Teaching Quantum Mechanics with Blended Learning

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ABSTRACT

Quantum mechanics is very difficult for the beginners to learn, because of its high degree of abstraction and the high request to the advanced mathematical knowledge. For undergraduate students majoring in materials physical at the University of Jinan, the quantum theory is particularly difficult. The main reason is their fragile mathematical basis and students' indifference. The aim of our developmental work is to supply the mathematical knowledge reasonable and inspire the students learning interest in the limited class hour, based on the blended learning. We share here the concrete examples of how blended learning has been used into quantum mechanics teaching. Our blended learning practice provides ideas for developing new ways of quantum mechanics teaching. Whether camera-ready or not, please follow the guidelines.

INTRODUCTION

Quantum mechanics is a branch of physics, which is the fundamental theory of nature at the smallest scales of energy levels of atoms and subatomic particles. It is the basic theory of modern physics. For undergraduate students majoring in materials physical at the University of Jinan, quantum mechanics is a main course. As we all know, it is very difficult for the beginners to study quantum theory because of its High degree of abstraction and the high request to the complex mathematical operation and advanced mathematical knowledge. In the University of Jinan, the course of quantum mechanics is arranged for the undergraduates of materials physics in the fourth semester. But before that, students are taught only fundamental physics and linear algebra. while the complex variable method and the method of mathematical physics, which is very important for quantum theory learning, are not even sincerely professed in our colleges. Therefore, the mathematical foundation of our students is weak. It is particularly difficult for our students to learn quantum mechanics. Furthermore, students are interest in the specialty course with strong practicability, and think that the course of
quantum mechanics is very tedious and is no use studying. So, It is a worthy question to explore:

How to supply the mathematical knowledge reasonable and inspire students learning interest in the limited class hour?

In this paper, we will share some useful teaching methods, based on the blended learning. Blended learning[1] is an education program that combines online digital media with traditional classroom methods. It is reportedly more effective than purely face-to-face or purely online classes[2]. Students were able to better evaluate their understanding of course material via the use of blended instruction. In this work, we will present concrete examples of how blended learning has been used into quantum mechanics teaching.

The present paper is structured as follows. We first introduce the history and characteristic of blended learning. Implementation of blended learning in quantum mechanics teaching is shown in the next section. We finally draw our conclusions.

The Theory of Blended Learning

Blended learning is an education program that traditional classroom methods with online learning program[3]. The traditional classroom contains very little or even no technology. A teacher who explains concepts in a lecture format and then involves students through class discussions, small group work, or independent work. While, online learning means that, students learn completely off-site and students interact virtually both with the curriculum and their teacher-of-record. The blended learning process includes five key ingredients[4]: (1) Time: students can learn on their own time and are not confined by the schedule of the school. (2) Place: students learn inside the brick-and-mortar school setting, but may also have opportunities to work off-site, for example at home or at a community library. (3)Pace: students work at their own speed, taking more time when needed and advancing more quickly when appropriate. (4)Path: students learn using a variety of instructional approaches, for example small group collaboration or individual instruction using online tools. (5)Teacher of record: students are taught by in-person teachers or by virtual teachers, and may also receive support from paraprofessionals to bolster online learning components. Blended learning focuses on optimizing achievement of learning objectives by applying the “right” learning technologies to match the “right” personal learning style to transfer the “right” skills to the “right” person at the “right” time[5]. In what follows, we will show some examples of how blended learning method have been used into quantum mechanics teaching in the University of Jinan.

Implementation of blended learning in quantum mechanics teaching

The selection, organization and primary presentation of blended learning content as well as the design and development of learning activities and assessment are pivotal responsibilities for the instructor. According to our students characteristics, we will show our practices from the following two areas: Combining online teaching with practice application, and supplement the mathematical knowledge online.
1. Combining online teaching with practice application

Quantum mechanics contain profound theories, abstract concepts and complicated mathematical calculations, which make the course difficult for students. Therefore, during the learning procedure, we should establish a deeper connection between quantum mechanics and practice applications. This can not only gradually eliminates students fears and enhances student's study enthusiasm. The establishment of quantum mechanics theory not only affects the development of materials, biology, chemistry and other disciplines, but also has prompted many new achievements continue emerging, for example, quantum computers, quantum teleportation, topological insulators[6]. Therefore, introduction of the frontier developments related to quantum mechanics can let students feel the charm of quantum mechanics and fully mobilize students' learning enthusiasm. Because the teaching time is limited, we supply some practice application of quantum theory online.

At the beginning of the course, we introduce some new advanced technology with video. For example, news reports declared that Chinese scientist Pan together with his research group members, have achieved quantum teleportation with multiple degrees of freedom for the first time worldwide[7]. Our students are proud of the progress of our national science and technology when they watched the news. Students are also interested in the problems existing in the scientific research. For example, how to realize teleportation? What is quantum entanglement? How to generate entangled states? By explaining the connection between these problems and the basic theory of quantum mechanics, students' interest in learning can be stimulated.

2. Reasonable supplement of mathematical knowledge

Quantum mechanic learning is very difficult for students because of its high degree of abstraction and the high request to the complex mathematical operation and advanced mathematical knowledge. In our university, materials professional students only have the basic knowledge of higher mathematics. They haven't studied the complex variable method and the method of mathematical physics. While these knowledge is the foundation of quantum theory learning. For example, the contents of Schrodinger equation, one dimensional linear harmonic oscillator and hydrogen atom, will become difficult to understand, if students do not master the above mathematical knowledge. In the interpretation, teachers can only give the results and don't analysis the deducing process of these context. This will cause students' understanding of the knowledge points is not deep enough. Over time, students will think the course difficult and boring. Therefore, reasonable supplement of mathematical knowledge in the limited class hour is the key to learn quantum mechanics.

3. Blended learning can seriously help

Some course contents and mathematical knowledge can be taught online. We first optimize the teaching content and put some special chapter online. The textbook we used is written by Zhou Shixun. The book is clear in logic, easy to understand and suitable for students in engineering colleges. Chapter four is the application of practice in the most part. It is fit for self-study of students. We supply the electronic version and instructional video of this content online. Students can freely finish online learning.
online homework, online questions, discussion and answering, etc. after class. This will save some instructional time. And on this basis, we supply mathematical knowledge reasonable. In order to avoid the monotony of mathematics knowledge learning, we add the mathematical contents that students have not learned and necessary into each chapter, and show how to use these knowledge. In this way, the students not only consolidate the knowledge of mathematics, but also master the basic principles of quantum mechanics. For example, when it comes to the Schrodinger equation, we first introduce the mathematical knowledge about the vector differential and the partial differential equations, and then introduce the Schrodinger equation. In addition, we also compiled mathematical knowledge involved in quantum mechanics into electronic lecture, which is convenient for students to consult. It is proved by practice that the methods is effective.

CONCLUSIONS

We have been teaching quantum mechanics with blended learning four many years. According to the blended learning process, an instructor can teach through a web-based classroom, and can also complete other teaching activities such as preparing lessons, assignments, grading, answering questions, etc. online. In addition to face-to-face classroom learning, students can freely finish other learning activities such as online learning, online homework, online questions, discussion and answering, etc. after class. Practice has proved that blended learning process can solve the problem exists in quantum mechanics teaching in our university. It can not only promote the teaching quality and efficiency, but also can train the ability of student's studying independently. Our teaching practice provides ideas for developing teaching and learning tools available for blended learning development and implementation.

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