

## Discussion on the Reform of College Physics Teaching

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**Abstract:** Traditional college physics teaching methods have limitations such as only being effective in achieving low-level learning goals, and limited time for students' attention and memory retention in the classroom. In the implementation process of teaching, there are issues such as conceptual understanding, problem-solving, and physical epistemology. With the development of science and technology, many teaching methods and teaching models have emerged, and each teaching method and model has its advantages and disadvantages. When choosing a teaching method to apply to college physics teaching, it is necessary to combine the characteristics of the teaching chapters of college physics, the characteristics of the teaching object, and the characteristics of the teacher to choose the appropriate teaching method.

### 1. Introduction

College Physics is a physics course for students majoring in science and engineering (non-physics majors). Due to the characteristics of the course itself, college physics teachers mostly use traditional teaching methods for teaching. The traditional teaching method is that teachers teach all the content following the textbook system. Normally teachers will process the textbooks carefully, try to teach all aspects involved in each concept and law to students, and teach the content prepared by themselves in class as vividly as possible, hoping to make the learning content easy for students to learn and memory. A large number of studies have shown that teaching methods based on traditional lectures have great limitations, leading to many problems in traditional teaching. To improve teaching efficiency, it is necessary to reform teaching methods.

### 2. Limitations of Traditional College Physics Teaching Methods and Problems in Teaching

The advantage of the traditional teaching method based on lectures is that teachers provide a clear and direct way to help students master subject knowledge. At present, the performance of teachers in many schools depends on students' ability to achieve good results in standardized tests, so whether they can effectively impart knowledge to students has become very important. It is an important goal of teaching to finish all the knowledge contained in the textbook, let students learn (remember) this knowledge, and achieve good results in the exam. However, cognitive science research shows that traditional teaching methods have some limitations, and there are some problems in the implementation of teaching.

#### 2.1 Limitations of Traditional University Physics Teaching Methods

##### 2.1.1 The Teaching Method is Only Effective in Achieving Low-Level Learning Goals

In the book "Taxonomy of Educational Objectives-First Volume-Cognitive Field" published by Blume et al. in 1956, the educational goals in the cognitive field were divided into six levels. From the low level to the high level, they were Knowledge, Comprehension, Application, Analysis, Synthesis, Evaluation, of which the first three are low-level goals, and the last three are high-level goals. Educational research has shown that traditional teaching-based teaching methods can only achieve low-level goals. Bligh found that lectures are only effective in disseminating information, and their effects are equivalent to methods such as reading, and will not be more effective [1]. The research of McKeachie and Kulik shows that: in terms of promoting factual learning, the lecture is

better than the discussion, and in terms of promoting higher-level reasoning ability, enthusiasm, and learning motivation, the discussion is better than the lecture [2]. The traditional teaching method based on lectures has the limitation that it is only effective in achieving low-level learning goals.

### **2.1.2 Students Have Limited Attention Span in Class**

The prerequisite of the teaching method is that students listen to the lecture and can “remember”. Research shows that as the lecture progresses, students’ attention will become lower and lower. Stuart and Rutherford surveyed the classroom attention of 1353 students. The data showed that the students’ attention was concentrated rapidly after the course began, reached a peak at 10-15 minutes, and then gradually decreased. The research concludes that the longest time of the course using the teaching method should be limited to 30 min [3]. Teachers who use the teaching method tend to overestimate how much students pay attention to what they teach. The fact is that even better students come to the classroom, on average, they spend only about half of their time listening carefully. The explanation given by cognitive psychology is that the duration of human attention is limited, with an average of about 15 minutes. The traditional teaching method that focuses on lectures has the limitation that students can keep their attention in class.

### **2.1.3 Memory Retention Time is Limited**

Teachers hope that through their careful teaching, students can quickly remember this information. The effect of students' memory and the time of memory retention are much different from the subjective expectations of teachers. Students can only remember 42% of the classroom information at the end of a class, and only 20% of the information can be recalled a week later. After a month or a year, students will retain and remember even less [4]. Cognitive science research has shown that long-term memory is generative, context-dependent, structured, and interrelated. It is difficult to form long-term memory just by listening to the teacher's detailed explanation. Because of the limitations of human memory, the traditional teaching method that focuses on teaching has the limitation of keeping memory time-limited.

## **2.2 Problems Existing in Traditional University Physics Teaching**

### **2.2.1 Problems in Conceptual Understanding**

Students enter the classroom with existing concepts. These concepts are often inconsistent with the scientific concepts in the curriculum, and are stubborn, and are not easy to eliminate through traditional teaching methods, so they are also called “misconceptions”. The misconceptions exist widely among students, and the existence of misconceptions creates obstacles to the learning of new courses. Research by Hestenes and Wells et al. showed that: “The existence of misconceptions make students unable to understand physics classes, which leads to forcibly memorizing some unrelated fragments and doing meaningless Homework makes many students feel tired of studying.” [5]

### **2.2.2 Problems in Problem-Solving Performance**

Goldberg and Bendall's research shows: “In traditional teaching, students use memorable and formula-centered problem-solving methods as orthodox tools for learning physics. They cannot reason with the concepts and laws they have learned in the face of an unfamiliar environment because their knowledge is only composed of scattered, small amounts of facts and formulas. When encountering an unfamiliar environment, what students show is their wrong concept.” [6] In traditional college physics teaching, lecturing, and doing exercise is one of the important links in teaching. Studying sample questions, doing after-class exercises, and “immersing themselves in exercises” before exams have become effective strategies for learning physics and getting good results through exams. Most of these exercises are to train students to use formulas to solve equations. They rarely use the important and basic methods in scientific thinking about constructing models, proposing hypotheses, and estimating orders of magnitude.

### **2.2.3 Problems in the Epistemological View of Physics**

For more than 20 years, international physics education research has been focusing on the study of students' physics epistemology-on the understanding of the nature of physics and physics learning methods. Students' cognition of the nature of physics and their attitude towards learning physics will have a direct and significant impact on their learning. For example, students think that physics is composed of a large number of concepts, which are not related to each other. In physics learning, they memorize a large number of physical concepts and mechanically use physical formulas. On the contrary, physicists firmly believe that physics is composed of some of the most basic laws. A large number of physical concepts and principles are based on these basic laws. They believe that in physics learning, it is necessary to deeply understand the essential relationship between physical concepts and principles and these basic laws. Studies have shown that: using traditional teaching methods, teachers often lead students to find answers directly “efficiently”, but the longer they learn physics, the more physics knowledge they accumulate, but their cognition level of physics is negatively shifted-the students' views are more deviate from the viewpoint of physics experts. Because simply accumulation of knowledge cannot allow students to understand that physics is a complex, consistent, concise, and organized theoretical system.

### **3. Emerging College Physics Teaching Methods and Models**

Due to the limitations of traditional college physics teaching methods and the problems in teaching, the pace of forcing the reform of college physics teaching has never stopped. Educational research results show that reforming university curriculum and teaching content has little effect on achieving these goals and reforming teaching models and teaching methods is the most effective way. Many scholars have raised the issue of teaching mode reform, and have conducted a lot of research and exploration on teaching methods such as flipped classroom, peer instruction, and MOOC.

#### **3.1 Flipped Classroom**

In 2000, in the paper “Inverting the Classroom: A Gateway to Creating an Inclusive Learning Environment”, Maureen Lage, Glenn Platt and Michael Treglia introduced their achievements by using the model of “flipped teaching” when they were teaching “Introduction to Economics” in The University of Miami. The flipped classroom, as a new teaching model, provides a new path for the mixing of old and new teaching methods. In this model, students watch instructional videos or other forms of course materials provided by teachers in advance outside of class, while class time is used to activate students' learning process and provide personalized guidance. Students learn the content of the course outside the classroom, and consolidate what they have learned, and conduct in-depth learning through exercises, discussions, and other learning activities in the classroom. This is exactly the opposite of the traditional teaching in class and homework after class, so it is named “Flip”. The traditional lectures can be kept in the form of videos for students to watch; and the classroom time originally used for lectures can be filled with new teaching methods. This makes the flipped learning model logically support the implementation of the new and old teaching methods at the same time, while the conflict between the two competing limited classroom time is no longer an obstacle due to the intervention of educational technology.

#### **3.2 Peer Instruction**

Peer instruction was founded by the famous professor of Harvard University Eric Mazur in the 1980s. The so-called peer instruction does not refer to the relationship of two persons, but a cooperative learning and mutual motivational learning model. In his book “Peer Instruction-College Physics Teaching Guide”, there is a complete set of models, from concept test questions to the use of classroom response systems (Clicker). Let students upload personal answers, teachers can intuitively understand the students' mastery of the question, and then discuss with each other and upload the answers again. This model can motivate students to learn independently and form a discussion-like classroom atmosphere. Students can discover their strengths and weaknesses and have a deeper understanding of concepts. Teachers can also observe students' thinking patterns in

the discussion, to promptly guide the wrong views in the discussion. This method is suitable for university classrooms that are not selective for teaching performance, especially in large classes with a large number of people.

### **3.3 Mooc (Massive Open Online Course)**

MOOC is a large-scale open online course. In 2012, Stanford University first created the COURSEERA course platform, and then MIT and Harvard University successively established a free EDX education platform, laying a theoretical and practical foundation for the generation and development of MOOC. Then students from all over the world flooded into the MOOC learning boom. In 2013, Tsinghua University and Peking University joined the MOOC course platform EDX, and domestic MOOC began to become popular. MOOC brings a variety of “famous teachers”, “prestigious schools”, “famous courses” and other high-quality educational resources previously enjoyed by only a few people into people's daily lives. Regardless of their social status and academic background, learners can apply for learning on the platform according to their needs. By completing watching teaching videos, participating in real-time comments, submitting homework, correcting each other's homework, completing test assessments, and obtaining a certificate of completion for this course. Therefore, MOOC provides learning opportunities and platforms for those who cannot enter universities to study, and at the same time promotes the development of education for all and quality education.

## **4. Discussion on the Reform of College Physics Teaching**

With the advent of the “Internet +” era, various information methods have been deeply integrated into university campuses. A lot of research and exploration of the flipped classroom, Peer Instruction, MOOC, and other teaching models have made some scholars have the wrong understanding that “traditional teaching methods should be eliminated”. The limitations and problems of traditional college physics teaching methods make us have to think about teaching reform. How should we choose college physics teaching methods?

### **4.1 Choose Teaching Methods According to the Different Content of College Physics**

The teaching content of college physics includes 5 parts of mechanics, heat, electromagnetics, optics, and modern physics. Each part of the content has strong logic and characteristics and should be combined with the characteristics of the content itself, such as whether this part has a “misconception”, whether it has the cultivation of problem-solving skills such as constructing models, proposing hypotheses, etc., to choose appropriate teaching methods. You can choose the flipped classroom, MOOC, peer teaching method, of course, it can also be the traditional teaching method. The characteristics of college physics courses determine that there is no single method of college physics teaching.

### **4.2 Choose Teaching Methods and Modes According to the Characteristics of Teaching Objects**

Teachers should also consider the characteristics of students when choosing teaching methods. For example, in some colleges and universities, some majors are practical engineering subjects, mainly male students, and more student-based teaching methods such as demonstration methods, discussion methods, and practical methods can be adopted, and the teaching content can be expanded in combination with professional characteristics. For example, for engineering mechanics, since it involves the analysis of the internal force of the beam structure and pile structure in the future application process, the teaching content of inertial mechanics and rigid body precession can be added. As for material mechanics, its future application process involves the manufacture of mechanical materials, so electromagnetic related knowledge such as material magnetization and energy band theory can be added.

### **4.3 Choose Teaching Methods and Models According to the Characteristics of Teachers**

Teaching is complex and changeable system engineering, and it cannot be a fixed and unchangeable method. A good teaching method is always relative. In addition to the factors of the course and the teaching object, the teaching method should also be selected according to the teacher's characteristics. The teacher's qualities such as expression ability, teaching skills, teaching style characteristics, organization ability, and teaching control ability all determine the choice of teaching method to a certain extent.

The traditional university physics teaching method has some limitations, and there are also some problems in the implementation of teaching. With the development of science and technology, teaching methods have entered an era of diversification. Each teaching method and model has its advantages and disadvantages. In the selection of teaching methods for college physics teaching, it is necessary to combine the characteristics of the chapter content of college physics, the characteristics of the teaching object, and the characteristics of the teacher to choose the appropriate teaching method. Which is: "There are certain teaching methods, there is no fixed method for teaching, and the most important thing is that there is an appropriate method".

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