International Journal of Education and Humanities
ISSN: 2770-6702 | Vol. 5, No. 3, 2022

CUPT Physical Innovation Talent Cultivation Under the CDIO Model

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Abstract: With the enactment and implementation of the National Medium and Long-term Education Reform and Development Plan (2010-2020) in March 2010, the requirements of quality education is the strategic theme of education reform and development and insisting on ability as the priority and other requirements have put forward clear requirements for the cultivation of talents in our universities. [1] On this basis, researchers from some universities in China specializing in physics have carefully studied the concept and various aspects of the IYPT (International Young Physicists' Tournament), fully realizing that this form of competition is different from the traditional scientific research training in our universities and has positive significance in improving the creative awareness, innovation, collaboration and practical skills of university students specializing in physics.

Keywords: CUPT, CDIO model, Innovation.

1. Introduction

The IYPT competition was first proposed by physicist Evgeny Yunosov in 1979 and was originally used by Moscow University to select the best students. The main objective of the competition is to train students in collaborative research, opinion, and debate on real-life physics problems, with particular emphasis on teamwork, open-mindedness, and presentation skills. [1] Because of its significant differences in scope and philosophy from the International Physics Olympiad (IPhO), the IYPT has been widely recognized by physics educators in various countries and has been extended to include physics competitions for university students in various countries. Since the first official competition was held in Moscow in 1988, the IYPT has attracted participation from more than 40 countries and regions internationally. As one of the most influential annual physics competitions in the world today, the IYPT is also known as the 'Physics World Cup'.

The China Undergraduate Physics Tournament (CUPT) is a national tournament in China based on the International Young Physicists' Tournament (IYPT). The event is supported by the Ministry of Education and is included in the work plan of the Steering Committee of Physics Teaching of the Chinese Physics Society, and is one of the most important innovation competitions for university students in the implementation of the National Innovation-driven Development Strategy and the National Education Medium and Long-term Development Plan. At the National Conference on Science and Technology Innovation, General Secretary Xi Jinping put forward five requirements, including "promoting the spirit of innovation and fostering a talent pool that meets the requirements of innovation and development". [2, 3] Premier Li Keqiang also pointed out at the symposium on reform and innovation in higher education: "For schools, the first thing is to cultivate talents, which is the fundamental task of schools. At present, the key is still to have the awareness of innovation and the ability to practice, which are all closely linked to innovation. So, I think these basic researches, how to cultivate the awareness of innovation is very important." [4] The value of CUPT in terms of talent training and collaborative innovation is highly compatible with the development philosophy of China in the new era, and is worth summarizing, improving and promoting. The content and format of the competition adopt the model of the International Young Physicists Championship (IYPT). On this basis, our university has participated in the first China University Student Academic Physics Competition for ten consecutive years since its inception in 2010, laying a solid foundation for the training of physics students.

With the increased emphasis on fundamental subjects at the national and university level, the level and scale of CUPT participation have grown by leaps and bounds under the changes to the regional system. In particular, we need to make further efforts to widen the beneficiaries of the competition, to effectively improve the overall training of physics students and bring about a higher level of innovation in student development. It is worth mentioning that in the 5th China University Student Physics Competition, Ruilong Ren and Qunfeng Lu, 2012 undergraduates from the School of Physics and Electronics of the University of Electronic Science and Technology, conducted a thorough follow-up study on one of the topics of this year's competition, "Hysteresis in the liquid-solid phase transition of chocolate", and their published teaching research paper "Hysteresis in the phase transition of chocolate" was successfully selected for the 2016 Highlights of the prestigious SCI teaching journal European Journal of Physics. [5]

To this end, we intend to use the engineering education concept of CDIO, an engineering education concept created by four universities in the United States, including MIT, after four years of research and development, which consists of Conceive - Design - Implement - Operate. Task-driven, case-based teaching. After students have mastered the basic physics knowledge, certain numerical calculation methods, and computer language of computational physics, they use the CUPT competition as a learning unit to design innovative experiments, focusing on the cultivation of students' practical ability, solidarity, and innovation consciousness, reflecting the principle of "learning by doing, learning by doing" and the project-based teaching mode. The combination of CUPT and CDIO will definitely broaden the benefits to students and enhance the all-round development of innovative talents in

physics.

2. Project Implementation Programme and Implementation Plan

2.1. Specific content, objectives and key issues to be addressed by the reform and research

Combining the CDIO model with CUPT, classroom teaching, and experimental teaching, the goal is to align the development of our physics discipline with the "double first-class" to form a virtuous cycle system of "promoting learning through competition, promoting teaching through learning, promoting reform through teaching, and promoting management through reform", and realizing the "competition +" characteristic talent training model of "student-centered, competition-based, ability-enhancing". With this objective in mind, we have focused on two key issues：

Broadening the benefits of competitions for students;

strengthening the cultivation of innovative talents in physics under the CDIO model.

In response to the objectives and the key questions to be addressed our research is divided into two directions：

Incorporating a flipped classroom that introduces the CDIO model into classroom and laboratory teaching, and integrating CUPT into all stages of undergraduate teaching.

In the cultivation of innovative talents, a multi-faceted talent cultivation system is realized.

2.2. The basis of the research

With the increasing attention paid to basic subjects by the state and universities, the level and scale of CUPT participation has grown by leaps and bounds as a result of the changes to the regional system. Since the inception of CUPT in 2010, our faculty, led by Yan Cui, Hong Gu and Yaofang Zhang, have formed the Tianjin University of Technology team to actively prepare for and compete in the competition. From 2010 to 2017, it won the third prize in the national competition for eight consecutive years. Since the introduction of the competition in 2018, it won the third prize in the North China Region in 2018.

With the University's advancement into the double first class and the emphasis on fundamental research, there has been an unprecedented response from students to the CUPT competition, with almost 50% of the incoming students participating in the selection process. However, due to the limitations of the competition, each school can only form a team of five students. In order to better enable undergraduate students to benefit from the event, we set up the "TGUPT" training camp under the theme of "Undergraduate Research" to train the team members and allow students who are interested in physics research to join in the research and grow together. The camp also allows students who are interested in physics research to join in and grow together.

2.3. Specific implementation plan

The specific implementation plan is divided into aspects of the process of promoting innovation in events based on the CDIO model and the coupling process of nurturing student innovation and feeding teaching.

2.3.1. An innovative process for promoting events based on the CDIO model

A. Organization of the tournament. In early August 2019, the title of the China University Student Physics Competition (hereinafter referred to as CUPT) will be announced by the CUPT Organizing Committee. in September 2019, three teachers in the group will discuss and analyze the title and roughly determine the experimental procedure and calculation process of the title. at the end of September 2019, an information meeting will be held for all freshmen and sophomores of the School of Physical Science and Technology and the selection rules will be announced.

B. Tournament selection. The selection of students for the tournament has been formed in 2019 in the form of an echelon training model. Five members of the team for 2020 will be selected from the ten experimental members of the previous year; ten experimental members will be selected from the members of the 2019 free entry team. The selected topics are the general pre-selection for the official CUPT competition, one topic per person, conducting innovative experiments under the CDIO model, independently completing three sessions of experimental production, computational simulation, theoretical analysis, and finally finishing with a twenty-minute PPT report presentation formation.

C. Judging of the competition. After the presentations, all instructors and faculty members, and participants in the selection process will vote by secret ballot to select the top five team members for that year's competition and the top ten team members for that year's experiment. The first CUPT team (experimental) and the second CUPT team (competition) are then formed.

D. Training for the tournament. During the normal teaching week in the first and second semesters, the four sections of experimentation, computational simulation, literature reading, and theoretical analysis are developed by tournament topic. Regular training sessions are held on weekends and weekdays from 6.30pm-9pm. The training is conducted in the form of team discussions, group meetings, and presentations. During the winter and summer holidays, intensive training is provided in the form of winter training (10 days) and summer intensive training (45 days).

2.3.2. Coupling the process of nurturing student innovation and feeding the teaching

In the process of fostering innovation in students through events, we emphasize teaching and learning to feed into each other. As shown in Fig. 1, the multi-faceted talent development system combines the academic year growth of students with a focus on innovation development.

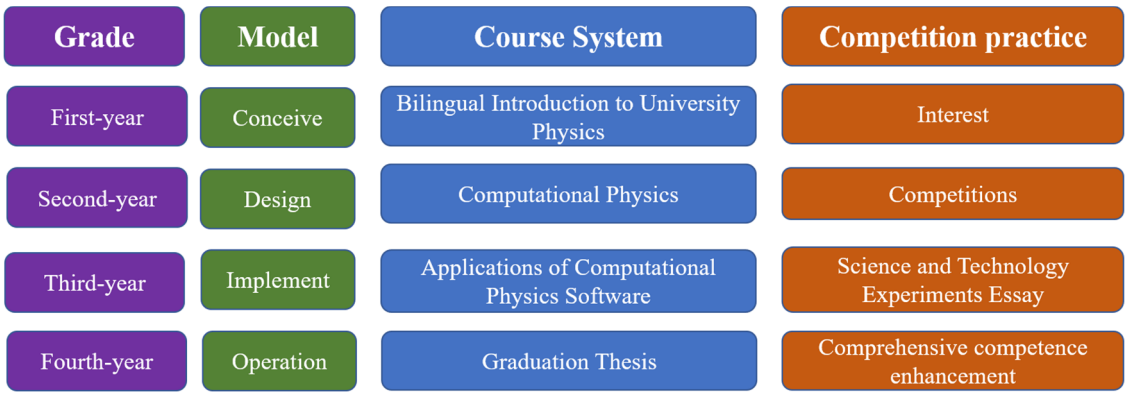

Figure 1. A multi-faceted talent development system

For freshmen, the C link in CDIO, i.e. conceive, is formed by using interest as a guide and experimental manipulation as a medium. In the course Bilingual Introduction to University Physics, students are familiarized with the competition questions to develop independent thinking patterns from their minds and to intervene in the practical training of university research from scratch in laboratory operations. In the classroom, the content is adjusted in real time to address problems that arise for the students, enabling real-time reform and fine-tuning of teaching.

For the sophomore midshipmen, the competition is used as a guide to take ownership of the whole picture and form the D link in CDIO, i.e. design. Also, in courses such as Computational Physics, students are given the opportunity to analyze the competition questions in depth, to shift from an analytical to a quantitative approach and to carry out an in-depth theoretical analysis.

For students in their third year who are at the maturity of their profession, the in-depth creative skills are oriented and the scientific and technical laboratory paper writing is used as a medium to form the I link in CDIO, i.e. implement. In courses such as Applications of Computational Physics Software, students are given the initial training to intervene in scientific and technical paper writing by building models based on competition questions and realizing the process of fitting theory to experiment. In the classroom, the content is adjusted in real-time to address problems that arise for students and to achieve pedagogical feedback.

For fourth-year graduates, the medium in which the thesis topic is carried out is oriented towards results, forming the D link in CDIO, i.e. operate. In-depth and systematic analysis of a single competition topic is completed in the thesis topic to form the thesis. In the supervision of the thesis, students are guided and nurtured in real time to solve problems that arise and to achieve complete control of their innovation process.

3. Summary

This project features the cultivation of innovative physics talents under the CDIO model of CUPT, based on the CUPT event but not confined to it, bridging the various links in the event, teaching, and talent cultivation. The project not only enhances students' ability to analyze and solve problems but also cultivates scientific research literacy and teamwork spirit, as well as improves innovation awareness and communication and expression skills, enabling students' knowledge, ability, and quality to be developed in a comprehensive and coordinated manner, realizing the innovative cultivation of physics talents.

Acknowledgment

This work was supported by Scientific Research Project of Tianjin Educational Committee (No. 2018KJ220).

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