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

Research on a CDIO-based practical teaching system in a *Logistics Engineering* major

Yan Zhan, Lihua Liang, Xiuju Lan, Jionglin Zhu & Qiong Lin

Zhejiang University of Technology
Hangzhou, Zhejiang, People's Republic of China

ABSTRACT: Higher education in China is shifting from a specialised to general education focus that is marked by a new campaign of teaching system reforms, by changing from specialist training to professional education. Based on development planning at Zhejiang University of Technology, combining professional features and demands for logistics talent from Zhejiang manufacturing development, this article proposes the global adoption of professional teaching and curriculum and a CDIO-based practical teaching system of logistics engineering. This can be achieved through rethinking CDIO engineering education by combining project teaching with practical work experience in corporations, improving the practical abilities of teachers and cultivating undergraduates' engineering practical abilities. The aim is to further deepen students' understanding of declarative knowledge, to enhance students' analytical abilities, develop their skills in conducting research, solving practical problems, and carrying out the related theoretical and practical tasks, to promote students' competitiveness in their subsequent academic and professional studies. Results have shown that this system is an effective practical teaching model.

INTRODUCTION

According to the Ministry of Education, the total number of college graduates in 2014 will reach a record high of 7.27 million, an increase of 0.28 million over the previous year. About 80% of these graduates come from the second and third tiers of undergraduate and vocational colleges, and the rest from China's premier universities (i.e. those in the Project 211 and Project 985 groups of universities). Compared with 211 (Project 211 - national key universities and colleges) and 985 (Project 985 - world class universities in China) that cover key undergraduate universities, graduates from the second and third tiers of undergraduate and vocational colleges, became part of the most affected groups. Due to strategic and organisational uncertainty and unreformed disciplines, those graduates were affected by 211 and 985 as they are not getting advantages from faculty, education funds and social awareness, etc, which will undoubtedly disadvantage them in seeking employment.

As recruiters form an important stakeholder of institutes of higher learning, it is imperative that feedback is obtained with regards to the key capabilities required of graduates in order to meet changing industry trends in various engineering professions. The graduates from the second and third tiers of undergraduate courses also face competitive pressure from vocational graduates because of their closer proximity to the market needs. Employers usually prefer vocational students because their practical background means they integrate into the work environment quickly. With the economic globalisation and the wide application of information technology, the modern logistics industry, known as *the third profit source*, is becoming a new driver of economic growth. Shanghai, Shenzhen, Beijing, Dalian, Shenyang, Tianjin and other cities have a modern logistics industry as a pillar of the new round of economic development, and the Zhejiang Provincial Government also attaches great importance to the development of modern logistics.

A joint committee to consider modern logistics development in the Zhejiang Province was established in August 2001, preparing timely development plans, accelerating the construction of logistics facilities, initiating policies, cultivating the logistics market and getting the rapid and healthy development of modern logistics in Zhejiang Province on track. The experience of developed countries shows that having an excellent logistics management team is of vital importance for modern logistics development. However, further complications unfold as industries are continually evolving to meet rapid global demand and practice. Hence, defining a set of competencies that can accurately map the attributes outlined by industry with the aim of addressing the *skill-gap* will continue to be a challenging endeavour for the logistics engineering sector.

According to authoritative surveys, the logistics professional has been listed as one of 12 categories with personnel shortages, and the gap amounts to more than 0.6 million senior logistics professionals. This includes enterprise logistics management personnel, consultants, logistics engineering technical personnel, international logistics talents and scientific research logistics personnel. Seventeen undergraduate colleges have set up logistics majors in Zhejiang

Province, 10 of them in Hangzhou. Data released by the Ministry of Personnel showed that the initial employment rate of logistics graduates in recent years exceeds 90%, while only two universities, Zhejiang University of Technology and Zhejiang University of Science and Technology are producing logistics engineering graduates in the province.

Current engineering education has not been planned in light of the global economic system and knowledge management. Systems thinking, team coordination ability, professional ethics, creative work in combination with engineering design, and so forth, have been ignored [1][2]. The method of teaching was teacher-centred feeding , with teachers being at the centre in the whole process of practical teaching. Students receive ideas in class in the oriented professional training system but ignore self-study, which is important for them to learn how to take advantage of autonomy and creativity fully. It is fortunate that many institutions have now realised the importance of practical teaching, setting the average ratio of practical training and theoretical teaching hours to about 48:52, with some specialised courses that meet or exceed 50:50.

Originating from the reform experience of the Massachusetts Institute of Technology (MIT), in collaboration with three Swedish universities, many universities in China have adopted the CDIO (Conceive, Design, Implement and Operate) concept and undertaken a series of trials in recent years. The CDIO concept was considered as a new model for engineering education and its goal was to develop students' ability in engineering application and to solve their employment problems efficiently. The CDIO concept tried to change the way knowledge was sought and shed light on the long-term puzzle about which was more important between the knowledge-inductive and capacity development in engineering education. Combined with years of teaching experience and the advanced education concept of CDIO, the application of project-driven teaching methods in practical teaching for a logistics engineering major was discussed, and a practical teaching system meeting the requirements of an application-oriented *Logistics Engineering* major was created.

BASIC IDEA OF PRACTICAL TEACHING SYSTEM

The CDIO Education Model

CDIO works as an education concept and methodological system to guide the reform of the engineering education training model. It combines conception, design, implementation and the entire operation process as the means for developing students' engineering ability. CDIO is an engineering education model adopted by leading engineering schools in the USA, Europe, Canada, UK, Africa, Asia and New Zealand. The CDIO Initiative offers an education that stresses engineering fundamentals, set in the context of the Conceiving-Designing-Implementing-Operating process, which engineers use to create systems and products.

Nowadays, companies and society require engineers to have a wide range of knowledge and skills that would allow them to meet labour market expectations and to venture successfully in a world that is changing at a rapid pace [3][4]. While CDIO stresses the importance of engineering practical education, the emphasis is to provide students with the skills of active learning, practice, problem-analysis and problem-solving, and focus on vocational skills training, professional ethics, and teamwork and communication. These requirements were fully reflected in this study of practical teaching system reform and practice.

PROJECT TEACHING METHOD

The project-based method is a medium of instruction introduced during the 18th Century into the schools of architecture and engineering in Europe when graduating students had to apply the skills and knowledge they had learned in their studies to problems they had to solve as practitioners of their trade, for example, designing a monument or building a steam engine [5].

Unlike traditional education, the project teaching method attempts to allow the student to solve problems with as little teacher direction as possible; the teacher being seen more as mentor, helper, coach and facilitator rather than as the deliverer of knowledge and information. The project teaching method can direct students' own learning by their individual interests and desire for knowledge, and develop abilities of independent learning, analysing and solving practical problems [6]. A project method classroom focuses on democracy, collaboration and experiential learning, rather than rote learning and memorisation, to solve *purposeful* problems.

COOPERATIVE EDUCATION

Cooperative education combines classroom-based education with practical work experience in corporations. A cooperative education experience, known in this context as *co-op*, provides academic credit for structured job experience. Cooperative education is also the use of active participation methods in which students learn how to work together to solve problems, this is normally founded on the principles of children's rights, equality, equity and participation in decision-making. *Co-op* was founded in 1906 by Herman Schneider, Dean of the College of Engineering at the University of Cincinnati [7]. Since then, many institutions have adopted the cooperative option in engineering education. Nowadays, to ensure quality in cooperative engineering programmes, the Accreditation Board for Engineering and Technology (ABET) has developed standards in this regard. Wilson et al redesigned a new vision that involves conceiving, defining and presenting co-op *as a curriculum model that links work and academics - a model that is based on sound learning theory* [8].

Cooperative education offers benefits to students, the companies receiving students as interns and the educational programme. Friel showed that the benefits of cooperative education for employers include pre-recruiting, technical support and low cost engineering support, among others [9]. Cooperative education can also help in meeting educational objectives. Parsons et al tried to show the role of student professional experience in meeting those ABET criteria, which are more relevant to non-technical engineering skills [10]. Despite all the benefits of cooperative education, the process of developing a cooperative programme depends on many factors, such as the general educational policy of the country, cultural and technology issues and the economic environment. Linn et al provided some general tools and guidelines to assist in the development of a successful co-op programme [6].

CONSTRUCTING A CDIO-BASED PRACTICAL TEACHING SYSTEM

Located in the Yangtze River Delta economic zone, Zhejiang University of Technology (ZJUT) is a comprehensive key university owned by the Zhejiang Provincial Government. A majority of the students are from the local province and 80% of those choose a workplace in cities in Zhejiang and Jiangsu provinces, such as Hangzhou, Wuxi, Ningbo, Suzhou and Nanjing. College enrolment can provide more students with specialised knowledge, and can train and cultivate a contingent of professional personnel with technological and managerial knowledge to meet the needs of economic and social development.

The overall gap between high and low levels of student enrolment has widened significantly over the last 15 years. After going into specialisation stages, some students are able to complete the courses easily, while preparing for the postgraduate entrance examination and the civil service examination; others opt for direct employment or entrepreneurship. It would seem that the most urgent task is the global optimisation of professional teaching content and curriculum system, combining with current status of logistics engineering discipline, professional features and the demand for logistics professionals in the manufacturing industry in Zhejiang Province. This would provide different courses and upgrade training substantially to very different challenge levels to students from different backgrounds, and guide students in understanding themselves properly and achieving the desired outcomes of being work-ready and life-ready.

FRAMEWORK OF A CDIO-BASED PRACTICAL TEACHING SYSTEM

According to the training objectives of logistics professionals, with the combination of a project-driven teaching philosophy and cooperative education learning, the schematic framework of CDIO-based practical teaching system of logistics engineering major was established, as shown in Figure 1.

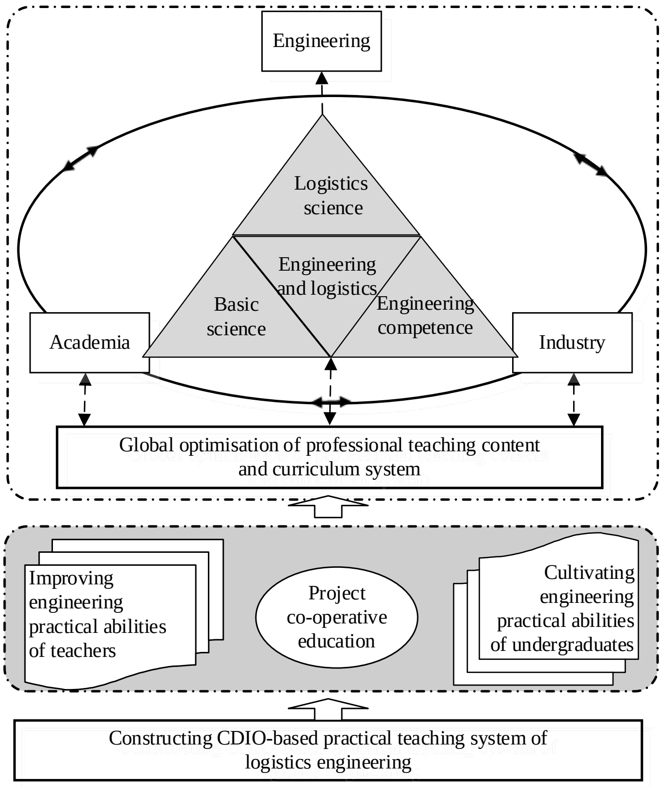

Figure 1: Schematic framework of CDIO-based practical teaching system of *Logistics Engineering* major.

Constructing a CDIO-based practical teaching system should keep pace with national economic development. Teachers should be encouraged to enhance engineering practical abilities, taking part in work groups, which meet on a continual basis in order to share experiences, with the assistance of experts on university pedagogy, scholars, tutors and university advisers. Engineering and logistics is the field in which knowledge of the applied mathematical and natural sciences gained by higher education, experience and practice is devoted to the application of engineering principles and the implementation of technological advances for the benefit of a man-machine system operating under changing environment.

In addition, the *excellent engineer cultivation plan* is combined throughout the entire process of the CDIO-based practical teaching system. Students work in an active learning setting known as the collaborative learning environment, using e-mail, chat rooms, bulletin boards, interactive Web sites, videoconferencing, along with multi-media resources and other creative means for engaging students actively in the development of knowledge.

Teachers should feel empowered and poised to take advantage of the many micro- or classroom-level practices that can assist them in learning about, and cultivating, relationships with their students, supervising the implementation process to ensure the quality of learning, and engaging individual students to apply for university-level, provincial and national project *National University Student Innovation Program*, through collecting research results, publishing research papers or applying for patents.

SPECIFIC MEANS OF IMPLEMENTATION

Strengthen the Laboratory Building

Logistics engineering education for the professional focuses primarily on analysing, applying, implementing and improving existing and emerging technologies, and is aimed at preparing graduates for the practice of engineering that is close to the product improvement, manufacturing and engineering operational functions. The cultivation plans are designed to have experiential learning as the educational backbone. Moreover, lecture courses emphasise the application of mathematics, science and engineering and teachers strive to prepare laboratories that are modern, project-based, inquisitive and synchronised with the lectures.

Under actual laboratory conditions, the management system and operational mechanism were reformed to strengthen the building and management of specialised laboratories, hardware laboratories and open laboratories. These laboratories have become the main locations for students to participate in different course experiments and innovation activities, and an important place for teaching and scientific research.

Taking technical training philosophy as the guiding ideology, system software, case tools and development tools - an integrated development environment was established and a platform for various presentations was built, which provided strong guarantee for practical teaching.

BUILD A PLATFORM FOR INNOVATION AND PRACTICE

Constructing a curriculum system, with the CDIO syllabus consisting of technical knowledge and reasoning, personal and professional skills and attributes, interpersonal skills, is the foundation of innovation and practice for students. Every type of curriculum should be developed by the reformation of teaching ways. A curriculum of public classes and departmental electives was introduced.

A curriculum of professional features and orientations was developed by providing students with some projects on team-work, inviting experts and scholars from other universities and managers from enterprises to discuss the practical challenges and share their experiences, new ideas and research results. The new A-level of professional teaching content and curriculum system should place greater emphasis on practical work, including that outside the classroom or laboratory.

It is of great importance to enhance and improve the practical engineering abilities of teachers in new and diverse ways and setting up the teaching ideology of advancing with the times, cultivating students foremost and taking practical teaching as the priority in the process of engineering education. Based on practical training (including in-class experiments), leaders in global optimisation of professional teaching content and curriculum systems drew attention to what they identified as most teachers’ main need, which was to be able to try out practical examples and develop their own confidence and skills, together with technician support. Students were encouraged to participate in university-level, provincial and even national level logistics design contests, and so on.

The application of engineering skills and students' performance will be demonstrated in curriculum projects for different grades, integrated practice of professional skills, comprehensive experiments and graduate internships, both inside and outside the classroom. These activities build a platform for students to participate in scientific research, social practice and innovation.

ESTABLISH LOGISTICS RESEARCH INTEREST GROUPS (LRIGs)

Many teachers have their own research fields with a particular research direction. In order to increase the incorporation of accessibility considerations into different research directions in logistics fields, and to enable students to participate in the actual research activities of teachers and suggest research questions that may contribute to new projects, various Logistics Research Interest Groups (LRIGs) were established in those research fields. The instructors would introduce research topics, allocate tasks and give appropriate technical guidance to students. Students could gradually improve their own scientific research capabilities and their ability to solve engineering problems. In addition, a novel joint undergraduate programme for specialisation in logistics engineering with some famous logistics companies was proposed, and students were sent in small batches to those companies to complete graduate internships. Through this session, students could understand the different requirements at various stages of corporate development, and learn the importance of the right way of doing things, good working attitude and high teamwork spirit; thereby, enhancing their employability and competitiveness.

THE IMPACT OF A PRACTICAL TEACHING SYSTEM ON STUDENTS

An exploratory survey-based study was carried out in several stages. The survey covered 266 students from Zhejiang University of Technology in China, 69% of whom were male. The students graded the CDIO-based practical teaching system according to general and specific objectives of logistics engineering. Students were from the second or third years of Bachelor engineering studies. All were enrolled in one of the classes with professional laboratory experiments in such courses: warehousing and distribution management, supply chain management and system simulation.

A brainstorming process had identified an initial framework of nine generic skills (life-long learning skills, leadership, research skills, communication skills, teamwork, problem solving skills, systemic thinking, willingness to learn and hands on experience) of high significance in the professional field of Logistics Engineering. A quantitative analysis was, then, performed with the students' specifications of their level of agreement to some statements in a questionnaire. The scores (on the Likert scale) could, then, be used to determine initially acceptable levels of generic competencies needed for their career. The results showed the importance of a higher rate of communication skills and teamwork, systemic thinking and hands on experience ranked lower.

Then, a sample was chosen made up of 198 participants requiring different logistics specialties: warehouse managers (16), storekeepers (45), logistics schedulers (22), depot coordinators (30), procurement assistants (28), logistics analysts (20), supply chain analysts (12), business consultants (17) and database managers (8). These participants corresponded to current job positions in different sources through personal contact or electronic mails. An estimation of the average skill demands revealed that a higher rate of communication skills and teamwork was valued, and that leadership and willingness to learn ranked lower. Data obtained from the students' initial perceptions on the skills and the participants' correspondence to current job positions is comparatively presented in Figure 2 and Figure 3.

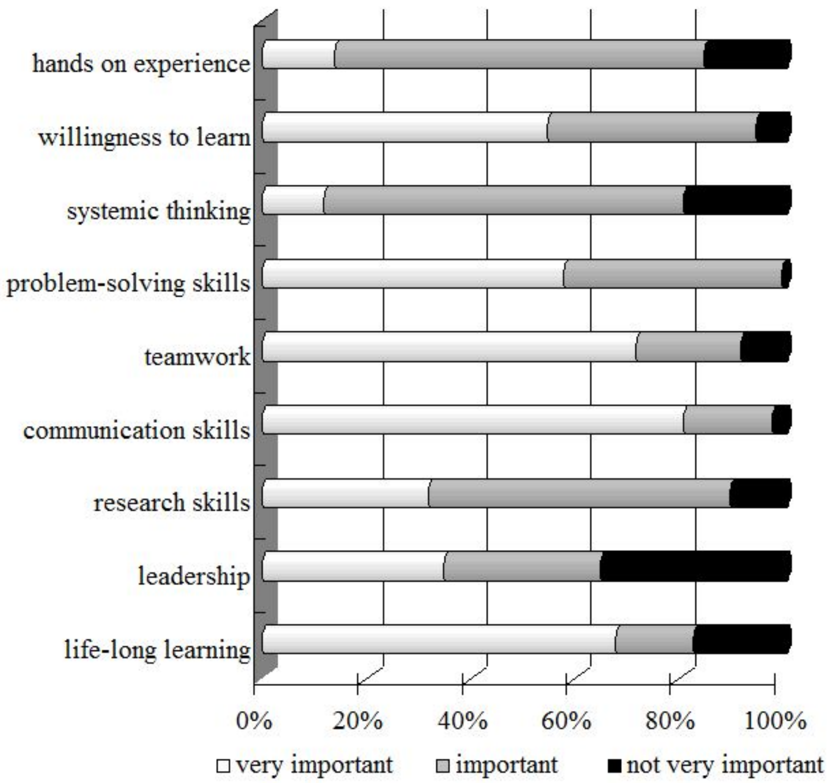

Figure 2: Students' initial perceptions vs. skills needed on job offers (Students' initial perceptions on generic skills).

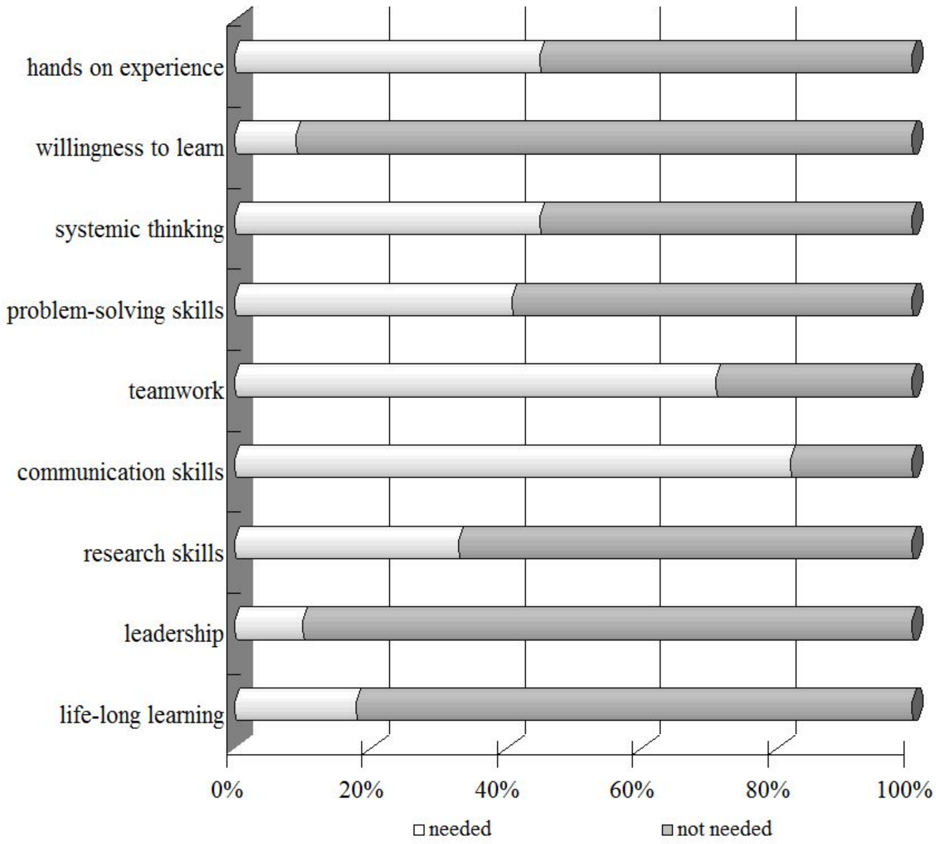

Figure 3: Students' initial perceptions vs. skills needed on job offers (Generic skills needed on job offers).

Discipline-specific tasks were also analysed, and the fundamental knowledge required in the job positions was linked to subjects of professional teaching content and curriculum; thus, providing students with access to higher-order learning designed to confirm and/or focus students' career goals and subsequent major(s) to pursue.

Through the research and practice on CDIO-based practical teaching system of logistics engineering major, several logistics research interest groups were established. During the past few years, college-level provincial level awards have been received more than 10 times.

By participation in actual research projects, students developed their self-learning ability and independent working skills, which has stimulated the curiosity of students and improved their ability of systemic thinking in a variety of fields. Table 1 shows the number and proportion of students of the logistics engineering major that participated in research projects.

Table 1: Statistics of students that participated in research projects.

Grade	Number of participants	Proportion of participants
2006	23	14%
2007	28	16%
2008	35	21%
2009	51	30%
2010	59	35%

CONCLUSIONS

This study was implemented from 2009 in the logistics engineering major. After five years of tough work, a CDIO-based practical teaching system was widely recognised and praised by students.

Good results have been achieved in practical training, not only improving undergraduates' engineering practical ability, cultivating students' employability and career transferable skills to some extent, but also improving engineering practical abilities and scientific research of young teachers.

Finally, this research was expected to assist other universities to re-examine the quality monitoring system of their educational process cycle to address any shortfalls in the logistics engineering major education.

ACKNOWLEDGEMENTS

The authors are grateful for the partial financial support from the Teaching Reform of College of Mechanical Engineering of ZJUT of China (Optimisation of professional teaching content and curriculum system of logistics engineering major based on *three creativity* principles), the Graduate Teaching Reform of College of Mechanical Engineering of ZJUT of China under Grant (Nos. JXY201313 and JXY201314), and the Scientific Research Start-up Foundation of Zhejiang University of Technology (No. 102006429).

REFERENCES

1. Wang, G.., Interpreting and thinking of CDIO engineering education model. *China Higher Educ. Research*, 5, 13-14 (2009).
2. Chen, C.L. and Zhu, Z.Q., Reform in engineering education based on the concept of CDIO education. *Educ. and Modernization*, 3, **1**, 30-33 (2010).
3. Ramírez, M., La importancia del desarrollo de competencias del futuro ingeniero. *3er Foro Nacional de ciencias básicas: formación científica del ingeniero*, México D.F.: Universidad Nacional Autónoma de México (2009).
4. Palma, M., De los Ríos, I., Miñán, E. and Luy, G., Hacia un Nuevo Modelo desde las Competencias: la Ingeniería Industrial en el Perú. *Proc. Tenth LACCEI Latin American and Caribbean Conference*. Panama: LACCEI (2012).
5. Knoll, M., The project method: its vocational education origin and international development. *J. of Industrial Teacher Educ.*, 34, **3**, 59-80 (1997).
6. Linn, P.L., Howard, A. and Miller, E., *Handbook for Research in Cooperative Education and Internships*. Taylor & Francis (2011).
7. Burnet, G. and Greisch, J.R., The ten most outstanding engineering education and engineering technology achievements of the past century. *J. of Engng. Educ.*, 83, **1**, 1-5 (1994).
8. Wilson, J.W., Stull, W.A. and Vinsonhaler, J., Rethinking cooperative education. *J. of Cooperative Educ.* (Winter-Spring) 31, **2-3**, 154-165 (1996).
9. Friel, T., Engineering cooperative education: a statistical analysis of employer benefits. *J. of Engng. Educ.*, 1-6 (1997).
10. Parsons, C.K., Caylor, E. and Simmons, H.S., Cooperative education work assignments: the role of organizational and individual factors in enhancing ABET competencies and co-op workplace well-being. *J. of Engng. Educ.*, 94, **3**, 309-318 (2005).