The Development Strategy of Engineering Education System in the Digital Age

Chieh-Yu Lin [1] and Hsiaoping Yeh [2]

[1] *Department of International Business, Chang Jung University, Tainan, Taiwan, ROC, Tel:(+886)6-2780123ext334, Fax:(+886)6-2780662, jylin@mail.cju.edu.tw*

[2] *Department of Business Administration, Chang Jung University, Tainan, Taiwan, ROC, Tel:(+886)6-2780123ext323, Fax:(+886)6-2780680, hpyeh@mail.cju.edu.tw.*

Abstract: With the rapid growth of information technologies , the digital age has arrived. They make more and more innovative products and electronic/digital services possible. Our economic society and life are changing significantly in this digital age. The digital revolution in our world is spurring on facilities, hardware, software, services, and capital investment. In order to keep the competence in the digital age, many countries and enterprises pay much attention to the development and the application of information technologies. In the digital age, a well-designed engineering education system should also keep pace with the fast changes of the real world. This study will investigate the development strategy of engineering education in the digital age. According to the characteristics of the development of the digital revolution, this study will introduce **3I** strategy to develop the engineering education that can satisfy the industries' needs in the digital age. **3I** strategy means that the engineering education in the digital age should be developed with the following three configurations: **I**nternet, **I**nnovation, and **I**nternationalization. Internet conducts a new business model, electronic business. So far, many industries all over the world lavish much attention on the electronic business. Innovation is the only way for an enterprise to survive in the digital age. For high-technology industries, especially, much attention is paid on the development of innovative products or services. Internationalization can help industries to gain more profit. With the advanced information and communication technologies, many companies can enter the global market in lower costs. As internet, innovation, and internationalization are current trends in the digital age, how to educate a student to become a **3I** engineer is an important mission for engineering education.

Keywords: internet, innovation, internationalization, digital edge, engineering education

1. Introduction

As we enter the 21st century, we experience one of the most important changes in our lives - the move to a digital age. Due to the recent rapid advances in information and communication technologies, our society changes rapidly. It is well known that engineering education and a high-technology society are closely related, and an intensive interaction between education and technology would come up to a wealthy society and a peaceful world. There is general consensus that the engineering curriculum that has evolved during the last century needs to be restructured to meet new societal needs and a transforming industrial scene. In order to keep in pace with the fast changing world, it is necessary to review the engineering education frequently and to urge schools to make necessary improvement or reform on the educational programs. This paper will introduce the development strategy of engineering education system in the digital age.

2. Trends in the digital age

With the rapid growth of information technologies, a new era, the digital age, has arrived. They make more and more innovative products and electronic/digital services possible. The digital revolution is happening much more quickly. Our economic society and life are changing significantly in this digital age. The digital revolution in our world is spurring on facilities, hardware, software, services, and capital investment. Vice President of USA, Albert

Gore Jr. has said : *'We are on the verge of a revolution that is just as profound as the change in the economy that came with the industrial revolution. Soon electronic networks will allow people to transcend the barriers of time and distance and take advantage of global markets and business opportunities not even imaginable today, opening up a new world of economic possibility and progress.*" In order to keep the competence in the digital age, many countries and enterprises pay much attention to the development and the application of information technologies.

According to the characteristics of the development of the digital revolution, **Internet**, **Innovation** and **Internationalization** (**3I**) are three major trends in the digital age. In the digital age, Internet conducts a new business model - electronic business. The electronic business implies that business transactions are held by computer-mediated network. Internet provides a two-way communication channel to let enterprises fulfill the whole or part of traditional business activities. So far, many industries all over the world lavish much attention on the electronic business. Innovation is the only way for an enterprise to survive in the digital age. For high-technology industries, especially, much attention is paid on the development of innovative products or services. In the digital age, Internationalization can help industries to gain more profit. With the advanced information and communication technologies, many companies can enter the global market in lower costs.

It is well known that the objective of engineering education is to train students being able to design, fabricate, and analyze engineering problems. It is also important for engineering education to meet the needs of industries. In the digital age, the environment industries confronted changes rapidly. A well-designed engineering education system should also keep pace with the fast changes of the real world. As **3I** (**I**nternet, **I**nnovation, and **I**nternationalization) are the current trends for industries in the digital age, how to educate a student to become a **3I** engineer is an important mission for engineering education. This study will introduce **3I** strategy to develop the engineering education that can satisfy the industries' needs in the digital age. **3I** strategy means that the engineering education in the digital age should be developed with the following three configurations: **Internet**, **Innovation**, and **Internationalization**.

3. Internet

The use of modern information and communication technologies and global information networks will greatly influence the way of work and life of people in the future information society. Teachers and schools play an important role in the all-side preparation of the younger generation for an information society and for the integration of new information technology into teaching plans of school. From the very developed nations to those emerging from the primary levels of agriculture and manufacturing, the use of information and communication technologies of all kinds is increasing as fast as the schools can install and implement campus wide information systems, workstations, and personal computers. More and more schools place much emphasis on the application of information technology to education. When the concept of the Internet is introduced into the engineering education system, we should consider the followings:

(1) How to form an educational system in which students and teachers can learn to consider information technology to be a useful tool for formation and reviewing their knowledge,
(2) How to build the framework for spreading experiences among students, teachers and people,
(3) How to manage the ability to get, sort and choose information to be the basic skills,
(4) How to face the tendency to change searching for information for knowledge from understanding the subject.

Although there are great differences worldwide as to how the Internet is being conceptualized and applied within the engineering schools, several elements are generally accepted. These include multi-media, computing, communications, software standards, electronic publication, and common database. Engineering education is generally moving toward an information rich, student centered future in which learning can be conveniently extended beyond the engineering school. According to research results, many learning theories ask for personalized access to information, interactive simulation systems, providing material for learning at own speed, learning alone or in groups, and more personalized guidance through tutors. The Internet is a powerful tool to support the engineering education system to satisfy these requirements.

Because of providing a fast, efficient and easy way to access the information, the world wide web (WWW) provides a variety of information in the forms of database, pictures, movies, multimedia or interactive displays. More and more academic and research institutions or universities in the world construct their own web sites to demonstrate their educational goals, academic activities, excellent training programs, and their innovative and important research results. Through these web sites and the associated links with other web sites, people can easily obtain new information and knowledge they need, and learn how to solve their problems and do their innovative

works.

In the cyber world, people are able to communicate and exchange information anywhere almost at any moment. Huge amount of data can be transferred across computer systems only in a minute, and the data can be any kind of hypertext documents or the multimedia. The WWW is an internet-based hypermedia initiative for global information sharing and allows people to work together. In addition, the hypertext from many resources worldwide may use hyperlink to make an information network through the WWW. By one's finger tip, one is able to retrieve the information or to be educated. Accordingly, the WWW virtual library and the WWW virtual university through the Internet will come true.

Due to the great power of the Internet on the diffusion and exchange of information, and personal computers are so popular for every person to possess, people nowadays are easy to surf on the Internet and get the information anywhere and at any moment. Therefore, WWW is a very useful tool for educational purposes that it should be introduced to the students and teach them how to utilize it. According to research results, most educational web sites consist at least one of the following four elements:

(1) educational programs,
(2) illustrative pictures and movie archives,
(3) teaching materials: texts, notes, and data of course study,
(4) interactive study materials.

Open and distance learning is the other popular application of the WWW to the educational system. Currently, distance learning is described as learning environment, student centered, offering course material or modules using modern information technology. Many schools begin to establish their distance learning environment. According to our investigation, the students appreciate the idea of WWW material in general. But they would not learn directly from the WWW but rather print out at least parts of it and use it as a reference. What they really wanted were interactive tutorial and online testing. If the hypertext version is compared to the paper material, the main disadvantage of hypertext material is that reading a computerized version is not as comfortable as reading a paper version. As long as there is no device as easy to handle as paper and capable of displaying on-line information, many people will prefer course material on paper.

However, as already known, hypertext material can be established in a much more structured way, leading to a better overview. The reader can always choose to go deeper into a subject or to move on. This can build a student-centered learning environment and the students can learn at his own speed. Additionally, he can configure the pages according to his personal preferences of fonts or even colors. A further advantage is the possible integration of multi-media into hypertext. In many cases, a good animation gives a better explanation than single pictures and words. Other features like a full-text search are impossible in paper versions, making hypertext useful as reference guide. These results lead to new approaches. If hypertext material should be successful, it is not enough just to translate a paper version to the web page, but it is necessary to take advantage of the hypertext features as described above. Moreover, the other main attraction of the WWW is interactivity, leading us to the design of an interactive laboratory following the rules of open and distance learning concepts. Although the WWW can improve the engineering education system, the most important disadvantage of using WWW based training software was the large investment of time at the beginning, which is typical for the setup of learning software. It might be only reasonable for large numbers of students or for more than one lecture whose content does not change too much over time. In developing the open and distance learning environment, the students have to be better trained how to use the online environment from beginning. It is better to offer parts of the lecture either face-to-face or online, but not both. The students found it confusing to have parts provided in both ways. The online support resulted in better ratings at the final examination of the whole lecture. It is necessary to provide more off-line material and perhaps even off-line tests for those who cannot afford the online costs.

4. Innovation

The technical environment into which engineers will emerge in the digital age will be characterized by knowledge-based industries with high value added products, a high reliance on the application of fundamental science in product development, and a development-to-design-to-manufacturing process relying on a high level of simulation and information flow. According to our research, many industries hope that the graduate should have creativity, the ability to work with people, the willingness to analyze and develop the already accumulated knowledge and skills, the ability to speak foreign languages and use computers, and knowledge involving the fundamentals of economy and marketing. Thus it is necessary to restructure engineering education to meet world

needs and to introduce innovation into the curriculum.

The success of an innovation depends not only on its technical qualities, but also on the process by which its basic ideas are communicated. Many technologists believe that advantageous innovations will sell themselves, that the obvious benefits of a new idea will be widely realized by potential adopters, and that innovation will therefore diffuse rapidly. Seldom is this the case. Most innovations, in fact, diffuse at a disappointingly slow rate. However, many engineering students have no idea about these. We think that the curriculum of management of technology is important for engineering education system.

Management of technology studies

(1) technological innovation,
(2) concepts and techniques for managing technological innovation,
(3) understanding long-term economic development,
(4) understanding how national science and technology infrastructures contribute to competitiveness,
(5) forecasting changes in product, production, and service technologies,
(6) effectively managing the engineering and research functions in business systems,
(7) integrating technology strategy into business strategy.

Scope of management of technology covers

(1) organizational analysis,
(2) system analysis,
(3) technology forecasting and planning,
(4) innovation procedures,
(5) technical project management,
(6) marketing experimentation ,
(7) entrepreneurship.

The central concept of management of technology is the idea of "technological innovation". Technological innovation is the invention of new technology and the development and introduction into the marketplace of products, processes, or services based on the new technology. It comprises new products and processes and significant technological changes of products and processes. Invention is the creation of a functional way to do something, an idea for a new technology. It is motivated by the desire to solve problems or to provide new functional capability. Innovation is introducing a new or improved product, process, or service into the marketplace. Invention results in knowledge. Innovation results in commercial exploitation of knowledge in the marketplace. An innovation has been implemented if it has been introduced on the market (product innovation) or used within a production process (process innovation). Innovations therefore involve a series of scientific, technological, organizational, financial and commercial activities. The economic benefit of invention occurs through innovation. Despite the importance of the concept of technological innovation, it has not been always well understood or well managed because the concept bridges the business and technical worlds. There has been a cultural gap between managers and engineers. In the past, business schools mostly ignored the business functions of research, technology, engineering, and development. Conversely, engineering schools mostly ignored the management aspects of engineering and the generic aspects of technology. Accordingly, the education of managers, engineers, and scientists has been incomplete in acquiring a generic understanding of both management and technology. As a result, both managers and engineers have had to round their education about managing technological innovation through experience and continuing education. Curricula in MOT provide a compact way to gain an understanding of technological innovation.

5. Internationalization

In the modern world, the term "internationalization" was adopted by the business world during 1980's after the emergence of Japan as an great economic power. During 1990's, it became more common and has resulted in a completely changed concept of doing business in the 21st century. Now people look every thing from global perspective rather than narrow regional or national boundaries. The faster and highly reliable means of communication and transportation have shrunk the world. The modern information society aided with the Internet has completely changed the international business concept. With this new concept of globalization, and open market economy, the industries all over the world started establishing their plants in this newly found international market. For the success of this new economic concept and in order to obtain maximum benefits from it, trained manpower is absolutely necessary. This is the area where educational institutions have to play an important role.

In this internationalized economy, the traditional employment does not exit anymore. Unemployment is structural and is generated by the combination of new technologies and costs reduction, to make companies more competitive. However, job opportunities are growing for those who are prepared to face the challenge of changes. We have interacted extensively with a variety of leaders in Taiwan's industries. The common message that they send to educators is while ready-to-use-skills are highly desirable, education of a generic nature is much more preferred. The long-term viability of an industry requires technical talent that is adaptable, flexible, and has a capacity to learn. These drivers are all the more important given a future in which international manufacturing and marketing and engineering with cross-cultural skills will be demand.

For a multinational company, the manpower is not the same as providing to its own country as the language, cultural, political, geographical and historical differences are so varied that it requires a whole new generation of trained people with an entirely different approach. Engineering education system should look at this problem from a global perspective and start internationalization of their educational programs with engineering taking lead as they are the most in demand by the multinational companies. Fortunately, more and more schools notice this requirement. Much emphasis has been placed on the curricula of foreign languages. Some universities have started some concrete steps in this direction by collaborating with foreign universities.

However, for developing a successful internationalized engineering education system, it is necessary to have close contacts with academicians related government agencies, academic institutions such as universities, and industries in the respective countries. A suitable exchange mechanism of students and faculties has to be developed to provide better understanding of each other's economic, social, cultural, educational and industrial system. In order to make the internationalization successful, it would be better to exchange students and faculties with other countries especially with the universities, which are going to participate in an international collaboration program. This will provide an opportunity to students and faculties to know about the societies, economics, cultures, traditions and engineering education systems as well as the industrial problems in other countries.

6. Conclusions

The end of the last millennium has been marked by the transition from industrial to information society. Methods and means of computer, automated control, use of information technology, and elements of artificial intelligence had already been employed in industrial society. In this millennium, during the transition to information and education society, new perspectives should open to these methods and means. The information society imposes a paradigm shift in education and training. People in the digital age need to be trained and retrained to keep up with the pace of technological and social change. The engineers of tomorrow must be able to solve problems that have not been even formulated during their studies. Traditional education systems, based mainly on lectures and textbooks supplemented by workshops in disciplines that are only loosely coupled and which is completed when students leave school, cannot prepare them for solution of complex problems in interdisciplinary teams. This study introduces a development strategy involving the Internet, Innovation and Internationalization for the engineering education system in the digital age.