2006-811: THE EDUCATION ADVANCEMENT PROJECT IN TAIWAN: REAP ON PRECISION MECHATRONICS

Wenlung Li, National Taipei University of Technology
Jhy-Cherng Tsai, National Chung-Hsing University, TAIWAN
Wei-Chung Wang, National Tsing-Hua University, TAIWAN
Cheng-Kuo Sung, National Tsing-Hua University, TAIWAN
Jennie Wu, Ministry of Education, TAIWAN

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The Education Advancement Project in Taiwan: REAP on Precision Mechatronics

ABSTRACT

Anticipating the engineer demands due to the quick development of the hi-tech industries in Taiwan, the Ministry of Education (MOE) has initiated the ‘The Research and Education Advancement Project’ (REAP) to assure both quantity and quality of the manpower can meet the needs. The major goal is to re-arrange the educational resources in such a way that they can be more efficiently used while the quality of graduates can be further raised. Firstly, several so-called the “strategic industries” are identified depending on the country’s economy plans. In the mean time, the programs that matching with those strategic industries are initiated one after another by MOE. Unlike the traditional educational programs, the REAP emphasizes the inter-university collaborations. Among these many capstone programs in REAP, the precision mechatronics program, started in 1997, includes the most important, comprehensive and fundamental technologies for industries. Major achievements of the program include establishment of the expertise laboratories, the educational resource integration and outcomes sharing, the e-education, the hands-on project competitions and the community service. In addition, the program also encourages the communities to organize the academy-industry alliances (AIA). During year 2001 to 2004, ten educational alliances, directed by the educational resource centers (ERC), were formed in the past four years with more than 78 academic and 25 industrial partners participated. Moreover, about 54 expertise laboratories are established together with accompanying courses and lecture materials. The outcomes and facilities of the each ERC, such as lab instruments and course materials, are shared among partners in each expertise alliance. In addition, the program has designed the hands-on competitions to upgrading the practical hands-on ability of engineering students. The competition is now an international event. It is worthy to mention that the competition uses the real-time video via internet and the carefully designed schedule to avoid the time zone differences. As the conclusions, the outcomes of the program have shown that such a cluster-based expertise community is an efficient approach to integrate and to share the educational resources, especially for hi-tech engineering educations. What the program has achieved is difficult through the traditional engineering departments. However, it has been also observed that the bandwidth of the network can be a critical factor to this new education model.

Keywords — Precision Mechatronics, Academy-Industry Alliances, e-Education.

INTRODUCTION

As it is well-known that the engineering manpower today cannot be boosted in a short period, unless it has been carefully deployed and nurtured at least a few years back. If one looks closely on the modern engineering education, he or she may quickly finds the contents of the courses have been changed to fit the industrial needs. For example, the computer-aided tools have been widely introduced to the classes now-a-day. Thus, it seems for many engineering educators that the tedious calculation works can be simply skipped. There is no need to include too many hours of “skill-training” in problem solving skills, which were considered to be important. Engineering drawing, as the other example, perception of drawings is more imperative than how pretty engineers can be drawn. Any CAD software can make much prettier drawings than highly trained engineers. Furthermore, the course contents in engineering education are somewhat outcomes-
oriented. And, the industries always drive the course contents from their own view or their needs. Thus, the contents of course may just too much to learn from the viewpoint of engineering students. As a consequence, it may turn out the low quality graduates, instead of high quality ones that can fulfil the needs of industries.

Anticipating the engineer demands due to the quick development of the hi-tech industries in Taiwan, the Ministry of Education (MOE) has initiated the so-called ‘The Research and Education Advancement Project’ (REAP) to assure both quantity and quality of the manpower can meet the needs. The main goals of REAP are to enhance the current sciences educations and to assure the quality of the students can meet the needs of year 2020. In the mean time, the REAP is also intended to play as a pilot run that links the traditional education organizations\(^1\). The idea behind is simply: MOE wants to improve the local environments of engineering educations using limited resources. In other words, REAP offers the education contents that may be difficult to achieve through the current Taiwanese institution systems. In fact, REAP includes many capstone programs that are flexible and mission-oriented in their contents. Briefly, the contents of REAP can be classified into four categories\(^{1,2}\): They are re-construction of courses for strategic industries, environments enhancement for heuristic educations and for the educations of sustainable developments, and humanity development. Among them, the sub-programs under the course re-construction project are the programs for the so-called “strategic industries” that are identified by the country’s economy plan. In 2003, several industries were firstly identified as more competitive in next 10 to 20 years and supposed to be more important or vital to the island. They are industries in display technologies, communication, M2B (Manufacturing to Business), IT, nano-tech, bio-tech, and precision mechatronics. Among them, the precision mechatronics was first initialled at 1997, and included the most important, comprehensive and fundamental technologies for the local industries. The present report intends to introduce the second phase of the program, from 2001 to 2004. Reports of these two phases are well documented in Chinese. However, the readers who are interested in the outcomes may be referred to reports\(^3\)\(^-\)\(^5\) for detail.

PROGRAM GOALS & GUILDINES

To include newly developed technologies into a course may not as simple as just put them into the syllabus. For example, lots of courses require experimental works so that the student can have the “feeling” of that course material. In general, however, the matching apparatuses are expansive, not only to buy but to maintain them as well. As a consequence, only a few universities can afford it. Besides, it is non-sense that all (or the most) universities to own the similar instruments in a small island country like Taiwan. Therefore, the first goal of the program is to encourage those universities or labs which have similar and expansive equipment are willing to share their facilities with the near-by universities. The idea is actually originated from the research collaborations between labs, which are commonly seen in Taiwan. One may notice that to share the facilities for researches is much easier than that for education. The main reason stems in the researches are project-oriented and have their own funds. The program wants to transplant the idea to the engineering education so the educational resources can be more efficiently used.

Since it is a new model in education, a white cover book (the strategic plan) was established prior to the deployment of the second phase of the program. It has been mentioned in the white cover book of REAP on Precision Mechatronics\(^6\), the guidelines of the program are (IC)\(^3\). Or, the three I’s stand for Inter-university, Inter-national and Integration, while three C’s for Collaborations, Clustering and mutual Complements. In other words, the REAP on precision mechatronics program intends to integrate the educational resources of different universities, if possible. However, before the integration of such resources, the interactions among the professors are generally essential. This can be achieved by either research or teaching collaborations. And, it is much easier today than before since the new technologies come in so fast. Similar to students,
the professor who is teaching a course with new technologies also has abundant of new materials to be learned within a limited short period. The best way to resolve the situations is mutually complemented. Or, each professor is an expert of one or two domains of knowledge. He or she does not have to be omnipotent in all domains, which is quite impossible. Thus, the course can be taught by a team of experts instead of a single professor. In the meantime, the each professor needs to prepare his lab only focuses on the area he is in charge of. The students simply move from one lab to another if lab courses are required. Or, the professor may travel along with them as well. From which, the professors can understand each other much better than they use to be. The further collaborations are thus possible.

THE ACTION PLANS

According to the white cover book, several suggestions have been issued and briefly reported as follows:

(1) ERC: Originally, the program at the first stage focused on organizing the strategic alliances for engineering education. Each educational alliance is a cluster of an expertise for one specific domain knowledge. Unlike a traditional department, the one that plays as the leader is the so-called the educational resource center (ERC) or the center school. The professor who is in charge of the ERC supposed to have the richest domain knowledge and more hardware setups in that expertise. Meanwhile, the leader shall be open-minded and is willing to share his educational resources at least within his or her cluster. The possible resources that may be shared include not only the hardware like teaching facilities, lab equipment, but the software such as the course materials as well. At the end of 2004, there were six educational alliances directed by ERC’s in the whole island. Their geographical locations are shown in Fig. 1. These ERC’s are:

- The Precision Measurement Alliance focuses on precision measurement technologies, both contact and non-contact types. The alliance, led by the Department of Mechanical Engineering (ME) of National Taiwan University, is formed by 10 partner institutions, 5 research organizations together with 3 companies.

- The Opto-mechatronics Alliance intends to integrate mechanical, electrical and electronic, as well as optical and software/control engineering. The alliance consists of 32 academic institutions and labs, and more than twenty research institutes and companies. It is led by the Department of Applied Mechanics in the National Taiwan University.

- The Medical Mechatronics Alliance aims on developing educational programs on the medical mechatronics. It consists of 8 academic institutes and over 17 industrial organizations, hospitals and companies as its partners. This ERC locates at the ME Department of Chang Gung University. The university has a need on related technologies since it owns also a medical center and hospitals. The alliance works closely with national-wide rehabilitation assistive technology centers and shares resources with their constituents through providing its know-how.

- The Micro-Electro-Mechanical System (MEMS) Alliance consists of 9 institutions and is led by the Department of ME of National Chiao-Tong University. The alliance is geographically 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 sets the goals on the process and automation technologies of precision and fine molding. It is formed by 23 institutions, 3 research institutes and one industrial organization. The ERC is led by the ME department of Chung Yuan Christian University. The alliance also close related with four international research institutions including US, Canada and German.

• The Precision Industrial Machinery Alliance focuses on two different 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 4 and 5 institutions joined in the each area as partners.

In addition to these six ones, several ERC’s were terminated through the yearly evaluations. It does not imply that those domains of knowlege are less important. The reasons of the termination mainly depended on the performances of the ERC’s could not meet the originally promised goals. For readers’ information, those terminated ERC’s are:

• The Precision Machine Tools Alliance is situated at central Taiwan where machine tools are the major industries. The alliance emphasizes on the technologies for machine tools and is led by the Department of ME at the National Chung-Chen University. Seven institutions, with focus on either machining process or on high speed spindle technologies, joined this alliance.

• The Precision Components Alliance seeks the fundamental technologies of components. There are two ERC’s located separately at the north and south of Taiwan. The northern one is located in the National Tsing-Hua University, while the southern one National Cheng-Kung University. The northern center, consisting of 6 universities, two research institutes and 14 companies, focuses on the components and integration of media storage systems. On the other hand, the southern center, formed by 5 institutions, stresses on the applications of fine fabrication, especially on mechanical and mechatronics of computer systems.

• The Mechatronic Servo Systems Alliance is led by the ME department of the National Chung-Kung University. The alliance has 6 institutional members. The ERC emphasizes on the integration of servo and control systems, including pneumatic, hydraulic, and electrical servo systems.

Although each ERC is formed in the way that based on the same interest and industrial technologies among resource centers and partners, the major educational missions include the developments of educational materials for the domain-specific engineering programs, such as curricula and laboratory practices, and hands-on project competitions.

Figure 1 Geographical Locations of ERC’s in Taiwan.
(2) AIA: As it has been mentioned earlier, this program intends to unite some resources from not only academic sides, but from industries as well. The so-called academic-industry alliance (AIA) is thus formed depending on the domain of knowledge. Under the AIA infra-structure, the students involved in the program obtain their first-hand domain knowledge that close to industries. Therefore, they can generally get their jobs with satisfaction. Certainly, on the other hand, the participated industries in the educational alliance can get the engineering manpower with the minimum job lag time in return. In other words, the ERC plays not only a resource divider, but also a resource provider through acquiring resources and donations from the industries.

(3) e-Education/e-Tools: Despite some engineering educators’ skepticisms, the lure of anywhere anytime learning has proved, educationally as well as financially, e-tools irresistible. Not much different from some other reports, in order to more efficiently improve and facilitate engineering education, e-education is emphasized in the program. Similar terminologies have been used, for instance, a computer-network-based or internet-based tool, e-learning, and remote or distant learning, etc. Specifically, the e-tools may include, but not limited to, e-training, e-learning and e-sharing. That is the reason why the program puts “e-education” instead of other commonly seen terms. The contents of the e-education at least comprise like the expertise community networking, domain-specific multimedia course materials for lectures, virtual labs and experiments, e-bulletins, and e-newsletters, etc. In addition to as an aid of teaching and learning, the e-education tool also serves a communication network within the expertise community, in which the same “jargons” are used. Furthermore, the tool also provides assessment. Readers are referred to ref. 2 for detail.

(4) Expertise/Strength Labs: Since each ERC develops new course contents that may accompany with the lab experiments, the needs of costly equipment somehow are inevitable. The program encourages the ERC or its participant institutions to set up the expertise labs under careful planning so that the resources will be more efficiently utilized. In other words, the ERC has to make sure there exists no or at least minimum number of double-invested facilities. As a consequence, the institutions within the ERC can individually focus to establish a few labs that are supposed to be more competitive. In case of the course works need in a place that doesn’t have such experimental equipment, the ERC can share the equipment through the carefully arranged schedule. The students may even go to the other ERC’s labs if indeed the experiment is needed. By doing so, the institutions can set up their goals to develop what they really want to. They may be even affordable to get the most advanced ones, since they don’t have to buy all items. They can just concentrate to set those expertise labs. Therefore, the educational resources can be utilized more efficiently.

(5) Hands-on Projects/Competitions: In addition to above mentioned action plans, the program has designed the so-called hands-on competitions to upgrading the practical ability of engineering students. The competitions are held by each ERC every year. In addition to the small amount of compensate, each ERC has to carefully design the topic closely related to its domain technology. Most of times, the topics are industry-oriented. Meanwhile, teamwork and creativities are emphasized in those competitions. All engineering students are welcome. However, only a few winning teams can take part in the final national competition each year. The competition is now an international event. It is worthy to mention that the competition make use of the real-time video via internet under the carefully designed schedule to avoid the time zone differences. The use of such a real-time video has saved lots of expense and made the international competition possible. Furthermore, the participating students of different languages can directly in dialog through the real time network. The event eventually becomes a bi-annual international hands-on video conference. The model is so successful that the responsible ERC has been invited to organize special sessions at international conferences such as IEEE CDC and ECC 2005.
FORMATION & ORGANIZATION

Refer to Fig. 2, the MOE first forms its consulting board, which later called the program steering board. In addition to education ministry, the members of the board are across of ministries of the government. The major mission of the board is to select the program office (PO) that is responsible for the program operation in addition to monitor the directions of the program. Together with PO, the board is also responsible to review the performances of all ERC’s every year. Therefore, the total number of ERC’s and its associated educational alliances are not fixed. Figure 3 shows the four-tier organization of the program under the MOE, Taiwan.

Based on the strategic plan white book, a call for proposals, with the given guidelines in which clearly specify the missions and goals of the program, was first open to all interested and qualified institutes. The proposals are then reviewed and evaluated by PO together with the steering board. Ten ERC’s were formed in the first year. After the yearly evaluations, these ERC’s are further merged into nine, and finally to six in the following years based on their yearly performances. Each alliance of the ERC normally consists of several partner institutions and industrial companies that focus on the same domain of knowledge and technologies. While the ERC is responsible for the steering of the corresponding educational alliance and provides administrative assistances, the partner institutions mainly 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.

Figure 2. The formation of the program.

Figure 3. The organization of REAP on Precision Mechatronics.
Once the ERC forms its educational alliance and gets together all possible resources through the community, the whole clusters of expertise become a powerful education group. The ERC plays as the key role in this engineering education program in that particular domain. From the education sides, before the program the university laboratories take almost forever to complete since instruments are often expansive. However, totally 54 expertise labs have been founded or enhanced through this program, refer to Table 1 below for the detail statistic listings. More importantly, the accessibility of these labs is much higher than any other traditional ones. The main reason stems from the program has designed a ‘stick’ that evaluates ERCs’ performances every year in addition to the budget carrots. The outcomes of the former year may seriously affect the ERC’s budget from PO of the following year. That is, the better ERC performs the more money it gets from PO. In addition, the evaluation results can be easily browsed by all public, no matter he or she is in the program or not. As a result, the competitions among the ERCs are then automatically cultivated. Consequently, it benefits the students.

As far as the size of the program is concerned, it comprises more than 78 academic and 25 industrial institution partners dedicated to this program in 2004, even though the number varies each year. Note also that the individual ERC is encouraged to obtain its own funds from the industries through all kinds of educational activities, such as training courses. In addition to these self-generated funds, the program office also allocates certain amount of budgets from the government to promote the REAP/PM program. The total input budgets are listed in Table 1 from all ERCs in the mentioned four-year period.

<table>
<thead>
<tr>
<th>ERC</th>
<th>2004</th>
<th>2003</th>
<th>2002</th>
<th>2001</th>
<th>Expertise Labs</th>
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<tr>
<td>Precision Ind. Machinery</td>
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<td>2,500</td>
<td>4,640</td>
<td>3,819</td>
<td>9</td>
</tr>
<tr>
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<td>3,750</td>
<td>4,930</td>
<td>3,959</td>
<td>12</td>
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<tr>
<td>MEMS</td>
<td>3,840</td>
<td>3,200</td>
<td>4,814</td>
<td>3,070</td>
<td>8</td>
</tr>
<tr>
<td>Opto-Mechatronics</td>
<td>3,000</td>
<td>2,750</td>
<td>800</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>Mold Automation</td>
<td>2,080</td>
<td>2,100</td>
<td>-</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>Med-Mechatronics</td>
<td>2,520</td>
<td>1,600</td>
<td>-</td>
<td>-</td>
<td>1</td>
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<tr>
<td>Precision Machine Tools</td>
<td>-</td>
<td>2,100</td>
<td>4,350</td>
<td>3,068</td>
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<td>Precision Components(S)</td>
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<tr>
<td>Precision Components(N)</td>
<td>-</td>
<td>2,500</td>
<td>4,814</td>
<td>5,068</td>
<td>6</td>
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<tr>
<td>Annul Input Budgets</td>
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<td>22,000</td>
<td>27,596</td>
<td>20,114</td>
<td>54</td>
</tr>
</tbody>
</table>

Table 1. ERC’s Budgets Allocated by the Program Office (1,000 NT$, 32 NT$ = 1 USD).

It may be also worthy to look at the number of the participants or students that directly gain the benefit from the program. According to the statistics summed up from the all ERC's, the number of participating students, both from the universities and from the industries, varies ca. 13,000, 17,000, 21,000 and 7,400 from 2001 to 2004, respectively. The statistics of year of 2004 may be incomplete. The total numbers of these training courses, workshops and seminars are ca. 118, 408 and 328 for year 2001 through 2003.

OBSERVATIONS & CONCLUDING REMARKS

Before the precision mechatronics program is included to REAP, there exist many discussions and doubts about this non-traditional model that based on domain-oriented and academic-industry strategic alliances. One may refer to the report of Wu for the discussions. However, it has been clearly seen from the outcomes of the four years that the program (REAP/PM) is really worthwhile. As far as the authors are concerned, the program has not only advanced the
engineering educations in Taiwan, it enhances the related researches as well10. Not to mention
the hands-on competitions, the domain-oriented courses and workshops do widely disseminate
the knowledge to the general public. Nevertheless, the program substantially provides a new
possibility that nurtures the hi-tech engineers to fulfill the modern industries’ needs in Taiwan.

In addition to the accomplishment the program has attained, several observations may be worthy
to mention. Firstly, the capability of webs and the band-width of the communications can be fatal
to the program. The main reason stems in that the activities of this program are mainly inter-
institutionwise. And, it highly depends on the internet. Unless the web-communication is ready
at hand, otherwise, there is no way to make the program successful. Secondly, the multimedia
course materials which are highlighted in the present program due to their fast transmission
through the webs, may be a plus or minus in the program. The plus comes from the colorful
pictures and animation that really attract the interests of students. However, experimental
experiences normally cannot be replaced by courses like the virtual lab or e-lab. ‘Learning by
doing’ is still one good way that let engineering students to gain good feeling about the domain
knowledge. Finally, the leadership of the individual ERC can be also a key factor to this non-
traditional and inter-university program.

ACKNOWLEDGEMENTS

This program has been sponsored by the Ministry of Education, Taiwan. The authors want to
express their gratefulness for the assistance and cooperation from the project leaders of all ERC’s.
It would be impossible to make this program so successful without their efforts. Besides, advices
and suggestions from the Steering board, in particular from Dr. Chung-Biau Tsay and Dr. Ying-
Chien Tsai are the important driving force to the program.

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