The study of constructing a knowledge innovation model in an electrical engineering department at an institute of technology

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ABSTRACT: The article explores a knowledge innovation model to be used in institutions of technology and education. Fast paced technological change has created an era that relies heavily on a knowledge-based economy. In order to keep up with the times, teachers have to instil into students qualities like creativity and the ability to relearn. Students need to gain attributes that will make them capable of keeping up with issues in innovation and problem-solving techniques. The building of a knowledge education platform that revolutionises traditional teaching methods and embraces new age diversified learning is the only way to establish a knowledge innovation model, thereby keeping up with a future that revolves around a knowledge-based economy.

INTRODUCTION

As the world experiences constantly amazing technological breakthroughs and innovations, there are also dramatic changes occurring in society and in the everyday way of life. In order to cope with this diversified and ever-changing society, people will not only need to enhance themselves with knowledge but also their capabilities in problem solving and knowledge innovation.

In Taiwan, since the dawn of the 21st Century, there has been a focus on education in order to deal with this ever-changing life. Years of quality and quantity expansion, and the numerous talents cultivated from different levels in schooling and at institutions, have seen a tremendous contribution towards Taiwanese society, economy, politics and culture [1].

This was especially made apparent with Taiwan's accession into the World Trade Organisation (WTO). The impact focused on revolutionising technology educational institutions, emphasising demands in high level technology talents, promoting business and technology industries, actively improving resources in technology education (teachers, equipment, courses, methodologies and material), and special attention to cultivating areas like research and development, Quality Control (QC), automation, electrical engineering and electronics.

The Development of Knowledge Economics

The concept of a knowledge-based economy originated in the USA in 1992, with the new US economy demonstrating its focus on the development of knowledge economics.

The knowledge part of a nation's economy is primarily founded on the processing of large amounts of information. Absorption and manipulation results in creativity and, ultimately, wisdom. With the Internet revolution, a large amount of information has augmented the value of knowledge, which has led to the realisation of high returns through the claiming of intellectual property. Yahoo and Microsoft are both typical examples of this particular type of success.

Literature indicates that certain factors help to determine global competitive advantage, such as innovation, speed and revolution. New ideas of knowledge lead the field, while technology innovation and speed decide whether a win or a loss emerges. Alternatively, although the selection, sharing, storage and innovation of knowledge are important, the ultimate goal is still in the application [2]. However, whether the modification is in thoughts/ideas, organisations/systems or equipment/ technology, the inclusion of applications in modern knowledge innovation and scientific tools is essential in order to deal with the challenges of speedy revolutions in this era of the knowledge-based economy.

The Cultivation Target of Technology Institutions

Automated industrial society is a prime example of a technology institution that has been cultivated. In automated industry, the demand for technicians is relatively low compared with the demand for personnel with the knowledge and skills in maintenance, application design and research [3].

In the future environment of global competitiveness, the key to business survival will be through the application of Research and Development (R&D) capabilities. This primarily stems from the following:

- School education.
- Societal education.
- Business sector education.

An ideal situation would encompass the school education system with an early start on students' capabilities in R&D and knowledge innovation. This would then enable education in the business sector to advance even further [3].

The main education target of a technology institute is the cultivation of high-level engineering and management personnel. The mission here is to coordinate the nation's economic development plan with the cultivation of high-level talents [4]. At present, education and learning is a very important area. The official educational programme revolves around how knowledge workers obtain their jobs and their social status; it will also see educational institutions becoming the centre of a knowledge society [5].

Attributes of a Creative Personality

In order to effect a higher level of knowledge innovation, learners must have in their personality a high level of creativity. Based on the acknowledgement psychology of Sternberg, it is recognised that personality, when combined with a high level of creativity, also produces the following attributes:

- A higher level of inner motivation that is less dependent on outer enforcement.
- Greater concentration on ongoing matters.
- The will to overcome obstacles and withstand vagueness and incompletion during the development process.
- Diligence in innovation and work improvements [6].

In addition, the research of Csiksentmihalyi pointed out other attributes of this type of personality, namely:

- Such a personality is primarily energetic, but sometimes quiet and seemingly unconstrained.
- A creative personality is often intelligent and a bit naive.
- Cerebration comes about often under interaction between imagination and reality.
- A creative person can be rebellious and independent, passionate and yet objective towards his/her job.
- Openness and sensitivity often leaves them in a contradictory state of both happiness and sadness [7].

Implementing Strategic Planning and Activities for Knowledge Innovation

Strategic planning is a rational decision-making process. Hill and Jones state that strategic planning begins with a mission and a goal; this is followed by decision making, and then comes analyses of external factors, particularly opportunities/threats, as well as internal factors, such as the organisation's advantages and disadvantages [8].

At the implementation stage of a strategy, it is vital to design an organisational structure, establish this structure and install control mechanisms that are compatible with the strategy, identify any design modifications that may be needed to the control system and management strategy, and lastly inspect feedback from the system in order to determine the success of desired mission and goal.

The *integrated cerebration diagram* combines the fishbone diagram, which specialises in laying out the features and key factors. The *mental diagram cerebration method* of Leonardo da Vinci is surprisingly beneficial to the complete planning and implementation of knowledge innovation activities for electrical engineering departments at institutions of technology.

Among those already mentioned, the *mental diagram cerebration method* is especially beneficial for the logistics and distribution of cerebration. It clarifies the depth and width of certain subjects and further expands both upwards and downwards for a more complete and correct judgement.

In order to elevate the learning of innovative thinking and problem solving skills, society's emphasis on democracy and innovation is very important [9]. The focus of technological development should be present in breakthroughs and innovations, and also in the replacement of old knowledge for the creation of new knowledge. In order to adapt to this fast changing society, people will need to use their creativity, apply their ingenuity and have problem solving capabilities. All of these are necessary features for future technological talents. It follows then that when technology becomes deeply rooted, the level of industries will be upgraded, and living standards within society will improve dramatically.

Knowledge innovation is a key success factor for business operations in this knowledge-based economic era. The only factor that has generated the greatest impact on modern management is the innovation ability based on knowledge [10].

Ji-Chen Chang interprets knowledge as follows:

- Knowledge is comprised of key characteristics, like being systematic and logical, including values of accumulation and transfer.
- Knowledge is everywhere and emphasises capabilities of adoption and reliance.
- Knowledge has the attribute of special field expertise [11].

Experts have pointed out that the essence of knowledge innovation should at least have the following features:

- Be able to provide different solutions to the same problem.
- Have an ingenious combination for the same set of sources.
- Involve innovative new concepts towards management.
- Incorporate unique judgements in line with trends of the future.
- Be a clear understanding of the core competences.
- Have the ability to continuously self-evolve [2].

There are two processes involved in guiding an individual subject towards continuous knowledge innovation; these are the tacit and explicit processes [12]. The tacit process refers to the stages of mental operation that are related to some specific scenarios. Two particular principles in its implementation, delayed judgement and solving for quality within quantity, are similar to the brainstorming technique. On the other hand, formalising, institutionalising and transmitting compose the explicit process; examples include discovering in-depth new information via numerous external sources, or alternatively, internalising the obtained external information in order to reach the basics of knowledge innovation.

The concept of knowledge innovation is illustrated in Figure 1. From small to large, the X-axis represents the individual member, group, department, organisation and cross-organisation. The Z and Y-axis, respectively, represent tacit and explicit knowledge. The organisation of knowledge

innovation is the interaction of both tacit and explicit knowledge among members, and the knowledge spiral processes of internalisation, assimilation, dissimilation and combination are constantly repeating.

Nonaka and Takeuchi refer to the concept of organisational knowledge creation as the capability of new knowledge generated by the organisation and passed onto the entire organisation, including its products, services and systems [13]. They state that organisation knowledge creation is built on the following procedures:

- Sharing tacit knowledge;
- Creating a concept;
- Confirming this concept;
- Prototyping;
- Expanding cross-sectional knowledge [13].

This is based on observations from knowledge creation processes and an organisation's internal knowledge creation conditions.

Figure 2 shows the interaction between four activities that can be considered to be helpful to knowledge creation, involving external/internal factors and time contexts [14].

Innovation implies creation and revolution. Innovation relies on the processes of creating knowledge, applying knowledge and expanding knowledge. In the view of the economist, J.A. Schumpeter, it is a process of *creative destruction*, because economic growth can only be sustained if continuous innovation is maintained [15].

CONCEPT OF THE KNOWLEDGE SPIRAL

Among different levels of individuals, groups and schools, knowledge can be accumulated and displayed by a positive spiral-type growth and this is achieved through systematic, planned and meaningful learning activities [16]. Although knowledge management is often defined as a process of systematically adopting, assimilating, creating, learning and using information, the circulation of knowledge management is of a spiral concept. This dynamic circulation consists of

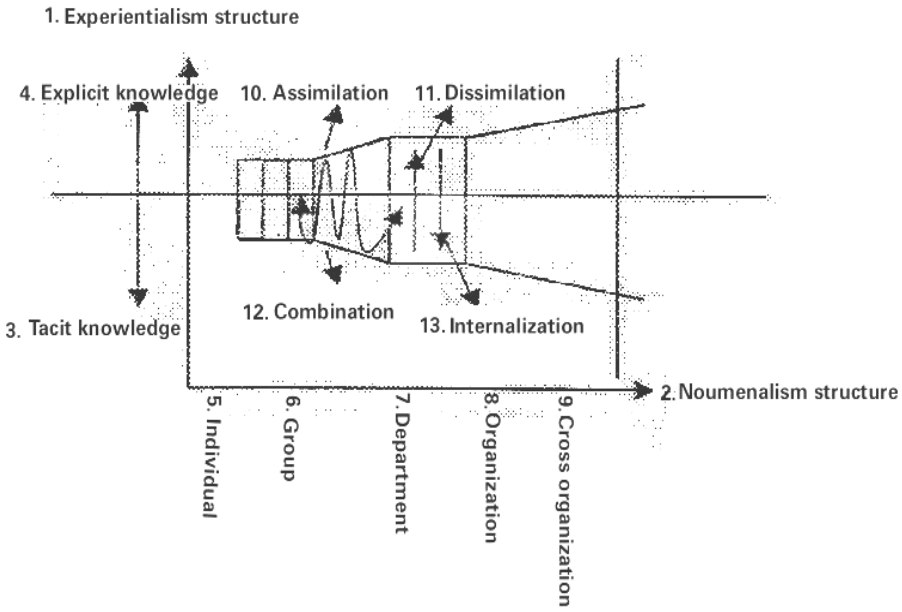

Figure 1: The path and management of knowledge transfer [13].

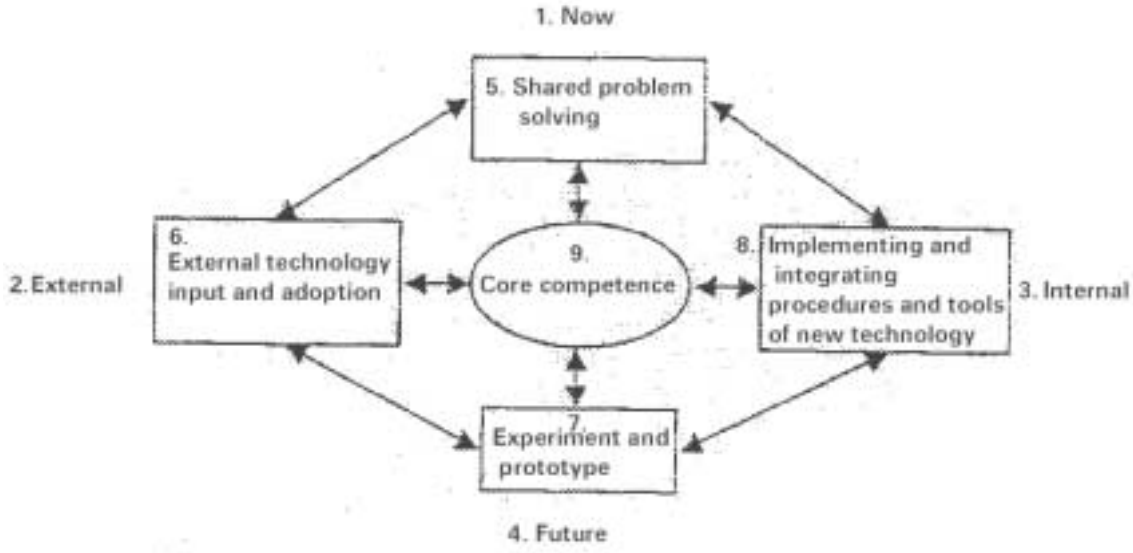

Figure 2: Interaction of four activities that can be considered to be helpful to knowledge creation [14].

institutional management (common culture of knowledge), business intelligence (knowledge dissimilation), group learning (knowledge sharing and connecting) and innovation management (knowledge innovation) [17].

The Spiral Growth Concept of Group Learning

Lant and Mezias' spiral growth concept of group learning suggests that an organisation promotes knowledge learning [16]. The accumulation of organisational knowledge comes from spiralled growth. The motivation of an organisation to promote learning activities comes from the work efficiencies of its members. In another sense, the purpose of achieving spiralled knowledge growth from group learning is to encourage the organisation to set up a new target or goal. The core concept is for an organisation to learn new practices and procedures, and not just improve existing methods [16].

Janszen's Innovative Spiral

In studying the knowledge spiral, Janszen thought that innovation also possessed the same characteristic of spiral growth. Janszen suggested innovation as a combined description of an organisation, technology, application and market niche or client groups [9]. The route of the innovative spiral begins from the organisation to technology innovation, and gradually moves towards application, then expanding to different groups of clients, before finishing with feedback from clients to the organisation for further innovations [9].

Besides its emphasis on personal creativity, the process of knowledge creation should also combine both internal and external mental mechanisms. Personal creativity should come under different levels, natures and subjects, hence creating an open and free environment, adopting different concepts, and thus being able to create new knowledge.

Boisot proposed the knowledge-moving diagram in the three-dimensional space [18]. This diagram formed the learning circulation model diagram for organisational members' social interactions. The diagram showed that the movement of knowledge in three-dimensional space is a dynamic circulation that follows the sequence of individual knowledge, proprietary knowledge, textbook knowledge and common knowledge [18].

From the above, the building of a knowledge innovation model should be based on relating concepts and theories in knowledge innovation, exploring related concepts of knowledge innovation, the knowledge spiral concept, organisational learning theory and applications, as well as group learning theory and organisational applications.

PURPOSE OF THE RESEARCH

Based on the above research background, the objectives of the research are as follows:

- Plan for the external and internal environments that effect knowledge innovations in courses of electrical engineering in departments of technology and academic educational institutions.
- Explore theoretical models of knowledge innovation in courses of electrical engineering for departments of technology and academic educational institutions.
- Establish a model for knowledge innovation in courses of electrical engineering in departments of institutions of technology.

RESEARCH METHODS

The theories involved include: the knowledge innovation concept, knowledge spiral concept, group learning theory and the application of mobile research.

The method incorporates the following principles:

- Document study: explore external and internal factors that effect knowledge innovation in electrical engineering departments in technology and academic educational institutions; conduct strategic planning to identify factors that influence knowledge innovation. Further, undertake an in-depth study of various theories of knowledge innovation and establish a theoretical model.
- Professional consultation: aim at analysing the feasibility and appropriateness of knowledge innovation and make adjustments to the theoretical model.
- Interviews with schools and high-tech companies: it is envisaged that the main interview subjects will be reputable technology universities and educational institutions, and companies that perform well in knowledge innovation in areas like IC circuits, computer and related peripherals, communication and opto-electronics.

The stages will be as follows:

- Devise a research plan;
- Undertake documents study;
- Give professional consultation;
- Carry out a study of theories and applications;
- Carry out a study of related factors;
- Devise an interview content;
- Establish a knowledge innovation model for electrical engineering departments of technology at academic educational institutions;
- Provide conclusion and suggestions.

BUILDING A KNOWLEDGE INNOVATION MODEL

The content of knowledge innovation includes all kinds of knowledge creation activities, such as confirmation, adoption, evaluation, processing, sharing, value adding, creation and connecting.

Knowledge innovation activities are closely connected with an external knowledge network. The sources of organisational knowledge innovation include all potentially required information as dictated by the internal and external environments of the organisation.

BUILDING A KNOWLEDGE INNOVATION STRUCTURE

Building of a Theoretical Model

The theoretical model of this research includes concept, method, mechanism and procedure. It has been pointed out that method is the application of concept and category; for example, that the mathematical method is a concrete application for a series of concepts, including mathematic numbers and forms.

All methods are subjective and are conscious, intellectual activities; it is the media between the host and guest. The so-called method, based on philosophical and logical understanding, is to take a hold of reality from the relevant theories and implementation, yielding a sum of approaches and paths in order to attain a certain purpose or behavioural pattern in all fields of activities. In other words, methods can be seen as approaches taken in the intellectual and implementation processes in order to understand subjects and, further, to reform other subjects.

Sociologists often use the induction method to build their theory, starting with observing the dimension of living and looking for models that can establish a set of common principles [17]. Simply put, induction is to generalise specifics into generality, while deduction is to deduct the generality to specifics, like applying theory to a specific individual case.

Specifically, the focus will be on knowledge innovation related theories, centring on market applications that challenge today's new age electrical engineering departments of technology educational institutions. Proper research methods will be adopted, starting from a definition of knowledge and the knowledge innovation concept, and conducting philosophical arguments and logical thinking, extraction, inclusion, analogy, and imagination for the construction of this model [19].

The theoretical model building procedures follow the stages of operation environment planning of electrical engineering departments at technology educational institutions. This will be achieved by using theory as the foundation, research methods as guidance and, lastly, building a theoretical knowledge model for electrical engineering departments at technology educational institutions. The pertinent stages are described below.

The planning of an operation environment of electrical engineering departments at educational institutions involves:

- Government policy;
- Market orientation;
- Course design;
- Organisation vision;
- Teaching strategy;
- Personality characteristics;
- Teacher qualifications;
- School infrastructure.

The theoretical study incorporates:

- The knowledge innovation concept;
- The knowledge spiral concept;
- School learning theory.

A study of theoretical model includes the following:

- Plan the background that affects the knowledge innovation environment;
- Take technology educational institutions' development vision as the knowledge innovation target;
- Use the knowledge spiral concept to guide organisational innovation;
- Utilise knowledge to define the essence of knowledge innovation at a technology educational institution;
- Take organisational learning theory as the main body of the knowledge innovation model.

BUILDING THE THEORETICAL KNOWLEDGE INNOVATION MODEL

The height of the knowledge spiral can be use to determine the knowledge innovation capability of a business organisation. Lower levels of knowledge innovation on the spiral indicate a higher level of knowledge innovation efficiency in group learning activities in an organisation. This is shown in Figure 3.

RESEARCH RESULTS AND DISCUSSION

Concepts of knowledge innovation, accumulation and transfer can be obtained from documented studies of knowledge innovation, macro-perspectives of knowledge management, or established theories from the perspective of knowledge transfer and creation. Yet, the relationship of knowledge accumulation, transfer and innovation is vague and not easy to sort out. Therefore, fuzzy theories in knowledge processing were adopted as a basic concept and helped to trigger the author's fuzzy relationship towards the accumulation, transfer and innovation of knowledge.

The application model of knowledge innovation utilises new knowledge as a catalytic agent, activating sensitive and innovative scenarios, and introducing related information to shape the new knowledge. This is based on the trends and market orientation to fully display the new knowledge value.

In the teaching process, knowledge innovation course design relates to bringing better teaching methods through teachers' creativity in their own field and application of their experiences, knowledge and skills. Through the introduction of new knowledge sharing and tools, improved knowledge innovation acceleration media may also be formed, triggering new senses or creation for the shaping of new knowledge.

Knowledge innovation and teaching strategy relate to schools of technology educational institutions and above, which are official educational places for knowledge distribution, creation and application. With personal knowledge accumulation, teachers are able to produce new inspiration and knowledge through group learning processes and brainstorming activities.

CONCLUSION

Proper planning of a knowledge innovation environment can elevate a school's competitive edge. Today's dynamic internal and external environments are challenging schools in sustaining continuous innovation and competitiveness for survival. Knowledge-created values have already surpassed traditional production factors. Now, the pursuit of new knowledge has become the motivating factor for knowledge innovation at educational institutions of technology.

The evaluation of knowledge innovation environments and the proper application of planned tools can promote the development of knowledge innovation. Schools can expect positive effects from a powerful knowledge innovation environment. The application of the knowledge innovation concept can promote value at an educational institution of technology, as knowledge has the value of accumulation and sharing, enhancing an individual's specialties. Furthermore,

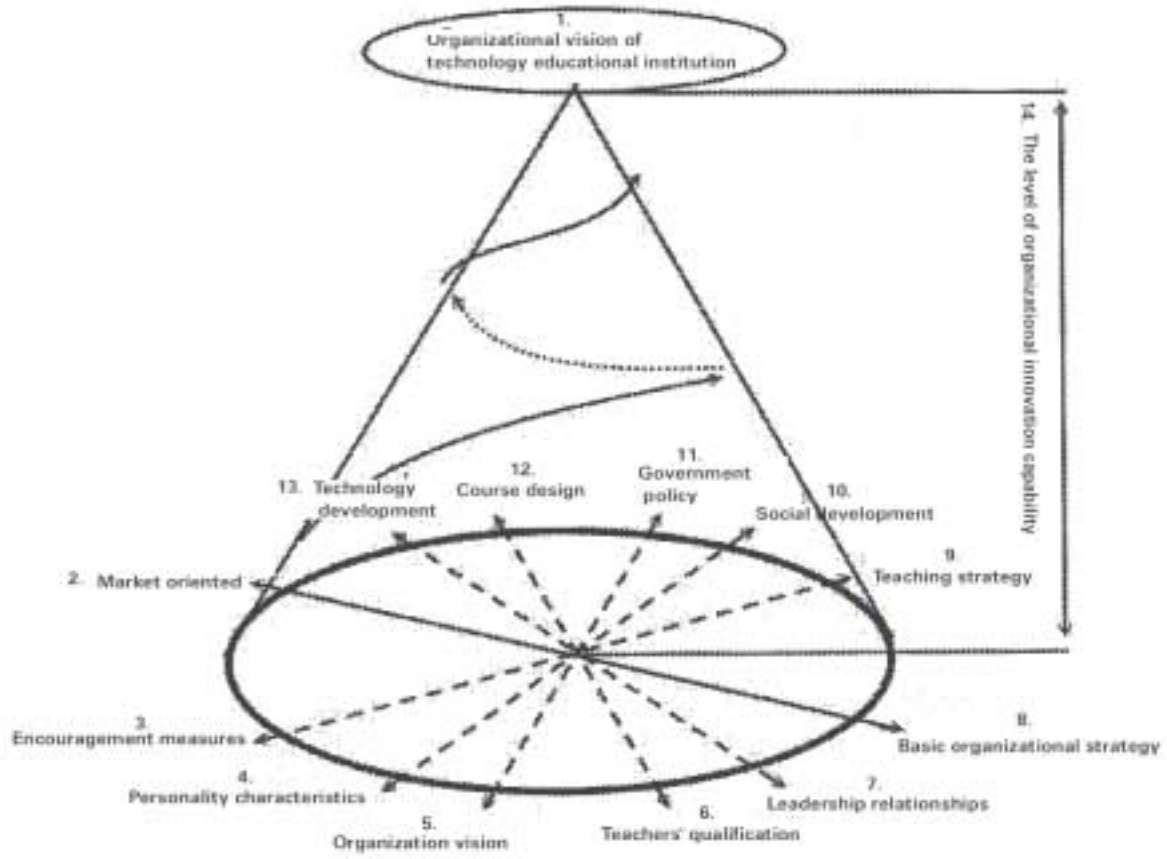

Figure 3: The theoretical knowledge innovation model for a technology educational institution.

knowledge innovation, in general, will help a person to cope with time demands and competitive students.

REFERENCES

1. Science and Technology Statistic Principles of National Science Association of Administration Yuan. Taipei: National Science Committee of Administration Yuan (2000).
2. Liao, T-W., The research of an actual application of knowledge management in school administration. *Joint Publication of Citizen Educational Research*, 9, **9**, 1-33 (2001).
3. Hon, Z-C. and Lee, D., Research of Required Knowledge Building for the Nation's Industrial Technology Talents – Knowledge Category Analysis. Taipei: National Science Committee of Administration Yuan (1984).
4. The Educational Targets of the Nation's Educational Institutions of Technology and Profession. Technology and Profession Bureau (1987).
5. Hickman, G.R., *Leading Organisations.* Thousand Oaks: Sage Publications (1998).
6. Sternberg, R.J., *The Nature of Creativity - Contemporary Psychological Perspectives*. Cambridge: Cambridge University Press (1988).
7. Csiksentmihalyi, M., *Creativity Flow and the Psychology of Discovery and Invention*. New York: Harper Collins (1996).
8. Hill, C.W. and Jones, G.R., *Strategic Management: An Integrated Approach* (4th edn). Boston: Houghton Mifflin (1998).
9. Janszen, F., *The Age of Innovation*. Hemel Hempstead: Prentice Hall (2000).
10. Hsu, S-J., *Company Reform in the Era of Knowledge Economy*. In: The Confusion and Review of Knowledge Economy. Taipei: Tiensha Yuanjan, 73-88 (2001).
11. Chang, J-C., The study of enhancing teachers' knowledge innovation ability: an implementation model of joint exercise research. 2000 Exercise Research - Local Educational Reform Outlook, Thesis of Academic Seminar, 277-296 (2000).
12. Wu, M-H. and Huang, J-J., The study of company knowledge innovation content in the era of knowledge. *Economy, Technology and Prof. Educ.*, 66, 6-10 (1990).
13. Nonaka, I. and Takeuchi, H., *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*. Oxford: Oxford University Press (1995).
14. Leonard-Barton, D. *Wellspring of Knowledge: Building and Sustaining the Sources of Innovation.* Boston: Harvard Business School Press (1995).
15. Schumpeter, J.A., *Capitalism, Socialism, and Democracy*. New York: Harper Collins (1984).
16. Lant, T.K and Mezias, S.J., *An Organisation Learning Mode of Convergence and Reorientation*. In: Cohen, M.D. and Sproull, L.S. (Eds), Organisational Learning. Thousand Oaks: Sage Publications, 83-88, (1995).
17. Lee, D. and Chang, J.C., The study of theory-application coordination condition for high-tech talents in educational institutions of technology and profession. *Thesis of the 13th National Technology and Profession Educ.*, 17-26 (1998).
18. Boisot, M., *Knowledge Assets Securing Competitive Advantage in the Information Economy*. Oxford: Oxford University Press (1998).
19. Chow, T-H. and Chang, J-C., The inspiration from company knowledge innovation management theory. *Technology and Professional Educ.*, 66, 2-5 (2001).