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The comparison between series and parallel: Integrated experimental teaching model for pharmaceutical engineering students based on criteria for accrediting engineering programs in China

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ABSTRACT

The thought of criteria for accrediting engineering programs was introduced into major experiments for pharmaceutical engineering in Wuhan Institute of Technology. Aiming at the disadvantages of experimental teaching in pharmaceutical engineering in China, the integrated experimental teaching mode was introduced. Through the comprehensive study of a drug, original drug synthesis, pharmaceutical analysis, pharmaceutical preparation, and pharmacology experiment courses are linked together. Systematicness and integrity of the experiment were enhanced through re-integrating the corresponding experimental content and projects; the composite knowledge structure with the longitudinal and transverse connection of theoretical knowledge obtained through experiment was formed. With the evaluation criteria of pharmaceutical engineering experiment based on Chinese “Criteria for Accrediting Engineering Programs”, by comparing series and parallel teaching modes in a three - year period (2013–2015), the effects of experimental teaching in series and parallel on relevant knowledge structure of 324 undergraduate students (a total of 324 undergraduate students, 99 in 2013, 122 in 2014, 103 in 2015) of pharmaceutical engineering were studied. Not only to let them experience series, but also to let them experience parallel. The correlation data were compared using *t*-test to compare the differences between groups, final assessment data for students were subjected to a comparative statistical analysis. The results showed: in comparisons of students with higher scores in experimental report, experimental operation, and mastery of relevant knowledge, the proportions of the students in series teaching were respectively 40.50%, 11.40%, and 25.03% higher than those in parallel teaching; the proportion of students satisfied with series teaching was 23.03% higher than the proportion of students satisfied with parallel teaching. Through a comparative survey of students’ approval of series and parallel teaching, it’s discovered that series teaching could arouse the students’ interest in the experiment course more than parallel teaching could, make them clearly recognize the real significance of the experimental project training, and eliminate the adverse effects of traditional parallel teaching on the students to a certain extent. In the series integrated experimental teaching, students’ learning initiative and creativity were fully demonstrated. With the comprehensive evaluation system issued by Wuhan institute of technology, the influence of series teaching method on the students’ academic abilities was studied through the comparative analysis on the scores of the students’ graduation theses before (2011–2013) and after (2014–2016) the series teaching reform. The results showed: the series teaching method could significantly improve the quality of graduation thesis in the subject implementation, innovation ability, and subject progress. The work can be used for reference by other major engineering courses, thus integrating related courses into a whole, and promote the sustainable development of Engineering Education in China.

1. Introduction

Pharmaceutical Engineering in China, which is a cross disciplinary discipline with strong engineering technology based on

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chemistry, pharmacy, biotechnology, engineering and so on, is the newly established major in 1998 after the adjustment of undergraduate major in Ministry of education, and belongs to chemical engineering and pharmacy (Ministry of Education of the People's Republic of China, 1998). Experimental teaching of pharmaceutical engineering is an important part of the major curriculum system, and is an essential way to cultivate students' ability of practical innovation, scientific thinking and comprehensive analysis (Wu et al., 2001). In recent years, the experimental teaching has attracted more attention of educators due to its special role in the cultivation of science and engineering students' innovative spirit and practical ability (Huang and Huang, 2013).

Higher education is a critical leverage point in creating a sustainable society (Dyer and Dyer, 2017). Skill acquisition is important in engineering education, especially skills involving practical problem solving (Hettiarachchi et al., 2016), and experimental skill is one of them. The Accreditation Board for Engineering and Technology (ABET) approved the Engineering Criteria 2000 (EC, 2000) for accrediting engineering programs in the United States and made the new criteria effective beginning in the fall of 2001 (Kurt, 2000). In China, with the introduction of "Criteria for Accrediting Engineering Programs" in recent years, there is no unified criterion in the university curriculum, and lack of researches and examples in this area (Wang et al., 2016). Pharmaceutical engineering in Wuhan institute of technology is the national characteristic major and provincial brand major, and has accumulated a lot of practical experience with development for nearly 40 years. The teaching reform and research of pharmaceutical engineering have won the first prize teaching achievement in Hubei Province for 3 times, and made a series of achievements of teaching reform. Especially in the specific aspects of the curriculum reform, there is a deep accumulation.

Higher education institutions across the world are increasingly placing an emphasis on students' acquisition of a broader range of skills or attributes within the taught curriculum (Filho et al., 2016). "An ability to design and conduct experiments, as well as to analyze and interpret data" is one of the program educational objectives in student outcomes of criteria for accrediting engineering programs in the United States (ABET Engineering Accreditation Commission, 2012). Subsequently, graduation requirements as part of criteria for accrediting engineering programs in China made it clear that "students could carry out the research of complex engineering problems with the principle of science and the scientific method, including experimental design, analysis and interpretation of data, and reasonable and effective conclusion obtained through the information synthesis" (China Engineering Education Accreditation Association, 2015). With the cultivation of the ability as the teaching objective, at the same time, in view of the shortcomings and deficiencies of traditional experimental teaching in many domestic colleges and universities, an integrated experimental teaching mode could be constructed, which could be combined with the experience and the conditions of the major education and training objectives. The mode could set up experimental content comprehensively and systematically through reintegration of experimental content, make the experimental procedure and the design process have continuity, and experimental projects have permeability, so as to effectively improve the quality of experimental teaching. The major experimental teaching system is composed of drug synthesis, pharmaceutical analysis, pharmaceutical preparation, and pharmacology experiments, could lay the foundation for students in the future production, testing, research and development of new drugs in pharmaceutical enterprises.

2. The integrated experiment

2.1. The concept of integrated experiment

Following the rules of students' understanding and the requirements of the experimental teaching syllabus, the integrated experiment is to reasonably arrange the experimental content and the setup time, set up experiments in a hierarchical manner and form experimental curriculum system. The integrated experiment is arranged from shallow to deep, from simple to complex, from the individual unit to the comprehensive application, make each experimental content and training project completed systematically, comprehensively and reasonably (Li and Su, 2009; Pearson and Hubball, 2012). Through reasonable integration of the experimental content and progress, the level progression from a single simple experiment to the comprehensive design experiment, and cross and penetration between related subjects could be realized.

2.2. The advantages of building integrated experimental teaching

Through integrated pharmaceutical engineering experimental teaching reform, the content of experiment, the operation, and the analysis method could be effectively integrated and be related to the classroom knowledge. This allows the experiment to change from simple verification to comprehensive design and application. Integrated experimental teaching model has the following advantages:

- The combination of theory and practice is formed in a large degree, the cross penetration of relevant subject knowledge has been realized, so that students have a more systematic and comprehensive study (Froyd and Ohland, 2005; Zhang et al., 2014).
- The experimental goal is clear, the repeated experiment could be avoided, and integrating the original several single experiments together (Bécu-Robinault and Tiberghien, 1998) could avoid unnecessary waste of resources.
- As far as the experimental content settings and the experimental projects are concerned, the experiment course is a kind of inquiry-based learning for students (Bernard et al., 2007). With level progression, composite experimental training from the shallow to the deep could enable students, from perceptual knowledge to rational cognition, to become the protagonist of the experimental teaching. The teacher just needs to guide the key point in the experiment, so as to improve the students' active responsibility on the experimental operation sense and enhance students' sense of inquiry (Phelps et al., 2008).
- Mental preparation combined with physical practice can beneficially affect students' laboratory skills (DeMeo, 2001). The relevance and systematicness before and after the experiment could increase the students' enthusiasm and participation. The results of the previous step will imperceptibly set up problem scene for later experiment. Students with questions and reflections could take seriously every step of the operation in the next experiment; at the same time, through independent thinking of experiment, students could obtain the experience of taking the initiative to acquire knowledge in problem solving experiment, the experimental interest and ability to use their own knowledge to solve practical problems could be improved.