

# Excavation and Arrangement of Course Thinking Elements in Quantum Mechanics

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## ABSTRACT

Course thinking is a hotspot in the curriculum reform of universities of China, and is the demand to achieve the educational objective of morality education. Taking quantum mechanics as an example, we proposed our viewpoints about course thinking, such as what is course thinking, how to realize it and what is the difference between course thinking and ideological and political education, and so on. It is concluded that course thinking is not a new thing, but to complete the responsibility of teaching and educating people of a teacher.

**Keywords:** *course thinking; ideological and political education; element; quantum mechanics*

## 1. INTRODUCTION

In 2014, Shanghai Municipal Party Committee and Municipal Government proposed the educational philosophy of course thinking, and required all teachers to play active roles in rural teaching to deeply excavate the ideological and political teaching resources in professional courses, and to achieve the final educational objectives [1]. In June 2020, the Ministry of Education organized a working video conference to overall promote the construction of course thinking in the institutions of higher learning, and carried out the guiding outline of ideological and political construction of college courses. Wu Yan, the secretary of high education, proposed to blow a new wind of ideological and political construction in colleges. Right now, the attempt and exploration of course thinking have been carried out vigorously in colleges [2~7]. However, many problems, such as what is the ideology and politics? How to realize it in professional courses? etc., are still controversial and have no a clear statement from recognized authorities. In the teaching process of quantum mechanics, we always discuss the world views and methodologies in it with students, and deeply realize that the differences of world views of quantum mechanics with classical physics create confusion to students, and strongly feel the anxious mood of them. Under the circumstance, we are sure that the right guidance can deeply influence the formation of the world view of students. Hence we try to introduce the course thinking in quantum mechanics for several years and gain much experience.

In all courses of physics, quantum mechanics is the hardest to understand and has the richest ideas. In the development of quantum mechanics, there are many conflicts in world outlook and methodology with classical physics, and its development course and cognitive process to the physical world completely embody the dialectical materialism in natural sciences. So quantum mechanics is the most suitable course in physics for ideological and political

education. Quantum mechanics is full of ideological and political elements, but these elements need to be unearthed and put in order and then it can be possible to be changed into educational materials. For that reasons, we carded many knowledge points and the educational elements behind them, and carefully thought the possible influences of these elements on student's ideas, and explored the connotation and extension of ideological and political education. We tried a little, and the following is what we do in the course thinking of quantum mechanics.

## 2. CONNOTATION AND EXTENSION OF COURSE THINKING

At present, course thinking has become a hot word among university administrators, and is always discussed in various teaching meetings. However, for the questions, such as what course thinking is, what the differences of course thinking with ideological and political education are, ..., and so on, there is still no an acknowledged answer. We think that, unlike ideological and political education, course thinking shouldn't be confined by ideological and political courses, but far beyond it in connotation and extension. The different course has different ideology and politics, which is depended on course contents and its development process, not by man-made. Course thinking is not to find the political evidences or bases in ideological and political courses, but to obtain educational materials from concrete courses and guide a matter along its course of development, moulding ideas and beliefs of students and cultivating their moral sentiment without a word. We think that the connotation and extension of course thinking far exceed ideological and political education. In short, all elements in education field all belong to the domain of course thinking; with ideological and political education forming two mainlines to cultivate the world views and outlook on life of students. In specific teaching, it is absolutely not ideology-politics for the sake of ideology-

politics, and should stop fabricate something out of nothing and do not make it politicised. In fact, ideological-political education just emphasizes the teacher's educational responsibility, which is also the requirement of the policy of education of our party in the new era. Professional course teachers in colleges generally put a lot of emphases on teaching, and ignore their educational duty or hand it over to class advisers or counsellors. The teaching evaluation system for college teachers also does not embody the responsibility of educating people. A good teacher is the person who teaches courses very well. In fact, teaching well is only a half responsibility of a teacher. The educational idea of ideology and politics is to require teacher to complete the duty of educating people, and this idea asks for more requirements for teachers. It not only demands teachers know well specific knowledge but also possess moral high ground, humanistic accomplishment and ideological consciousness.

### **3. SEAMLESS CONNECTION OF COURSE THINKING WITH IDEOLOGICAL-POLITICAL EDUCATION**

Generally, college teachers have good academic background, rich knowledge reserve and high professional competence, so it is not difficult for them to refine the ideological and political elements from professional courses. However, it is not easy for them to change these elements into educational materials. This in fact is how to realize ideological politics in concrete courses. The so-called course thinking is in what way teachers can make students naturally accept the ideas behind the elements of ideological politics to form a correct outlook on life and the world. Whether course thinking can be effective or not is determined by many factors, including, whether or not there exists a conflict between the ideas in professional courses and ideological-political education; Teacher's explaining is in place or not; How to guide students when they have different views of point with teachers? and so on. These questions are the key and difficult points of course thinking. The highest realm of course thinking is to educate as life-giving spring breezes. To reach such a state, teachers need to familiarize with the related knowledge of ideological and political courses. Without higher philosophical accomplishment and human feelings, it is difficult for teachers to seamlessly connect natural sciences with philosophy. This puts forward a high demand on science and engineering teachers. These teachers need to make up for philosophy and read some extra-curricular books to expand their knowledge. In teaching quantum mechanics, when we encountered epistemological problems, we first of all gave these questions in the curriculum QQ group for free discussion of students. Students can speak their pieces and discuss each other. According to students' talks, we read the related reference and carefully prepared countermeasures, never expressing our opinion abruptly. For example, when we taught the chapter of quantum entanglement in quantum mechanics,

we first gave several questions to students for discussion, such as, does there exist a spooky action at a distance between entangled particles? If there exists, why cannot this spooky action be measured in macrocosm? If it doesn't exist, why is there perhaps a connection between the measured values of physical quantities of entangled particles? and so on. For these questions, students freely speak and discuss. For students' speeches, no judgment, we simply introduced the decades of debates on entanglement among Einstein and Bohr and the final experimental results in the 1980s. Students can pass judgment on their points of view by themselves according to historical realities. It not only diffuses the students' thinking, but also develops their scientific attitudes of seeking truth from facts.

The main course of ideological and political education is the basic principles of Marxism, including the principles of Marxism political economics, dialectical materialism, historical materialism and scientific socialism. Among them, the dialectical materialism has the closest relationship with natural sciences, especially the dialectical materialist theory of knowledge. As a teacher of professional courses, he or she should study the ideological and political courses, in particular the principles of Marxism, has correct world outlook, and familiarize with the philosophical thoughts behind educating elements. In teaching, one can quickly and seamlessly apply Marxist principles to his class, and ensure the correctness of education direction.

### **4. PROJECTING ACADEMIC PROMINENCE AND GIVING STORY CHARACTERS FOR THE ELEMENTS OF COURSE THINKING**

In people's minds, ideological politics is to sermonize insipidly, a teacher spouting off and students spiritlessly listening. A scene like this is very common in ideological and political classrooms, so you may well imagine how about the teaching effects. One wants to break out of this cycle in course thinking only when you find the brightened dots to fascinate students. Hence, we proposed to add strong plots to ideological and political elements under the premise of ensuring their academic quality. The so-called academic nature is to ensure these elements to meet with academic norms. This is the fundamental requirements. On this basis, ideological-political elements are endowed vivid story plots and make them more suspenseful, more interesting and more communicable in order to arouse students' interest and curiosity. The followings are two examples we do in actual teaching. One is the statistical interpretation of wave function. When we taught the chapter of wave function, we first introduced the sharp conflicts between Bohr's school and Einstein's school in the form of stories, including the EPR paradox, Schrödinger's cat, Einstein's local realism and final experimental demonstration. In the process of teaching, we first reorganized their points of view, sorted out the logics of their debates, mined their stories in daily life, and finally

introduced the experimental confirmation. So in the learning process, students can appreciate the refutation techniques of great masters and study their argumentation reasoning process so that students can train their logical thinking and acquire a better understanding on wave function. The other example is Einstein's photoelectric effect hypothesis. Like air, light is a common matter and must not be lacking in human life, but people's understanding of light has gone through a long and tortuous process from Newton's corpuscular theory to Huygens' fluctuation theory, and then to Einstein's theory of light quantum. Each breakthrough in understanding includes many debates even struggles and novel experiments, and finally leads to a great progress in science. Along this academic main line, we introduced the related historic events, debates, experiments and progress so that students can completely understand the cognitive process of light. Each breakthrough in understanding is the need of actual production and living, and leads to a great progress in physics. This is the academic main line. The principles of philosophy along with the main line are that people's understanding of things always spirals up. In the meantime, we also introduced China's achievements in optics in ancient times, such as the rectilinear propagation and reflection of light in Mohist Canon, the dispersion of light in southern song dynasty, the interpretation of Zhang Heng on lunar eclipse, and so on. The aim is to let students understand China's contribution to natural sciences, so that increase their pride and cultivate students' patriotic spirit. In a word, good materials need to be carefully organized and designed to work for us, achieving the ideal educational effect.

We always put forward some epistemological questions for student discussion at regular intervals. These questions are all related to the fundamental questions of quantum mechanics, such as the measurement problem, the collapse of quantum state, the relationship between quantum mechanics and philosophy, and others. Generally, we do not interfere in students' discussion; only pay close attention to their speeches. The purpose is to let students say what they really think. Finally, we will give currently accepted answers for each question for references. Usually students' points of view are not correct, but such free discussions open up students' idea, train their ability of independent thinking and logical reasoning ability, and strengthen their exchange and cultivate the spirit of cooperation.

## **5. EXCAVATION AND ARRANGEMENT OF IDEOLOGICAL AND POLITICAL ELEMENTS**

As one of the two pillars of modern physics, quantum mechanics turns over the cognition of classical physics on the natural world, breaks the bonds of classical physics on human brain, and explains the physical world from a whole new perspective. Its tortuous course of development elucidates flawlessly the dialectical materialism. There

exist many ideological-political elements in quantum mechanics, such as Planck's quantum hypothesis which overturns the cognition of continuous change of energy of classical physics and uncovers the mysterious thin veil of quantum world; the statistical interpretation of wave function which first denies the deterministic interpretation on the physical world of classical physics and thinks that everything in nature is indeterminate and probabilistic; Louis de Broglie's matter wave hypothesis which thinks a physical particle as a unity of two opposites and whether a particle or wave is determined by measurement. This hypothesis fundamentally turns over the materialistic view of classical physics; Quantum tunnelling effect which figuratively expounds the law of change from quantity to quality of dialectical materialism; Quantum entanglement which lead to a long dispute of 30 years between Albert Einstein and Niels Henrik David Bohr; local realism and non-local reality of inter-particle interaction which is the central point of argument of Einstein and Bohr, and so on.

Take two examples to illustrate how to excavate ideological and political elements in professional courses. The first is about the probability interpretation of wave function. The probability interpretation is proposed as one of the postulates of quantum mechanics, but this postulate has its experimental and ideological basis. At that time, there existed two main viewpoints about matter waves, one is the matter wave packet of Schrödinger, and the other is the alternative wave. The idea of alternative wave is denied soon after it is proposed. For the viewpoint of matter wave packet, Max Born, a German physicist, disapproved Schrödinger's idea and thought that this idea over emphasizes on the fluctuation of electrons and ignores its particle nature. Influenced by the atomic or molecular tests by James Franck, a colleague of Max Born, Born thought that Schrödinger's interpretation is wrong. Inspired by the idea of Einstein's light intensity, that is, light intensity represents the number of photons; Born firmly believed

that the square of absolute value of wave function  $|\psi|^2$  is the probability density, that is the probability of finding a particle in a unit volume. The probability interpretation unifies the interpretations of volatility and partiality of matter particles, and has a huge impact on scientific concepts. Although the concept of probability has been widely used in classical statistical mechanics and kinetic molecular theory, this is the need to deal with a large number of particles, and the collision process of two particles is still determinate and meets with the determinism. However, in quantum mechanics, this process is probabilistic and indeterminate, and violates the determinism of classical physics. In the view of classical physics, mechanical determinism is equal to the causal relationship. So the probability interpretation maybe denies the causal relationship, which is an unbreakable rule in the eyes of most physicists. These debates belong to epistemological problems, and are the highest level of physics. Through excavating the problems of philosophy behind ideological and political elements, we can train

students' philosophical accomplishment and help them to establish correct material views and methodology.

The other example is about the uncertainty principle proposed by Werner Karl Heisenberg, a famous Germany physicist. The principle tells that the position and momentum of a particle cannot be measured at the same time, i.e.,  $\Delta x \cdot \Delta p \geq \hbar / 2$ . This conclusion originates from Heisenberg's thought experiment, that is, gamma ray microscope experiment. The process is described as follows: if one wants to measure the position of an electron, he should observe the photon reflected by the electron using a microscope. The shorter the wave length of photon is, the higher the photon energy is, and the more precise the measured value is. However, the photon can obviously change the state of motion of the electron, influence its momentum and cause its momentum measurement inaccurate. The higher the photon energy is, the bigger the impact is. As an assistant of Bohr, Heisenberg even was questioned by Bohr [8]. The central points of their debates are not the principle itself but the explanation of ideological basis behind it. Heisenberg thought that the uncertainty principle tells the application boundary of classical concepts like position and momentum, and Bohr thought that volatility and partiality are two aspects of matter particles and only are treated equally one can completely describe physical phenomena. It is because of their arguments that another famous principle, the principle of complementarity, comes into being. Through carding the development course of ideological and political elements, we can make students understand the history of quantum mechanics, and train their logical thinking.

There are still many knowledge points in quantum mechanics such as superposition principle of quantum states, double slit interference of physical particles, electron spin, identity principle, and so on. Each of these knowledge points is all good ideological-political elements, but they are only raw materials for educating, only if these knowledge points are further treated, they can give full play to the role of education. In daily teaching, we have refined and retreated over 20 such knowledge points by taking academic as the main line and story as a bridge. On the basis of respecting historical facts, we focus on the conflicts between classical physics and quantum physics, enrich storylines to deepen students' understanding and memory. So that these course thinking elements can be easily remembered and spread among students.

## 6. CONCLUSIONS

Comprehensive course thinking has been the consensus of China's higher education, and extensively implemented in colleges. Taking quantum mechanics as an example, we elaborated on what course thinking is and how to realize it in professional courses. And we proposed to make ideological-political elements storytelling under the guarantee of academic norms. This is only a useful attempt. In fact, there still exist many questions to explore in course

thinking, for example, how to evaluate the influence of ideology and politics on the teaching effect of professional courses? How to realize the seamless connection of course thinking with ideological-political education without arousing students' disgust? How much time it should take up in a course? Is course thinking necessary for any courses? and others. These problems should be further discussed. Course thinking is a means to impart knowledge and educate students, and the need to realize the educational target of morality education. Only can we continuously explore in teaching practice, the course thinking which differs from person to person and differs from course to course can be optimized.

In fact, course thinking is not the additional requirements for specialist teachers, it is the basic requirement of the party's educational policy. A teacher has to teach courses and educate people. Educating people is to cultivate students' world outlook, outlook on life and values. At present, teachers' educational responsibility has been weakened in higher education. Course thinking is to lead higher education to return to the original intention and mission of education. We believe that we will certainly achieve the goal of education as long as we work hard.

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