ASSESSING MANAGERIAL LEARNING EFFECTS: A STRUCTURAL EFFECT MODEL FOR ENGINEERS

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ABSTRACT

Facilitating engineers to become competent engineering managers has been called worldwide. To explore whether management is learnable in engineering, this study configure a structural effect model by three different but possibly interrelated managerial learning activities. The model is grounded on the basis of implicit belief and self-efficacy theories, and career stage and work characteristic models. The results suggest that self-provided learning style is the most effective, whereas this self-training concept is inspired by task characteristic learning opportunities supported and designated by the organization. Formal and off- the-job class taking appears simply able to improve engineers' efficacy behavior and is the least effective.

INTRODUCTION

Managers of engineers or engineering managers must not only retain hands-on involvement with technical matters, but at the same time assume new administrative duties [9]. Engineering curriculum therefore suggests a shift from simply science and technology to include the social system that cultivates the science and technology. National Academy of Engineer, for instance, indicates that team communication, ethical reasoning, and societal and global contextual analysis skills are as well the essential attributes of engineering workers other than technical excellence.

Development of these working strategies involves both the individual's learning behaviors and the organization's job contexts. Use of both formal off-the-job classroom training and informal on-the-job learning from every day work experience are suggested [8]. In addition, self-training, which stresses informal self-provided learning activities, is as well required for modern managers, because the lack of self-awareness appears to be the source of the big mistakes in careers and organizations [5].

Regardless the learning approaches and opportunities, for effective learning trainees must at least be motivated by their beliefs that the learning is effective in improvement for better performance, because the idea of certain skills being perceived as more or less improvable is a potential force to stimulate one's self-efficacy for successfully learning the skills. The primary research question in this study therefore is: To what extent, career-relevant continual learning activities interact with workplace characteristics to enhance engineering workers in learning and developing management, especially in enhancing their beliefs about improvability of their managerial career skills and self-efficacy for management?

In order to answer this question, this study starts by describing theoretical framework to configure a structural effect model among various types of managerial learning opportunities, mediated by individual beliefs about improvability of managerial skills. The central ideas focus on the interrelated direct and indirect effects given by three types of learning activities.

RESEARCH BACKGROUND AND QUESTIONS

Interaction of Learning Activities for Management

Different learning approaches comprise different benefits. Classroom training, either by corporate internal off-the-job classes or certified extension school programs, moves learners from their workplaces to classrooms, where they can learn with a group of students of similar learning interest and avoiding the distractions of work. When focusing on social issues, class taking has been found useful in enhancing employees' social competencies [10]. On the contrary, self-training concerns self-occurring activities, by which people learn through self instruction at their own paces, whereas learners may become sluggish due to lack of clear learning plans and supervisions. Skills in this dimension, such as self-sustaining, self-managed learning ability, and self-objectivity and development orientation, are greatly recommended in modern managerial careers, because they are the foundation upon which other types of managerial skills are built [5].

Managers perhaps benefit the most by informal and on-the-job learning. Through design of functions and characteristics in the workplace and the job, the employers offer informal learning opportunities on the job to the employees. Based on characteristics at work, promising managers are motivated to develop both task mastery and leadership responsibility when they attempt to accomplish the expectations from the organization [3]. Clearly, the success of this learning process involves both the organization and the manager to work together along with the development of the process. On the one hand, the organization contributes to job content design associated with required skills; on the other hand, the manager seizes the on-the-job learning opportunities to develop better the required competencies.

While defined separately, the three ways are often performed interactively in actual learning. However, little research seems pays attention to their interacted effects. Much has been done in recent years on the subject of career continual learning focus mostly on the direct associations between personal learning behavior and workplace characteristics. However, learning can be planned and emergent [7], thus the effects can be interactive.

Outcomes in Learning

The outcomes of managerial training fall into two broad categories: skills and conceptual models, where skills concern what people do and conceptual structures concern why people do it in the way [5]. Managerial learning therefore is both behavioral and cognitive, and the two are connected in the way that thought follows action but that mental rehearsal improves physical performance. Accordingly, we may conclude that learning for management affect not just the managerial competencies but also the conceptual understanding of the managers.

People care and reflect more on their unsuccessful experiences; by critical reflection, they look for possible recoveries from previous failures. Naturally, their attentions focus on those capabilities that they lack and need to be much improved unless such opportunities are no longer or almost not obtainable. This searching for obtainable need process, seemingly, is analogous to the implicit belief theory that people have more favorable attitudes toward learning when they believe that a poor or lacked competence is more or less improvable and acquirable [4]. The theory therefore creates a framework within which persons interpret the world and determine the degree to which they believe their personal characters are improvable or acquirable by learning, as opposed to the degree of fixed ideas [6]. Based on the theory, it is obvious that an effective learning comprises two major components: learning opportunity and personal beliefs in acquiring new and better performance patterns by going through that

opportunity. This idea of personal beliefs about the improvability of certain competencies by certain learning opportunities therefore provides us a framework to explore how various training activities mediate a person's mental concepts toward the lacked skill learning.

In addressing a learning-oriented model, Maurer et al. [6] reveal that though self-efficacy is highly related to and affected by improvability belief, it is a type of belief differs from implicit belief, and should both be included within a model of learning and development. That is, improvability belief reflects one's general theory of reality, while self-efficacy is bound to a specific person within a specific situation [2]. In other words, a person may believe that it is possible that one's own competencies could be increased, whereas he or she may not have high self-efficacy for developing the competencies because of, for example, personal infeasibility or no opportunities.

Low self-learning engineers are easy to get derailed, and to avoid it they need to self-evolve managerial abilities, including planning, communication, directing, motivational, and leading, along career development [11]. The also need to be managerially competent in the three interrelated parts: knowledge, skills and attitudes [1], and self-aware in modern management [5]. Following these, we may conclude that the skill profile required by engineering managers today comprises three folds: business know-how, interpersonal skills, and self-regulating.

Self-efficacy also considers one's self-confidence regarding the designated outcome associated with the skills he or she possesses [2]. A job usually entails to both tasks and people, in which some jobs may concern a large portion about tasks and technologies, while others have to interact largely with people. Eventually, a manager has to be both task- and people- capable to accomplish assigned jobs. A manager therefore possesses administrative self-efficacy if he or she possesses self-efficacy for accomplishing both types of responsibilities.

Based on the discussions, this study aims to answers the following questions by a structural model:

(1) How do the three types of learning –classroom training, self-training, and task characteristic learning– interact to enhance engineering workers in learning about management?

(2) Does learners' belief about improvability of managerial skills mediate the effects of the three styles of managerial learning and their interactive effects?

(3) Does learners' incremental improvability belief increase further their competent and ad administrative self-efficacies for management?

METHOD

Measures

Formal Classroom Training. This measure comprises corporate internal classes and external courses offered by extension universities outside the workplace. The classes include only management relevant lessons, such as general, upper level and self management, and organization/culture orientation. The purpose is to gauge the amount of formal off-the-job training.

Self-training. This measure comprises reflection on one's experience, involving with professional organizations, and reading professional books or journals to keep current. The purpose is to gauge the amount of self-provided learning opportunities.

Task characteristics. This measure pertains to three dimensions: work autonomy, influence status, and managerial position level, because these dimensions are able to offer the specific characteristics for

engineers in learning management on the job. The purpose is to gauge the amount of learning on the job opportunities for management. Other than self-rated managerial position level, the measure comprises four statements regarding "whether a worker works under supervision", "can do work on one's own", "own the right to influence organization", and "has the status to represent the company".

Beliefs about improvability of managerial skills. This construct is defined as individuals' beliefs about improvability of multiple career-relevant aptitudes, including knowledge, abilities, skills, and other characteristics required for managerial career development. The measurement includes 15 managerial skills typically required by engineering managers.

Competent Self-efficacy. This construct is defined as an engineer and manager's judgment about whether or not he or she, as a manager, can actually conduct three types of competence at work: business know-how, interpersonal skills, and self-regulating skills. The measurement comprises a profile of 10 job skills pertinent to these three dimensions. In the order, they are "ask pertinent business questions", "deal business issues at appropriate detail", "have objectivity in business information", "make logical decision", "convey understanding to others", "speak in a clear and well-organized way", "advise others with tact", "hard work", "use time effectively", and "plan and execute in line with the plan".

Administrative self-efficacy. This construct is defined as a manager's judgment about whether or not he or she is task- and people- capable to accomplish assigned jobs. Example items include "plan new assignments", "decide direction", "supervise the unit to execution", "orientate new employees", "schedule works for subordinates", and "supervise subordinates based on their strength and weakness".

Sample

We conducted an empirical survey to collect data to test the model. The sample came from 449 engineering workers in the high tech sector of Taiwan. They are all involved with R&D in a certain extent. Among them, about 82% of the subjects are male; their ages fall mostly between 25 and 40 with an average around 36 years old; they all have a college degree or higher education. In working, on the average, they have worked for ten years, but only with the current employers for an average of 5.2 years, which may imply the high job mobility of young engineers before 30.

RESULTS

The analysis begins with Exploratory Factor Analysis to examine the factor dimensions in the six measurements and remove the improper items. Cronbach's reliabilities, all larger than 0.7, and factor contents suggest internal consistencies and content validities of these instruments. In the correlation tests, factors in each learning style are correlated significantly with each other, and with improvability beliefs and self-efficacies, except work autonomy. Work autonomy is only correlated significantly with managerial position level, but not with most of the other variables. Further study based on Structural Equation Modeling (SEM) then follows to explore these relationships in details.

The current SEM uses the average factor scores as the indicators. Table 1 summarizes the final results of this SEM. The goodness-of-fit indices were all acceptable (GFI=.939, AGFI=.915, CFI= .961, RMR= .052, chi-square = 246.6, df=109). In addition, in the separate tests, all six measurement models achieve GFI and AGFI values greater than .9 (not shown due to limited space), and none of them correlates significantly with the indicators in the other measurement models. One thing to be noticed, though, is that work autonomy is not significant in the latent construct of task characteristics. Task characteristic learning therefore comprises only influence status and managerial position level.

Table 1 displays both direct and total effects between each pair of variables in the current SEM. Only paths with significant effects are shown. The table also calculates contribution percentages of each variable on administrative self-efficacy, and sums over their total effects to show the extent to which each variable contributes to the model as a whole. Based on these data, task characteristic appear to be the only exogenous variable in this model, affecting significantly and directly on self-training and improvability beliefs. However, self-training makes the most contributions, not just on administrative self-efficacy (27%), but also on the overall model (41%). Classroom training contributes the least; it benefits 12% on administrative self-efficacy, and only 5% on the overall model.

Overall, these results suggest that the effects of task characteristics and self-training can be implicit and indirect, because they both impact on administrative self-efficacy through persons' improvability beliefs and then their competent self-efficacy. In contrast, the effect of formal classroom training is more explicit and direct, because it bypasses personal implicit beliefs and competent self-efficacy to affect directly on administrative self-efficacy.

Table 1 Analyses of direct and total effects and overall contributions of each variable

Sources / Effects	Career continual learning opportunities			Improvability beliefs	Competent self-efficacy
	Task characteristics	Self-training	Classroom training		
Direct effect (↓) :					
Self-training	0.36***				
Classroom training		0.77***			
Improvability beliefs	0.32***	0.53***			
Competent self-efficacy		0.29***		0.45***	
Administrative self-efficacy			0.27***		0.73***
Total (direct and indirect) effects (↓):					
Self-training	0.36				
Classroom training	0.27	0.77			
Improvability beliefs	0.51	0.53			
Competent self-efficacy	0.33	0.53		0.45	
Administrative self-efficacy	0.32	0.60	0.27	0.33	0.73
Contribution analysis (↓):					
Contribution (%) to the final administrative self-efficacy:	14%	27%	12%	15%	32%
Sum of total effects and contribution (%):	1.79 (30%)	2.43 (41%)	0.27 (5%)	0.78 (13%)	0.73 (12%)

*** P<0.001

DISCUSSION

Facilitating engineers to become competent engineer/managers has been recommended worldwide. This study contributes to configure a structural effect model that explores the following benefits of interactive learning for engineering management:

(1) Task characteristic learning concerns persons' experience at work. By defining it as influence status and managerial position level, this study demonstrates task characteristic performs as a single exogenous learning foundation that directly inspires learners' self-trained motivation and implicit beliefs about learning.

(2) Although task characteristics provide the basis for managerial learning, the greatest benefits accrue to those who can self-train, because self-training activities facilitate up to twice as many learning effects, compared with task characteristics, regardless of their position status.

(3) The benefit of self-training is particularly true for workers who are less likely to have on-the-job managerial learning opportunities, such as R&D engineers. They not only engage more in self-training, but also take more off-the-job managerial classes than general engineers or managers.

(4) Different ways of learning should not be assessed separately but rather combined to reach a superior method. We suggest starting with self-training, because this self-administered approach can provide the most benefits, according to the current findings.

(5) Both the learners and the organizations should be aware that self-training is based on task characteristic learning opportunities provided by the organizations. Namely, the best way in engineering management requires the organization to design task characteristics associated with the required job skills and the individual careerists to self-learn the opportunities.

(6) Influence status refers to the power that an engineer can execute over an organization, and position level reveals the amount of managerial responsibilities assumed. Therefore, engineers can use learning on the job opportunities to develop managerial influence, such as by initiating formal and informal activities that require the support of others and getting others to participate.

(7) Organizations should also supplement class lessons for young engineers. The topics can be ranged from corporate cultural orientation to leadership and upper-level management, in line with the position status and involvement of managerial work of careerists.

(8) Evaluation of learning effects is as important as design of learning activities. Without evaluation, learning can be totally in vain. As suggested by current findings, implicit beliefs and self-efficacy measures can be helpful. In addition, the measurements are multi-dimensional and mentality and skill involved.

REFERENCES

[1] Bailyn, L. *Living with Technology*. Cambridge, MA: MIT Press, 1980.

[2] Bandura, A. 1986. *Social Foundations of Thought and Action: A Social Cognitive Theory*. Englewood Cliffs, NJ: Prentice-Hall.

[3] Carlson, D. S. & Rotondo, D. M. 2001. Differences in promotion stress across career stage and orientation. *Human Resource Management*, 1986, 40(2), 99-110.

[4] Dweck, C. S., Chiu, C. & Hong, Y. Implicit theories and their role in judgments and reactions: a world from two perspectives. *Psychological Inquiry*, 1995, 6, 267-285.

[5] Hogan, R. & Warrenfeltz, R. Educating the modern manager. *Academy of Management Learning and Education*, 2003, 2(1), 74-84.

[6] Maurer, T. J., Wrenn, K. A., Pierce, H. R., Tross, S., & Collins, W. C. A beliefs about 'improvability' of career-relevant skills: relevance to job/task analysis, competency modelling, and learning orientation. *Journal of Organizational Behavior*, 2003, 24(1), 107-131.

[7] Megginson, D. Planned & emergent learning. *Management Learning*, 1996, 27(4), 411-428.

[8] Paauwe, J. & Williams, R. Seven key issues for management development. *Journal of Management Development*, 2001, 20(2), 90-105.

[9] Rimler, G. W. The Transition from engineer to engineer/manager. *Industrial Management*, 1991, 33(6), 17-18.

[10] Rowold, J. & Kauffeld, S. Effects of career-related continuous learning on competencies. *Personnel Review*, 2009, 38(1), 90-101.

[11] Yeh, Q. J. Exploring career stages of mid-career and older Engineers - when managerial transition matters. *IEEE Transactions on Engineering Management*, 2008, 55(1), 82-93.