Combining Problem and Lecture Based Learning for Production System Modeling and Simulation Course in Industrial Engineering Education

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Abstract - Production system modeling and simulation is an important technical course of industrial engineering education for undergraduate students. This paper presents an initial implementation of hybrid problem based learning (hPBL) method for the course, which combine problem-based learning (PBL) and lecture based learning (LBL) in teaching and learning process. The learning object and content of the course is introduced. An hPBL curriculum schedule is design for the course within a large classroom environment. The various open end problems of modeling and simulation are formulated for group collaborative learning. During learning procedure, the basic concepts and problem solving steps are introduced at the LBL classes, while the PBL classes focus on solving of selected problems. The hPBL greatly arouses the learning interest and improve the learning efficiency of students. The course is evaluated based on the students’ survey. The examination score of hPBL is analyzed and compared with pure LBL classes.

Keywords – Industrial engineering education, lecture based learning, problem based learning, production system modeling and simulation

I. INTRODUCTION

In the new millennium, innovation will be the very important motivation for China development. Besides the technical ability personnel, more and more person with creative thinking ability will be needed. The engineering education must enable students to meet the growing challenges and the increasingly more complex demands for the work. Professional problem-solving skills dealing with uncertainty and interpersonal communication ability are two important qualities for the new era students. However, today’s engineering graduates lack these skills and have difficulty applying their fundamental knowledge to problems of practice. This requires that teaching, learning and assessment are conceived in such a way that they provide students with several opportunities to support the development of these competencies [1].

Problem-based learning (PBL) originated in medical education to enable a smoother transition of students into clinical education at hospitals, and prepare them better for professional practice [2]. PBL represents a major shift in educational paradigm to problem-based, process-oriented, discipline-integrated, and student-centered learning in collaborative small groups. The goals of PBL include fostering active learning, interpersonal and collaborative skills, open inquiry, real-life problem solving, critical thinking, intrinsic motivation, and the desire to learn for a lifetime. The traditional lecture-based learning (LBL) method is deductive, which begin with theories and progressing towards application of those theories. The teacher presents information without a discussion of why the mathematical models are being developed and what practical problems they will solve [3].

PBL is a philosophy that has to be adapted to the specific situation of a university and the nature of the discipline or subject field in which it is applied. Problem-based approaches to engineering courses may better prepare engineers for the types of work they will actually perform upon graduation and entry into professional practice. A number of studies have reported engineering implementations of PBL and some have identified challenges that were experienced by the engineering student.

The integration of the PBL method into the overall teaching methodology was implemented within the Department of Electrical Engineering [4]. The role of PBL facilitators and the characteristics of the PBL problems were posed in the courses. The usual way of learning technical knowledge about a microcontroller is by reading relevant handbooks and textbooks. Tse and Chan [5] proposed using the problem-based learning to convey such engineering knowledge. The case study in biomedical materials course [6] showed that students made significant improvements in their problem-solving skills, written communication and self-directed learning, which are defined as the desirable professional engineering skills for engineering students. Sanjeev et al. [7] presented the design and construction of a PBL-based course in materials science at the junior level in a mechanical & aerospace engineering department. They assessed the ability of a PBL course based on longer complex problems to enable students to learn both fundamental knowledge of the subject matter and also problem solving skills and contrast it with outcomes in a traditional lecture based course.

Barrows [2] admitted that varying degrees of PBL are often necessary, given the wide variety of contexts in which the method was attempted. One of the challenges the teachers face when implementing PBL is student resistance and discomfort when transitioning from the traditional curriculum to a PBL curriculum. Therefore a hybrid problem based learning (hPBL) maybe an eclectic choice. More importantly, the studies delivered through a combination of PBL and lecture format also showed a significant improvement of student problem-solving skills [8]. The hybrid model is favored as an attractive model in consideration of time, efforts and resources for its acceptance and implementation. Retention of a significant

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portion of the didactic lectures in hPBL puts the teachers and students in a comfort-zone and thus faces less resistance to curriculum change [9]. It is believed that the hPBL method may provide a more challenging, motivating and enjoyable approach to education [10].

In China, the LBL approach still dominates as the preferred teaching approach from the primary schools to the universities, in which most of the focus is on content coverage. The students are habitual to traditional teaching and evaluation methods. In order to make the students progressively accommodate to the transition, the hPBL approach is a compromising appropriate choice. This paper is the preliminary attempt to adopt the hPBL to the course of industrial engineering education.

II. COURSE DESIGN

A. Course object and content

Industrial engineering is concerned with the development, improvement, and implementation of integrated systems of people, money, knowledge, information, equipment, energy, materials, analysis and synthesis, as well as the mathematical, physical and social sciences together with the principles and methods of engineering design to specify, predict, and evaluate the results to be obtained from such systems or processes [11]. Production system modeling and simulation (PSMS) is one of the main courses offered to the third year students of industrial engineering in the college of mechanical science and engineering, Huazhong University of Science and Technology (HUST).

The main objective of PSMS course is to provide an insight into how simulation modeling can aid in effective decision-making for discrete event system (such as production, manufacturing, logistics facilities, supply-chains, service et al). The students should understand the general concept and be provided with the primary problem solving ability for the practical different types of real life complex problems of business and industry after completing the course. Therefore, the course covers topics and issues such as the fundamental logic, structure, components and management of simulation modeling for discrete event system, the analytical techniques for interpreting input data and output results pertinent to simulation models based on probability theory, the modeling and simulation methods for the queue system and inventory system. It is also demonstrated how computer simulation can be used to successfully model, analyze and improve systems under study. Some simulation software (Arena, Flexsim and Quest) is used to build and execute the models.

There are 32 academic hours for this course. It was taught using traditional didactic teaching which included four hours of lectures in seven weeks. In the eighth week, four hours modeling and simulation exercise will be carried out for an example system by using chosen commercial discreet event system simulation software. In the classroom, additional lecture notes (PowerPoint slides) are used as the main media to teach the course content. Some home works are delivered after each class in order to force the students comprehending and reviewing the knowledge. The final exam including main memorial knowledge will be hold to give the score of every student. According to the past teaching experience, the students will have ideal scores for the course. But the problem-solving ability cannot be confirmed when students face with the new practical cases.

Problem-based learning in engineering is a natural fit since it espouses developing students’ ability to solve ill-structure problems, increasing critical thinking skills, and broadening their communication skills [12]. Considering the education situation in China and its practical application for the future engineering career, the hPBL learning and teaching method is adopted for PSMS in order to motivate the problem solving ability of the industrial engineering undergraduate students of HUST.

B. A hPBL method for PSMS

Because of the limited academic hours for PSMS, the teaching process should be more effective for course content and practical exercise. Engineering students feel that less content is covered when inductive teaching is used compared to deductive, lecture-based approaches. Students very often are unable to solve a problem if they do not know the steps or sequence to follow [6]. The teacher has to carefully think about what content to teach with the problem based approach and what to cover with lecture in hPBL process.

Engineering has a hierarchical knowledge structure so that students need to have adequate basic knowledge to be successful at learning later concepts [13]. For the PSMS course, the basic concepts and the main steps of modeling and simulation are challenges to students without any preliminary knowledge about the course. Consequently, it is important to teach these knowledge by lecture before using problem-based learning, as the PBL method will not compensate for students’ lack of proficiency in those basic concepts [14].

For our teaching reform, Fig. 1 shows the schedule of the PSMS course combined the LBL class (grey block) and PBL (white block) method. It can be seen that the content proportion of the teacher centered and the students centered are changed gradually with the proceeding of the course. In the first half of the schedule, LBL method is mainly used to teach the basic concepts and techniques of modeling and simulation, which will quickly set up the essential foundation for the course. In the second half of the schedule, PBL method will be dominated to give the students chance for exploring the solution of the simulation problems. At the beginning of the class, a set of modeling and simulation problems are presented to the students. The problems mimic the real modeling and simulation scenario and correspond to the job specification of the assigned role as industrial practitioners. It is more like a project, but will be solved paralleling to the course. Besides the project problems,