Teaching Reform Practice in the Background of Education Internationalization: An Example

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Abstract. Nowadays internationalization has been thought of as an important tendency in engineering education. The teaching practice for a certain course, therefore, should also adapt to the needs for talents development within such a background. Recently, following the education internationalization concept, the authors performed a systematic teaching reform on a course for postgraduates majoring in chemical engineering, including update and improvement on syllabus, contents, teaching methods as well as outcome assessment. In this paper we presented our thoughts and specific practice, in hope of being beneficial to other higher education practitioners.

Introduction

Globalization is one of the most profound social development phenomena in the contemporary era. In the field of education, globalization consists in the spontaneous flow and optimal allocation of human resources and material resources worldwide. With the collision and fusion of national education concept, teaching methods and management methods, the ultimate purpose of internationalized education is to cultivate graduates who can not only serve the local social economy, but also effectively participate in the international competition [1,2].

As the implementation of the “The Belt and Road” strategy, which is going to bring about deep changes on the economy and culture of involving countries, it is expected that the world demand for international engineering talents will continually increase. How to reform the teaching practice to adapt to such situation is obviously an important issue for every teacher engaged in higher education. Xi’an is an ancient capital and eastern departure point of the Silk Road, where both Xi’an Jiaotong University and Northwest University locate. In addition, Xi’an Jiaotong University initiates the foundation of University Alliance of the Silk Road (UASR) [3] including more than 100 members from 5 continents, aiming at cooperative education and establishment of international higher learning platform. As such, the authors feel obliged to integrate the internationalization concept into the daily teaching practice, and the postgraduate course “Optimization Method and Applications in Chemical Industry” provides an appropriate vehicle.

Course Background

Outline

Optimization is a quite general concept covering multiple disciplines, and the methods find rather wide applications. And with no exception, a variety of optimization problems arise in the chemical process, such as minimization of Gibbs free energy for complex chemical equilibrium, profit maximization from reasonable production planning. Apparently, the solution to these problems, especially those of complex structure and large scale, cannot do without efficient methods. Process system engineering, which is an important research area in Chemical Engineering discipline, has particularly close tie to the optimization theory and practice. It focuses on integrated tuning and
emission control for chemical process system, and has been found helpful with regard to energy conservation and efficiency improvement.

“Optimization Method and Applications in Chemical Industry” is one major course supporting the research of process system engineering. Such a postgraduate course has been opened at School of Chemical Engineering, Xi’an Jiaotong University for more than 10 years. Due to the emphasis on the connections between mathematical theory and engineering background, the course is popular among students and about 1/3~1/2 postgraduates at the school will register for its study each year. Correspondingly, the reform on the teaching of the course is meaningful in making the whole learning platform of the school more “internationalized”.

Reform Orientation
The authors believe that communication in a diverse environment is one of the fundamental skills of international talents, while linguistic ability makes an essential part of it. Therefore, the construction of the course as a bilingual one, which also lays the foundation to open it as fully English course to attract foreign students, will be the first objective. Second, considering the limited class hours of the course, the refinement of contents and teaching methods is necessary to guarantee the learning outcome. Because optimization courses are common worldwide, the update of syllabus in reference to successful experience from foreign universities is helpful. Last but not least, the informatization means play an increasingly significant role in the teaching, and provides a public platform facilitating cooperative and interactive education. Hence the construction of a course website with rich contents and functionalities should also be done.

Reform Measures
Preliminary investigations on the optimization course syllabus for non-mathemac majors (chemical engineering, electrical engineering, management) in some famous foreign universities, e.g. Purdue University, University of Texas Austin, Norwegian University Science & Technology, Indian Institute of Technology, were made by the course group. In combination with the characteristics of the professional fields, we set the goal of this course as “training internationalized talents with innovation ability and efficiency consciousness working in the energy chemical industry”. Accordingly, we have developed a new syllabus and teaching plan, the specific measures can be summarized as follows.

Course Content
The syllabus of the abovementioned foreign universities are compared and summarized. On one hand, although the theoretical framework, i.e. unconstrained optimization, linear programming and constrained optimization, is roughly the same, each part of the contents take drastically different weights for each university and professional. For example, the optimization course given to management-majored students puts a lot of emphasis on the linear programming, in particular the duality and its economic meaning. On the other hand, there are some common practice like the introduction of latest research on optimization algorithms, the emphasis on software application, as well as independent statement for the least squares problem and solution.

In view of these, the course group refined the original teaching contents as follows:

1. The classroom teaching on optimization theory is much shortened and stresses on the main ideas & features of various algorithms. The lengthy mathematical derivation, which can be easily found in the references provided in the course website, is left for the interested students to study after class.

2. Some frequently encountered topics, including the least squares fitting of experimental data are discussed in detail. The physical meaning of the objective function and constraints, as well as selection of appropriate algorithm are highlighted. These contents would better support the follow-up research work of attending students.

3. The application of Excel[4,5] and Matlab[6], two commonly used software for optimization, are frequently demonstrated to model and solve the example problems. Thanks to such user-friendly
software, the students are largely free from laborious programming work and could better focus on the mathematical formulation of the problem, which also fits their practical needs afterwards.

**Online Platform**

Autonomic learning is one of the most important characteristics of graduate education, and it is also in line with the current advanced concept of student-centered education [7]. The online platform is exactly a powerful tool guiding students to realize autonomic learning. Therefore, the course group constructed the course website in the Curriculum Center Platform of Xi’an Jiaotong University (http://cc.xjtu.edu.cn/G2S/site/preview#/home/v?Currentoc=480), the contents include course introduction, tutor curriculum, syllabus and teaching plan, demonstration of previous students’ reports, references and related web links. The “teaching materials” column provides a wealth of documents, e.g. course slides, related monographs, courseware, research papers on certain topics, which can to a large extent meet the needs for students’ self-study. In addition, through the course website BBS, effective communication and interaction among students, between students and teachers can be achieved. Besides, the students’ feedback through this channel, including those after course study, could serve as a solid basis for the continuous improvement on the course.

**Bilingual Teaching**

How to achieve a perfect balance between professional knowledge transfer and English environment building, is one of the crucial issues in bilingual teaching by college teachers [8,9]. Too much English always generate repulsive effects for the students, and the understanding about the technical contents may probably deteriorate. Referring to the past experience and suggestions from elder experts, the authors implement bilingual teaching in the following ways:

1. Present the slides in pure English, while teaching is conducted in Chinese, so that attending students could well understand the content. The slides were made partly in reference to the courseware from internet, such as “Optimization of Chemical Process” by University of Texas Austin, “Optimization” by Politecnico di Milano and “Numerical Optimization” by San Diego State University. All the slides were uploaded to the course website, thus the students could learn by themselves after class.

2. Encourage class discussion in English in a progressive way. Some survey concludes that Chinese students’ listening and speaking ability is relatively poor compared to reading and writing, hence the measure could make up for such weakness to a certain extent.

3. Requirements of English are highlighted in the assessment scenario. The final report and the oral presentation, which takes a large weight of 60% for the total score, are asked to be completed in English. Moreover, a certain amount (typically 10) of English papers in the prestigious journals should append to each report as references, while part of them could be found in the course website.

**Case Study**

Previous experience has shown that the engineering-majored students' understanding of the modeling and solution of optimization problems, can hardly be separated from the application background [10]. The course group, therefore, formulated a few cases from personal or group research practice in correspondence to certain algorithms, including “Optimal experimental design for the kinetic studies based on volumetric method”, “Minimization of Gibbs free energy of chemical reaction state simulation”, “Energy and material network integration in process industry”. These cases are pretty close to the research topics of the postgraduates attending the course, and have a certain complexity so as to inspire their deep thinking. Through display of the solution to these cases, the students could further deepen their understanding about the optimization theory, as well as how to combine them with the application background.

**Assessment System**

This course is designed to teach students the basic theory of optimization and the software implementation through a series of exercises, ultimately achieving the purposes of training students
awareness of energy conservation and helping them carry out professional research. To this end, the group has set up a multi-level evaluation system:

1. Quizzes. During a visit to Tokyo University Science, one of the authors contacted such a flexible and pithy evaluation method. We adopt it to check for the students’ knowledge on basic concepts and algorithms, and the questions mostly come from the textbooks [11,12], which are relatively simple and intuitive. For example, put down the pseudo code of BFGS variable metric method.

2. Programming assignment. Programming work is very useful for the students to learn and grasp the logic of optimization algorithm. At present, the conjugate gradient method with different schemes (Fletcher-Reeves, Polak–Ribiere–Polyak, Hestenes-Stiefel, Dai-Yuan, etc) is required to be used for solution of a simple problem, and the results including convergence & efficacy discussion should be presented in a format of Journal of Xi’an Jiaotong University.

3. Reports related to personal research topics. The problems can come from different fields, and should have a certain complexity, say, several tens of decision variables and constraints. Through the step-by-step procedure to accomplish the reports, including literature survey, problem formulation, software solution and results analysis& discussion, the students are expected to further develop their abilities to apply optimization technique in their postgraduate research and even professional career.

Summary

The education internationalization has brought great challenges to the teaching at colleges and universities. In this paper, we gave an example to reform practical teaching in accordance to such a concept. The authors have carried out the above measures since 2015. From the authors’ own experience, the classroom atmosphere gets more active and the involvement of the students for the teaching improve markedly, largely receiving the desired effect.

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