English language learning, computer-assisted pedagogy, Western and Oriental phonetics, and phonology.

Yo-Ping Huang received a Ph.D. in electrical engineering from Texas Tech University in 1992. He is currently a Professor in the Department of Electrical Engineering at National Taipei University of Technology, Taiwan. His research interests include intelligent information retrieval, data mining, artificial intelligence and application systems for handheld devices. He is a senior member of the IEEE. He also serves as secretary general in National Taipei University of Technology.