

Heuristic Teaching and Dialectical Thinking Education in Theoretical Mechanics

A Case Study of Conservation Law of Motion of Mass Center

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Abstract—Favorable teaching effects have been acquired in the practice of integrating heuristic teaching idea and interaction teaching model between teachers and students in the teaching design of “conservation law of motion of mass center” unit in the course of college theoretical mechanics and cultivating the dialectical thinking ability of students by means of linking with materialistic dialectics contained in the subject knowledge.

Keywords—theoretical mechanics; heuristic teaching; dialectical thinking education

I. INTRODUCTION

Theoretical mechanics is the first technical basic course tightly connected with engineering technology exposed to students of engineering colleges. Therefore, guiding the independent thinking of students in the teaching process of theoretical mechanics is of great importance to the cultivation of independent observation and thinking customs and the formation of scientific thinking method and practical engineering problem solving ability of students. Focusing on the enlightenment of thinking process and thinking method of students [1], heuristic teaching attaches importance to the fully development of students' cognitive process and particularly thinking process in teaching activities on the theoretical basis of the latest research achievements of contemporary psychology. Adopting heuristic teaching in the theoretical mechanics helps to optimize teaching effects. At the same time, as the reflection and application of materialistic dialectics in thinking area, dialectical thinking emphasizes to understand the cognition object on the basis of connection and development principles and to recognize objects in the unity of opposites [2]. Dialectical thinking ability refers to the ability to apply the basic theories and basic views of materialistic dialectics in the comprehensive and multi-angle thinking of various kinds of practical problems, so as to find out comprehensive knowledge and recognition in regard to the essence of things and to acquire the ability to solve practical problems. Generally speaking, lower grades college students may not consider problems in a comprehensive way and may be lack of dialectical thinking ability, therefore, it is necessary to emphasize dialectical thinking education in teaching process. With a case study of the “conservation law of motion of mass

center” teaching unit, this article illustrates the implementation of heuristic teaching and dialectical thinking education in theoretical mechanics course.

II. POSITION AND FUNCTION OF TEACHING MATERIAL

The “conservation law of motion of mass center” unit refers to the content of the theorem of motion of mass center in Section III of Chapter X of Theoretical Mechanics (Edition VII) edited by the theoretical mechanics teaching and research office of Harbin Institute of Technology and published by the Higher Education Press, which includes two parts, namely the content and the application of the law. The implementation of this teaching unit is based on the fact that students have learnt the theorem of motion of mass center and understood that the motion of mass center in the system of mass points is related to external force only and has nothing to do with internal force. It is of great importance to the enhancement of students' ability to solve problems related to the motion of mass center in which case the external force principal vector is equal to zero or its projection is equal to zero, to the improvement in understanding of the fact that even though internal force cannot change the motion state of mass center, it does change the motion of part of the system, and to the development of dialectical thinking.

III. STUDENTS ANALYSIS

The teaching objects of this course are mainly sophomores with advantages of active thinking and enthusiasm for novelty, therefore they can positively participate in the classroom activities under the guidance of the teacher; while on the other hand, their deficiencies include short span of concentration and incomprehensive consideration, and therefore it is necessary to use some special means to stimulate the interests of students, such as watching animation, videos and proposing questions, and properly give directions to students from different angles when solving practical problems.

IV. TEACHING OBJECTIVES

A. Knowledge Objective

To master content of the conservation law of motion of mass center; to be skillful at applying the conservation law of motion of mass center in solving practical problems.

B. Ability Objective

To cultivate the logical thinking ability and dialectical thinking ability of students; to train the ability of students to utilize logical reasoning, mathematic deduction, modeling, analysis and synthesis methods to solve theoretical mechanics problems; and to train the application practice ability of students.

C. Emotion Objective

To enable students to realize the extensive presence of mechanical problems and improve their interests on this course; to guide students to learn the philosophical thinking of mutual transformation of advantages and disadvantages through the proverb that every crisis can also be seen as an opportunity, and advocate humanistic spirit; to properly introduce historical materials relating to mechanics and improve the scientific taste of students.

V. TEACHING PROCESS

The content of this unit includes the law and its application, the teaching procedure design of which shall follow the

cognitive laws from sensibility to rationality and from rationality to practice. Considering that the teaching task of this unit is closely related to life and production, and relevant reasoning and deduction processes are not complicated, the teaching model shall be interaction between teachers and students. In order to guide students to take the initiative to think and explore, it is necessary to adopt problem-driven method and heuristic guidance method, and to instruct students to apply observation method, analogy method and induction method for learning. Teaching process of this course is indicated in “Fig. 1” and the specific teaching process is as follows.

A. Establish Situation and Introduce in New Lesson

The teacher displays the living example in daily life, namely the person- trolley problem related picture, which indicating a static trolley staying on the smooth horizontal ice surface and a person standing at the tail of the trolley, and puts forward the question that when the person moves from the tail to the head, if the location of trolley changes and how it changes if applicable, so as to stimulate the learning interests of students. When students are ready to give their answers, the teacher plays the animation and displays the right answer. Then stimulate the curiosity of students and draw forth the teaching content of this unit by means of the second question “how to explain such phenomenon”.

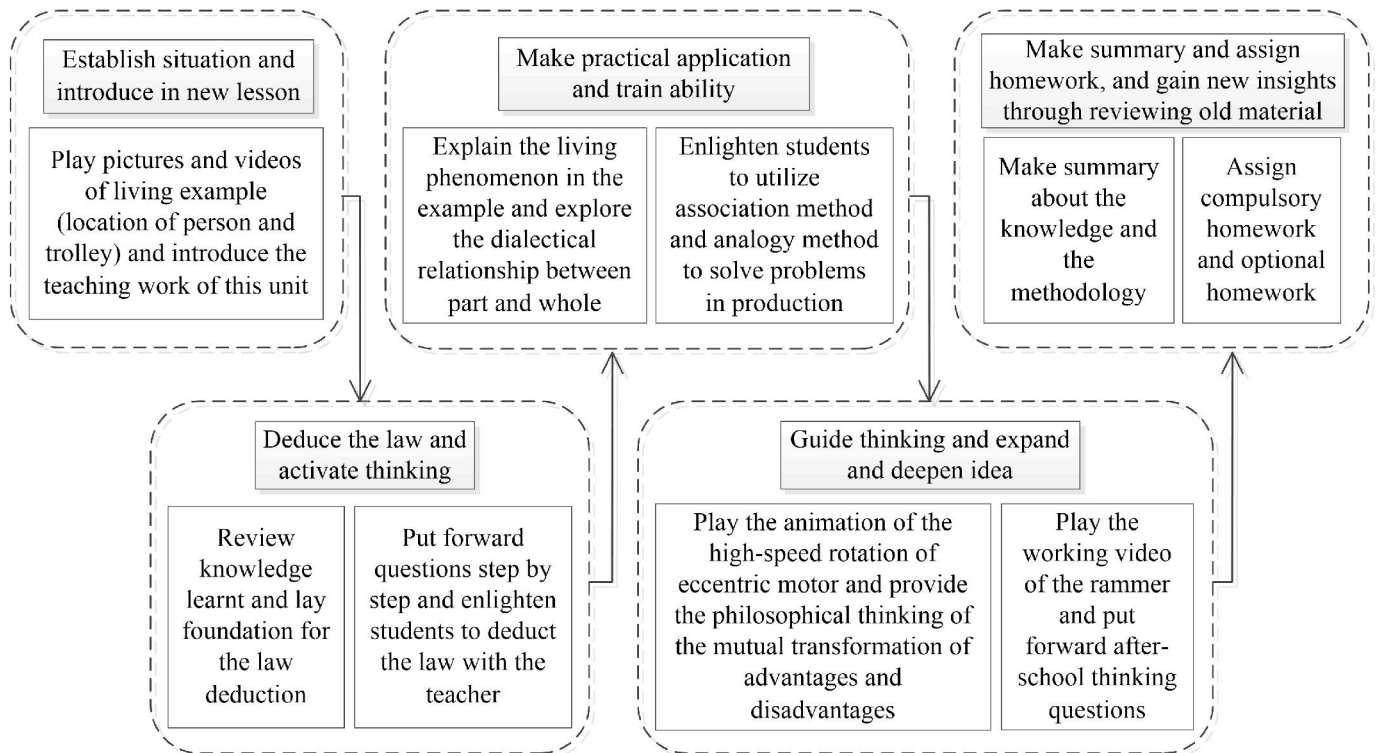


Fig. 1. Teaching flow chart of the “conservation law of motion of mass center” unit

B. Deduce the Law and Activate Thinking

Review the content related to the theorem of motion of mass center and guide students to deduce the conservation law of motion of mass center by means of a series of questions and enlightenment such as “if the item on the right side of the equation in regard to the theorem of motion of mass center is equal to zero constantly, what conclusions can be achieved, and if the system is static at the beginning, what conclusions can be deduced”, so as to train the logical thinking ability of students. In order to give students more time for thinking, the deduction process shall be completed in combination with the blackboard-writing. Profound comprehension of the conservation law of motion of mass center is one of the key teaching points of this unit. Students usually can notice the difference between the conservation law of motion of mass center and the theorem of motion of mass center, but may neglect the relationship between them. Therefore, the teacher shall guide students to summarize the essence of the law, indicating that the conservation law of motion of mass center describes the law of motion of system mass center in which case the external force principal vector is equal to zero or its projection is equal to zero, which is the exceptional case of theorem of motion of mass center, and thus point out the specific-general dialectical relationship between them and instruct the dialectical thinking of students. Next, introduce the origin of theorem of motion of mass center and the conservation law of motion of mass center, namely the work of Newton, the *Mathematical Principles of Natural Philosophy*, which proposed that the motion state in regard to the common center of gravity of two and above objects won't be changed owing to the interaction between objects. Therefore, without external effect and obstruction, the common center of gravity of all the interacted objects may be static or make rectilinear motion at constant speed.” Such process is favorable for students to further understand the relationship between the two laws on the one hand, and improve the scientific tastes of students by means of the introduction of historical materials relating to mechanics on the other hand.

C. Make Practical Application and Train Ability

Firstly, utilize the conservation law of motion of mass center to explain phenomenon in daily life. Starting from the analysis of external force exerted on person-trolley system, compare with the preconditions of conservation law of motion of mass center and guide students to use the law to explain the person-trolley system problem proposed in the example so as to deepen students' understanding of the law and respond to the previous teaching process. Although the internal force interacted between person and trolley cannot change the motion state of the mass center of the entire system, it does can change the motion of some part of it (person or trolley). It is exactly the motion of mass center of different parts which compose the entire system that guarantee the stillness of the mass center of the system. The teacher shall guide students to explore the dialectical relationship between “whole” and “part” and cultivate their dialectical thinking ability.

Secondly, utilize the conservation law of motion of mass center to solve problem in production, namely the shell motion problem when the motor rotor is eccentric. Showing students the structure drawing of a frequently-used motor, namely three-phase cage-type asynchronous motor, the teacher tells them that when the rotor is eccentric, problem emerges, so as to attract students to take the initiative to study the issue. Later on, the teacher instructs students to grasp the principal contradiction and establishes the mechanical model of motor, so as to enable students to learn the major idea and method in theoretical mechanics to solve problems, namely the modeling method. Next, the teacher enlightens students to use analogy method. Letting students known that conditions such as “no friction is counted in”, “the initial state is static”, and “when some part of the motion in the system has been known, figure out the motion of the other part” are identical with those of person-trolley system, the teacher further enlightens students to consider and apply conservation law of motion of mass center to find out the answer. When the motion equation of electric motor shell is acquired, play the animation which indicates the reciprocating motion of unfixed eccentric motor on the horizontal plane. The abscissa position of system mass center indicated in the animation remains unchanged, which enables students to directly observe the “conservation of motion of mass center”, deepens their understanding and lays a foundation for the thinking questions below.

D. Guide Thinking and Expand and Deepen Idea

On the basis of such direct demonstration of practical engineering problem and answer, the teacher further displays the motion state of motor under the circumstance of high rotor speed. Students can observe the jumping up of motor and may tend to think it is not a favorable phenomenon on the basis of inertia thinking and consider that eccentricity shall be avoided in the engineering project. At this moment, on the basis of affirming the judgment of students, the teacher can quote the celebrated dictum of ancient philosopher Lao Zi, “every crisis can also be seen as an opportunity” and point out the philosophical thinking of mutual transformation of advantages and disadvantages, and consequently introduce the rammer, which utilizes this phenomenon play its role in the project, and play the working video of a rammer, so as to enable students to comprehend the fact that disadvantage may turn to be advantage under certain circumstance on the basis of positive thinking and research. Later, assign the explanation of the jumping up phenomenon of the machine as after-school thinking question for the purpose of increasing the ability of students to analyze and solve problems independently.

E. Make Summary and Assign Homework, and Gain New Insights Through Reviewing Old Material

The teacher shall make brief summary about the knowledge and methodology learnt on class respectively so as to enable students to have a comprehensive understanding about the knowledge structure of the lesson and make conclusions of the problem-solving methods commonly used

in theoretical mechanics. In addition, the teacher shall assign homework for the purpose of gaining new insights through reviewing old material. The assignment is composed of compulsory one and optional one, which can be selected in terms of the level and interest of students.

VI. TEACHING EFFECT

Heuristic teaching idea and interactive teaching model are integrated in the teaching design of this unit and the implementation of teaching process is realized mainly through problem-driven method and heuristic guidance method. By means of the explanation and solving of practical problems in life and production, the teacher can stimulate the enthusiasm and interest of students to learn theoretical mechanics; students can answer questions actively and watch animation and video seriously, on such basis, the brief “means” applied in teaching process for the purpose of stimulating interests play a positive role; By means of the multi-angle enlightenment of teacher, students can think actively and apply association method and analogy method to solve practical problems and train their practical ability. Linking to the materialistic dialectics contained in the subject knowledge, the teaching process can inspire and cultivate the dialectical thinking of students.

REFERENCES

- [1] G. Eason, B. Noble, and I.N. Sneddon, “On certain integrals of Lipschitz-Hankel type involving products of Bessel functions,” *Phil. Trans. Roy. Soc. London*, vol. A247, pp. 529-551, April 1955. (references)
- [2] J. Clerk Maxwell, *A Treatise on Electricity and Magnetism*, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68-73.