Cluster-Based E-Education Network on Precision Mechatronics

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ABSTRACT: *While engineering education involves technical illustrations as well as hands-on experiments, it is more difficult to employ e-education based on computer network in engineering education as it needs technical expertise to lecture and to develop required material. This paper investigates a trial of a national web-based e-education network on precision mechatronics supported by clusters of institutions distributed nation wide. The e-education network is composed of education resource centers located nation wide. Each center focuses on a certain technical field on precision mechatronics, including precision machine tools, precision measurement, industrial machinery, precision components, micro electro-mechanical systems, mechatronic servo systems, medical mechatronics, precision molding, and optomechatronics. A cluster of expertise from its partner institutions and from cooperated industry is then formed by the center. Distributed and cooperated lectures and e-educational material, such as course media, course and seminar video, and virtual laboratory, developed by the cluster form the nation-wide e-education network. It appears that this is an effective way to share resources and to promote e-education. It is also observed that expertise cluster is an efficient approach to form an e-education network in a specific technical domain.*

1 BACKGROUND

Precision mechatronics, including precision machinery and mechtronics, is one of the most important industrial technologies in Taiwan. Based on the need for manpower in this field, the Ministry of Education (MOE) has established a mission-oriented project "Educational Improvement Program on Precision Mechatronics" (EIPPM) to meet the requirements since 2001. The goal of the program at early stage is to set up the fundamental curricula, laboratory facilities, and multimedia courseware. It is then found that engineering education must be close to industry and thus institutions must be grouped to develop industry-oriented educational programs and curricula. The EIPPM project therefore is focused on the integration and sharing of educational resources including curricula and laboratory facilities. As mechatronics is a technology in action, hands-on training is also planned as another focus in the project. Scheme and plans are proposed to achieve the goal. Among many discussed proposals, industry-oriented academic-industry strategic alliance is proposed, discussed and approved at the project [WU, 2000]. This strategic alliance model is also used in other educational programs as reported in WU [2001]. One of the goals of these alliances is to integrate and to share teaching facilities, including laboratory equipments, faculties, and multimedia course material, as well as engineering hands-on competitions to establish the nationwide education infrastructure. The academic-industry alliance is a cluster of expertise with manpower in research, education, industrial development and techniques. Moreover, as an alliance consists of institutions and companies national wide, it is a challenge to integrate and share resources through such a distributed cluster.

Engineering education is an important issue in the past two decades. Various technologies have been discussed and tried in order to improve and to facilitate engineering educations [SOHLENIUS, 1988; BEAUFAIT, 1991; SIMPSON, 1994]. Among many other technologies, computer-network-based or

internet-based education, including e-learning and remote learning, has been proposed and tried. Different programs and/or scheme based on such concept has been widely tried and discussed. Many trials, such as in TUTTAS & WANGER [2002], FJELDLY [2002], and in DAKU & DIEFES-DUX [2003], have been reported that internet-based technologies do facilitate remote learning. This extends the contents of e-learning from computer-aided instruction such as course media to resource sharing such as e-lab. Although it showed that internet-based technologies can enhance the achievement of e-learning, it is an issue to plan and to design education programs employing internet-based technology to a large scale. Furthermore, it is more difficult to implement such a program in engineering education as it involves technical illustrations as well as hands-on experiments that needs technical expertise to lecture and to develop required course material without lose the contents and spirit of engineering education. This paper is focused on discussing an implementation of a national web-based e-education network on precision mechatronics supported by clusters of institutions distributed nation wide. Contents, activities and status of the educational network as well as on-going progress and observations are also discussed in the paper.

2 ACADEMIC-INDUSTRY ALLIANCES ON PRECISION MECHATRONICS

Based on the strategic plan of the EIPPM, a call for proposal for academic-industry alliances are first open to interested and qualified institutes. The proposals are then reviewed and evaluated. Twelve nation-wide academic-industry alliances on Precision Mechatronics are formed in the first year. , These alliances are further merged into ten, nine, and six alliances in the following years based on their contents, performance and evaluations. Each alliance consists of an educational resource center and several partner institutions and industrial companies in the same field. While partner institutions focus on the contents and activities of the program, such as setting up the field-oriented feature curricula and laboratory facilities and developing feature course material, the resource center provides administrative assistance.

Educational resource centers of these alliances are located around the island, from northern to southern Taiwan. Each educational resource center is steered by its steering committee with committee members from both academic and industry. Other institutions can join the alliance to share the resource with the obligation to open its laboratory facilities and to develop curricula together. The alliances are briefly described as follows [TSAI *et. al.*, 2003].

- The Precision Measurement Alliance focused on precision measurement technologies, either contact or non-contact type. The alliance, leaded by the Department of Mechanical Engineering (ME) of National Taiwan University, is formed by ten institutions, five research organizations and three companies. The resource center, combined with the Northern Taiwan MEMS (Micro Electro-Mechanical System) Center sponsored by the National Science Council, also shares educational resources on MEMS.
- The Optomechatronics Alliance is intended for the integration of mechanical, electrical and electronic, as well as optical and software/control engineering. The alliance consists of 32 academic institutions, increased from seven in year 2001, and more than twenty research institutes and companies. It is leaded by the Department of Applied Mechanics of the National Taiwan University. The Alliance shared many facilities with the Precision Measurement Alliance as the two educational resource centers located at the same campus.
- The Medical Mechatronics Alliance is a special group aimed on developing programs on medical mechatronics. It consists of eighteen academic institutes and over seventeen industrial organizations, hospitals and companies as partners. The educational resource center allocated at the ME Department of Chang Gung University as there is a need on related technologies at the university-owned medical center and hospitals. The alliance work closely with national-wide rehabilitation assistive technology centers and share resources with them as the alliance provides technologies for these centers while the rehabilitation assistive technology centers supply platforms for the alliance.
- The Micro Electro-Mechanical System Alliance consists of nine institutions leaded by the Department of ME of National Chia-Tong University. The alliance is divided into three groups. The Northern Taiwan group focuses on silicon-based MEMS technology; the Central Taiwan group stresses on non-silicon energy-based fine fabrication technologies; and the Southern Taiwan group emphasizes on bio-MEMS technologies.

- The Mold Automation Alliance is aimed on the process and automation technologies of precision and fine molding. It is formed by 23 institutions, three research institutes and one industrial organization with the educational resource center at the ME department of Chung Yuan Christian University. The alliance also signed strategic contracts with four overseas research institutions in the US, Canada and German.
- The Precision Machine Tools Alliance is formed as machine tool is one of the major industries in central Taiwan. The alliance emphasizes on the technologies for machine tools with the resource center located at the Department of ME at the National Chung-Chen University. Seven institutions, with focus on either machining process or on spindle technologies, joined this alliance as this industry involves processes and key technologies for machine tools.
- The Precision Components Alliance allocates two educational resource centers as it consists of fundamental technologies. The resource centers are located in the National Tsing-Hua University in northern Taiwan and in the National Cheng-Kong University in southern Taiwan. The northern center, consisting of six universities, two research institutes and 14 companies, focuses on the components and integration of media storage systems that. The southern center, formed by five institutions, stresses on the application of fine fabrication on mechanical and mechatronics of computer systems.
- The Precision Industrial Machinery Alliance focuses on two areas: the semiconductor processing equipments and rapid prototyping equipments. The resource center is located at the ME department of the Southern Taiwan University of Technology with four and five institutions joined in each area as partners.
- The Mechatronic Servo Systems Alliance is leaded by the ME department of the National Chung-Kong University with six institutional members. The Alliance is aimed on the integration of servo and control systems, including pneumatic, hydraulic, and electrical servo systems.

Although each alliance is formed based on the same interest and industrial technologies among resource centers and partners, it has educational missions including the development of domain-specific programs such as curricula and laboratory practice, and hands-on project competitions. As each alliance forms field-oriented resources, including university faculties, researcher, industrial engineers, as well as design/fabrication/inspection facilities and creativities from hands-on project competitions, it becomes a cluster of domain-specific expertise and resources naturally. This arrangement adds to the performance and productivity of the alliances as examples shown in CHANG [2002], CHENG & RO [2002] and CHIOU *et. al.* [2002].

3 THE NATIONWIDE CLUSTER-BASED E-EDUCATION NETWORK

As these educational alliances integrate resources, the clusters of expertise and facilities become a powerful group for promoting engineering education in the specific field. While each alliance sets internet-based distributed web sites, often located at the resource center and partner institutions, as platforms for news posting, communication, discussion, and technology sharing, these web sites form a cluster of community with same interest. These internet-based clusters provide a base for constructing the nationwide e-educational infrastructure specifically for the community on precision mechatronics.

Figure 1 shows the model of the network where partner institutions and resource center of the same alliance are networked via mutual hyperlinks, shown as the external chains in the figure. The web sites at program office provides an entrance to the community that links to all educational resource centers and is hyperlinked to the homepage of MOE, as shown at the center of the figure. In addition to regular communication among members of the EIPPM program, a monthly electronic newsletter issued by the program office provides a communication platform of activities, forum discussion, and showplace of achievement. [TSAI *et. al*., 2003]

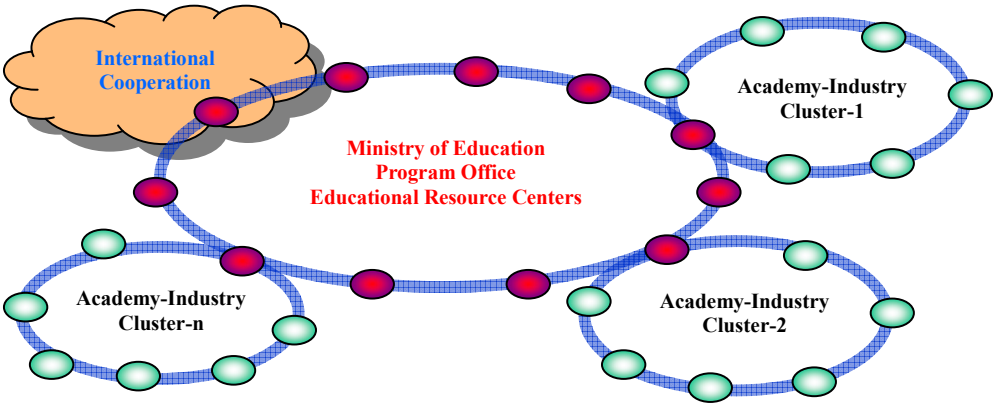

Figure 1 – Model of the nationwide cluster-based e-education network [TSAI *et. al*., 2003]

4 ACTIVITIES AND PROGRESS OF THE NETWORK

Among many items in the educational improvement program, digital education is one of the major items to be promoted. The digital education program, a sub-program of the EIPPM project, is intended to set up a test bed for digital education for a large community and distributed group. The above mentioned cluster-based educational network provides a digital information network among the strategic alliances and among the partners for achieving this goal. This network provides the infrastructure and digital environment for e-training, e-education, and e-sharing.

Activities based on this network include, but not limited to, developing community forum, publishing community newsletter, developing domain-specific multimedia course material, establishing digital laboratories and virtual experiments, developing domain knowledge bases, and conducting distributed training [TSAI *et. al*., 2003].

In addition to hardware construction for the network and the electronic newsletter, contents of the digital education program are also under developing. For example, several multimedia course materials, including "Introduction to Precision Mechanical Engineering," "Precision Measurement," and "Mechanism Design", have been completed and shared to partner institutions while some others are under development. Figure 2 is an example of multimedia course material shared by partner institutions at the northern Precision Components Alliance. Figure 3 shows another example of inter-institutes developed multimedia course material with e-laboratory video by the MEMS Alliance. Figure 4 illustrates another example of distributed e-education on virtual injection developed by the Mold Automation Alliance. Many action items are currently conducted and performed including the development of e-laboratory, virtual experiment, distributed training, and interactive e-learning.

Figure 2 – An example of multimedia course material shared by partner institutions at the northern Precision Components Educational Resource Center

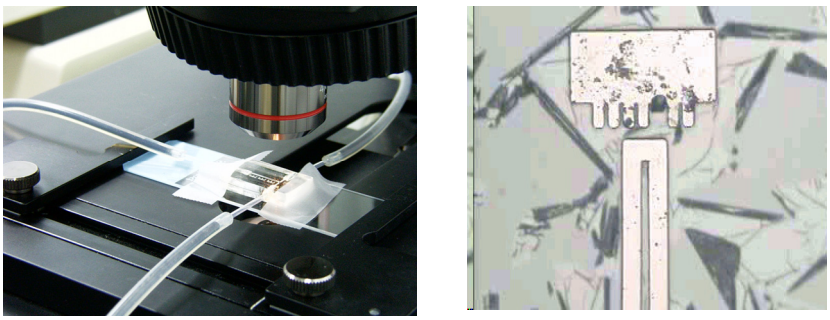

Figure 3 – An example of inter-institutes developed multimedia course material with e-laboratory video by the MEMS Alliance

Figure 4 – An example of distributed e-education on virtual injection developed by the Mold Automation Alliance

5 OBSERVATIONS AND DISCUSSIONS

The cluster-based educational network is an effort to construct a nationwide educational network for the community on precision mechatronic technologies. It is a test bed for digital education for a large community and distributed group. The network provided a platform for digital education including e-training, e-learning and e-sharing.

It has been observed that many network-based educational activities has been conducted, performed, or planned through the developed cluster-based educational network. For example, inter-institute course media, as shown in figures 2 and 3, has been developed and tried in specific clusters. Multimedia course material with virtual laboratory as shown in figure 4 also provides an effective approach for on-line learning. More than thirty course media in various fields are under developing, in addition to those six course media already developed. These course media, including multimedia slides and e-lab videos, enhanced the digital education of the EIPPM project. We also found that video meeting through the developed educational network provide a safe and efficient way for communication that keeps the program running, in particular during the SARS period in year 2003.

Although we have observed that the established network provides the infrastructure for digital learning in a large scale, some issues and challenges, both technical and social such as the effect on learning models via e-laboratory and virtual experiment, based on such an e-educational network will be faced in the near future and need further investigation.

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REFERENCES

BEAUFAIT, F. W. Engineering Education Needs Surgery. In *Proceedings of 21st Frontiers in Education Conference*, 1991, pp.519-522.

CHANG, R.-J. Problem Solving and Curriculum Development in Precision Engineering. In *Proceedings of 2002 IEEE/ASME International Conference on Advanced Manufacturing Technologies and Education in the 21st Century (AMTE2002)*. Taiwan: National Chung Cheng University, 2002. paper C151.

CHENG, C. H. & RO J. Curriculum Development in Precision Mesurement for the MEMS and Smart Structures Undergraduate Program. In *Proceedings of AMTE2002*. Taiwan: National Chung Cheng University, 2002. paper C158.

CHIOU, S.-J., TSAI, J.-C., WANG, G.-J., CHEN J.-L., FANN, K.-J., CHEN, T.-Y. & TSENG P.-C. A Program in Precision Machine Tools Techmologies. In *Proceedings of AMTE2002*. Taiwan: National Chung Cheng University, 2002. paper C164.

DAKU, B. & DIEFES-DUX H. An Effective System for Implementing Self-Learning, on-line Instruction for Engineering Students. In AUNG, W. *et. al.*, editor, *Innovations 2003: World Innovations in Engineering Education and Research*. USA: iNEER and Begell House Pub., 2003, pp.307-318.

FJELDLY, T. A., STRANDMAN, J. O., BERNTZEN, R & SHUR, M. S. Advanced Solutions for Performing Laboratory Experiments over the Internet. In AUNG, W. *et. al.*, editor, *Engineering Education and Research –2001: A Chronicle of Worldwide Innovations*. USA: iNEER and Begell House Pub., 2002, pp.135-145.

SIMPSON, I., Engineering Education in Europe. *IEEE Transactions on Education*, Vol. 37, No. 2, May 1994, pp.167-170.

SOHLENIUS, G. Engineering Education as a Part of Industrial Society - Product Quality, Process Quality and Quality in Engineering Education. *Robotics and Computer-Integrated Manufacturing*, Vol. 4, No.3-4, 1988, pp.659-667.

TSAI, J.-C., LI, W., SUNG, C.-K. & WU, J. Y. J. Towards A Nationwide Web-Based E-Education Network on Precision Machine and Mechatronic Technologies in Taiwan. In *Proceedings of ICEE2003*. Spain: University of Valencia, 2003. paper 3956.

TUTTAS, J. & WANGER, B., "Distributed Online Laboratories", in AUNG, W. *et. al.*, editor, *Engineering Education and Research –2001: A Chronicle of Worldwide Innovations*, USA: iNEER and Begell House Pub., 2002. pp.117-125.

WU, Y. J. J., Strategic Planning of Engineering Educational Programs in Ministry of Education, Taiwan. In *Proceedings of ICEE2000*. Taiwan: National Chung-Kung University, 2000. paper TuA4-1.

WU, Y. J. J, Strategic Alliance of Academy-Industry Cooperation on Aerospace Technology Education, Taiwan, R.O.C. In *Proceedings of ICEE2001*, 2001. paper 399.