

## Training engineering undergraduates in building environment and energy

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**ABSTRACT:** The objective of this study was to investigate reforming the teaching of a building environment and energy engineering (BEEE) major. A new course covering building energy efficiency and oriented toward low carbon emissions was developed. For the BEEE major at Ningbo University of Technology, the curriculum, experiments and training were presented and discussed. The application of thermal and energy conservation technologies were emphasised in teaching the practical sessions. Experiments, scientific research and subject content were determined and implemented. The results show that the approach was innovative, of high quality and provided an international vision for BEEE undergraduates. The results of this study may be beneficial in research attempting to improve the teaching of engineering.

### INTRODUCTION

Engineering education is the activity of imparting knowledge and the principles related to the professional practice of engineering. Sustainable engineering involves using energy and resources sustainably. In recent years, sustainable education has become common around the world and is an important trend in civil engineering and architecture [1][2].

In June 2010, China's Ministry of Education put forward *A Plan for Educating and Training Outstanding Engineers*, which is significant for higher engineering education. As well, a new *Quality Project* was launched to promote, in universities, the fostering of advanced professional talents suitable for the local economy and society [2].

Training provides an end-to-end process for undergraduates, from pre-employment training to recruitment with accredited qualifications. Much attention has been devoted to sustainable training about buildings in recent years. Tohoku University demands that students evaluate methods for sustainable building development. At Concordia University of Canada, undergraduates are required to understand the basic knowledge of building structures, building facilities and project management. Aalborg University in Denmark gives equal importance to architectural design and architectural technology [3].

In China, Tsinghua University, Tongji University, Harbin Institute of Technology and Chongqing University have adjusted their curricula to accommodate the training of building environment engineers [4-6]. It is now clear there is a trend in education towards sustainable development. The undergraduates of BEEE are required to master green building technology and be aware of trends in building energy efficiency. In this article, the new course concerned with energy efficiency and low carbon emissions at Ningbo University of Technology (NBUT) is presented and analysed.

### CULTIVATING TALENT

Newly built universities, such as NBUT give top priority to multi-disciplinary engineering and technology specialties. From 2004, NBUT started to offer undergraduate courses and was one of only four universities in Zhejiang, China, that could offer a BEEE major. The course covers design, operational management of the building environmental system, scientific research, training in English, computer applications, heating, ventilation, air conditioning and electrical installations.

The aim of NBUT and BEEE is to develop professional skills emphasising the core components of the curriculum. This includes building energy conservation oriented towards low carbon emissions. Theoretical teaching and the *point-line-surface-body* practical teaching system were implemented. Emphasis was placed on engineering quality and innovation.

## THE CURRICULUM

The building environment course specification is shown in Figure 1. This course is based on current technology and has a sound theoretical base.

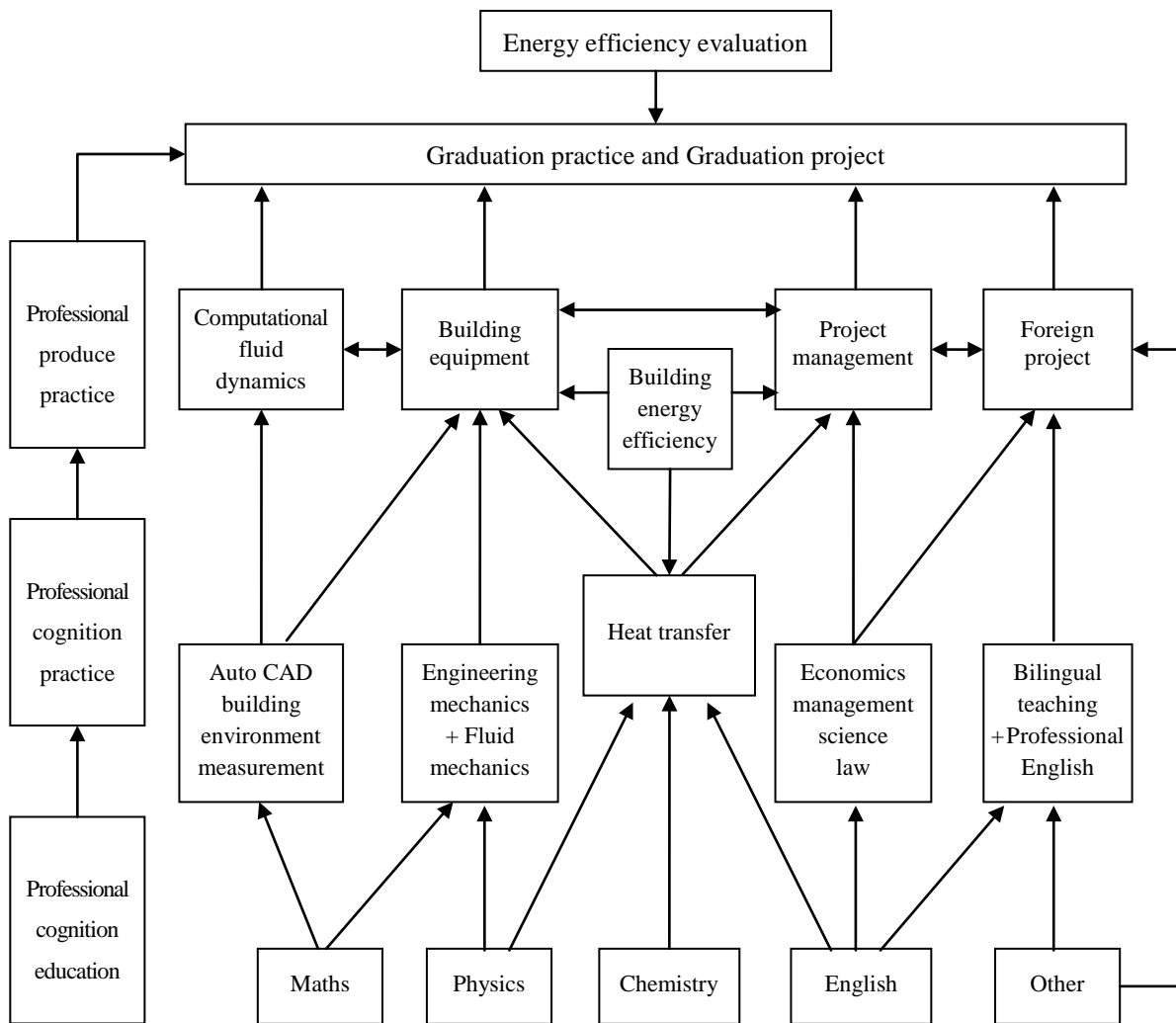


Figure 1: The specialty courses system of the building environment.

In this system, total teaching should be about 2,200 class hours, the practice teaching should take more than a quarter of the total and the practice teaching time is approximately 40 per cent of total hours. Through emphasising building energy conservation, energy conservation knowledge merged with specialised courses, such as HV&AC (High Voltage and Alternating Current), helps develop a building and environmental discipline. The course makes effective use of the teaching resources [7-8] and stimulates the enthusiasm of students regarding energy conservation.

The reorganised course highlights the discipline's applicability and practicality. The reformed system aims to improve students' knowledge of, and ability in, the two core components of theory and practice. The basic principle is to *improve energy conservation*, and to combine the core course to improve basic skills with the specialised course to improve professional skills. It is useful for students in improving their overall engineering ability through practical engineering.

The theoretical teaching is referred to as the *first classroom*; the practice or practical teaching is referred to as the *second classroom*, and all the extracurricular activities of students are referred to as the *third classroom*. The second and third classrooms are a continuation of, and supplement to, the first classroom. Credit hours are accumulated during the three kinds of classroom.

All learning in the first, second and third classrooms leads to compulsory credits. Additional credits were awarded for research projects, special achievements, patent licensing, papers published and technical proficiency certificates. Students need to achieve six of these additional credits. These credits could count towards other public courses. Practical education and academic education are closely linked, but have their own characteristics. Their integration increases the quality of a student, and develops the student's practical ability in a way that an academic education alone cannot achieve.

## THE TEACHING PLATFORM

Practical teaching is crucial to engineering education. A new course was established, with building thermal engineering and building energy efficiency, at its core. Multi-layered training and improvement, from basic to comprehensive knowledge, encompassing relatively independent subjects to multiple related subjects, were featured in this course. The three levels of teaching are shown in Figure 2.

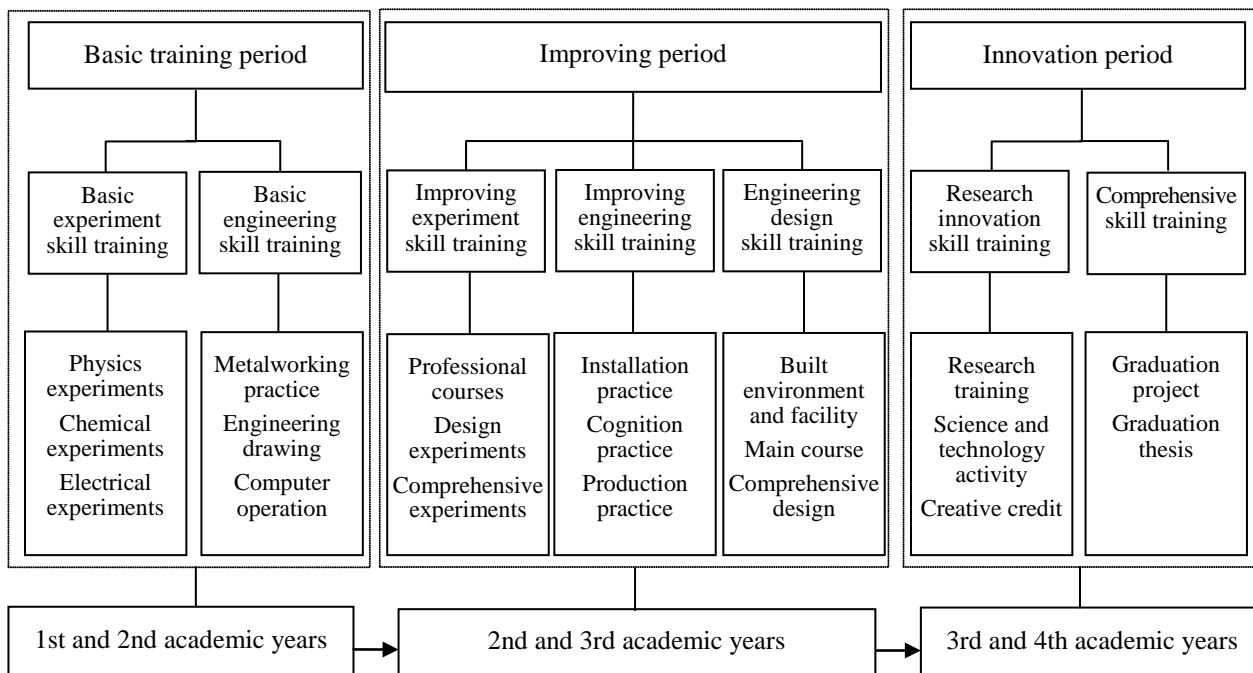


Figure 2: A new cultivating system of applied talents training.

The aims behind the basic training period is to understand and describe the functional requirements and internal structure of products in the building environment field. This period is scheduled for the 1st and 2nd academic years.

The improving period includes three parts. These are experiment, engineering skill and engineering design. This period covers design, retrofitting energy conservation into buildings and production practice. This period also emphasises the students' ability to analyse and solve problems.

The innovation period has two parts and these are research innovation and comprehensive skills training. The former includes research training, science and technology activities and creative credits. The aim is to train the students to discover, analyse and solve problems. The comprehensive skills training includes a graduation project and graduation thesis. It helps to promote the application of knowledge, and the skills of co-operation, self-development and independent research.

## PERSONNEL TRAINING

Engineering education typically is accompanied by supervised training as a requirement for a professional engineering licence. Modern building construction needs not only students with academic knowledge but also with knowledge of advanced techniques. There are three approaches to developing these advanced abilities.

**The Open Experiment:** the academic major has an excellent teaching demonstration centre - the *Energy Efficiency Engineering Centre*. The laboratory opens to students and staff 24 hours a day. It is a showcase of engineering practice, and is ideal for improving practical abilities. The open laboratory allows the sharing of practical resources and stimulates students in solving practical problems. The cost of running the laboratory is borne out of public finances.

**Scientific Research:** the building environment team was awarded with the status of Excellent Teaching Team of Zhejiang Province in 2008. Relying on advanced equipment and excellent teachers, scientific research is an important way of training students. Therefore, students should be encouraged to undertake research. *Self-motivated, free exploration, independent innovation* is the mantra for training in order to develop professional talents. The academic major includes a series of projects, which students are encouraged to undertake. The projects are given grants, and those students with excellent projects are recommended to apply for the undergraduate science and technology innovation project award. The contents include statistics on energy consumption, ground source heat pumps, energy storage air conditioning and heat transfer enhancements. Students should enter the profession as early as possible with an understanding of the academic frontier and having mastered the basic methods and techniques.

Subject Contests or Competitions: subject competitions are the means to integrate theory with practice and to demonstrate innovation. Contests include the *Challenge Cup* Competition of Science and Technology and a contemporary mathematical contest in modelling; the Emerson Cup Air Conditioning and Refrigeration Design and Application Competition; the CAR (Chinese Association of Refrigeration)-ASHRAE undergraduate design awards, which includes a structural innovation competition and collegiate programming contest. The students recently have enjoyed significant success in various subject contests, and won the Grand Award of the Challenge Cup National Undergraduate Curricular Academic Science and Technology Works Race, three second prizes and one third prize from the Zhejiang Provincial Challenge Cup Competition of Science and Technology, which attracted the attention of the news media.

## CONCLUSIONS

The framework for a new curriculum was outlined. The major subject and practice methods were presented and discussed. Experience has proved that this system improves innovative ability and quality. This guide was designed to help educators develop effective energy education programmes. It provides an outline of a basic energy curriculum unit, and of all the curriculum options.

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