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Construction of experiment teaching demonstration center with interests driven, independent experiments, and exploratory innovation

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ABSTRACT

Experiment teaching is the essential part of engineering undergraduate teaching and the important way of strengthening theory teaching content, training students' practical ability and expanding students' innovative thinking. With the goal of "strengthen experiment teaching, practice link and theory teaching, emphasize ability training, improve teaching quality", the research and practice of exploratory innovative experiment teaching system and platform was fully carried on in this study. And the effective complementary atmosphere of theory teaching and experiment teaching has been formed, by building the experiment teaching system—with students as the center and ability training as the core—to change the students' way of accepting passively and practicing largely and repeatedly, and to guide students to independently participate in the whole process of learning, practice and doing pioneering work, with the support of national engineering mechanics demonstration center and strengthened platform. That fully played the role of the experiment teaching in the cultivation of talents, and maximized the students' gains.

KEYWORDS

Experiment teaching; Virtual simulation; Exploratory; Innovation; Reform.



INTRODUCTION

The general idea of this study is that emphasizing system reform, carrying on the research and practice at three levels: education idea, cultivation mode and operating procedure, following the rule of talent growth, forming the management mode of six-in-one—Dean's Office, Youth League Committee, College, Center, Teacher and Group Leader—according to the characteristic of students in different major, the idea that innovation comes from practice and joint direction by “double-channel of in-out class, combination with learning, research and production and four-in-one: school, center, college, enterprise” and greatly improving students' innovative practical ability. At present relevant majors of more than 300 domestic colleges and universities learned and draw the training mode, method and measure of exploratory innovative experiment teaching system and platform, while relevant majors of more than 90 colleges and universities purchased the equipments and relevant resources having intellectual property rights. That has a positive influence on the reform of undergraduate's innovative practical ability training method. The main contents are as follows:

EXPERIMENT SYSTEM—CONTINUUM OF COMPREHENSIVE EXPERIMENT COURSE, INTEGRATING SUBJECT ADVANTAGE AND SURMOUNTING SUBJECT BOUNDARY

Innovation system—continuum of comprehensive experiment course integrating subject advantage and surmounting subject boundary

The technology basic course comprehensive experiment (separately open) according to the progressive relationship of discipline theory system - 《engineering mechanics innovation experiment》: integrate experiment teaching contents and resources according to the progressive relationship of subject knowledge system^[1], reform the experiment of experiment technology basic course originally attached to theory course, first combine the experiment of “theoretical mechanics”, “material mechanics”, “fluid mechanics”, “engineering mechanics”, “architectural mechanics” with the experiment of “the structure vibration test analysis”, open the independent comprehensive experiment course 《engineering mechanics comprehensive innovation experiment》. The comprehensive experiment course have reflected a reasonable structure of the civil and mechanical engineering technology basic experiment contents: guided by the application of the concept, theory and method of basic mechanics in daily life and engineering practice, arranged by five blocks—statics, kinematics, dynamics, strength theory and dynamic testing, and related to many fields, such as, civil engineering, machinery manufacturing, electric power transmission, aerospace, articles for daily use, magic toys, fashion acrobatics. The progressive experiment system^[2] of self-designed and engineering measurement, not only educated students comprehensively on practical ability, but also improved students' understanding and application in teaching course and trained students systematically. That belong to the continuum of experiment course (form the experiment system in chain structure by different experiment course content according to its inherent logic relation and hierarchical progressive relations, be composed of traditional verification experiment course, cross experiment course, comprehensive experiment course and design (innovative) experiment course)^[3], and design experiment according to the 3D attribute—subject category grade level and experiment type^[4], satisfied in the demand of training students' ability of practice and innovation. The experiment course of all levels contacted and supported each other, and broke the barrier of traditional experiment mode. Comprehensive experiment course surmounted the boundary of subject and course, with systematicness, inventiveness and practicability. That gave students more autonomy and responsibility, undertook the experiment activity in the way of self-control and self-guidance. Students were allowed to select and arrange their experiment content according to their interests, requirements and advantages, undertook the experiment activity according to their own experiment methods and characteristics, and finally improved students' innovation ability in exploratory teaching.

Reform experiment teaching by innovative idea, build experiment system of four levels, expand and build innovative experiment constantly

Build experiment contents of different levels to guide students' independent learning, cooperative learning and research learning gradually. The comprehensive experiment course, with all-opened mode (time, site, content and method), abandon previous mode of operating and testing step-by-step by the specified experiment steps, and set up contents of four levels according to the students' cognitive progress to science:

"Basic Experiment": select and complete a certain number of basic experiments and questions according to the given tasks, schemes and steps;

"Comprehensive Experiment": comprehensive experiment integrated among all kind of courses according to inner logic relation.

"Design Experiment - subject, purpose, scheme and implementation": give the experiment subject in the form of principle and task, allow students to select the design experiment content according to their interests, requirements and expertise, open experiments according to their own experiment methods and characteristics, guide students to learn experiment design and method research of specific experiment.

"Innovation Scalability Experiment - Scientific Research": find problems and search the way of solving problems": Self-assigning experiments, improved students' learning interest and innovation ability in exploratory learning^[5], set up a hierarchy experiment from simple to difficult to guide students to explore and innovate with questions according to the major, interest and ability of students, specially designed experiment teaching links for self-proposition of innovative

experiment, optimized the experiment system (basic experiment, technology basic experiment, major experiment) and the system and structure of experiment system (demonstrating, validating, design, research), training students scientifically in all directions, broaden students' horizons and scope of knowledge, and developed their comprehensive quality^[6]. For example, students minored in this course can select the interested scientific research, plan the programs and methods of research, design experiment and experimental steps, and expand their scope of knowledge in research and experiment, improve the ability of their hands-on experiments and solving problems.

Build the comprehensive, designing and innovative experiments constantly, update the innovative experiments contents combined with the frontier of relevant subjects

Independent experiment can inspire the innovative thinking. Innovative experiment, with subject-prospective, certain difficulty and operable, also should be built in experimental content to inspire the creativity and thinking of students. The construction of innovative experiment in the following way, reflected the guiding idea that converting the achievements of scientific researches and discipline competitions into high-quality teaching resources^[7]:

Self-proposition related to contents of experiment course – build the exploratory idea in basic training;

Proposition conversion of various discipline competitions - track the forefront of discipline and improve the ability of innovative design;

Actual study subject of enterprise - (scholarships provided by enterprise) follow scientific and technological progress and market demand, get some exercises in actual research and development abilities, strengthen the sense of competition; Conduct market research, raise issues, get business investment with business cooperation, but make up a certain profit;

Curriculum design issues - integrating in various aspects of proposal, design, implementation, summary, simulation and theoretical derivation analysis and respondent, and systematically exercising

“Return design to student”, build innovation comprehensive experimental platform reflecting academic foreland, using the academic achievements’ transformation

Exploration means the exploring the unknown. From the perspective of the considerations of the experiment device’s design, determining in advance experiment content is necessary to design and product experiment device, and do the experiment after that, so it is difficult to form experiment device by unknown content. According to this view, the training of students’ innovation ability became difficult to complete for the university experiment center. In fact, the teaching experiment center also can had the function of the scientific research laboratory, making the designability and creativity becoming the main connotation of experiment center^[8], according to the building of process, such as, the cognition of scientific research, critical and creative thinking and practical inquiry. The fundamental problem of the experiment teaching reform, is to pay attention to training students’ exploratory spirit, scientific thinking, practical ability and innovation ability, and to change the actuality that experiment is attached to theoretical teaching and can only verify the theory^[9]. The function of experiment facility is determined by the experiment content, especially the design content reflecting students’ innovative thinking, instead of that experimental facility determine which experiment we can open. That is the idea “return design to student” this project put forward. According to the process of cognizing, practice and innovation design, this project got the multi-function material mechanics testing machine and structural mechanics combination testing machine into the market, which was designed and developed carefully for many years, with students’ participating in and independent intellectual property rights. And the experiment system, equipment and device is determined according to the students’ innovative content, instead of that experimental device determine which experiment project and content can only be opened. This is one of the implementing ways of the idea “return design to student” this project put forward. This achievement was discussed in the national mechanics teaching symposium for many times, and got the participating experts’ consistent high praise including the national teaching master and professor Yuan Si in Tsinghua University. At present, that was purchased directly for application by 90 colleges and universities, such as, Zhejiang University, Tongji University, Harbin Industrial University, Dalian University of Technology, North China University of Hydraulic and Electric Engineering, Qingdao University of Science and Technology, Liaocheng University, Shandong Architecture University, Shenzhen University, Ludong University, Naval Aeronautical Engineering Institute, Liaoning Transportation Institute, Henan University of Technology, Dalian Ocean University.

The integrated experiment device is characterized by not only covering all the typical material mechanics basic experiment, but also having a very wide development space to other courses and scientific research, experiment module combined flexible, being easy to designing and innovative experiment, keeping the design space for the students, having different implemented way of the same experiment, decided to what, how and what degree of the experiment all by students^[10]. Therefore, the comprehensive experiment device have achieved a great-leap-forward reform of experiment device, while broken the situation of device development lagging behind experiment content research in the traditional experiments (the innovative experiment can’t be completed by the experiment device) . That is, innovative experiment content can be designed according to the existing device, and extended infinitely following innovative thinking.

Modern teaching methods and measures

Engineering mechanics experiment center took the opportunity of the construction of the first national virtual simulation experiment teaching center, adhere to the principle of “combination of emptiness and reality, choosing reality

instead of emptiness”, and construct each experiment according to the systems of four levels: cognizing specimen (engineering modeling), forming a concept (trend analysis), quantifying the notion (clearing boundary), engineering design (new design)^[11,12]. And it made the teaching resources, such as, virtual device, virtual operating, experimental video, animation showing, experiment analysis database, experiment instruction, experiment preparing reports and relevant specification, to give the students a basic understanding about refining of model, experiment equipment and experiment equipment before experiment, and help students to understand the experiment principle and imitate and to analysis the experiment having been stored in the databases. In this way, students can imitate experiment online anywhere. The influence on experiment’s result and design made by the various factors’ change can be fully compared, validated and explored in experiment, while all kinds of design and analysis software can be effectively used to carry on the innovation design after experiment.

Engineering model : make the experiment teaching source, such as, experiment video, animation, experiment analysis database, electronic experiment instruction, prepare report and test specification, help students understand previously the model refining, experiment equipment and experiment process, clear the experiment theory, and analysis experiment data stored in database.

Forming concepts: Experiment is affected by various factors. So, it is necessary to the formation of design concepts, that understanding the effect of change of factors on the result of experiment, the mathematical relationship and the scope of application. Students can analysis the effective factors of experiment having analytical solution by relevant software and get the result of experimental factors’ effects combined with the virtual device.

Concept quantification: accurately calculating the model is the premise of design. And rationally and effectively using a variety of design and analysis software is the important judging criteria to professional ability. On this basic, our virtual experiment contain: analysis process, video showing, typical example, simulation analysis of the changing of example parameter, building new example simulation analysis, and so on.

Engineering design: build virtual experiment platform using professional software.

Scientific ability evaluation system

Based on the examination of the summative evaluation, students' experiment ability was evaluated by examination paper grades of the experiment course due to the character-“summative assessment”. But the way of evaluating experiment in examination room will make student return to the examination room and the examination pattern reciting the theorem and operation procedures mechanically, with classroom, teachers and teaching material as the center, even if the experiment content and way was reformed and the proportion design experiments was expanded. It is crucial to break up the way of evaluating students' ability from the incentive mechanism, factually evaluate students' experiment ability, thinking and design ability, analysis and summary ability, and innovation ability instead of exam-taking ability, set up a scientific ability evaluation system-the grade evaluation principle.

The post-reform grade evaluation of experiment course, for example, 《engineering mechanics innovative experiment》 course, is in accordance with the ability test of experiment. And the innovative score was set up for experiment design especially to make the innovation institutionalization.

Complete innovative experiment: the scores from 0 to 10, encourage innovation.

Large designing experiment is by the manner of team. The Performance evaluation also included group leader (selected by student) grading and grading design defense.

MANAGEMENT MODE OF SIX-IN-ONE

Management system and operation mechanism reform is the organization guarantee of teaching experiment. Researching and implementing the scientific, practical and opened laboratory management system and operation mechanism adapted to experiment teaching, ensure teaching experiment go well. The research contents are connected to depend on and promote each other. The research and implementation are in effective coordination. This project build the networked information platform of experiment teaching and laboratory management from hardware to software, create the experiment environment of personalized experiment and learning, combining the effective management mechanism helpful to motivate student to learn and improve the ability^[13], build the operation mechanism and management mode of six-in-one: School Administration Office, Youth League Committee, Institute, Center, Experiment Teachers, Group Leader^[3].

ACHIEVEMENTS OF CONSTRUCTION

In the comprehensive experiment, students’ ability of research and innovation design was greatly improved, due to the research training contacting with the actual scientific research subject. After the construction for many years, engineering mechanics experiment teaching center of Yantai University, was approved as the Shandong Province Engineering Mechanics Experiment Teaching Demonstration Center in 2011 and the first National Engineering Mechanics Virtual Simulation Experiment Teaching Center in 2013, and became the only one national virtual simulation experiment teaching center without mechanics. Since 2012, professor Qu Shuying, the director of center, opened the experiment skill training courses for the teachers of vocational and academic college for three years in a row. Center held national academic conferences at more than 10 times, such as, national structural mechanics and elastic mechanics teaching seminars, national structural engineering

academic meeting, national conference on mechanical and methodology, basic mechanics experiment teaching seminars, experimental mechanics teaching steering committee and national association of director of the mechanics discipline demonstration center; and international academic conferences at more than 10 times, such as, steel structure's research reviewed, future of the concrete. The three academic meetings of them, 2014 symposium and training course of basic mechanics experiment teaching, experimental mechanics teaching steering committee and national association of director of the mechanics discipline demonstration center, sponsored by the Chinese mechanical society and hosted by the Chinese mechanical center in August 2014, have more than 300 representatives. During the conference, the Chinese mechanical center trained the strain gauge paste technology and test principle for mechanics experimental teachers from more than 80 colleges and universities. More than 300 domestic colleges and universities' relevant majors studied and learned the experiment teaching system, training mode, training methods and training measures of Yantai University engineering mechanics experiment teaching center. 90 colleges and universities' relevant major purchased our equipment and relevant resources having intellectual property. That played good role of demonstration and radiation of the mechanical demonstration center.

Students attended the first national basic mechanics experiment contest, and got group grand prize (the national second prize), three individual grand prizes, seven individual third prizes. Then professor Hong Jiazhen, the director of the institutions of higher learning mechanics teaching steering committee, made a specialized research for Yantai University, and made a promotion in nationwide colleges and universities. Students took part in the national Peiyuan Chou mechanics competition and got the number one in the province's colleges and universities in four consecutive competitions. There is only one in universities of Shandong and only 5 in the national, that getting the national first prize three consecutive terms in the national college students' advanced mapping technology and product information model competition. The students' academic papers of mechanics experiment teaching was included by SCI, awarded a total of 35 prizes including the grand prize and first prize in various kinds of innovative competition for national college students. Engineering mechanics teaching team awarded the provincial teaching team; major the engineering mechanics center affiliated with awarded the first batch famous university engineering key major in Shandong province, provincial characteristic major. Engineering mechanics course awarded the provincial excellent courses in Shandong province. 3 persons in subject team awarded provincial teaching masters.

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