Research on Teaching Mode of Thermal Power Plant Course Based on TRIZ Theory

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Abstract: Thermal power plant course is an important professional course closely related to the actual production of power plants. This course covers some complex and abstract theoretical knowledge such as thermal power generation, cogeneration, heat-power-cool cogeneration, etc. It is difficult to achieve the expected teaching effect only by the way of teaching in the limited class hours to make students grasp such complicated knowledge. TRIZ theory is introduced into the teaching process of this course to improve its teaching methods and content, so as to cultivate students' problem-solving ability. At the same time, cultivate students' ability of active discovery learning and teamwork, and evaluate students' learning results in a reasonable way. After the implementation of this teaching mode, students evaluate tearchers' teaching quality from seven aspects in five evaluation grades. The evaluation results show that the very satisfaction rate reaches 74.4%, the satisfaction rate reaches 99.3%, and the ranking of teaching quality evaluation rises from 31st to 3rd place. This teaching mode provides an important basis for the reform and innovation of education.

1. Introduction

Thermal power plant course is an important professional course closely related to the actual production of power plants [1]，this course is generally set within the curriculum system of energy and power engineering major, and the course time is generally the sixth semester [2]. The knowledge it covers is the embodiment and externalization of some knowledge in engineering thermodynamics, steam turbine principle and boiler principle courses, and it transforms some knowledge in professional basic courses such as heat transfer and fluid mechanics [3]. Through the study of this course, students can understand the energy conversion process in the process of thermal power generation, master the calculation steps and methods of power generation efficiency of power plants, analyze the thermal economy of thermal power plants, and understand the mechanism of the energy conversion process of thermal power generation, cogeneration and heat-power-cool cogeneration [4].

This course mainly uses the blackboard teaching form in classroom [5]， the teacher is the main body in the whole teaching process. The key point of the whole teaching process lies in how the teacher teaches and pays less attention on whether students' learning is effective. This course involves many content, such as power cycle and thermal economy of thermal power plant, its regenerative heating system and heating system, etc.. At the same time, some theoretical knowledge of the course is very complex and abstract, so the single teaching means is difficult to meet the needs of students' learning, still may make students can't keep up with teachers' teaching progress, learning interest plummet, learning motivation gradually fade, not to mention that the students have refined, systematized,

internalized and transformed the knowledge they have learned.

Engineering students are the backbone of innovation, and their innovation ability is related to human development and social progress. Innovation ability is the core of education for students and the main index to evaluate its effectiveness. Cultivating and improving students' innovation ability is not only an inevitable requirement of the reform and development of higher education, but also an objective need of the innovation-driven era [6]. The lack of innovation ability has become very obvious in the many student training quality problems, and it is an urgent problem to be solved by the student tutor, the student course teacher and the student education manager. Under the traditional teaching mode, most students solve problems in engineering practice and production and life in accordance with their inherent thinking, which is easy to form stereotypical thinking, thus inhibiting innovative thinking and not conducive to the cultivation of innovative ability, many researches on students' scientific research and innovation ability have been carried out simultaneously, Liu Pengjing et al [7] pointed out that Chinese college students had weak innovation consciousness and lack of innovation ability, also analyzed the current situation and existing problems of students' innovation ability, probed into the reasons for the lack of innovation ability of Chinese college students, and put forward some improvement measures; Qi Fugang and Peng Juan [8] pointed out that the innovation ability of students was the core of the cultivation of students, and proposed the cultivation modes of building open laboratories, setting up training courses, raising innovation funds and building innovation practice bases, which can provide certain reference for the cultivation of students' innovation ability in other disciplines. Li Yifei and Ju Zhanjie [9] analyzed the problems existing in the process of cultivating students' innovation ability from four aspects, those are enrollment, course teaching, scientific research practice and assessment, and systematically considered relevant improvement countermeasures; Ji xiaoli et al [10] proposed countermeasures and suggestions for improving the cultivation of innovation ability of management science students from the perspectives of environmental construction, practice form, base construction, supervisor responsibility, assessment and evaluation on the basis of the current situation and causes of innovation ability cultivation. A large number of innovations can be applied to heat transfer systems of thermal power plants, such as heat transfer enhancement of nanofluids, heat transfer enhancement of fluids under pulsatile flow field, heat transfer characteristics of fluids under reciprocating motion, and heat transfer enhancement of fluids in wave-walled tubes [11], which requires teachers to update knowledge and adjust teaching contents in a timely manner. However, this part of knowledge cannot be timely added to the programming teaching material, making the teaching content and the current scientific and technological innovation not coordinated.

In the traditional teaching process, the learning form of middle school students is mainly passive reception learning and lack the training of active discovery learning, resulting in the students' insufficient ability of active discovery learning, which makes it impossible for students to find problems in production practice in time, and even if they do, they cannot use what they have learned reasonably to solve or optimize problems.

The traditional assessment method of course performance is mainly composed of three parts: the usual results, experimental results and paper results, the assessment proportion is 10%, 10% and 80% respectively. The grades of usual results are mainly based on students' attendance and performance in class. The assessment of experimental results is based on the completion of the experiment and the analysis and summary of the experiment report; The paper grade is based on the standard answer of the test. Only by the above three assessment methods to examine the degree of students' mastery of

this course, the assessment results are relatively one-sided, not objective. For example, some students with better test scores have poor ability to solve practical problems, while some students with poor test scores have stronger ability to solve practical problems. Through the analysis and summary of the production practice effect, it is found that there is no direct relationship between paper score and hands-on ability. Therefore, it is necessary to improve the assessment method to objectively reflect the learning effect of students.

2. The Overall Teaching Improvement of Thermal Power Plant Course with the Introduction of TRIZ Theory

2.1. The Improvement of Teaching Methods with the Introduction of TRIZ Theory

The introduction of TRIZ theory has changed the teaching form of lecture-based teaching (32 hours in total and 26 hours in lecture-based teaching), reduce the 26 hours of blackboard teaching by 8 hours, 2 hours of which is used for discussion class and the remaining 6 hours for TRIZ theory training. This teaching mode can make teachers as the main body of teaching develop towards students as the main body of learning. During the implementation of the discussion class, the students independently consult, collect, and organize useful information about the thermal power plant under the guidance of the teacher. In this process, students can actively understand the characteristics of different unit capacity thermal power plants, and systematically analyze the principle of thermal economy of the thermal system. The introduction of TRIZ theory can cultivate students' ability to solve problems actively, enhance students' interest in learning, stimulate students' enthusiasm for active learning, and promote internalization of students' knowledge, so that the whole teaching process can develop in the direction of effective teaching. The implementation process of discussion class and project-based teaching based on TRIZ theory is as follows: 1. Teachers set up open topics related to thermal power plants for students to choose; 2. Develop specific implementation plans for discussion courses and projects; 3. Develop discussion classes and the evaluation criteria of projects and score requirements; 4. Based on the TRIZ-based project, the outstanding projects will be recommended as college students' innovative activities after modifying and perfecting.

2.2. The Introduction of TRIZ Theory Can Expand the Teaching Contents

TRIZ theory can play a role in expanding the content of teaching, which is conducive to keep the teaching content consistent with social development. This teaching mode requires learners to explore the engineering problems in production and life. Learners can learn about cutting-edge knowledge and problems in thermal power plants in the engineering problems of excavation, such as how nanofluids strengthen heat transfer of heat exchangers in power plants, what are the advantages and disadvantages of using nanofluids to enhance the heat transfer of heat exchangers in power plants, how the disturbed flow fields can be integrated into the heat transfer of power plants and the influence of heat exchanger tube type on heat exchange efficiency, etc.. Some of the cutting-edge knowledge consistent with social development can be integrated into traditional teaching content.

2.3. The Introduction of TRIZ Theory Can Improve Students' Ability to Discover Learning and Solve Production Practice Problems.

The introduction of TRIZ theory can gradually transform students' learning from passive reception learning to active discovery learning. The teaching mode can also guide students to discover problems and design corresponding solutions based on understanding the constraints of the problems, and then monitor the effectiveness of the solution strategies in the role of metacognition, and

constantly adjust the solution strategies and implement solutions. In the process of continuous reflection, adjustment of solutions, and ultimately develop students' ability to solve problems with metacognitive strategies. Under the influence of metacognitive strategies, students can quickly match the theoretical knowledge learned with the problems in production practice, and quickly propose optimal solutions to solve practical problems in production practice and achieve the purpose of learning. Through the continuous training and strengthening of TRIZ theory, students can develop the following abilities:Concretize and externalize the knowledge related to thermal power plants in engineering thermodynamics, steam turbine principle, boiler principle course; Transfer part of the knowledge in the professional foundation course such as heat transfer and fluid mechanics, etc. to the thermal power plant curriculum; Master the calculation steps and calculation methods of the power generation efficiency of the power plant, and analyze the thermal economy of the thermal power plant, comprehend the mechanism of the thermal power generation, cogeneration, heat-power-cool cogeneration; Be able to effectively communicate with industry peers and the public on issues arising in the process of thermal power generation.

2.4. Improvement of the Assessment Method by the Introduction of TRIZ Theory

The introduction of TRIZ theory has improved the content of the assessment. The curriculum is adjusted by five parts of performance to comprehensively assess students' learning effect, which are the usual performance, discussion class, project, experiment and final exam. The specific assessment methods for students' learning effects are as follows: 1. Usual performance is mainly based on the student's class attendance and performance, up to four times unexcused absences, qualification examination this of course will be canceled; 2. Discussion classes and course projects: Firstly, group the students, 4-5 people in each group, each group has a team leader; secondly, each group selects the appropriate topic and uses lottery to determine the group reporters and their reports order; and finally, to evaluate the situation based on completion of the task team and the contribution of each student in the group. Based on the TRIZ theory, the results of the discussion class and the course project accounted for 10% and 30% of the total score respectively; 3. Experiment is evaluated based on student participation and preparation of the experiment and it accounted for 10% of the total score; 4. Ending exams: In order to improve students' ability to solve problems, the proportion of objective questions (selection, judgment, fill in the blanks, etc.) in the final exams should be controlled within 20%. 50% of the total scores is based on the exam results; 5. If the total score of the course is less than 60, the course will be unqualified.

Compared with the assessment method before the reform, the assessment result produced by the assessment method after the reform is more objective, comprehensive, fair and just. At the same time, it can feedback the teaching effect of each teaching stage in a more detailed way, which is convenient for students to carry out effective learning. It can provide important reference for improving the teaching method and provide important basis for education evaluation.

3. Positive Effects of the Implementation of TRIZ Theory

A large number of scholars [12-17] have applied TRIZ theory to the field of innovation. Wang Zhen and Duan Jianwei found that it has a good effect when the TRIZ theory system and the mode of its practical application are used to cultivate the spirit of college students' innovation and entrepreneurship. Liu Baoli, taking mathematical modeling as the application object, analyzed and practiced the application of TRIZ theory's innovative thinking method and problem analysis method, and affirmed the advantages of TRIZ theory in the teaching and competition of mathematical

modeling. Wu Yuxin and Cai Ting combined TRIZ theory with innovative experimental courses, and built an environment with Pro/Innovator and CBT/NOVA as supporting experiments to cultivate students' innovative consciouseness and ability. Xiang Hua, Zhang Yuan and others applied TRIZ theory to the education and graduation design process of higher vocational students to improve students' exploration and innovation ability.

Taking the undergraduates majoring in energy and power engineering in grade 2014 as the research object of teaching method reform, the teaching mode based on TRIZ theory of thermal power plant course was implemented for the first time. After the implementation of TRIZ theory teaching, the ability of students to collect necessary information and solve practical engineering problems has been greatly improved. Some students can discover problems, design and formulate solution, and eventually analyze and solve those problems at a faster speed. The students' innovation ability has been increased significantly, and a few students have applied for utility model patents.

Under the new teaching mode, the assessment results are more comprehensive and objective, and the new teaching methods and contents are more suitable for the course of thermal power plants. The reform of thermal power plant curriculum based on TRIZ theory has been recognized by the vast majority of students. Through the teaching platform, the school conducts a comprehensive evaluation of teachers' teaching effect from seven aspects: being a model for others, respecting and helping students, organizing and designing courses, explaining and expressing courses, reflecting the student-centered autonomous learning model, the management and assessment of course teaching process, and the improvement of relevant knowledge, ability and ideology. Students evaluate these seven aspects through the online platform. Each aspect of the evaluation is divided into five levels and each level's score is proportional to satisfaction: very satisfied (corresponding to the score of 4.80), satisfactory (corresponding to the score 4.30), basically satisfied (corresponding to a score of 3.80), unsatisfactory (corresponding to a score of 3.30), and very dissatisfied (corresponding to a score of 2.80). First, calculate the single item mean value of each large item, and then calculate the weighted average of the seven items, and finally get the total teaching quality evaluation result. The specific calculation method is shown in Table 1.

Table 1. On-line evaluation results of teaching quality evaluation for thermal power plants in autumn semester 2017

Evaluation index	A single average	Weight	Quite satisfied	satisfaction	Basically satisfied	Yawp	Very dissatisfied
Learn from others; Decent dress, decent manners, standing lecturing (except foreign language listening courses), on time, class is over, do not randomly change the class, do not finish class in advance.	0.4736	0.1	69	8	1	0	0
Respect and help students;Full of spirit, willing to help and respond to students, willing to listen to the opinions of students, give students guidance in many aspects, teaching and educating.	0.6979	0.15	57	20	0	1	0

Curriculum organization and design;Clear course requirements, well prepared, easy for students to understand, teaching content can reflect the latest trends in the subject, appropriate examples.	0.6931	0.15	55	19	3	1	0
Explanation and expression;Clear understanding of the teaching content, explain the simple, with the help of necessary examples or charts, multimedia courseware content image, intuitive, rich.	0.6988	0.15	58	18	2	0	0
It embodies the student-centered model of independent learning. In the process of teaching, it can provide a large number of opportunities for students to actively participate in teaching, such as doing projects, discussions and so on.	0.6998	0.15	60	15	3	0	0
Management and examination of course teaching process; Able to control the teaching order, strict and standardized attendance, effective management of all practical teaching links, careful correction of homework.	0.464	0.1	56	20	1	1	0
In this course, I learned something, and my interest in this field increased, and my knowledge, ability and thought improved.	0.9215	0.2	51	25	1	1	0

According to online evaluation results of the thermal power plant course, the unsatisfactory evaluation rate is only 0.7%, the satisfactory rate is 99.3%, and the very satisfactory rate is 74.4%. It shows that the project-based teaching mode based on TRIZ theory has been successfully implemented, and the teaching mode has been unanimously praised by the vast majority of students. This course won the third place of online evaluation of teaching quality in the autumn semester of 2017 (38 course references). Compared with the 31st (42 courses) and 19th (39 courses) of online evaluation of teaching quality in the same period in 2015 and 2016, it rose 28 and 16 places respectively, and was rated as excellent courses of Yanshan University.

Based on the implementation of TRIZ theory and its preliminary results, we will continue to improve and promote the teaching of TRIZ theory to improve students' problem-solving ability and enhance their innovative ability.

4. Conclusion

The tightness of the actual connection between thermal power plant course and power plant production determines the applicability of the course based on the TRIZ theory teaching model.

Introducing the teaching model based on TRIZ theory in the teaching process can improve the teaching method of the course and enrich its teaching content, enable students to develop active and meaningful learning habits, and improve students' ability to solve production practice problems and innovate. The teaching mode also perfected the assessment method for students' learning effects, and finally won the students' unanimous praise.

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