

# *Experimental Teaching Reform under the View of Innovative Ability Cultivation*

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**Abstract**—Given the long-standing issue of “laying too much stress on theoretical knowledge teaching, while neglecting the cultivation of practical ability” in China’s higher education being increasingly exposed, the cultivation of undergraduates’ practical and innovative ability has been a matter of wide concern both to educators and the educated. Considering the needs of innovative ability foster of the local college students, according to the cultivating of experimental ability, exploring and studying ability and innovative ability, some important problems consisting in the integrated reform of experimental teaching, such as the educational concepts, the setting up of the class system of experimental teaching, the teaching method reform and the building of experimental teachers were discussed.

**Keywords**—innovation ability, experimental teaching, integrated reform

## I. INTRODUCTION

Expanding education reform regarding innovation and entrepreneurship in colleges and universities is an urgent need in light of the ambitious implementation of state-driven innovation strategies and an increase in economic quality and efficiency. Moreover, it is also an important measure for promoting the comprehensive reform of higher education and facilitating higher-quality entrepreneurship skills and employability among graduates. Widening this reform is of great importance for pushing forward teaching reforms in higher education; promoting the closer integration of higher education with science and technology, and economy and society; accelerating the cultivation of innovative and entrepreneurial talent with broad vision, an innovative spirit and daring to devote themselves to their practice. This will, ultimately, provide powerful intellectual support for building an innovation-oriented country, achieving the “Two Centenary Goals,” and realizing the great dream of rejuvenating the Chinese nation.

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being increasingly exposed, the cultivation of undergraduates’ practical and innovative ability has been a matter of wide concern both to educators and the educated[1]. For the past few years, experimental teaching reform has made a number of fruitful results. A large number of basic experimental teaching demonstration centers and national provincial key laboratories have been established. Especially, a breakthrough progress has been made in instituting of the integrative, design, exploratory and innovative experimental projects, which has played a positive role to improve college students’ practice ability and innovation ability. But as shown by graduate surveys, college students in China are not very satisfied with the actual effects of the cultivation of practical ability cultivation that they undertake during their academic years. This suggests that colleges and universities have failed to achieve the expected outcomes in terms of the cultivation of these abilities among their students[2]. In the face of such a reality, local colleges and universities, especially those mainly working on cultivating practical talents, arguably have to re-examine the comprehensive reform of experimental teaching, and clearly define and efficiently solve the following critical and urgent problems.

## II. STRAIGHTEN THE FUNDAMENTAL AIM OF EXPERIMENTAL TEACHING, THUS PROVIDING A CLEAR GUIDE FOR THE COMPREHENSIVE REFORM OF EXPERIMENTAL TEACHING

The traditional experimental teaching is teacher-centered and teaching- focused, meaning that the entire teaching design which is conducted around “teaching” and the “learning” of students is limited within it. In this context, experimental ability is treated as a skill and imparted in the form of “knowledge”. In this experimental teaching mode, the accumulation and development of students’ autonomous, dynamic experimental exercise ability, innovation consciousness and innovation ability were not put as the main teaching purpose. This leads to fact that the students’ experimental ability and creative ability are “natural” accumulation, and consequently results in the students’ lack of

the ability of applying knowledge creatively. Given this situation, what kind of experimental teaching is appropriate in China's colleges and universities, especially those aiming at cultivating first-line, high-level technical talent in education and teaching, engineering technology, and other related fields? What is the real purpose of experimental teaching?

Experimental teaching is defined as a teaching form under which students are directly or indirectly instructed by their teachers to learn, research and explore through experimental methods. If theoretical teaching aims at imparting existing knowledge and purely conceptual contents to students, in experimental teaching students should be able to train their operational abilities and cultivate an innovative consciousness; that is, the ability to explore and research new problems using existing theories. According to this definition of experimental teaching, its intrinsic aim should be to cultivate students' operational ability, exploration & research ability, creative ability and innovative ability. If high vocational and technical teaching focuses on the cultivation of students' operational skills, then college/university education - in addition to experimental operational ability - should focus on cultivating students' innovative ability and that of exploring and researching new problems with existing theoretical knowledge. Only when management cadres and teachers in higher institutions change the original wrong view of experiment teaching serving the theoretical teaching, and from the angle of cultivating the ability of students, grasp the student ability training as the main purpose of the experiment teaching, and carefully achieve this goal in the experiment teaching process, the problem of insufficient exercise in the students' experimental ability and innovation ability should be solved fundamentally. Otherwise, even if possessing a more advanced laboratory instrument equipment and more excellent experimental teaching environment, the student could not obtain the experiment ability and innovate ability. The view of equipment and conditions determining the quality of teaching is wrong. In the experiment teaching of students' ability training, the experiment equipment and conditions are a necessary carrier or medium, but the key factors are cultivating modes, cultivating aims and the student situations in the influence on students to acquire the exploration ability, research ability, innovation ability.

### III. WITHIN THE AIM OF ABILITY CULTIVATION, A SCIENTIFIC EXPERIMENTAL TEACHING CURRICULUM SHOULD BE CONSTRUCTED.

In order to construct a scientific and rational experimental teaching curriculum, we need carefully to analyze and research the specialties, discipline fields, basic status, overall cultivation aims, service orientations and other factors relevant to students themselves, breaking down practical operational ability, exploration and research, and innovative ability in specific details, and thereafter cultivate them through specific courses. The experimental teaching curriculum system can be categorized into two key aspects: experimental courses to be taken by students during their academic years; and the experimental content to be learned in each course. In recent years, the reform of experimental teaching content has mainly focused on reducing verification experiments and increasing

comprehensive and design-oriented experiments; satisfactory results have been achieved. Despite this, there has been little change in the experimental curriculum structure of each specialty program, and the coordination and unification of experimental content across the various experimental courses has been less than satisfactory. In fact, the reform of the teaching content of each experimental course remains in the state of "each fights its own battle".

Many experimental courses have been established as necessary by related theoretical courses, making it difficult to design each course and thus resulting in a lack of comprehensive experimental courses. In addition, there is also a lack of integrity in the setting of each experimental course, and in the design of experimental contents for each specialism. It is, therefore, arguably necessary for various specialties to organize experts to determine the basic operational skills, applicability of the knowledge they have gained to practical scenarios, and the level of innovative ability that the students should possess. Following this, and in accordance with the conditions of different colleges and students, specific experimental courses and contents should be set uniformly, so that basic operational skills experiments can be rationally matched with comprehensive, design-oriented experiments and opening experiments in each experimental course[3]. Only by this process, a scientific and rational experimental teaching curriculum system can be constructed to provide a powerful guarantee for the cultivation of experimental and innovative ability.

On the experiment contents, the rate of the exploratory experiment would be increased properly[4,5]. Different from general validation experiments, exploratory experiment is to explore the unknown phenomena and the experimental results, while the verification experiment is to verify the known theory and predictable results. Exploratory experiment is designed and completed independently by the students under teacher's guidance; the verification experiment is carried out in accordance with the known experimental scheme. An exploratory experimental result is uncertain, the verification experiment result is certain. In exploratory experiment, students are always in independent thinking and actively exploring process, and can try to explore the unknown fun. It can stimulate students' interest in exploring the unknown, stir students' study initiative, and improve student's independent study ability and creativity. Exploratory experiments can cultivate and enhance the consciousness of the students' experiment, help the student to learn and pay attention to study through the experiment to solve scientific and engineering problems.

### IV. THE REFORM OF EXPERIMENTAL TEACHING MODES AND METHODS IS THE KEY DETERMINANT OF THE QUALITY OF EXPERIMENTAL TEACHING.

Traditional teacher-oriented experimental teaching places students in a subsidiary role. Generally, the preparation for each experiment is undertaken by teachers, while students only need to conduct the experiment following detailed steps provided in their textbooks. Given that no independent thinking or work is involved on students' part, they usually lack an

accurate impression of the contents of the experiments they conduct. This outdated experimental teaching method with low efficiency must be reformed.

#### A. *Radical reform of experimental teaching modes and methods*

We must advocate the experimental teaching mode of "brief and succinct teaching by teachers, and combination of reflection and practice by students," and abandon "duck-stuffing", cultivating students' awareness and ability by enabling them independently to complete their experiments. For experiments relating to basic skills and operations, teachers should work in modern teaching facilities, and adopt graphical representation and other methods to provide careful explanation and meticulous instructions. For designed experiments, teachers should pay attention to guiding students to design a rational experimental program, instead of doing it for them. It is very important that students are guided to participate in the whole experimental course, including the preparation of reagents, instruments and equipment, etc. This mode of teaching can not only stimulate students' interest in the experiment and mobilize them to participate in it, but also encourage them fully to understand the whole experimental process, clearly appreciate the importance of each link influencing the success of the experiment, and gradually cultivate their scientific literacy. For the experiments not involving basic skills or operations, teachers are advised to complete the role transition from being "teaching-oriented" to "instruction-oriented", while students transit from "experiment" to "test".

Regarding the assessment of experimental results, the focus should be determined by the different experimental types. For example, with experiments involving basic skill and operation, the assessment should focus on students' degree of mastery over basic operations; for comprehensive and design-oriented experiments, the assessment should concentrate on their experimental design abilities and on independently completing the experiment, as well as on their initiative and creativity reflected during the process.

#### B. *Strengthening the reform of experimental textbooks*

The biggest weakness in current experimental textbooks is too comprehensive and meticulous in contents. Only need to "according to their order", students can know the experiment scheme, method, step, phenomenon and reason, even the result of the experiment, without independent thinking. This is one of the important reasons causing students are not good at thinking, not good at designing experiment scheme, not good at his check information, not good at solving the problems in the experiment. The experimental textbooks must be rewritten combining the experimental curriculum and experimental teaching contents and reform. The student must be prevented to have the dependence on the experimental textbooks. The level of comprehensive and design experiments must be paid particular attention to ensure that the student shall refer to a variety of references to carry on the design of experiments.

#### C. *Strengthening the application of modern education technology in experimental teaching*

With the increasingly widely available applications of computer technology, many fields are moving in the direction of computerization, networking and virtualization. The teaching of experimental courses, by virtue of its strong guidance and complexity of management, are especially suitable for new reform through the application of multimedia, virtual network and other computer technology[6]. This is because, firstly, in the explanation of basic skills, basic operational experiments and other relevant experiments, the multimedia courseware prepared by animation and imaging technology can be used to improve students' perceptual understanding and make teaching more visual. Secondly, online simulation teaching software can be developed to provide students with a more vivid and convenient experiment preview via the teaching platform of the campus network, and thus make their self-study more convenient. Finally, network resources can be enriched to improve the functions of network in teaching. Colleges, universities and schools can create common resource libraries, links, navigations and so forth on their websites, thus making it convenient for students to retrieve data, enquire as to primary materials, and so forth.

#### V. BUILDING A HIGH-QUALITY EXPERIMENTAL TEACHING TEAM PROVIDES AN IMPORTANT GUARANTEE FOR THE SUCCESS OF EXPERIMENTAL TEACHING REFORMS

In experimental teaching, contact opportunities between students and teaching staff obviously increase. This, then, means that the teaching and practical experience, innovative awareness and other key qualities of teaching staff exert a significant influence on the cultivation of students' comprehensive and experimental abilities. On that account, building a stable and high-quality experimental teaching force is an especially urgent task in the context of experimental teaching reform. In the USA, most experimental technicians - the backbone force of laboratory work - have a Bachelor's degree or above, with roughly 50% also holding Masters degrees and/or Doctorates. This explains and underlines their orderly laboratory work and excellent practical effects of their experimental teaching. Compared with them, there is still a huge gap that China needs to narrow in terms of the quality of its laboratory technicians. Moreover, China's colleges and universities need to reinforce their guidance and support policies to attract high-quality talent with a high academic level and a strong innovative ability for experimental teaching. Experiment teachers have to conscientiously perform the duty of a teacher in the work, wholeheartedly service for experimental teaching. Experiment teachers have to love experiment teaching in the thoughts, strive to build a laboratory, dedicate themselves to the experimental teaching, consciously abide by the rules and regulations of the school. Experimental teachers should consciously safeguard the interests of the school and students. University experiment teachers shoulder the responsibilities of students to develop good moral quality. Laboratory has become an important base of fostering talents, so the experiment teachers should have the lofty dedication, enthusiastically work for the laboratory construction and experiment teaching, contribute to the construction of the

laboratory and experiment teaching. To foster high level, high technical personnel possessing thinking ability, innovation ability and problem solving ability, to improve the quality of experiment teaching, the experiment teachers are the key. Schools should not only have the experiment building and advanced equipment, but also the abundant experiment teachers. So, the school must bring in some high title and highly educated teachers to work in the laboratory. Meanwhile, young teachers' training of professional knowledge and experimental technology must be strengthened to effectively improve the quality of experimental teaching.

As long as China adheres to the teaching aim of “the cultivation and development of students’ innovative ability,” constructs a scientific experimental teaching curriculum system and invests passion and energy in the practice of experimental teaching to achieve this aim, the country will be able successfully to explore a new path that suits experimental teaching in local colleges and universities. Furthermore, these actions will arguably improve the actual effect of experimental teaching in the cultivation of students’ innovative ability.

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