Research on Experiment-Guidance-Theory teaching mode in optics course

Lai Jiancheng*, Li Zhenhua, Ji Yunjing, Qi jing, Song yang
Department of Information Physics and Engineering, Nanjing University of Science and Technology, Nanjing, Jiangsu210094, China

ABSTRACT

Optical theories were all originating from the experimental phenomena, as a result, we can combine the theories and experiments organically in optics teaching that can make the teaching content more intuitive and vivid to stimulate the students' learning interests. In this paper, we proposed the "Experiment-Guidance-Theory" teaching mode in optics course by integrating the theory of optics courses with corresponding experiments. Before the theoretical learning, the students would do some basic experiments to observe the optical phenomena on themselves and answer the corresponding illuminating questions to put themselves into the role, and then the teachers explain the corresponding optical methods and theories, at last, the students must attend an expansive discussion and innovation experiment around the optical theme to expand their scientific view and innovation ability. This is a kind of inquiry-based teaching method, which can stimulate the students' studying interests and improve learning initiative. Meanwhile, the ideas of scientific research also be integrated into teaching, which is beneficial to cultivate students' ability to carry out innovative research.

Keywords: Experiment-Guidance-Theory, teaching mode, optics course

1. INTRODUCTION

It has been the hot issues of the practice of teaching reform in colleges and universities to stimulate students' learning interests and improve the teaching quality by optimizing the course content and introducing the innovative teaching methods. Each optical teacher carries out different teaching methods in their own teaching practice to find out the optimal teaching method of their optical courses based on their teaching resources, quality of students and the needs of society[1]. Ji Yanjun et al. carried out the instructional design of "physical optics" through CDIO (conceive, design, implement, operate), to change the declarative teaching methods and achieve the combination of theory and practice, class and extracurricular, teaching and competition[2]. Chen Yongzhu et al. explored the implementation of innovative education in engineering optical teaching to change the traditional "spoon-feeding" teaching method[3]. Yue Baowang et al. studied the application of analogical method, logical thinking method and approximation method in optical teaching in universities to apply the science education method into the optical teaching[4]. The existing teaching research illustrated that the traditional optical teaching model has problems with content not intuitive and teaching method dull, that result in the poor learning enthusiasm and teaching effect[2-5]. As a result, Our teaching team propose the "Experiment-Guidance-Theory" teaching mode used in optical course, that integrate the optical theory teaching with experiment teaching organically to enhances the teaching content's intuitive and vivid and then stimulate student's interest in learning and improve teaching quality.

2. EXPERIMENT-GUIDANCE-THEORY OPTICAL TEACHING MODE

2.1 Planning and implementation of teaching content

The teaching content is composed of several teaching units. Each teaching unit covers a knowledge group. A knowledge group consists of the basic concepts, theorems, methods, experiment and applications around an optical phenomenon. The teaching process of each unit is designed into three steps. The first teaching session is used for students to do same basic experiments. The students observe the optical phenomena carefully in their own experiment, think and complete the inspiring problems well designed by teachers. The students are naturally attracted into the optical teaching scene, so

* laijiancheng@njust.edu.cn; phone: +86-025-84315699

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that they can think the optical phenomenon consciously. The second teaching session is designed for teachers to explain the corresponding concepts, theories or laws with the optical devices and phenomena, that make the students knew the corresponding optical theories and methods' "past", "present" and "future". "Past" represents the developing process of concepts, laws and methods. "Present" represents the current content and application of concepts, laws and methods. “Future” the latest progress and frontier issues of concepts, laws and methods. The third teaching session is designed as a exploratory study of the knowledge expansion or experiments in conjunction with cutting-edge research, and the student must complete a unit design report for the exploratory. Above design of teaching unit organically combine the experimental content with theoretical content, which avoids the traditional boring "spoon-fed" teaching method, and achieves the all-round interaction of teaching and learning, thus enhancing the students to complete the conversion from passive learning to positive learning.

2.2 Teacher equipment

According to the principle of levels, tasks, fixed point and capacity, a pyramid-shaped teaching team was build to complete the teaching planning, curriculum management, classroom teaching and experimental assistant teaching etc. The senior professors take charge of the curriculum, and responsible for the design of teaching unit, implementation of teaching tasks, supervision and assessment of the teaching quality. Professors, associate professors and senior lecturers form into the teaching staff team, cooperating with the curriculum leader to finish curriculum construction and teaching tasks. Young teachers and masters compose the teaching assistants' team, who work for experimental counseling and extracurricular Q & A. Above staff equipment realize the seamless convergence in all aspects of the teaching task. And all teachers can cooperate organically and are distinct from one another to ensure the optimization of teaching quality.

2.3 Course management and evaluation

Grid management and performance evaluation method used in the "Experiment-Guidance-Theory" optical teaching mode. It strengthens the process of management and weaken the one-time final exam. With the advantages of school wireless network without blind spots, preview and after-school expansion are integrated into the course of daily management and assessment. The efficiency and quality are all considered in to the performance evaluation as a weight factor. One unit one assessment method helps the students who do not learn at ordinary times and embrace Buddha's feet in one's hour of need to put right, by that means to risen the teaching quality.

3. PLANNING CASE OF TEACHING UNIT

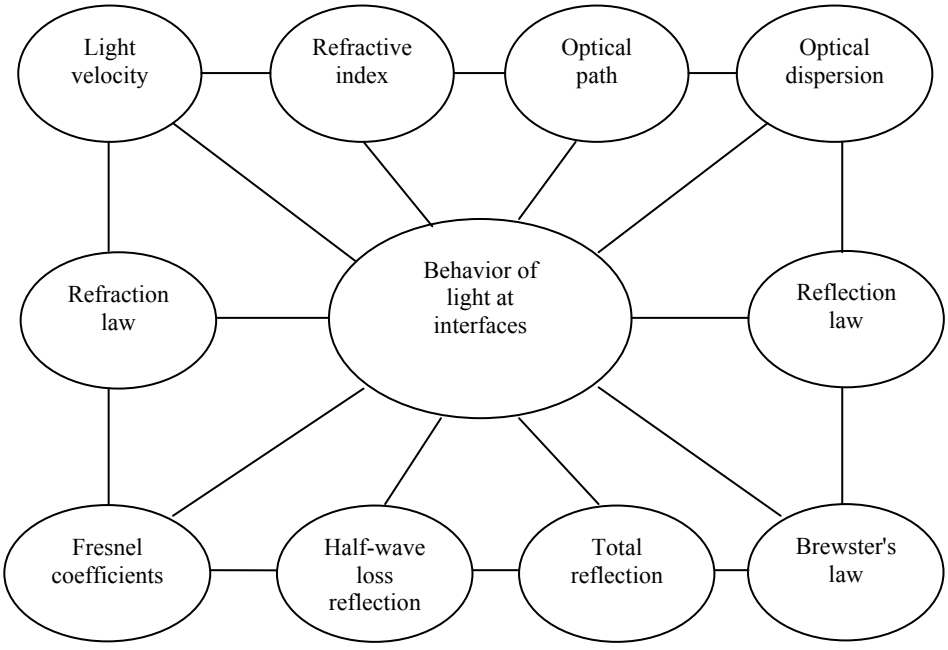

Figure 1. Content of teaching unit

As shown in Fig.1, Taking the behavior of light waves at interfaces as a theme, we form the light velocity, refractive index, optical path, dispersion, refraction law, reflection law, total reflection and Fresnel coefficients into a teaching unit to constitute an organic knowledge group.

3.1 First teaching session - Guidance experiment

In this session, you can let the student do an interesting guidance experiment - optical stealth. Put a button on a shallow chassis, and the glass cup up, pressing on the button; a classmate observe from the side, another classmate pour water slowly into the cup, until not seeing the button; At this time, if you add some water to the plate, you can slowly see the button appearing again. Attentions: Watch the buttons from the side, you can always see the button from the top of the button.

Thinking:

1) When the cup is gradually poured into the water, how the button is stealth? Why does the effect of the button reappear when the water is added to the shallow chassis again? See Fig.2 and explain the phenomena.

2) When the chopsticks insert half in the water, seeing the chopsticks "broken", what is the reason?

3) How does light propagate in the medium? How do we quantitatively analyze the process of light propagation?

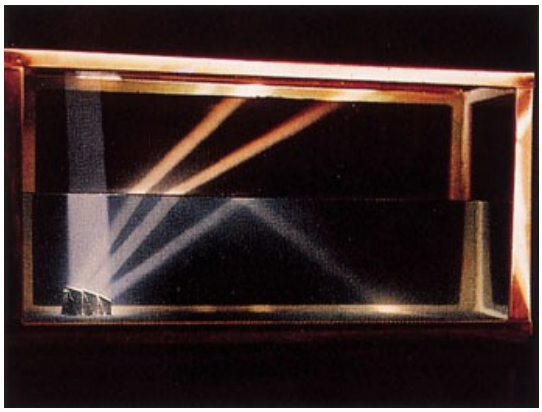

Figure 2. Total reflection phenomenon and optical stealth

3.2 Second teaching session - Theoretical teaching

1) According to the guidance experiment, discussing the demand of quantitatively analyzing optical refraction, and introducing the building history of refraction law and French scientist Fresnel, and then teaching the content of Snell's law in detail.

2) Explaining the concept of refractive index and optical path and explaining the relationship between the speed of light and refractive index, the relationship between the wave equation and the physical properties of the medium, and then discussing the dispersion phenomenon.

3) As shown in Fig.3, intuitively illustrating the application of reflection and refraction law in the optical design and the influence of dispersion on the light propagation by Zemax software. Under the condition of light emitting from denser medium into a thinner one, introducing the total reflection phenomenon and discussing the total reflection condition. To consider: the whole reflection of the light near the interface in what happened?

4) Based on the consideration of total reflection, introduction the theoretical modeling and calculation of the refraction and reflection from the opinion of wave optics, which provides the theoretical basis for Snell's law, and leads to the Fresnel coefficient of the optical wave at the interface.

5) Based on the Fresnel coefficient, discussing the amplitude and phase change of P and S components in the process of reflection and refraction, the half-wave loss, Brewster's law and its applications.

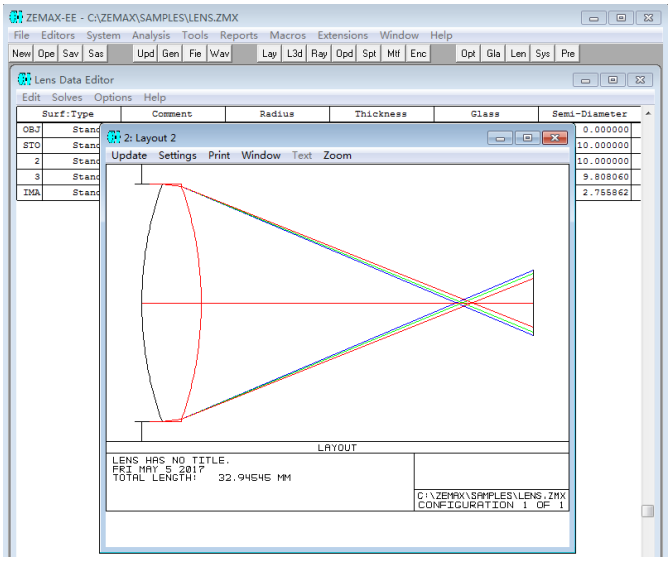

Figure 3. Light refraction by a lens illustrated using Zemax

6) Also based on the Fresnel coefficient, discussing the reflectivity and transmittance and illustrating the law of reflectivity and transmittance of P wave and S wave with the angle of incident light.

7) Seeing Fig.4 and explaining what is happening near the interface under the total reflection, to elucidate the evanescent wave, explain its characteristics, and introduce the frustrated total internal reflection and its application.

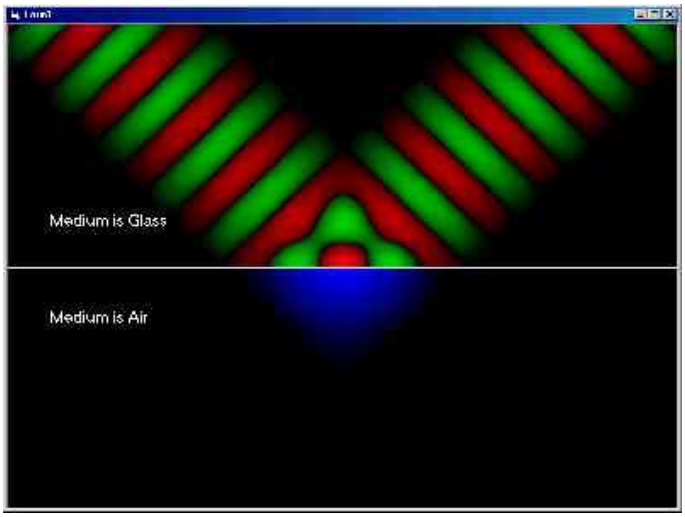

Figure 4. Evanescent wave in total reflection

3.3 Third teaching session - Expand training

Expand training is composed of a topic discussion and exploring experiment. The behavior of light on the interface of metal and left-hand material is selected as the discussion subject. The students must collect, compile, sort and summarize the corresponding literature and materials before class. Young teachers or senior graduate student assistants will organize the extensive class discussion by grouping. After then, a design experiment of refractive index measurement was also organized by the teaching assistant team. The students will develop the measurement scheme according to learned knowledge and complete the experiment measurement and the unit report independently. In this session, the optical content learned in the class can be linked with the research frontiers to expand the students' scientific view, and the theory can be related with the practice to enhance students' ability for solving practical problems.

4. SUMMARY

In this paper, an optical teaching mode of "Experiment-Guidance-Theory" was proposed. Taking the light propagation at interface as a theme, the light velocity, the refractive index, the optical path, the dispersion, the reflection law, the total reflection and the Fresnel formula were combined to form the teaching unit, and its implementation plan was illustrated which embodies the integration of theory and experiment, the combination of doing and teaching, that can realize the all-round interaction between "teaching" and "learning" to stimulate students' learning interest and force the students to transform from the "spoon-feed" passive learning to the active thinking and learning.

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