

IT training mode using hands-on inquiry based learning and CDIO

Yongheng Zhang, Feng Zhang, Xiaoyan Ai & Xialong Li

Yulin University
Yulin, Shaanxi, People's Republic of China

ABSTRACT: In order to cater for the demand for information technology engineering skills, hands-on inquiry based learning has become increasingly popular in the reform of engineering education. The study reported in this article describes an investigation into hands-on inquiry based learning as used in a project that included the CDIO (Conceive, Design, Implement, Operate) method. A CDIO-based hands-on inquiry based learning curriculum was developed and implemented. Experience shows that the training programme improves students' employability by making them better match the needs of business.

INTRODUCTION

The information technology (IT) industry is a knowledge- and technology-intensive business and, therefore, the IT curriculum needs to foster innovative information technology personnel [1]. Specifically, the teaching process needs to produce business-oriented IT professionals. With this in mind, this article is an exploration of the specific training model, hands-on inquiry based learning [2], for IT courses.

The authors report in this article on attempts to solve the problems of teaching current IT professional courses, such as the emphasis on theory, while ignoring practice; the traditional curriculum ignoring the needs of business courses; and the emphasis on complete systems, while ignoring the specific needs of enterprise.

Many Chinese and overseas universities have implemented the CDIO (Conceive, Design, Implement, Operate) method as part of education reform. The CDIO method applied to engineering education would cover all aspects, from research to product lifecycle. Students would benefit from active, practical learning [3][4]. Its main idea is to emulate practical engineering on projects, combined with teaching professional core courses. Students progress from *conceive* to *design*, to *implement* to *operate*, as an engineer would. The CDIO core idea is project-based teaching and hands-on inquiry based learning [5][6].

Hands-on inquiry based learning is the essence of CDIO that integrates theory with practical training [7]. From the market point of view, hands-on inquiry based learning is an attractive teaching model, which means that students meet companies' needs and satisfy market demand. Hands-on inquiry based learning is a concrete manifestation of *teaching to do* as the important content of engineering teaching.

HANDS-ON INQUIRY BASED LEARNING CONCEPT

The company's needs are for skills that can be quickly used in engineering and technical roles. But traditional teaching separates theory from practical training, i.e. the theory-based courses are completed first and, then, practical training commences. This teaching model results in students having a poor knowledge of the application of the theory and it leaves a big gap between job requirements and student abilities.

According to the results of a survey of a number software companies, the most important requirements for technical employees is the ability to master the latest software development technologies and programming. Companies want students to have solid knowledge, but also a strong ability to adapt, to understand and to master practical new technologies. Reform of the IT curriculum will involve abandoning the old curriculum and producing a new, integrated

curriculum that reflects new methods, new technology, and is responsive to the needs of enterprise. Students would learn to master the latest software development technologies to cater for the needs of business.

The teaching should mimic the atmosphere of the workplace using case-driven project-oriented teaching based on real project specifications, to ensure the relevance of the course content. The strong project orientation of hands-on inquiry based learning requires dually qualified teachers.

Major reforms are required as follows:

- Market demands should be reflected in the training model. Reform of IT majors should be based on the premise *essential but only enough*. Identify the location for the training, have clear specifications and develop personnel training programmes for the students.
- The product development process is used to implement the personnel training. Training objectives and the training curriculum are established according to the project. The product development process is key to the teaching, with the product quality a basis for measuring learning outcomes.
- Implementation of learning by doing requires teachers with the actual ability of analysis and project development. As well, they must be good at teaching and integrating theoretical knowledge with practical abilities applicable to real projects.
- The work environment needs to be an integrated teaching and learning environment but with an increase in the practical proportion compared with traditional teaching. Where appropriate, tasks should include training by simulation. The teaching would benefit from an entrepreneurial work environment and entrepreneurial management.

Actual enterprise applications are designed to promote students' interest in learning and a break away from traditional teaching by promoting learning through experimental verification. Learning is through problem-based inquiries, training students to think about ways of analysing problems and becoming independent learners.

HANDS-ON INQUIRY BASED LEARNING BASED ON CDIO

Personnel Training Programmes based on Hands-on Inquiry Based Learning

According to industry research, enterprise job requirements determine a project-oriented, case-driven, three stages training model, which has led to the development of IT professional training programmes. These reflect the technology at the core of the project and highlight the career orientation and training needed to strengthen application abilities.

Four years and eight semesters are divided into three major phases, i.e. 2 + 1 + 1 (2 + 1 + 1 refers to 2 years + 1 year + 1 year - students spend 2 years learning courses; 1 year they spend learning professional courses; and the last 1 year involves learning a project development course) viz. improve technical skills lasting four semesters; occupational training lasting two semesters; enterprise project and graduation thesis lasting two semesters. The training programme that uses hands-on inquiry based learning is shown in Figure 1 (in Figure 1, the meaning of 3 + 1 is learning professional courses in 3 years, and the last 1 year is spent on learning a project development course).

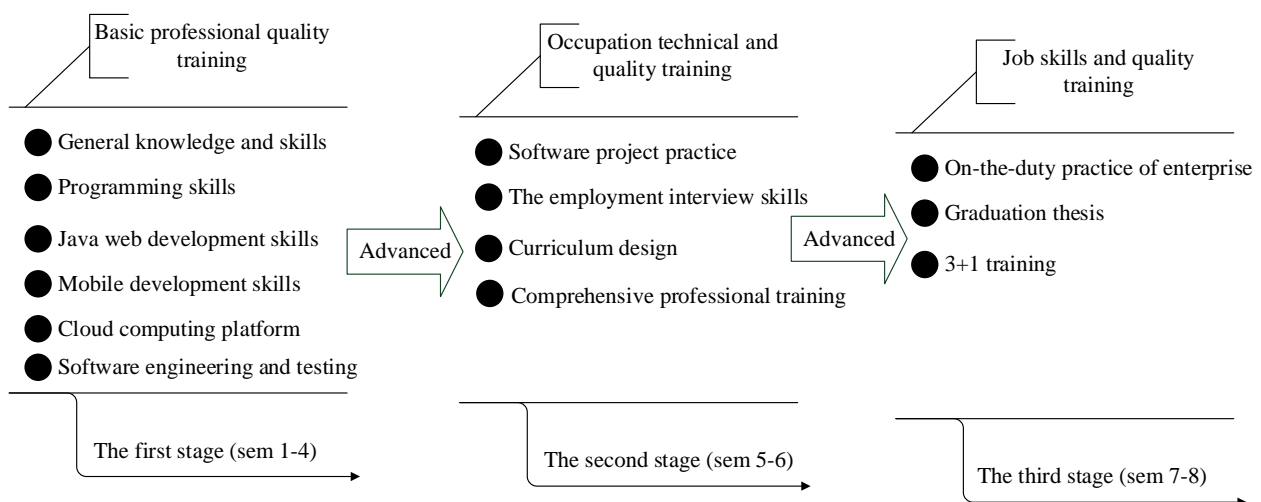


Figure 1: Training programme using hands-on inquiry based learning.

The stress throughout the entire process is on quality education. Training is of skills and quality simultaneously. Companies need application-oriented IT professionals of high quality and with good skills.

CONSTRUCTION OF THE CURRICULUM SYSTEM

The CDIO method emphasises that *conceive, design, implement* and *operate* constitute the entire life cycle of a product. Hence, projects to support an integrated curriculum will include processes and systems to support *conceive, design, implement* and *operate*.

Hands-on inquiry based learning emphasises the development of students' knowledge and skills to achieve the training objectives. An integrated curriculum and learning activities will have a double impact that reinforces the basic knowledge and engineering skills, as well as the practical ability of students.

The personnel training mode based on CDIO is shown in Figure 2.

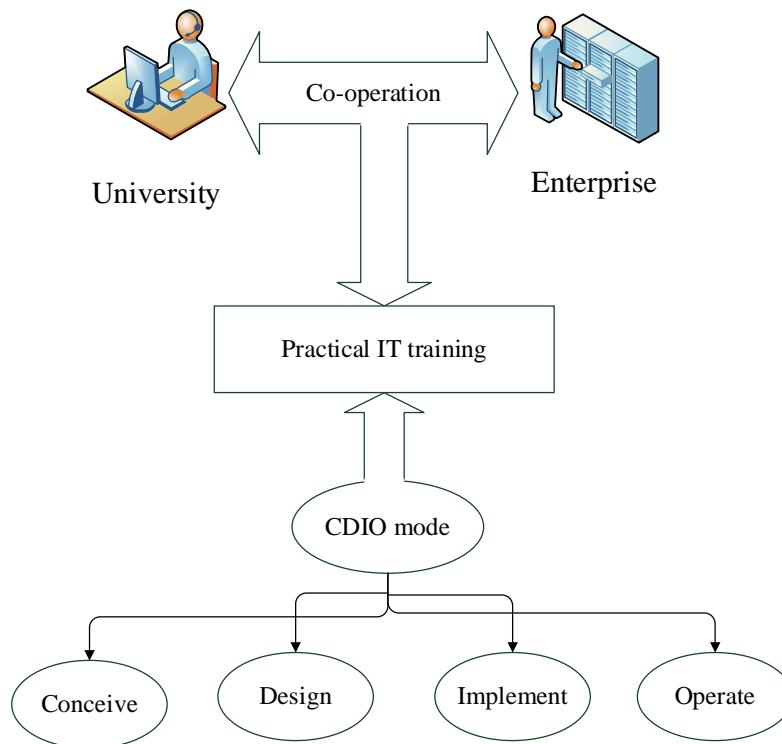


Figure 2: Personnel training based on CDIO.

CONSTRUCTION OF THE CURRICULUM SYSTEM

Construction of the schematic diagram for the hands-on inquiry based learning curriculum system is shown in Figure 3. As now outlined, the curriculum includes foundation studies, professional studies and advanced studies:

- Foundation studies cover the background or foundation knowledge the students need. Courses include English, mathematics, linear algebra, probability theory and mathematical statistics, physics, humanities courses, circuit and electronics technology, and the C language.
- Professional studies is the content of the main taught stage and the aim is to develop the students' theoretical and professional knowledge. The courses include IT composition theory, discrete mathematics, operating systems, introduction to IT, object-oriented programming, data structures, database systems, IT network technology, computing system architecture and an assembly language.
- Advanced studies. This is meant to reflect enterprise demand for skills and current research. Courses include:
 1. Embedded systems: Android design, operating systems, embedded application development environment and tools, hardware design, system software development (ARM), network programming, Linux programming and technical seminars.
 2. Web information systems: Java EE technology, Web development technologies, Spring + Hibernate + Struts development technology, EJB3 + JSF2 technology, Ajax + Web 2.0 technologies, Oracle, MySql databases

and modelling techniques, systems analysis and UML (unified modelling language), software project management, testing, UI (user interface) design, software development and management, and technology lectures.

3. Internet of things and communications: networking, wireless sensor networks, TCP/IP network protocols, embedded systems technology, sensor technology, RFID (radio frequency identification) technology, information technology and industrial field bus technology, M2M (machine to machine) technology, networking software, standards, middleware, information security infrastructure, communications engineering infrastructure, network programming, and technology lectures.
4. Comics and animation: animated scenes, 3D animation, two-dimensional animation, character animation, animation, post-production, Flash, Maya and Photoshop, as well as technology lectures.
5. Internal and external training: three years of theoretical and experimental teaching and a year in a corporate internship.

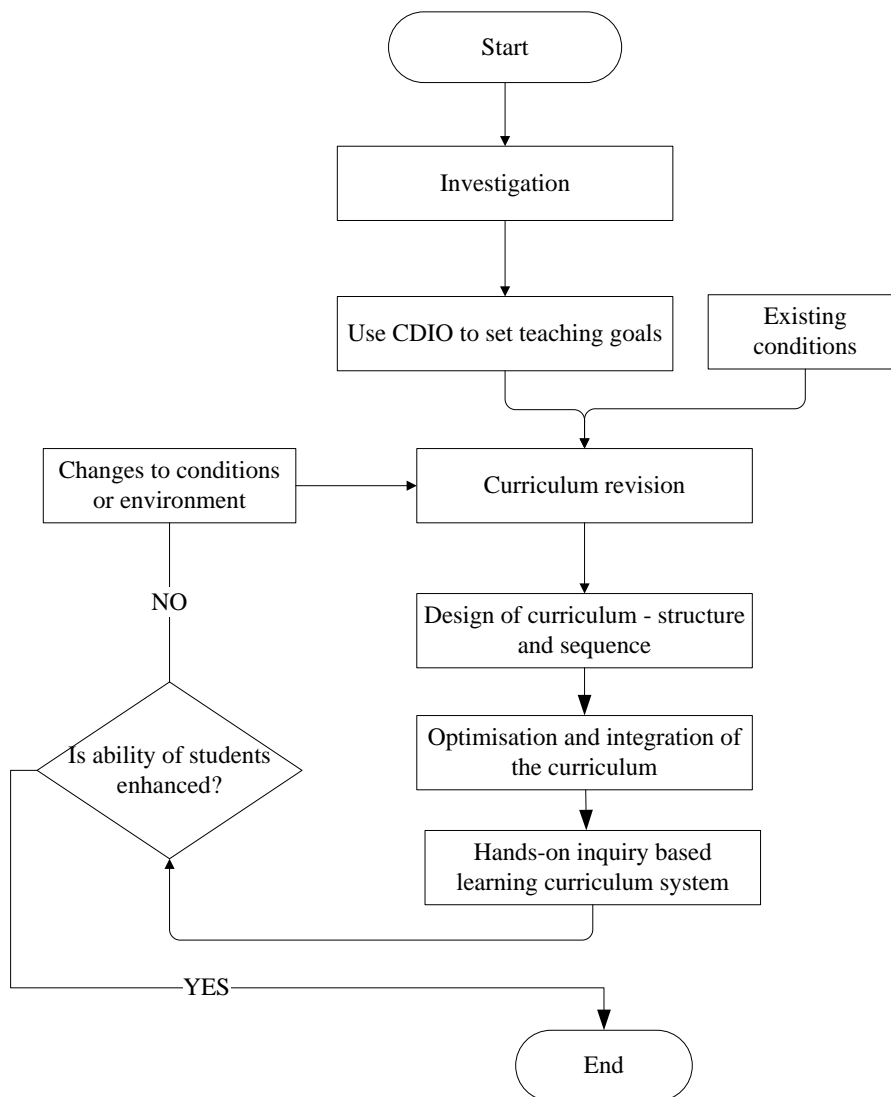


Figure 3: Construction of the hands-on inquiry based learning curriculum.

The hands-on inquiry based learning model is based on internal and external practice, with the introduction of an internship in an enterprise to carry out an actual business project.

This project-driven approach involves double mentoring by teachers and engineers, who are jointly responsible for technical and project guidance. Students in project development teams will have various roles in the team, and be involved in the whole process of project development. There they will experience the corporate atmosphere and the environment.

Training modes and the curriculum system of hands-on inquiry based learning is shown in Figure 4. Table 1 lists the hands-on inquiry based learning system based on CDIO.

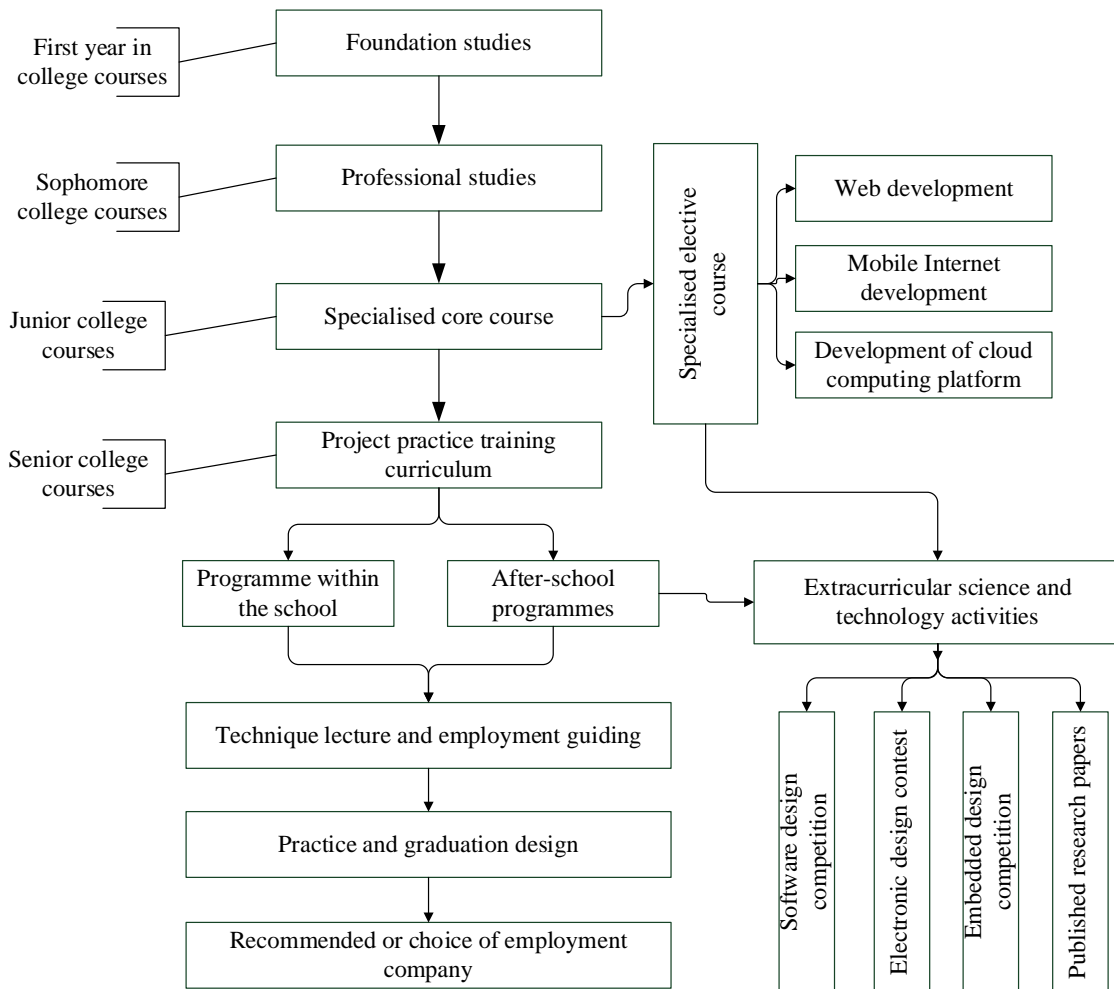


Figure 4: Training modes and curriculum system of hands-on inquiry based learning.

Table 1: The hands-on inquiry based learning teaching system based on CDIO.

First year in college	Sophomore college courses	Junior college courses	Senior college courses
Computer courses	Specialised basic courses	Specialised core courses	Project
General education	Professional skills	Employment skills	Engineering practice

PRACTICAL EFFECTS

Since September 2011, 1,200 students from Yulin University have participated in the hands-on inquiry based learning training mode. Their employment rate is 92%. Employer feedback is highly positive about the quality and ability of the graduates. With the job market for college graduates in a downturn, the employment rate of these graduates has actually improved.

The employment covers various types of IT enterprise, including outsourcing, e-commerce, e-government, telecoms, banks and securities companies. Locations include Beijing, Shanghai, Tianjin, Guangzhou, Wuhan, Shenzhen, Dalian, Suzhou and Guiyang. Analysis of employment statistics is shown in Table 2. The employment rate in the past five years is shown in Figure 5.

Table 2: Outcomes after adopting this new teaching mode.

Grade/year	Employment rate (%)	Wage level (RMB/month)	Social certification (Students obtained professional credentials)
2007/2011	90.0	2,800	58
2008/2012	91.5	3,500	72
2009/2013	92.5	3,800	85
2010/2014	93.1	4,133	90

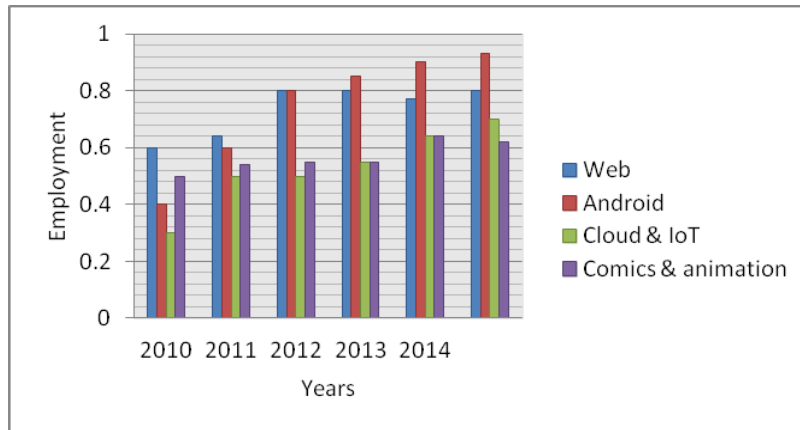


Figure 5: The employment rates over the past five years.

CONCLUSIONS

This study is a report on the use of hands-on inquiry based learning for information technology courses at Yulin University. An internship in an enterprise during which the student completes a real project is at the heart of the training.

Students complete the entire life cycle of the project, during which students working in teams apply knowledge to analyse and solve problems. Hence, they develop the ability to analysis, design, implement and operate a project to meet the enterprise requirements as an enterprise software engineer.

ACKNOWLEDGEMENTS

This work is partially supported by the Shaanxi Higher Education Teaching Reform Research Project (13BZ54, 13BY94), Shaanxi education scientific planning project in 2014(SGH140821). The authors wish to express their thanks for this help.

REFERENCES

1. Feng, G.Y., Practical teaching research on the course of production and operation management. *J. of Research on Exploration in Laboratory*, 8, 1, 12-15 (2009).
2. Erdosne Toth, E., Morrow, B.L. and Ludvico, L.R., Designing blended inquiry learning in a laboratory context: a study of incorporating Hands-On and Virtual Laboratories. *Innovative Higher Educ.*, 33, 5, 333-344 (2009).
3. Berggren, K-F., CDIO: An international initiative for reforming engineering education. *World Trans. on Engng. and Technol. Educ.*, 2, 1, 49-52 (2003).
4. Gong, S., Zhu, Y. and Yang J., Thinking on cultivation pattern in regional universities for IT innovative talents. *Computer Educ.*, 20, 1-4 (2012).
5. Qin, Z., Huang, Y. and Xu, H., The teaching reform of Java language in software engineering major based on CDIO concept. *Computer Educ.*, 19, 77-81 (2012).
6. Fan, R., IT talents training in higher vocational colleges based on actual projects. *Computer Educ.*, 8, 12-14 (2012).
7. Peet, D-J. and Mulder, K.F., Integrating SD into engineering courses at the Delft University of Technology. *Inter. J. of Sustainability in Higher Educ.*, 5, 278-288 (2004).