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Six-Link Teaching Methods for Improving the Creative Practical Ability -Taking "Mechanical Principle" as an Example

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Abstract. In the construction of "Emerging Engineering Education" and "First-Class Course", "Mechanical Principle" is oriented to the requirements of talent training, the application of innovative thinking and creative practical ability in teaching. Firstly, the teaching system of "Mechanical Principle" is reconstructed. Secondly, based on TRIZ Theory in teaching methods is improved in the "Teaching, Learning, Practice, Creation, Research, Competition" six links. Thirdly, closed-loop process evaluation is adopted in teaching reform shows that teacher evaluation, student achievement, student work and the achievement of curriculum objectives have been improved after the curriculum improvement. Especially in the second classroom, such as subject competition, innovation, entrepreneurship. The students' innovative practical ability is effectively improved.

Keywords. Teaching methods, Teaching system, Teaching evaluation, Creative practical ability, Mechanical principle.

1. Introduction

"Mechanical Principle" is an important basic course of engineering specialty, which plays an important role in achieving the goal of talent training, especially in cultivating students' ability of innovative design of mechanism [1]. It's hard to link professional knowledge with practical life and engineering practice. Based on the guiding principles of "First-Class Course" construction, it should focus on improving students' innovative comprehensive practical ability, reconstructing the course teaching system and improving teaching methods, so as to break the silence of the course [2].

Liu Xiaoyong et al. improved students' innovative design ability through the teaching reform of "Mechanical Principle" [3]. Wang Bo et al. adopted measures to strengthen the cultivation of students' innovative ability, such as subject competition projects, visiting exhibitions, participating in innovative experimental projects, and enriching curriculum design projects [4]. Yu Jingjun et al. introduced innovative design ideas into the teaching content, teaching methods and practical links in the teaching process of "Mechanical Principle", in order to cultivate students' innovative ability [5].

Teaching students innovative thinking method is an important way to improve

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students' innovative ability and institutional innovative design ability. The innovative thinking method of TRIZ theory is introduced, such as 40 invention principles and morphological matrix method in TRIZ [6]. Adopt innovative thinking methods to deal with problems in mechanism design and establish innovative design schemes.

The course group promotes the integration of theoretical teaching, experimental teaching and curriculum design, and reforms "Mechanical Principle" from the teaching system, teaching methods and teaching evaluation.

2. Based on TRIZ Theory in the Teaching of "Mechanical Principle"

By teaching the innovative thinking methods on TRIZ theory, the students' innovative design ability is improved. In TRIZ theory, the ideal degree of the system is proportional to the sum of useful functions and inversely proportional to the sum of harmful functions [7]. It is defined as:

$$I = \frac{\Sigma U_F}{\Sigma H_F + \Sigma C} \tag{1}$$

I is the ideal degree of the system. ΣU_F is the sum of useful functions. ΣH_F is the sum of harmful functions. ΣC is the sum of costs.

According to the formula, the ideal final result of the problem is a system with infinitely large useful functions, infinitely small harmful functions and infinitely small costs. The final ideal solution method is used to solve the problem of mechanism innovation design. As shown in Figure 1. Firstly, establish the ideal solution of the problem. Secondly, find the obstacles to achieve the ideal solution. Thirdly, find ways to overcome the obstacles. Fourthly, eliminate obstacles. Finally establish a solution.



Figure 1. An example of the final ideal solution.

3. Reconstruct the Teaching System of Course "Mechanical Principle"

Guided by the curriculum objectives, the course of "Mechanical Principle" adheres to the fundamental task of cultivating people by virtue, implements OBE education concept, strengthens the innovative thinking in practice, integrates ideological and political education, professional education, innovation, and entrepreneurship education, and constructs a new teaching system of "Mechanical Principle" [8-10], as shown in Figure 2. Through the course learning and application, students can stimulate the spirit of innovation, form three types of student's curriculum designs: classroom works, course design innovation works and subject competition works, realize the organic combination of imparting the knowledge, training the ability and shaping the value.



Figure 2. Teaching system of "Mechanical Principle".

The theory teaching of "Mechanical Principle" takes mechanism design as the main line, mechanism analysis as the design service, and students' ability of mechanical system scheme design as the goal. They are composed of four parts: mechanism structure, mechanism kinematics, mechanism dynamics and mechanical system scheme design. They are carried out step by step [11]. The composition principle and structure analysis are composed of linkage mechanism, cam mechanism, gear mechanism, gear train mechanism, intermittent motion mechanism and other mechanisms. Various mechanisms have different functions, types, characteristics, motion principles and design methods. Mechanism dynamics explains the basic concepts and theories of mechanical efficiency, self-locking, balance and machine operation. The design of mechanical system scheme can cultivate students' design ability of the whole machine.

The experimental teaching of "Mechanical Principle" includes the conventional experimental items such as the mapping of the mechanism and the assembly of the mechanism. Use the high-quality virtual experiment resources in the national virtual simulation experiment teaching course sharing platform to enrich the teaching content, carry out experimental rehearsals, help students master the corresponding knowledge points and improve the quality of experimental teaching.

The course design of "Mechanical Principle" adopts traditional questions or optional competition questions. Focus on the general process of product design and manufacture. Introduce modern design methods such as computer aided design. Combine scientific and technological innovation activities, such as mechanical innovation design competition, engineering training competition. During the course of completing, students carry out targeted learning. They take the initiative to communicate with each other, when they encounter problems. If there are problems that cannot be solved, they will take the initiative to consult teachers. The teacher needs to guide, observe, consult and evaluate the implementation. The reformed teaching puts forward higher requirements for teachers' professional ability and knowledge.

4. Improve the Teaching Method

The teaching spiral promotion is based on the six links of "Teaching, Learning, Practicing, Creating, Researching and Competing" based on repetition, feedback, promotion and

constantly summarizes the teaching experience in the implementation process. Through course learning and application, students can find problems and solve problems. It's important to have innovative consciousness, innovative ability and collaborative innovation [12].

- 1) Teaching. In a limited time to clarify the core knowledge points. Use the online teaching resources of First-Class Course to enrich students' learning content. Introduce enterprise engineering projects into the classroom to enhance students' professional cognition. Based on project guidance, teachers guide students from passive listening to active thinking, actively discuss and communicate, increase students' participation, and improve teaching quality.
- 2) Learning. Based on the iterative learning process, students can learn small knowledge points, repeat, and feedback continuously, forming a closed-loop process. Using the rain classroom, establish a learning feedback mechanism, including difficult problems, homework correction, unit testing and other aspects of feedback. Teachers focus on the common problems to answer.
- 3) Practice. In the study of theoretical knowledge and project-driven teaching, teachers can give students some major assignments to consolidate. For example, the design and manufacture of a model can be completed in groups. It can be printed in 3D, such as the rack-and-gear and linkage mechanism, the manipulator of opening and closing mechanism, as shown in Figure 3. Corrugated board, wood board and acrylic board can also be used to make models, as shown in Figure 4.



Figure 3. The application of 3D printing in the course of "Mechanical Principle".



Figure 4. The application of wood board in the course of "Mechanical Principle".

- 4) Creating. Teachers can transform the teaching and scientific research results of the course group into students' innovative practice guidance. Design some production models with practice to improve the challenge of the course. As shown in Figure 3, bionic mechanical horse, and bionic butterfly. When the model can realize its function, students gain a sense of achievement and professional pride and stimulate students' desire for knowledge.
- 5) Researching. The school carries out the special subject of scientific research service teaching. Students participate in the teacher's project. Cultivate

innovative design talents to meet the needs of society, industry and enterprises. Understand the knowledge and skills that enterprises really need. Students should be familiar with the product design and manufacturing process. Comprehensively improve the professional quality of students.

 6) Competing. Organize students to participate in class, college, school competitions. Select excellent works to participate in provincial and national mechanical innovation design competitions, college students' engineering training competitions, etc. As shown in Figure 5. Cultivate students' teamwork, innovative literacy and comprehensive practical ability.



Figure 5. Intelligent tea table for national college students' mechanical innovation design competition.

5. Improve Teaching Evaluation

Teaching adopts closed-loop process evaluation to reflect the situation of teaching and learning, as shown in Figure 6. According to the evaluation of teachers, students' achievements, students' works and students' satisfaction with teaching, the degree of achievement of curriculum objectives is analyzed. Continuous improvement is carried out to optimize the curriculum system, teaching methods and curriculum objectives, so as to improve the teaching quality [13-14].



Figure 6. Closed-loop teaching evaluation process.

Teacher evaluation adopts the teaching evaluation method of peer teachers, supervisory teachers, leading cadres and students' evaluation. The students' performance is evaluated by the combination of formative evaluation and result evaluation. Students master the method of using TRIZ theory to analyze and solve innovative design problems. The corresponding relationship between learning content and learning objectives, as shown in Table 1. Let H, M and L denote the strong, medium, and weak relations respectively. Reduce the proportion of final exam scores. Pay more attention to students' learning process. Adjust the proportion of rain classroom unit test, usual classroom

performance and classroom assignments. Give relatively objective comprehensive results of the course. To a certain extent, it reflects students' knowledge mastery and innovative comprehensive ability. If teaching evaluation reaches excellent, the teacher wins the teaching quality award.

- Learning content	Learning goal			
	Familiar with design process	Understand TRIZ theory	Apply TRIZ theory to innovative design.	Cultivate students ' ability of engineering quality, innovative thinking and so on
Demand analysis	Н	L	М	Н
Analyze technology conflicts	М	Н	Н	М
Find the right principle of invention	L	Н	Н	М
Analyze the application of the principle of invention	L	Н	Н	М
Give the scheme design	L	М	М	М

 Table 1. The relationship between learning content and learning objectives based on TRIZ theory

6. Implementation Effectiveness

Through the joint efforts of teachers and students, the curriculum reform has been continuously promoted. Students have received comprehensive training. The average value of students' comprehensive course scores increases year by year, as shown in Figure 7. It tends to be consistent with the achievement of course objectives. From the feedback from the course design, students know how to proceed with the design of mechanical products.



Figure 7. Students' comprehensive course scores distribution chart.

The course experience of the student for specific design objects, purposeful access to information and experience their knowledge acquisition by themselves. Innovative design and handmade ability have been effectively exercised. The submitted works have a sense of achievement.

The enthusiasm of students to participate in competitions has been continuously improved. The number of participating projects has increased. In recent years, the teachers have guided students to participate in the college students' mechanical innovation design competition. They have won one item for national second prize, three items for provincial first prize, three items for provincial second prize and two items for provincial third prize. It can be seen that the students' innovative comprehensive practical ability has been greatly improved.

7. Conclusion

The innovative thinking method of TRIZ theory is applied to the teaching reform of "Mechanical Principle" and improve students' innovative practical ability.

- 1) The teaching system of "Mechanical Principle" is reconstructed, which takes design as the main line, mechanism kinematics and dynamics as the support, and the innovative design scheme of mechanical system as the goal.
- 2) Innovative education is integrated into the six links and various teaching methods of "Teaching, Learning, Practicing, Creating, Researching and Competing".
- 3) The achievement of teachers' evaluation, students' performance, students' works and curriculum objectives are improved.

Design ability plays an important role, but there is a lack of various systematic innovative thinking methods. At the same time, it is also necessary to further explore and establish more application cases.

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