

# Application of the learning organisation paradigm in engineering education: an empirical research of universities in Taiwan

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**ABSTRACT:** The purpose of this study is to explore the relationship between knowledge management, organisational mechanisms and learning ability. Based on the related literature, the authors first established a research framework, formulated the research inventory and constructed a basic hypothesis about learning organisations in engineering education. Next, the authors interviewed seven chairpersons from various engineering departments and carried out an empirical survey of 386 engineering professors from 148 universities in Taiwan in order to apply the research framework and understand the relationships between the variables. The conclusion of this research indicates that knowledge management and management mechanisms can directly influence learning ability. Knowledge management can also indirectly influence learning ability through organisational mechanisms. It is envisaged that this study's result will shed broad light onto the relationship between knowledge management, organisational mechanisms and learning ability. Moreover, the suggestions provide concrete information for engineering education executives regarding the development of learning organisations on campus.

## INTRODUCTION

### Research Background

Peter Senge, in his book, *The Fifth Discipline: The Art and Practice of the Learning Organization*, first elaborated on the following five tools that could assist in the reengineering of organisations, namely:

- Systems thinking;
- Personal mastery;
- Improvement of mental models;
- Shared vision;
- Team learning [1].

So-called *learning fever* soon became prevalent around the world. Senge thought of these five principles as learning ability indicators in an engineering education learning organisation. In this study, prime concern is placed on these indicators.

Engineering education should emphasise knowledge management in order to enhance the learning ability of the organisation and to respond to challenges through knowledge creation, inventory, diffusion and transfer. The second focus of this study is how engineering education in universities applies *knowledge management* so as to predict the *learning ability* of the learning organisation.

Robbins asserted that a learning organisation is able to enhance its own learning ability through the help of organisational mechanisms, such as the development of strategies, organic organisational structure, organisational culture and transformational leadership [2]. The third emphasis of this study is how engineering education in universities strengthens the relationship between knowledge management and learning ability.

### Research Objectives

This study reviewed the previous literature and applied a case study from a university in Taiwan in order to understand the current situation of a learning organisation. There are three research objectives, namely:

- To explore the literature on knowledge management, organisational mechanisms and learning ability.
- To learn about the learning organisation within the context of engineering education and to acquire practical information through the analysis of a case study.
- To establish a theoretical model and research propositions of a learning organisation for engineering education at universities.

## LITERATURE REVIEW

This study discusses the materials of knowledge management, organisational mechanisms and learning ability from the perspective of a learning organisation. The relevant literature is integrated below.

### Orientation of a Learning Organisation

The learning organisation paradigm is a branch of organisational learning theory [3]. Liao claimed that both organisational learning and a learning organisation are closely connected to each other under the linkage mechanism of a learning system [4]. The members of a learning organisation can consistently exceed their limited ability, create a wanted result, develop a brand new, unprecedented and broad thinking pattern, devote wholeheartedly to their mutual goals, and learn together [5].

The experimental experience of English enterprises, which have undergone significant organisational reforms, reveals that

a learning organisation is the application of organisational development and learning, as concluded by Garratt [6]. In order to satisfy consumers' capricious demands, a large-sized organisation should be developed into a learning organisation in which the administrator/manager must develop personal or group learning abilities. Furthermore, there should be an atmosphere and environment that can inspire the organisation to learn.

Watkins and Marsick believed that, from the perspective of Human Resources Development (HRD), a learning organisation is an organisation that consistently learns and evolves [7]. The basis of learning lies in the individuals, groups, the organisation and in organisational interactions. Learning is a continuous process that exercises strategies and unifies with work. The learning result leads to changes in knowledge, belief and behaviour and enhances the organisation's ability to create and grow [8].

### Knowledge Management of a Learning Organisation

Peter Drucker pointed out that in *post-capitalisation society*, knowledge is the only meaningful resource under the new economic system; therefore, an organisation can survive in the competitive environment only through knowledge creation, inventory and diffusion [9]. This is elaborated on further below.

Nonaka and Tang both commented that the procedure of knowledge management initially creates new knowledge from the inside or outside of the organisation [10][11]. Internal knowledge is created through historians, Research and Development (R&D), and experience (or learning by doing). The resources of outside knowledge can be suppliers, customers and competitors. Thus, how to create knowledge *systematically* is a major challenge in knowledge management.

According to Lin, knowledge can be stored in three places, namely:

- Individuals (employees' skills and experiences);
- Organisations (managerial systems, values and norms);
- Facilities and equipment (physical systems) [12].

Grant introduced two concepts concerning knowledge diffusion, as follows:

- Firstly, the degree of knowledge diffusion is determined by the degree and level of common knowledge: the higher the degree and level of common knowledge, the easier the knowledge is diffused.
- Secondly, common knowledge literally means a common language, other forms of symbolic communication and compatibility in expert knowledge, knowledge infrastructure, common meaning, and understanding in individual knowledge areas [13].

Knowledge diffusion is a process of knowledge acquisition for knowledge receivers. During the process of knowledge diffusion, knowledge providers have acquired knowledge, but receivers have not. Therefore, knowledge diffusion can be explained as a process in which receivers acquire knowledge. In other words, *knowledge diffusion* is referred to as a process of knowledge transmission and the degree of understanding of knowledge receivers.

### Organisational Mechanisms of a Learning Organisation

Robbins believed that an organisation has to keep learning in order to become a learning organisation [2]. However, there are four things that need to be accomplished beforehand; they have to establish a strategy, redesign the organisational structure, reshape the organisational culture and transform the leadership.

Establishing strategies includes developing members' learning ability, transforming them into a new role and function of human resources, paying high regard to human resources and establishing an open learning environment. Organisational learning is established on the basis of mutual learning among members, which allows each of them to perform outstandingly and the organisation to grow continually. By offering mutual learning and a learning environment, members' *learning enthusiasm* and *learning ability* will become more established and fresh.

The concept of a learning organisation, as raised by Senge, is defined within the scope of an organic structure, which emphasises cross-functional and cross-hierarchical teams, flatness, division of powers and design of low formalisation [1]. This concept is tantamount to the above-mentioned one raised by Robbins, who stressed that an organisation must keep learning in order to evolve into a learning organisation [2].

The implementation of any new management system must be involved in the transformation of the organisational culture. Hence knowledge management will not succeed if the culture within the organisation does not transform into a culture that accommodates knowledge management. Wu and Wen, who had synthesised case studies of knowledge management companies conducted by domestic and foreign scholars, stressed that knowledge management should establish four cultural features, which can be abbreviated as a *knowledge-friendly culture* [14]. These four aspects are as follows:

- A culture of sharing experience;
- A culture of encouraging learning;
- A culture of trust and cooperation;
- A culture of creativity and support [14].

Burns advanced the theory of transformational leadership in 1978 [15]. This concept was used to determine those members who are psychologically transformed into an organisational member through the charisma of leadership. Transformational leadership puts emphasis on the utilisation of different approaches to motivate the organisation to learn consistently. Shaping organisational visions and inspiring members' knowledge can achieve this. Leaders should fully authorise members under the principle of trust and respect of members' professions to enable the organisation to keep learning, change the current environment, abandon traditional constraints, and evolve into a learning organisation.

### Learning Ability of a Learning Organisation

In his research, Lai reported that discipline is closely related to mental transfer, which means that a part of an entirety reflects the whole thing [16]. In this way, helpless people responding to events are transformed into active participants who can change the current situation. People who react to current situations are transformed into active future proactive individuals.

Five types of learning ability have been defined, namely:

- *Systems thinking*, which helps members to observe circular cause and effect relationships and the subtle interaction between individuals, the organisation and the whole. Members will be equipped with comprehensive critical thinking.
- *Personal mastery*, which means defining and underscoring one's real wishes, and conquering one's emotional withdrawal syndrome through the objective observation of situations in order to enhance personal ability and to exceed one's limits and realise self-fulfilment [17].
- *Mental models* refer to ingrained concepts and the ideas of individuals, which can be hard to change. To adjust a mental model is to abandon habitual self-defences and accept other people's opinions with an open heart through self-reflection. This process can help people sort out and examine their inner world pictures [1].
- *Establishing a shared vision* is another kind of learning ability. This must be a bottom-up formula, which integrates individual and organisational goals, and establishes a shared vision, thereby transforming this vision into a spotlight wherein people can work together in order to achieve it. This includes mutual commitment, value and purpose [1][18].
- *Team learning*, which is defined as the ability to achieve mutual goals. Team learning must adopt key dialogue and discussion skills. Dialogue skills emphasise finding the differences among apparent similarities in order to explore the truth; while discussion skills focus on determining the similarities among differences, thus gradually reaching consensus by raising different opinions.

## METHODOLOGY

### Sample

This research project is an initial study on the concept of the learning organisation. This research utilises a stratified sampling method, which is divided into public university, private university, public college and private college. The authors identified 386 valid samples of engineering professors in 148 Taiwanese universities and initiated an empirical survey. The authors also conducted pertinent interviews with seven chairpersons of engineering departments of various universities in Taiwan to ensure the research design.

### Method

An analysis of the studies was undertaken in February 2003. The methods used to conduct the research involved a qualitative and quantitative approach, as follows:

- *Qualitative approach*: Interviews were conducted with seven departmental chairpersons in engineering departments. Interviewees first received a fax with the questions to be asked in the interview. The interview was divided into two parts: open questions and in-depth interview. The results of the interviews established the research framework and basic propositions.
- *Quantitative approach*: A questionnaire was written based on three frameworks, namely: knowledge management, organisational mechanisms and learning ability. The questionnaires were designed using the Likert five scale and were distributed to professors of Taiwanese universities to understand the influence of research variables.

## ANALYSIS OF RESULTS

### Interviews with Departmental Chairpersons

This study undertook interviews with seven chairpersons from engineering departments of universities in Taiwan, and analysed the organisation's learning ability from the perspective of knowledge management and organisational mechanisms.

Engineering education at universities can be considered as a type of learning organisation. The learning ability of an organisation can be viewed as a dependent variable, which can be used to reveal the level of an organisation's learning ability. Knowledge management influences learning ability directly and positively, and it can also bring about a positive influence on learning ability indirectly through organisational mechanisms. These findings should be highly regarded by administrators and teachers in the field of engineering education.

With regard to the research variables, all seven departmental chairpersons considered Senge's five types of discipline, which include systems thinking, personal mastery, improvement of mental models, shared vision, and team learning, as learning ability indicators, an important tool to reform universities. Universities are an important place to implement knowledge management; knowledge creation, inventory, diffusion and transfer are crucial elements in order to carry it out. Organisational mechanisms in place at universities include developing and establishing operational strategies, an organic structure, a knowledge-friendly culture and transformational leadership, which should bring about the prime intervening effects in engineering education at universities.

According to the results of the interviews, the researchers built a learning organisation framework for engineering education in universities, as shown in Figure 1.

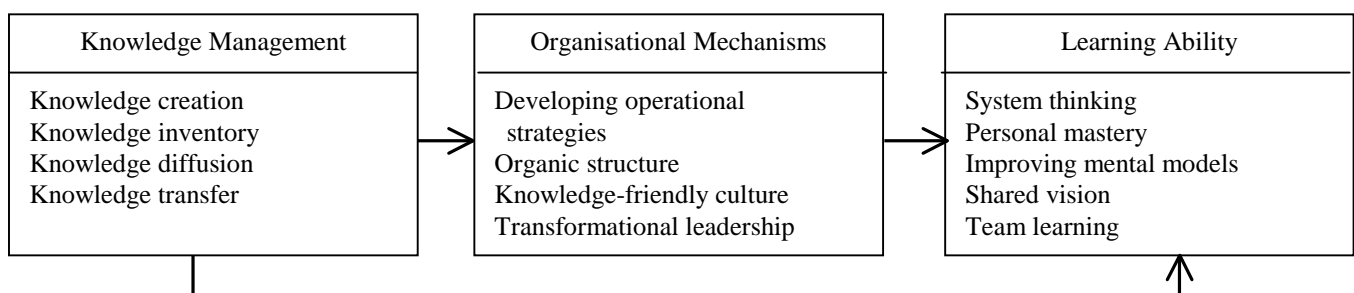


Figure 1: The framework of a learning organisation constructed from the results of the interviews.

The study sample consisted of 386 professors from the engineering departments of Taiwanese universities.

The study established the following three inventories using Cronbach  $\alpha$  above 0.70 for a total of all of the dimensions, with factor loading over 0.50, and an eigene value above 1.00, as recommended by Nunnally to measure reliability and validity [19]. The three inventories have been found to be reliable and valid, and are listed as follows:

- The Knowledge Management Inventory includes four dimensions, which are knowledge creation, inventory, diffusion and transfer. There are three questions for each dimension.
- The Organisational Mechanism Inventory includes four dimensions, which are developmental and operational strategies, organic structure, knowledge-friendly culture and transformational leadership, with three questions for each.
- The Learning Ability Inventory uses Senge’s five items of discipline as the learning ability index, and there are five questions.

It was hypothesised that a university is a learning organisation in this study. The four dimensions of knowledge management of the organisation have a significant influence on learning ability. The four dimensions of organisational mechanisms have an intervening influence on learning ability, and hierarchical regression analysis ( $\alpha=0.05$ ) was utilised to test the foregoing hypotheses.

Table 1 shows the multiple regression analysis on the influence of learning ability. Model 1 tests how the four dimensions of knowledge management relate to learning ability. It illustrates that knowledge creation, inventory, diffusion and transfer significantly influence learning ability. The Beta value of four variables is statistically significant using a  $t$ -test for learning ability. The determinant coefficient ( $R^2$ ) is 15.5%, and Model 1 also shows statistical significance in the F-test of learning ability ( $F=16.747$ ).

The intervening variable is used in Model 2. The four dimensions of organisational mechanisms also reflect a significant influence. The Beta value of the four variables is statistically significant in the  $t$ -test of learning ability. The determinant coefficient of the intervening variable ( $\Delta R^2$ ) increases by 48.8%. The results of Model 2 indicate a significant F ratio of 79.706 in learning ability. The determinant coefficient ( $R^2$ ) is 64.3%.

Based on the above analysis, this illustrates that the four dimensions of knowledge management can directly influence learning abilities with statistical significance. Furthermore, the four dimensions of organisational mechanisms have an intervening influence between knowledge management and learning ability with statistical significance.

CONCLUSION

The literature review and the results of the empirical research indicate the subsequent findings.

Engineering education in universities is one type of a learning organisation that emphasises organisational knowledge management and the development of organisational learning abilities.

An engineering education programme is a learning organisation that should place particular emphasis on the implementation of knowledge management and develop organisational mechanisms that would be beneficial to a learning organisation in order to build learning ability.

The model of an organisation, as shown in Figure 2, has been gained from the study results.

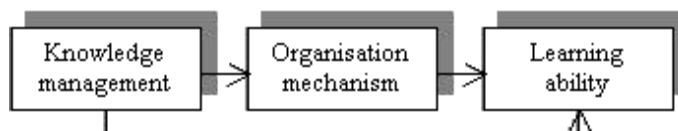


Figure 2: The model of an organisation as gained from the study results.

Table 1: Multiple regression analysis on the influence of learning ability.

Independent Variables	Model 1		Model 2	
	Beta	P value	Beta	P value
Constant Term	3.280*	0.000	1.971*	.000
<i>Major Influences</i>				
1. Knowledge creating	0.121*	0.029	0.042	0.251
2. Knowledge inventory	0.119*	0.049	0.005	0.905
3. Knowledge diffusion	0.162*	0.008	0.016	0.701
4. Knowledge transfer	0.203*	0.001	0.016	0.695
<i>Intervening Influences</i>				
5. Developing and operational strategies			0.229*	0.001
6. Organic structure			0.263*	0.000
7. Knowledge-friendly culture			0.262*	0.000
8. Transformational leadership			0.194*	0.002
$\Delta R^2$		0.155		0.488
$R^2$		0.155		0.643
df		(4,382)		(8,378)
F		16.747*		79.706*
*p<0.05				

Engineering education in universities should underscore knowledge creation, knowledge inventory, knowledge diffusion and knowledge transfer. These four dimensions trigger major positive influences on an organisation's learning ability.

Engineering education programmes at universities should adopt organisational mechanisms that are suitable for a learning organisation. This includes developmental and operational strategies, an organic structure, a knowledge-friendly culture and transformational leadership. Such mechanisms generate intervening and positive influences on learning ability.

This article presents research that should be considered as a preliminary study of a learning organisation. Its conclusion provides a research structure and establishes relevant propositions for the practical application of the learning organisation paradigm to engineering departments of universities. It is suggested that further research be designed based on this study. Researchers can enrich the content of the structure and aggrandise quantitative research instruments for advanced studies in this field.

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edited by Zenon J. Pudlowski

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