

# *Theme Analysis and Participation Strategies for the Innovation Design Competition for Mechanical Engineering*

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**Abstract:** The Innovation Design Competition for Mechanical Engineering provides a platform for college students to engage in innovative practices. By stimulating their innovative thinking, the competition has a positive impact on promoting innovative practical courses in higher education. With the theme of the competition as a guide, corresponding competition strategies are proposed. They effectively organize an integrated curriculum system that combines theoretical and practical courses and improve the quality of higher education. At the same time, the competition enables college students to directly face society, realize their own value, and receive ideological and political education in a subtle way.

## 1. Introduction

The National College Student Mechanical Innovation Design Competition is one of the most influential mechanical engineering innovation contests in China. It is approved by the Higher Education Department of the Ministry of Education and hosted by the Higher School Mechanics Subject Teaching Committee of the Ministry of Education. The purpose of the competition is to guide colleges and universities to focus on cultivating students' innovative design awareness in teaching, refine students' comprehensive design capabilities, and strengthen teamwork spirit among students [1]. In order to strengthen practical skills and project execution ability, this contest provides students with practical work experience in mechanical design and process manufacturing. Through this contest, we hope to attract and encourage students to participate in extracurricular scientific and technological activities, and create conditions for outstanding talents to stand out [2-3]. Through this contest, we promote the deep integration between universities and society, facilitate the development of innovative and entrepreneurial education in universities, and help the reform of higher education.

The Mechanical Innovation Competition is held biennially, and consists of three levels: university selection contests, regional preliminaries (Shanghai region: the Shanghai College Student Mechanical Engineering Innovation competition), and national finals. Among them, the Shanghai College Student Mechanical Engineering Innovation Competition is hosted by the Shanghai Municipal Education

Commission, with a yearly competition format and different themes each year. The main attraction of this contest lies in the fact that contestants must present their innovative designs based on a given theme. Participants need to work through a variety of stages including conceptualization, design, process and manufacturing before completing their actual products. Additionally, the process of preparing for the contest requires patience debugging and programming, which takes a relatively long time. Therefore, in order to prepare for the contest in a sufficient manner and design better innovative projects, it is crucial to analyze and study the theme and the corresponding competition strategies.

Focusing on the historical themes of the Mechanical Innovation Design Competition, we analyze and study the direction of the competition themes, including industry orientation, practical problems, practicality of presenting products, and topic selection. Based on this analysis, we provide a corresponding set of participation strategies for students that cover preparing innovative projects in advance, selecting topics based on a one-stop closed-loop innovation teaching model, and establishing a professional innovation guiding team. This provides students with a sound platform for innovative design, effectively improving the teaching quality of innovation and entrepreneurship courses at mechanical colleges. In addition, by incorporating classroom ideological and political education into each stage of the creative project, it naturally imbues students with ideological and political education, cultivating them in a subtle way.

## 2. Innovation Competition Theme Analysis

We select the historical competition themes of the National College Student Mechanical Innovation Design Competition and Shanghai College Student Mechanical Engineering Innovation Competition for analysis, in order to better understand the direction of the main themes of these Competitions. The National Competition has been held for 10 years with each year's theme shown in Table 1; the Shanghai Competition has been held for 12 consecutive years with each year's theme shown in Table 2.

Table 1: Historical Themes of the National College Student Mechanical Innovation Design Competition

Index	Year	Theme and Content
1	2004	No fixed theme
2	2006	"Health and Love", the content is "machinery for disabled, rehabilitation machinery, fitness machinery, sports training machinery"
3	2008	"Green and the Environment", the content is "environmental protection machinery, sanitation machinery, kitchen and sanitary machinery"
4	2010	"Cherish life, Contribute to the society", the content is "machinery for rescue, barrier-breaking, escaping and sheltering in a sudden disaster "
5	2012	"Living Well - Today and Tomorrow", the content is "recreational machinery and machinery for the home"
6	2014	"Phantasy-Dream Classroom", the content is "design and production of equipment and machinery for teaching"
7	2016	"Serving Society - Efficient, Convenient, Personalized", the content is "mechanical devices for sorting, counting and bundle coins; mechanical devices for packaging goods of different materials, shapes and sizes; mechanical devices for helping carry goods "
8	2018	"Pay Attention to People's Livelihood, Beautiful Home", the content is "small parking mechanical devices and small mechanical devices or tools"
Index	Year	Theme and Content
9	2020	"Smart Home, Happy Life", the content of "Mechanical devices for helping the elderly and modern smart homes"
10	2022	"Nature-Harmony", the content is "bionic and ecology restoration machinery"

Table 2: Historical Themes of the Shanghai College Student Mechanical Engineering Innovation Competition

Index	Year	Theme and Content
1	2012	"Nature - Harmony"
2	2013	"Meaning, Competing"; the content is "innovative teaching equipment"
3	2014	"Phantasy-Dream Classroom"
4	2015	"Harmonious Living", which is about "design and production of household mechanical appliances or utensils"
5	2016	"Serving Society - Efficient, Convenient, Personalized"
6	2017	"Multifunctional portable living and travel device"
7	2018	"Pay Attention to People's Livelihood, Beautiful Home"
8	2019	Under Intelligent Environment "Machinery +" - for home and campus life intelligent machinery
9	2020	"Smart Home, Happy Life"
10	2021	"Smart-Guard", bionic machinery
11	2022	"Bionic Machinery" and "Ecology restoration machinery"
12	2023	"Low-carbon Life and Smart Agriculture" and the theme of your choice

Through the analysis of these themes, we found that both the National and the Shanghai Competitions focus on practical needs in social development [2], aiming to solve problems in our daily life. The above-mentioned themes are usually closely related to the daily life of participating college students, which can greatly stimulate their curiosity and creativity, and make them change from passively receiving knowledge to actively learning. The overall characteristics and directions of the competition themes can be summarized in the following four dimensions:

### 2.1. Adhering to the concept of sustainable development and in line with the industrial policy

From table 1 and 2 we can see that the themes of the competitions follow the concept of sustainable development and are in line with the national industrial policy. The implementation of the innovative projects in the competition can vigorously promote national scientific and technological progress and enhance the country's industrial transformation and upgrading. China has now entered a new period of reform and development, and needs to carry out industrial upgrading and explore higher quality development, which requires vigorous scientific and technological innovation, development of new industries, and enhancement of industrial development momentum.

### 2.2. Addressing social needs and real-life problems

From the historical themes, it can be seen that the choice of the themes is mainly about "paying attention to people's livelihoods and creating a better life". The projects under these themes include green environment protection, wind-break and desertification control, care for the disadvantaged, smart homes, and social contribution. They are all closely related to daily life and concern everyone. This type of themes allows college students to experience the social needs in their daily lives and stimulate their desire for innovation. At the same time, they can use their professional knowledge to broaden their thinking and develop products that solve practical problems in life, which will make the society more enjoyable for everyone and improve the living standards of the disadvantaged groups. They will achieve a sense of self-fulfillment in the process.

With the themes targeting social needs, college students have a lot of room to play innovation and have opportunities to receive support from all sides. With the innovation projects directed under a single theme, it is easier for them to translate their design into real products and get recognition from the industry. Participating students also have the benefit of obtaining working experience during their

university years and better integrate their learning in the school with the work needed by the society.

### **2.3. Wide range of innovative ideas and high feasibility of product manufacturing**

The themes selected for the competition are relatively broad in direction, and college students can give full play to their intelligence and make use of the professional knowledge and skills they have learned during their college years to design and produce innovative works. As the competitions emphasize on innovative designs of mechanic structures, students can leverage the relevant knowledge of mechanical principles to create innovative design and combination of mechanical structures, cleverly realizing some new functions to achieve innovative breakthroughs. In addition, some works can also achieve innovation in terms of function and concept.

In addition to innovative design, the main point of the competition is that all designs need to be made into actual products for on-site demonstration. Only works that achieve the intended function are considered. The theme of the competition is chosen with the feasibility of the potential work in mind, so that college students can easily design and produce the work with low cost on campus. The innovative works usually focus on small and medium-sized products that are easy to demonstrate, and some of them can even be assembled and produced entirely from a 3D printer.

### **2.4. Self-selected themes with a focus on creative design**

Taking into account the aspects of industrial development and social demand, the competitions support participants to select their own themes. Before creating and designing products for self-selected themes, participants must complete relevant research and feasibility reports. The goals and functions to be achieved by a project under a self-selected theme, should first be demonstrated in 3D simulation or in relevant software. The more outstanding ideas can be further processed into physical products and recommended for participation at the next National and Shanghai competitions.

This introduction of self-selected themes has increased the competition's meaning and depth. Students can identify problems through their own research and come up with solutions that result in more innovative and original works. Especially for complex mechanisms that require greater difficulty in manufacturing physical products, simulation technology can be used to simulate the mechanism before manufacturing it into a physical product. This reform of supporting self-selected themes has prompted more and better innovative works to appear, and it has addressed the limitations of pre-determined theme selection.

## **3. Strategies for Mechanical Innovation Competition**

Drawing inspiration from the directions of the above-mentioned themes, effective participation strategies can be proposed and targetedly formulated to guide college students in innovative competitions. Our university's School of Mechanical Engineering has always attached great importance to cultivating students' innovative practical abilities, taken effective measures to guide students to participate in various mechanical innovation competitions, and achieved excellent results. For the mechanical innovation competition, the following measures and methods are mainly adopted.

### **3.1. Grasp the direction of the competition theme and prepare in advance**

Our School of Mechanical Engineering convenes and organizes experienced teachers with rich guiding experience each year to analyze and study the theme direction of the mechanical innovation competition, and proactively prepare innovative project topics. The main way is to cultivate a group of innovative projects through the college's "Mechanical Innovation Design" course, and organize

students to carry out corresponding innovative design. After the theme of the mechanical innovation competition is determined, selected projects that meet the theme will be recommended for participation. Some of the innovative projects can be directly entered as competition projects, and some closely related projects can be modified and adjusted slightly to fit the theme of the competition. Thus, when the theme of the mechanical innovation competition is determined, the selection of competition projects is completed almost simultaneously, leaving more time for the production and processing of subsequent works, greatly ensuring the completeness of each project's product.

### 3.2. Integrate the competition into a modularized curriculum system

Our school adopts a modularized closed-loop innovation teaching model, which consists of theoretical teaching, production practice, innovation design, and graduation design. This modularized closed-loop teaching system is a one-stop teaching system that integrates innovative design and innovative project based on theory teaching. At the same time, the competition theme is integrated into this innovation teaching system [4], achieving the integration of innovative design projects, design courses, and competition projects. This ultimately leads to the introduction of innovative case studies to classroom teaching.

When applying for grant for college students' innovative design projects or competitions, college students can obtain certain manufacturing funds. This means that the construction of a modularized closed-loop innovation curriculum system provides corresponding funding that supports the production of innovative competition projects. At the same time, the physical products of the competition projects can also be used as the results of innovative design courses' projects. In summary, both complement each other and have formed a virtuous cycle in helping students develop practical skills. The specific modularized innovation curriculum system is shown in Figure 1.

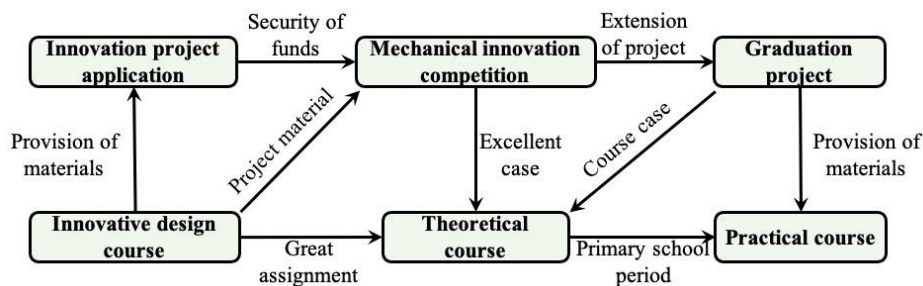


Figure 1: Structure of an integrated innovation course system

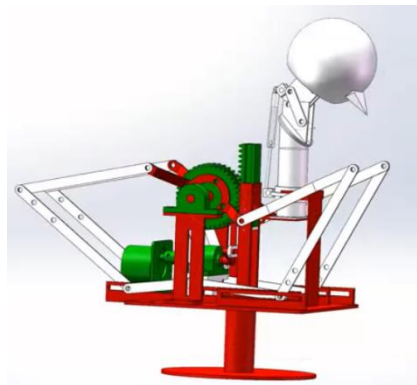


Figure 2: A creative design of the chicken egg breaking mechanism

In addition, the advantage of this integrated curriculum teaching system is that outstanding innovative works by college students can be used as case studies in theoretical courses [5] to guide

students in structural innovation and design. At the same time, innovative projects in the Mechanical Innovation Design Course can be used as homework for "Mechanism Theory" and "Mechanism Design", allowing students to continuously improve their innovative works while learning theoretical knowledge. This not only promotes teaching but also connects theory knowledge with practical design. Figure 2 is an example where a creative design of the chicken egg breaking mechanism that has been compiled into " Theory of Machines and Mechanisms " [6] textbook.

### 3.3. Forming a more professional innovation mentoring team

As the implementation time is relatively long, the process of submitting products to the Mechanical Innovation Competition requires experienced faculty to form a mentoring team. Our School of Mechanical Engineering has long established a professional faculty mentoring team, which includes experienced teachers from related majors such as mechanical design, mechanical manufacturing, automation, and electrical engineering. The members in the team effectively ensure the smooth participation of each work in the competition and provide logistic support throughout the process.

In addition, the school's innovation mentoring team organizes seminars and campaigns each year to encourage students to actively participate in the Mechanical Innovation Competition. They also provide in-depth explanations of the competition themes, the time schedule, and the qualification requirements. They guide students in applying for college student innovation projects, filling out project application forms, and introduce outstanding award-winning products from previous competitions as case studies for on-site analysis and teaching. The mentoring process for the competition is shown in Figure 3.

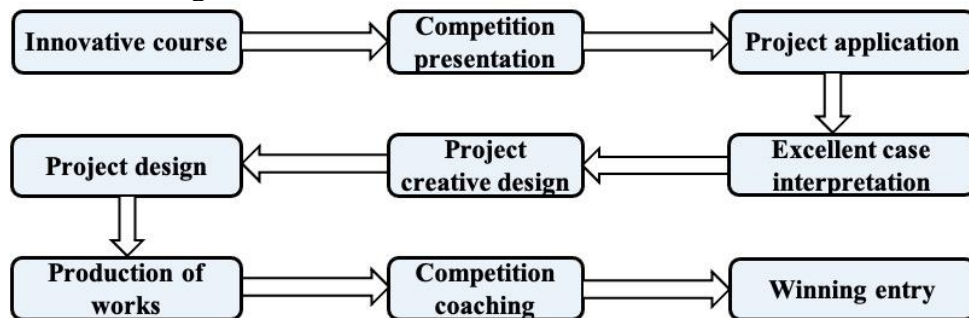


Figure 3: Innovation competition mentoring process

## 4. Conclusion

In this paper, we analyze and study the directions of the competition themes, including industrial orientation , practical problems, physical manufacturability, and self-selected themes, in conjunction with the past themes of the Mechanical Innovation and Design Competition. Based on this, a set of competition strategies is proposed including preparing innovation projects in advance by organizing experienced teachers with rich guiding experience to analyze and study the theme direction of the mechanical innovation competition, selecting topics in the integrated closed-loop innovation teaching model by consisting of theoretical teaching, production practice, innovation design, and graduation design, and forming a professional innovation mentoring team which includes experienced teachers from related majors such as mechanical design, mechanical manufacturing, automation, and electrical engineering. These strategies will provide students with an excellent platform for innovation design, effectively improve the teaching quality of the innovation and entrepreneurship practice course, and realize the organic integration of innovation project application, innovation practice course and innovation competition participation. At the same time, in the production of innovative works,

ideological and political education is integrated in each link so that positive political thinkings are naturally imbued in students' mind in a subtle way.

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