World Transactions on Engineering and Technology Education
Vol.12, No.2, 2014

A coupling mechanism for innovation education for engineering students based on knowledge management

Xiaoyan Zhang

Wuhan University of Technology
Wuhan, Hubei, People's Republic of China

ABSTRACT: The analytic method for causality relationships in system dynamics was applied to engineering education in this research study. It focuses on the subsystems of teaching, technological innovation, campus culture and social service. A causality relationship for the coupling of a technological innovation educational system for engineering students was constructed and specific feedback loops were identified. Also outlined in this article is the outcome of the research analysis of the roles played by knowledge inventory, self-knowledge increments and coupling knowledge increments in the education of engineering students.

INTRODUCTION

Education of engineering students in China has evolved into a comprehensive system over the past 50 years, covering teachers, students and research. However, several problems still exist. These include engineering education not reflecting frontier research, difficulty in integrating innovative teaching into the education and a disconnect between education inside institutes of engineering. The application of an innovative educational coupling system for engineering students could help to solve these problems, because it is established on the basis of knowledge management.

ELEMENTS OF THE COUPLING SYSTEM

Teachers, students, managers and other individuals have social demands that are involved in system coupling. The engineering student educational coupling system includes four aspects, and these are: a system knowledge inventory, knowledge increment, knowledge incremental driving force and knowledge incremental efficiency [1].

The system knowledge inventory includes an apparent knowledge inventory and a recessive knowledge inventory. An apparent knowledge inventory includes teaching materials, technology, academic theses, databases and software. A recessive knowledge inventory includes experience, concepts, thoughts on teaching and knowledge management capacities.

The system knowledge increment includes the knowledge transfer increment and the knowledge innovation increment [2]. The former is the knowledge increment produced through knowledge transfer, sharing and overspills among different subjects, while the latter is the increment of new knowledge created through innovative activities.

Teachers and students each have demands for one or several kinds of knowledge and skills during teaching and technological innovation activities [3]. There also can be a lack of knowledge among subjects within a coupling relationship or a mismatch between demands for innovation and the current knowledge inventory. All of these can be the driving force behind an increment of knowledge.

The knowledge increment efficiency reflects the increment of the knowledge inventory for a subsystem. It does so by influencing the increment of the knowledge inventory during the operation of an individual subsystem. It uses the knowledge transfer channels established among different subsystems to embody the level of system coupling. Knowledge increment efficiency is specifically defined as the knowledge transfer efficiency between teachers and students, as well as among students, teachers and the knowledge database, and between students and the knowledge database. The knowledge increment efficiency is influenced by an incentive mechanism, the level of mutual trust between the transferor and transferee, and similarities in terms of background culture.

ANALYSIS OF EACH SUBSYSTEM'S INFLUENCING FACTORS

The influencing factors are shown in Table 1.

Table 1: Influencing factors for each subsystem.

Subsystem	First-level class indexes	Second-level class indexes	Third-level class indexes
Teaching subsystem	Knowledge inventory	Explicit knowledge inventory	
		Tacit knowledge inventory	
	Knowledge transfer increment	Self-knowledge increment	Teachers' capacity to obtain knowledge
			Teachers' willingness to obtain knowledge
		Coupling knowledge increment	Knowledge transfer efficiency
			Knowledge transfer channels
	Knowledge innovation increment	Teachers' capacity to innovate	
		Teachers' willingness to innovate	
Technological innovation subsystem	Knowledge inventory	Explicit knowledge inventory	
		Tacit knowledge inventory	
	Knowledge transfer increment	Self-knowledge increment	Students' capacity to obtain knowledge
			Students' willingness to obtain knowledge
		Coupling knowledge increment	Knowledge transfer efficiency
			Knowledge transfer channels
	Knowledge innovation increment	Students' innovation capacity	
		Students' willingness to innovate	
Campus culture subsystem	Knowledge inventory	Explicit knowledge inventory	
		Tacit knowledge inventory	
	Knowledge sharing culture	Willingness to share knowledge	Students' willingness to share knowledge
			Teachers' willingness to share knowledge
		Knowledge sharing channels	Knowledge transfer channels
			Knowledge transfer efficiency
	Knowledge innovation culture	Teachers' willingness to innovate	
		Students' willingness to innovate	
Social service subsystem	Knowledge inventory	Explicit knowledge inventory	
		Tacit knowledge inventory	
	Achievement conversion increment	Quantity of innovation achievements	Teachers' innovation increment
			Students' innovation increment
		Achievement conversion capacity	Conversion efficiency
			Conversion channels

The influencing factors for each subsystem have been used to generate a preliminary causality figure on the coupling and evolution model for the technological innovation educational coupling system of engineering students using the Vensim software from Ventana Systems, Inc. [4], see Figure 1.

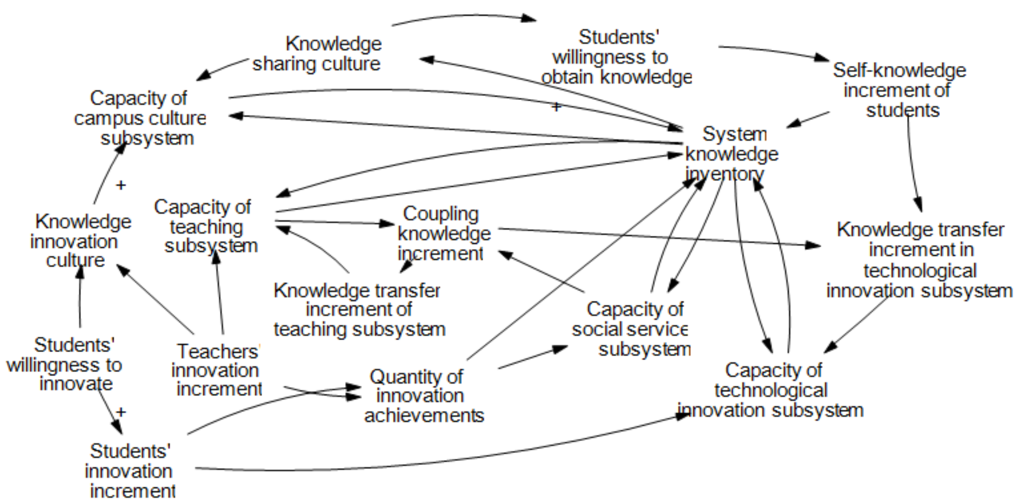

Figure 1: Coupling and evolution model for technological innovation educational system for engineering students.

According to Figure 1, there are several feedback loops within the system. The major feedback loops are shown in Table 2.

Table 2: Major feedback loops.

	Step1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7
Loop 1	System knowledge inventory	Knowledge sharing culture	Students' willingness to obtain knowledge	Students' self-knowledge increment	Knowledge transfer increment in technological innovation subsystem	Technological innovation subsystem capacity	System knowledge inventory
Loop 2	Teaching subsystem capacity	Coupling knowledge increment	Knowledge transfer increment within technological innovation subsystem	Technological innovation subsystem capacity	System knowledge inventory	Teaching subsystem capacity	
Loop 3	Social service subsystem capacity	Students' willingness to innovate	Knowledge innovation culture	Campus cultural subsystem capacity	System knowledge inventory	Social service subsystem capacity	
Loop 4	Social service subsystem capacity	Coupling knowledge increment	Knowledge transfer increment of teaching subsystem	Teaching subsystem capacity	System knowledge inventory	Social service subsystem capacity	

ANALYSIS OF THE COUPLING MECHANISM FOR THE TECHNOLOGICAL INNOVATION EDUCATIONAL SYSTEM FOR ENGINEERING STUDENTS

As described above, knowledge inventory, the self-knowledge increment and the coupling knowledge increment are the most important variables that influence the evolution of system coupling. Such variables lead to - and promote - system coupling, from low to high coupling levels. They also work from disorderly to orderly through concentration; they rise and fall, and they are synergistic.

An educational subject concentration mechanism focused on the knowledge inventory: a knowledge inventory concentration has been established on the basis of the changes to the knowledge inventory. This occurs under the influence of knowledge increments. These knowledge increments take two forms. First, the knowledge subjects of each subsystem are automatically concentrated around the system knowledge inventory platform.

This is done in order to lower the expenses associated with obtaining knowledge, obtaining a scaled economy of knowledge, a scope economic effect and a study economic effect. This produces the concentration effect. Second, there is a concentration of the knowledge subjects from each subsystem around the system knowledge inventory platform. This has led to competition among the knowledge subjects, and it has improved the willingness of the knowledge subjects to gain knowledge and apply new knowledge voluntarily. In addition, the new knowledge increment inside the subsystem, as well as the contradictions between it and the instinct structure and methods, will lessen the disorderliness in knowledge management. This causes each subsystem to try to establish a new order to realise a balanced and orderly system. This, then, promotes the development of the system coupling structure.

An educational knowledge rise-fall mechanism focused on the self-knowledge increment: the self-knowledge increment shows the knowledge increment inside the subsystem. This is decided by the capacity and willingness to learn knowledge shown by the personnel participating in innovation education. It is also decided by knowledge management recycling, and rise and fall of the management effect inside the subsystem itself. The self-knowledge increment results from the demands for knowledge, which are exerted on the external environment of the system by the personnel participating in innovation education. It experiences the influences of the driving force of internal coupling.

These personnel learn knowledge from the external environment through various channels. The self-knowledge increment of a single subsystem leads to a rise and fall in the knowledge inventory. These changes can be divided into either a minor rise and fall or a huge rise and fall, according to the forms of the movement. The knowledge rise and fall mechanism focused on the self-knowledge increment is the triggering condition for the technological innovation educational system for engineering students to form a structure at a higher coupling level.

An educational synergistic mechanism represented by the coupling knowledge increment: the coupling knowledge increment is an important part of the knowledge increment within each system. It is influenced by the knowledge inventory, knowledge transfer channel and knowledge transfer efficiency of the other subsystems. The level of the coupling knowledge increment reflects the scale, effect and speed of mutual co-operation among different subsystems. It directly influences the type and extent of the effect of a single subsystem on other subsystems.

The coupling knowledge increment's influences on the educational effect of a single subsystem take three forms. These three forms are promotion, maintenance and obstruction. When the coupling knowledge increment comes in the form of a deficiency in the system knowledge inventory, it takes on promotion. In cases where the coupling knowledge increment is not relevant to the development objective of the subsystem, it takes on maintenance. In cases where the coupling knowledge increment conflicts with the knowledge inventory of the subsystem, an obstruction is possible.

POSITIVE EFFECTS OF THE RESEARCH

This research provides an innovative educational management mode for engineering students. It features all-member participation and common benefits that are based on knowledge management. Such a method promotes unification of educational concepts. It also promotes the diversification of the subject education, and forms an all-member talent cultivation situation, which enriches educational resources and atmosphere through practice.

Promoting the unification of educational concepts of engineering by incorporating those that are innovative: educational concepts often fail to penetrate into teaching, scientific research, management and services. For this reason in engineering schools within the conventional educational system, innovative activities are oriented toward an elite. This has led to a lack of unified properties within the educational system, as well as inconsistent objectives among internal departments at specific engineering schools. The new mode described here is beneficial for helping engineering schools to break through the boundaries that exist between various teaching, scientific research and management departments. It is also useful for unifying the internal standards of engineering schools concerned with cultivating students with specific types of qualities. Furthermore, this mode adheres to the educational concept of cultivating students with an awareness of innovation in each department [5].

Promoting diversified development in content, forms and methods of subject education for engineering students: the subject education of conventional engineering students is composed mainly of classroom teaching and experiments in the laboratory. Here, the mode is generally the *ruled by one voice* method. This method features monotonous content. It does not reflect modern society and is seldom related to the daily practices of the engineering student [6]. This type of educational mode tends to create a sense of weariness among students towards their subject. The mode proposed in this article can help to promote a more diversified development of content, form and methods of education for engineering students. It can also enable engineering students to read, think abstractly, and come into contact with information that possesses the greatest practical value and research significance related to their subjects.

This happens both in China and elsewhere through enterprise practice, as well as through knowledge exchange platforms. They can also learn about the latest viewpoints, latest development trends and latest demands, as well. This helps to provide new challenges, opportunities and an orientation for professional studies. It also helps engineering students to effectively improve their capacity for carrying out independent learning, discovering innovation opportunities and translating ideas into research.

Promoting various social groups to participate in innovation education for engineering students and facilitating talent cultivation: the industry, enterprises and third-party social educational bodies can directly benefit from support for innovation education for engineering students. The method promoted here inspires various social groups to positively provide statistical data, carry out industrial skills training, provide practice bases, summarise technical demands for industrial development and grant financial aid to industrial college students. It also encourages the offering of external research instructors, points to frontier research directions and seeks out technological innovative talent. In this way, it provides benefits to engineering students by helping talent cultivation [7].

Promoting the establishment of a resource-sharing mechanism for education, as well as enriching the educational resources and atmosphere for engineering students: the application of this research can promote the establishment of a resource-sharing platform for engineering education. It can also strengthen the integration and interaction of educational resources between the following: teachers, teachers and students, teachers and external enterprises and scientific research institutes, students and external enterprises and scientific research institutes, disciplines, institutes of higher education, institutes of higher education and government, institutes of higher education and third parties [8].

It can also promote the construction of public educational resources and information platforms for engineering schools that are oriented towards frontier subjects and frontier industries. This method can be used to construct various types of platform, such as educational service consultancy platforms and educational databases (e.g. technological literature databases, teaching data databases, historical research databases, and skills databases). This would improve educational resources and the *atmosphere* in education by enriching educational content.

CONCLUSIONS

This study provides an effective way for institutes of higher education to pay attention to innovation education for engineering students. It can promote innovation by improving knowledge sharing and by providing resources among institutes of higher education, scientific research institutes and other entities.

REFERENCES

1. Li, Z., Lai, W. and Bai, X., System dynamics analysis on sharing of recessive knowledge in scientific research teams of institutes of high education. *Manage. J.*, 10, 1495-1504 (2012).
2. Brady, M.P., Multiple roles of student and instructor in university teaching and learning processes. *The Inter. J. of Manage. Educ.*, 11, **2**, 93-106 (2013).
3. Wu, H-Y., Wu, H-S., Chen, I-S. and Chen, H-C., Exploring the critical influential factors of creativity for college students: a multiple criteria decision-making approach. *Thinking Skills and Creativity*, 11, **3,** 1-21 (2014).
4. Lin, T., Research on synergetic innovation mechanisms based on synergetic theories. *Postgraduate Educational Research*, 2, 9-12 (2013).
5. Wu, K., Why type of college students are needed for the cultivation of innovative talents. *High Educ. Research*, 34, **1**, 11-15 (2013).
6. Zeng, H. and Zou, L., Technological innovative activities of college students: hierarchic and classified management. *High Agricultural Educ.*, 6, 99-101 (2013).
7. Jin, X. and Zhao, J., Promoting cooperation between institutes of higher education and scientific research institutes to construct a scientific and educational cultivation platform. *Chinese College Teaching*, 5, 21-22 (2013).
8. Wang, X., *Research on Cultivation and Assessment of Innovative Talents in Science Schools*. Hebei: North China Electric Power University Press, 41-47 (2008).