10.6977/IJoSI.201203_2(1).0004
J. P. Tsai, Y. G. Chen / Int. J. Systematic Innovation, 2(1), 46-54

Approach of course development for cultivation of innovative capability of students at university

Tsai, Jo-Peng[1,2*] and Yu-Gang Chen[3]

[1] Department of Computer Science and Information Engineering, Far East University
[2] Department of Information Management, National Sun Yat-Sen University
[3] Department of Innovative Design and Entrepreneurship Management, Far East University

* Corresponding author, E-mail: perng@cc.feu.edu.tw
(Received 27 November 2013; final version received 29 November 2013)

Abstract

Course design and development need to be considered in many aspects such as goals, features, resources, and constraints of each institution. Furthermore, it should conform to society's needs and should be improved according to the advances of knowledge. In order to cultivate students' capabilities corresponding to the needs of industries so that they can better cope with the severe competition in today's knowledge economy era, schools should have responsibility and endeavors to instruct students how to acquire innovative knowledge rapidly. In this paper, a systematic method of course development for cultivating the innovative capability of students at university was proposed based on knowledge chain model. An example implemented at Far East University in Taiwan was used to illustrate the feasibility of the proposed method. The concept and method proposed in this paper might be used as a reference and guidelines to promote the education of patent related courses at university.

Keywords: Course Design and Development, Patent Application and Protection, IDEF0 System Analysis, Knowledge Chain Model, Engineering Innovation Education.

1. Introduction

The cultivation of student's innovative capability has become more important for promoting his competitiveness in this knowledge economy era. However, due to the diversity of student's backgrounds and interests, how to effectively elicit the interest and reach the potentials of students is an indispensible prerequisite to approach the above-mentioned goal and this is also a problem worth studying. Though there are many courses which provide various tools and methods to cultivate the creative or innovative capability for the students, it is still insufficient to ensure whether the teaching objective of the course and the learning performance of student have been achieved, especially for the advanced creative courses or project-oriented courses. Therefore, in order to elicit the student's innovative capability, it is necessary to systematically analyze, plan and design a framework or method to reinforce engineering innovative education from a context-oriented perspective considering prior professional knowledge, basic creative knowledge, advanced creative knowledge, individual interests, etc.

Recently, TRIZ has attracted huge attention of industries and proved its effectiveness on innovative product development. Many innovative approaches have been proposed to increase the development efficiency of the product and process so as to help enterprise to enhance the competitiveness within it. Samsung Advanced Institute for Technology (SAIT) proposed a novel approach to predict prioritized directions of innovation as well as to create the most promising design of practical concept design so as to align the feasible direction of innovation based on the general evolutionary patterns of technical systems (Song et al., 2012). Yang and Chen (2012) integrated TRIZ evolution patterns with CBR and simple LCA methods to forecast the design of eco-products and used an example of a cell phone to demonstrate the effectiveness of the proposed model. Yeh et al. (2012) integrated QFD and TRIZ in the research and development process of a notebook. They identified major QFD contradictions, TRIZ inventive principles, and eco-efficiency elements to achieve green-design solutions. Sheu et al. (2012) developed a suitable contradiction matrix and invention principles for Chemical Mechanical Processing (CMP) equipment and processes in the semiconductor industry. Li (2010) integrated TRIZ and AHP to develop innovative design for automated assembly systems. He used TRIZ to propose the automated design alternatives under the innovative design consideration and to use an AHP to evaluate and select the best feasible alternative under multiple criteria.

TRIZ contains a variety of useful tools such as 40 inventive principles and the matrix of contradictions, laws of technical system evolution, substance-field analysis, and ARIZ (algorithm of inventive problems solving). However, as some of the courseware and content in TRIZ is complicated for students, it is worth developing a systematic course design for diverse students with different backgrounds. Mann (2004) has provided a systematic innovation method including four stages- problem definition, tool selection, solution finding, and solution evaluation. Sheu and Lee (2011) proposed a new systematic innovative process to facilitate and pace the systematic innovation and a platform to integrate heterogeneous resources and tools, such as TRIZ and non-TRIZ tools. Ogot and Okudan (2006) introduced TRIZ in a first-year engineering design course and the research results indicated that TRIZ makes it easier for students to generate feasible concepts to design problems. Turner (2009) proposed the "Advanced Systematic Inventive Thinking" (ASIT) method as a problem solving strategy for education. Sokol et al. (2008) implemented an empirical study on the efficacy of the Thinking Approach (TA) to language teaching and learning for foreign language education. In order to guide a user with no TRIZ education to the analysis of inventive problems, Becattini et al. (2012) developed a model and algorithm for computer-aided inventive problem analysis based on an original model and a dialogue-based software application integrating the logic of ARIZ (Algorithm for the Inventive Problem Solving) with some OTSM-TRIZ (General Theory of Powerful Thinking) models.

The innovative education has become more imperative in this knowledge era. However, there are few papers to explore how to plan and design the course and arrange the sequence of the correlated courses with systematic method. Therefore, in this paper, we focused on engineering innovative education and proposed systematic approach to design and develop the course for cultivation of innovative capability of students at university. Based on the above-mentioned argument, it reveals that the plan, design and implementation for a feasible advanced innovative course need to face many problems such as prerequisite courses, prior background and knowledge of students, cultivation of teachers' expertise, adaptive selection of the teaching materials, availability and affordance of teaching equipment, application of e-learning platform, design of teaching tools and method. Therefore, an adequate and systematic approach to provide the regulations and criteria for the plan, implementation, control and evaluation of an innovative course is essential.

The objective of this paper is to propose a systematic approach of course design and development for cultivation of innovative capability of students at university based on IDEF0 model and knowledge chain model for engineering education. The rest of the paper is laid out as follows. Section 2 describes the research method including the analysis for prerequisite courses of engineering innovative education, the plan of innovation-eliciting course, and the generation of a systematic framework and method for cultivation of innovative capability of students. Section 3 illustrates the application of the proposed method with a case study. Final section is the discussion and conclusion to illustrate the limitations, contribution and future steps of this paper.

2. Research Method

The approach of the course development includes three steps: first, analyze the prerequisite courses of engineering innovative education. Second, plan an innovation-eliciting course based on knowledge chain model. Third, generate a systematic potential eliciting and inspiring method. The detailed process was illustrated as follows.

2.1 Analysis of prerequisite courses

The analysis of the prerequisite courses of engineering innovative education was presented in this section. The IDEF0 is a structural analysis and modeling technique specially designed for the modeling of decisions, actions, and activities of organizations or for the complex and interrelated systems (Tsai et al., 2006). The results of an IDEF0 functional modeling is a hierarchical, functional decomposition of process functions, each of which consists of five basic elements: functional block, input, output, control, and mechanism. Fig. 1 shows the system analysis diagram for the prerequisite courses of engineering innovative education with the IDEF0 structural analysis model. The purpose of the process analysis is to fully understand the context of course development processes, including the activities and tasks involved, their constraints, and supporting resources, as well as the information flow in the process.

The activities in the Fig. 1 include (1) domain knowledge courses such as the professional course, (2) basic creative knowledge courses such as creative thinking and introduction to intellectual property rights, (3) advanced creative knowledge courses such as TRIZ and patent practices, and (4) integrated knowledge courses such as project-oriented or topic research courses. All of the activities, as shown in Fig. 1, involve many constraints such as course objective, prior knowledge of students, expertise and practice of teachers, affordance of equipment, and diversity of students. Furthermore, each activity involves plenty of iterative modification or refinement for course development. However, there are also various resources available such as teaching assistant, encouraging regulations, e-learning platform, Internet resources, and funds of project from government. By way of the IDEF0 analysis for prerequisite courses, it provides the visibility and direction of the innovative course development for eliciting student's interests and realize students' expertise.

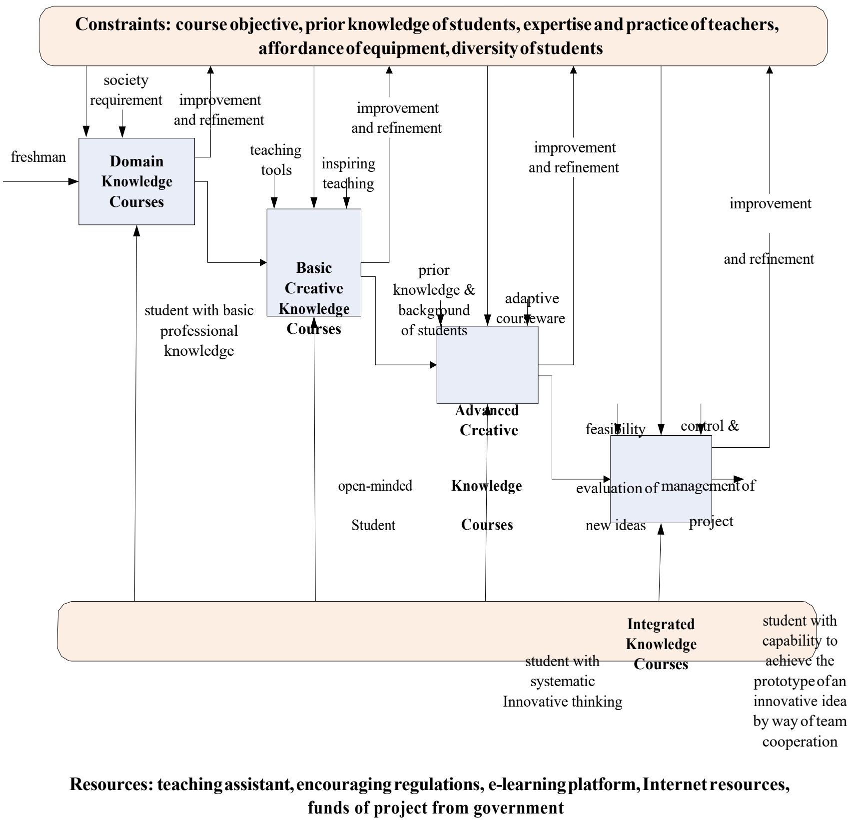

Fig. 1 System analysis of the prerequisite courses for engineering innovative education with IDEF0 diagram

2.2 Innovative Course Development based on Knowledge Chain

The concept of knowledge chain model proposed by Holsapple and Jones (2004) includes two groups of activities. One is the primary activities containing knowledge acquisition, knowledge selection, knowledge generation, knowledge assimilation, and knowledge emission. The second activities comprise leadership, coordination, control, and measurement. This framework could provide guidelines to approach the problem solving of course development from a systematic and context-based perspective.

As the knowledge chain model can provide guidelines and it gives a context-based perspective to manage, control and implement the knowledge management activities, this paper adopted it as a basis to propose a framework of course development for eliciting innovative potential as shown in Fig. 2. The primary activities of the knowledge chain framework are acquisition, selection, generation, assimilation, and emission. They focus on a sequential process and include acquiring knowledge from related courses, selecting needed knowledge to adapt student with different backgrounds, inspiring student to produce various new ideas by way of suitable course design, and encouraging students to write document such as a patent specification or achieve a prototype based a feasible idea, and supporting students to participate competition, to apply patents, to write a paper, etc.

The secondary activities are leadership, coordination, control, and measurement. They focus on planning the foresight strategies for teacher cultivation, curriculum plan, encouraging method; resolving disputes and reasonably allocating resources such as course arrangement, equipment, and funds; ensuring teaching quality and learning performance; and constructing objective evaluation criteria and mechanism. In order to effectively proceed the activities in the framework, it is necessary to consider the influence of resources and environment which are similar to the resources and constraints in the IDEF0 model. The final goal of overall activities is to enhance the competitiveness of students, schools, and even society.

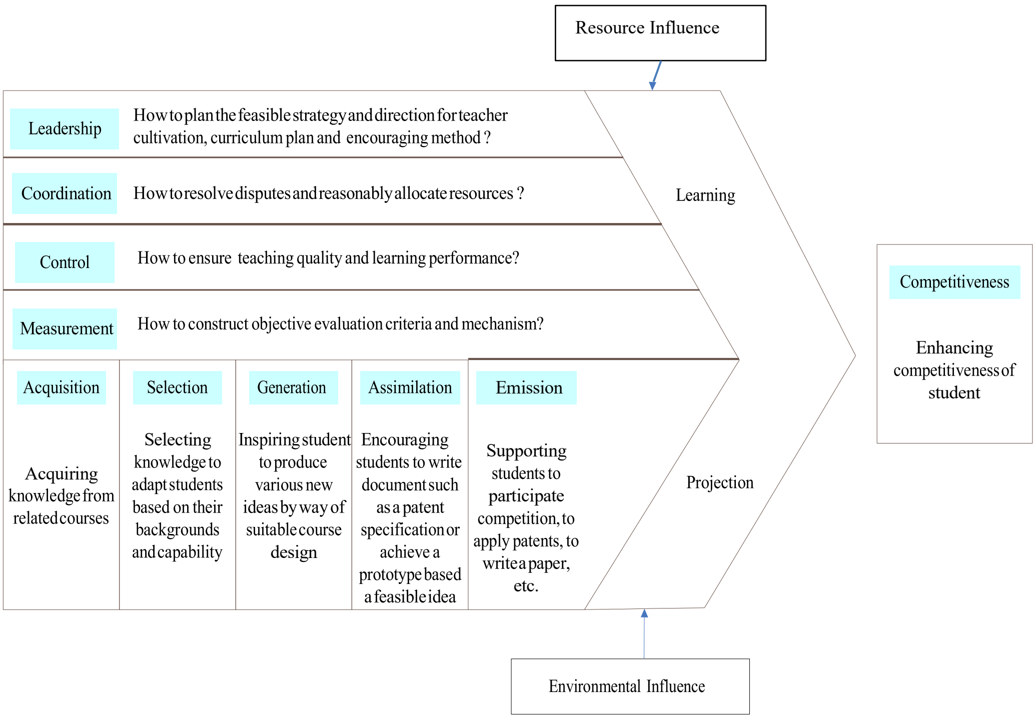

Fig. 2 Course design and development for cultivating innovative capability based on knowledge chain model.

3. Case Study

In this paper, we adopted a project implemented by the Department of Computer Science and Information Engineering at Far East University in Taiwan as an example to illustrate the proposed method. The name of the course is "High Technology Patent Appli- cation and Protection" and it is sponsored by Ministry of Education of Taiwan government. Prior to the course, Ministry of Education of Taiwan demand that every university participating this project needs to select at least one teacher as seeding teachers. All the seeding teachers need to join a 3-day training course in National Taiwan University. In the training course, the lecturer teaches patent knowledge and practices. As the electronic and information industries are very important for Taiwan, the contents of the training course were focused on case studies of patent application and protection. The expectation of Ministry of Education in this project is to educate the university students of electronic and information departments to have the patent knowledge to face the future challenge in their consequent career.

Fig. 3 shows the course development flowchart including course plan, course design, course implementation and evaluation along with the related resources and constraints. The aforementioned training course for seeding teachers could be considered as the problem-solving of the constraints in Fig. 3. By way of the resources of the sponsoring project, this course has double teachers. One is the seeding teacher and another is an industry expert with abundant practices experience of patent application and protection. In addition, Far East University also provides many incentive regulations for students to apply patents or join global competitions. The industry expert and incentive regulations could be considered as resources in Fig. 3.

Fig. 4 shows a snapshot of collaborative evaluation of students' reports with industrial expert. In Fig.3, the course plan module includes some activities such as to cultivate teachers, to analyze resources and constraints, to coordinate related members and to write projects to apply budgets. The course design module includes some activities such as to design teaching activities, to teach with industrial experts, to teach with the assistance of e-learning plat- form and to design homework and reports. The course implementation and evaluation module include some activities such as to teach patent knowledge, to analyze student's background, to demand mid-term proposal submission and presentation, to demand final-term report submission and presentation, and to collaboratively evaluate students' reports with industrial experts.

Besides the three main modules, there are also two modules, resources and constraints, needed to consider during the course development. The resources module includes elements such as industrial experts, teaching assistants, courseware provided by ministry of education, e-learning courseware, e-learning platform, and encouraging methods and mechanisms provided by schools. The constraints consists background and knowledge of teacher, background and capability of student, selection of feasible courseware, control of teaching activities, and quality control of final report.

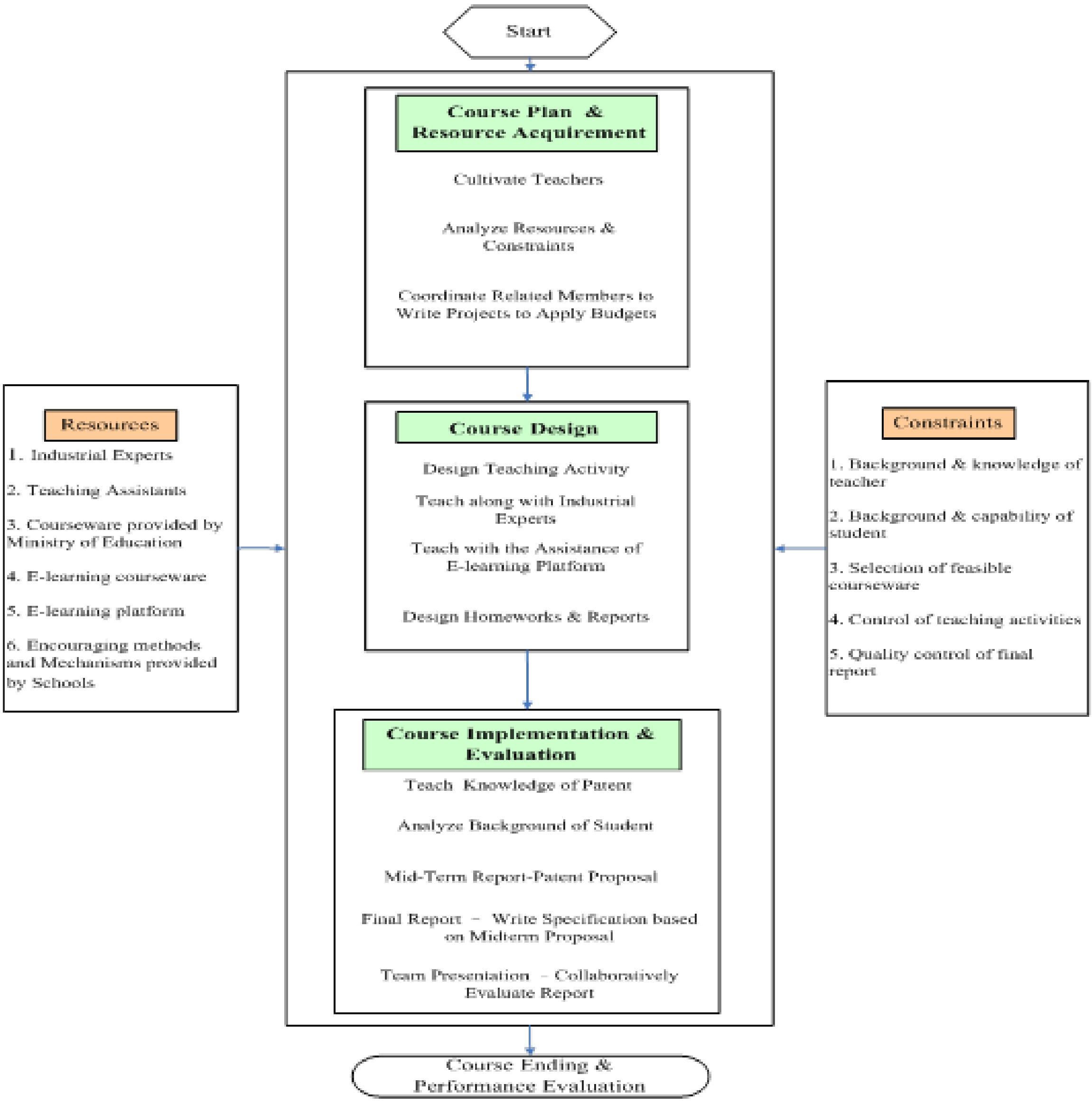

Fig. 3 The flowchart of plan, design, implementation and evaluation of course development

Fig. 4 A snapshot of collaborative evaluation of students' reports with industrial expert.

4. Conclusions

In this paper, we have analyzed the inputs, outputs, resources and constraints of a course development with IDEF0 system analysis. Subsequently, a framework of course development was proposed based on knowledge chain model. Furthermore, a case study was used to illustrate the implementing method and process based on proposed framework. The authors expect this re- search could provide guidelines or reference for en- hancing engineering innovation education and the method proposed in this paper is general in form to be applied for the other disciplines.

Acknowledgments

The authors would like to thank for the financial supports from Ministry of Education (Educational Project - High-tech Patent Application, Offense and Defense, 2008), Taiwan, R.O.C.

References

Becattini, N., Borgianni, Y., Cascini, G., and Rotini, F. (2012). *Model and algorithm for computer-aided inventive problem analysis*. Computer-Aided Design, 44(10), 961–986.

Holsapple, C. W. and Jones, K. (2004). *Exploring Primary Activities of the Knowledge Chain.* Knowledge and Process Management, 11(3), 155–174.

Li, T. (2010). Applying TRIZ and AHP to develop innovative design for automated assembly systems. *The International Journal of Advanced Manufacturing Technology*, 46(1-4), 301–313.

Mann, D. (2004). *Hands-On Systematic Innovation for Business and Management.* IFR Press.

Ogot, M. and Okudan, G. E. (2006). Systematic creativity methods in engineering education: a learning styles perspective. *International Journal of Engineering Education*, 22 (3), 566–576.

Sheu, D. D., Chen, C. H. and Yu, P. Y. (2012). Invention principles and contradiction matrix for semiconductor manufacturing industry: chemical mechanical polishing. *Journal of Intelligent Manufacturing*, 23(5), 1637–1648.

Sheu D. D. and Lee, H. K. (2011). A proposed process for systematic innovation. *International Journal of Production Research*, 49(3), 847–868.

Sokol, A., Oget, D., Sonntag, M, and Khomenko, N. (2008). The development of inventive thinking skills in the upper secondary language classroom. *Thinking Skills and Creativity*, 3(1), 34–46.

Song, M. J., Lee, J. G., Park, J. M. and Lee, S. (2012). Triggering navigators for innovative system design: The case of lab-on-a-chip technology. *Expert Systems with Applications*, 39(16), 12451–12459.

Turner, S. (2009). ASIT - a problem solving strategy for education and eco-friendly sustainable design. *International Journal of Technology and Design Education*, 19(2), 221–235.

Tsai, J. P., Lee, R. S., and Wang, Y. Z. (2006). University/college cooperation in course development: a case of synchronous collaborative teaching/learning for advanced engineering course development in Taiwan. *International Journal of Mechanical Engineering Education*, 34(4), 273–290.

Yang, C. J. and Chen, J. L. (2012). Forecasting the design of eco-products by integrating TRIZ evolution patterns with CBR and Simple LCA methods. *Expert Systems with Applications*, 2012, 39(15), 2884–2892

Yeh, C. H., Huang, J. C. Y., and Yu, C. K. (2011). Integration of four-phase QFD and TRIZ in product R&D: a note-book case study. *Research in Engineering Design*, 2011, 22(3), 125–141.

AUTHOR BIOGRAPHIES

Jo-Peng Tsai is an Associate Professor at Far East University in Taiwan. He has also had industrial working experience at Chung-Shan Institute of Science and Technology. He received his doctoral degree in Mechanical Engineering at National Cheng Kung University and is currently a doctoral student at the Information Management Department of National Sun Yat-Sen University. He has two master degrees, one in Mechanical Engineering and one in Information Management. He also holds a B.S.M.E. degree from National Taiwan University. His interests include Systematic Innovation, Green Product Design, Development and Evaluation of VR System, and Collaboration Engineering.

Yu-Gang Chen is a Professor at Far East University in Taiwan. He has also had industrial working experience at Industrial Technology Research Institute (ITRI). He received his doctoral degree in Mechanical Engineering at National Cheng Kung University and is currently the chairman of the Innovation and Creativity Center at Far East University. He has master degrees in Mechanical Engineering at Louisiana Tech University, America. He also holds a B.S.M.E. degree from National Cheng Kung University. His interests include Patent Analysis and Commercialization, Intellectual Rights Application, Innovation and Creativity Training, and Creative Mechanism Design.