

Construction of New Petroleum Engineering Curriculum in the Context of Emerging Engineering Education: An Example from Xi'an Shiyou University

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Abstract—This paper first review the current petroleum engineering curriculum of Xi'an Shiyou University, and examines its adequacy to deal with technological advances in petroleum industry and emerging engineering education needs. Changes to the curriculum structures and contents are presented.

Keywords—Petroleum Engineering; curriculum; emerging engineering education; Outcome based Education

I. INTRODUCTION

The goal of emerging engineering education is to set up and develop novel engineering majors which support new economy and new industries in China such as artificial intelligence, robots, intelligent manufacturing, cloud computing, etc. besides upgrading and reforming traditional engineering majors. Since the traditional definition of engineering can no longer meet the development speed and scale of engineering in today's era, the concept of the emerging engineering education arises at the moment. The main research content of the emerging engineering education is embodied in five new ideas, namely, new engineering education concept, new discipline and professional structure, new talent training method, new education and teaching quality, and new classified development system. Compared with traditional engineering, the emerging engineering emphasizes the practicability, cross-cutting and comprehensiveness of disciplines, especially the close integration of new technology with traditional industrial technology [1-3].

The petroleum industry has seen significant technological development including deep water development, unconventional oil and gas resources development such shale gas and oil. For example, shale gas will soon become the major supply of energy. These new developments pose challenges for the construction and development of the petroleum engineering major, and puts forward higher requirements for developing the professional manpower. How to achieve the breakthroughs in professional construction and talent training under the emerging engineering situation is the key to the transformation and upgrading of the new engineering construction of petroleum engineering major.

II. CURRENT PETROLEUM ENGINEERING CURRICULUM

A. Data and Information

Xi'an Shiyou University (XSYU) is a sole institute in the Northwest of China known for petroleum and petrochemical engineering programs. College of Petroleum Engineering (PE) is one of the leading colleges. Currently, the school consists of three departments: Petroleum Engineering, Oil & Gas Storage and Transportation Engineering, and Offshore Oil & Gas Engineering. By the end of 2015, the school has a total number of 2509 enrolled students, including 2070 undergraduate students (163 international students), 439 graduate students. The faculty team has 125 members. The selection is considered as a good sample for our study since the petroleum engineering curriculum is quite similar to other universities in China.

Table I lists the degree requirements for the bachelor of Engineering degree in petroleum engineering in percentages of the total degree credit hours required, categorized into courses in Petroleum Engineering, Basic Sciences (Physics, Mathematics, Chemistry, Computer), Social Sciences, Geosciences (GS), English and Other. The category labeled "Other" in the table includes other subjects such as physical and career education, etc.

TABLE I. DEGREE REQUIREMENTS FOR THE PETROLEUM ENGINEERING SCHOOL

Course	Credit Hours
Petroleum Engineering	23%
Basic Sciences	21%
Social Sciences	16%
Geosciences	6%
English	7%
Practical learning	20%
Other	7%

B. Review of Curriculum

According to the data presented in Table I, the following observations can be drawn:

- 1) The petroleum engineering courses content is about 23% of the total degree credit hours requirements.
- 2) The second highest content is the basic sciences about 21%.
- 3) The third highest content of the curriculum is the practical learning.
- 4) The social sciences constitute a 16% of the total credit hours.
- 5) The English is about 7% of the total credit hours.

The petroleum engineering content of the curricula is less than one-third of the total required credit hours, which is few and inadequate to provide the graduates with the knowledge and skills which the petroleum industry would like to have. The same contents have been for decades. While the industry is developing advanced technologies at a rapid pace, petroleum engineering education has experienced very little changes. Although some courses have made a few changes such as production decline analysis and pressure transient analysis in reservoir engineering courses, the materials introduced in the 1970's are still using in the most of courses. The curriculum does not adequately present the very important shale gas developments.

Petroleum engineering education would not be complete without acquiring reasonable practical experience, which is now fulfilled in the curriculum by capstone courses, field trip and thesis projects. Since real data and project are not used, the final result of the practical learning is ineffective in many cases.

The teaching model is that an instructor delivers course materials in the classroom and tests the student learning outcomes through assignments, quizzes, and exams. Most of instructors are teaching their courses in complete isolation from other courses without providing students with information regarding the importance of the material taught in relation to other courses, to the overall objectives of the degree, and most importantly to practical and field applications [4].

The new hired faculty members usually cannot relate their teaching courses to petroleum field operations and applications since they do not have the appropriate experience. It has been suggested that oil or service companies provide the young faculty practical opportunities including summer internship or joint research projects during their first two years of university employment.

III. CONSTRUCTION OF NEW PE CURRICULUM

In order to cultivate innovative and entrepreneurial talents of petroleum engineering that meet the requirements of the emerging engineering, the existing curriculum needs to be updated and reconstructed. Systematic innovative and entrepreneurial training, and engineering practice will be carried out throughout the four-year teaching process, the practical education is emphasized, and the Engineering

subjectivity of Engineering Education is embodied. The curriculum promotes innovation and entrepreneurship, and engineering ability is improved as a main goal. The curriculum re-orient objectives, reforms the teaching mode, updates the curriculum content, and guides and encourages the petroleum industry to deeply participate in the process of talents training.

A. Optimization of Curriculum

1) Modular curriculum. Around three core courses, curriculum modules are set up the total number of credit hours, reflecting the achievement degree of personalized training. At the same time, in order to meet the requirements of personalized teaching, a personalized teaching system based on the principles of minor courses and mutual recognition and replacement of courses should be established.

2) Serialization of practical teaching. The practical teaching is adjusted comprehensively, for example, the scattered practical training attached to different courses are formulated into group projects to shorten the distance between the courses and the industry.

3) Popularization of scientific and technological activities. The advantages of tutorial system and scientific research base are taken, encouraging the majority of students to participate in scientific activities to implement the second class.

4) Diversification of assessment methods. The course evaluation is changed to promote the change of teaching and learning methods. For example, the assessment can be divided into: final examination, quizzes, group project, technical paper review, classroom discussion, presentation, etc.

5) Diversification of teaching teams. It is no longer single teacher is responsible for a course, but a team to promote the interactions between the instructors.

B. Planning of Course Content

1) Strengthen the core courses. At present, we have already set up 6 core courses including drilling engineering, production engineering, reservoir engineering, well completion engineering, enhanced oil recovery and shale gas development. We are concentrating on reforming the cores high-and optimize the contents of the core courses.

2) Remove outdated and backward course contents. The curriculum must be developed according to the emerging engineering requirement and the petroleum industry needs.

3) Integration of elective courses. It is necessary to integrate elective courses, such as prevention of formation damage, drilling and completion fluid, workover engineering.

4) Develop new courses. We have tracked recent technological development in the petroleum industry and artificial intelligence, developed shale gas development and AI in Petroleum Engineering courses.

IV. NEW PE CURRICULUM

The new curriculum integrates systematic innovation and entrepreneurship training and engineering practice throughout the four-year teaching process. Taking the promotion of

innovation and entrepreneurship as the main line and the realization of engineering ability as the interior line, we have re-orientated the curriculum objectives, reformed the teaching mode and updated the curriculum structure and content. We have built four typical courses in the context of the emerging engineering education, including courses to stimulate students' interest in the frontier of petroleum industry, courses with field application, courses to cultivate the ability of life-long learning, and courses to train students' innovation and entrepreneurship.

Table II lists the percentages of the total degree credit hours required for graduation. The new curriculum has the following features:

1) Modular curriculum relates the core courses to each other and emphasizes their relevance to practical applications. For example, The reservoir engineering course is organized around three teaching modules to offer students with a full understanding of the fundamental concepts of field planning and development, well performance analysis and evaluation. The modules are linked by completing capstone projects using real field data.

2) The credit hours to petroleum engineering content of the curriculum are added by taking some credit hours from the social sciences and Other to account for the advanced technologies in the industry. New courses are introduced including shale gas development and artificial intelligence in PE. Technological advances in the unconventional oil and gas development have made it possible to generate tremendous amount of data, called Big Data. The big data has by 3V's properties, namely volume, velocity and variety [5]. The petroleum big data calls for more sophisticated data driven methods which include machine learning algorithms to convert the raw data into meaningful knowledge.

3) The practical learning becomes the second highest content in the curriculum increasing from 21% to 25%, mainly due to the addition that engineers in the oil companies involves faculty in mentoring students on internships and allow both work on real field projects which could add value to the companies while providing the practical experience to both students and faculty.

4) OBE (Outcome-based Education) concept was introduced in the designing the curriculum [6-7]. The focus is to have a clear idea of the ability and application level that students should achieve when they graduate, and then to update and refine the curriculum according to the petroleum industry needs to ensure that students achieve expected goals by integrating OBE engineering education with the curriculum.

TABLE II. DEGREE REQUIREMENTS BASED ON NEW PE CURRICULUM

Course	Credit Hours
Petroleum Engineering	28%
Basic Sciences	21%
Social Sciences	12%
Geosciences	6%
English	7%
Practical learning	25%
Other	3%

V. CONCLUSION

1) The current petroleum engineering curriculum at XSYU are ineffective in talents cultivation regarding with new and future technological developments and challenges in the petroleum industry.

2) Petroleum engineering course materials are still the same as what was taught 30 years ago to support unconventional resources exploitation and development.

3) Social sciences and other irrelevant subjects consume valuable credit hours which could be used strengthen and improve the content of petroleum engineering courses and practical training to cope with unconventional resources exploitation and development.

4) We have developed the new curriculum to promote creativity, practical learning, problem solving and life-long learning in the context of emerging engineering education.

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