Dialectical Thinking Education in Life Science Related Courses

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***Abstract*—Life Science is a science to understand the phenomena of life and reveal the essence of life, which contains abundant philosophical elements, especially the elements of dialectical materialism thinking. Putting dialectical thinking into teaching can help to improve students' ability to analyze and solve problems, and develop students' innovative thinking. However, how to innovate teaching methods and improve the dialectical thinking ability of college students is an important issue that college teachers urgently need to solve. Taking the course of molecular biology as an example, this paper analyzed in detail the materialist dialectic elements contained in the course, explored the teaching mode of integrating dialectical thinking into professional courses, constructed the "1 + 3" innovative teaching method, and elaborated the specific teaching path. The aim was to guide and train students to interpret the laws of life phenomena using dialectical thinking, explore students' potential for philosophical speculation, and achieve students' all-round development.**

***Index Terms*—Dialectical thinking, life Science, molecular biology**

I. Introduction

Dialectical thinking is a cognitive process and epistemological method to understanding causality and truth construction [1]. It is an important way of thinking to understand and transform the world, and an advanced form of human thinking. It is also an important prerequisite for the formation of innovative thinking [2]. For the contemporary college students, it is very important to cultivate dialectical thinking. Dialectical thinking is not only the ideological basis of forming scientific world outlook and outlook on life, but also the urgent need of improving college students' innovative thinking and ability. Therefore, how to develop the dialectical thinking ability of college students is an important task that college teachers urgently need to solve under the background of cultivating students' comprehensive quality.

Life Science is a science that studies the structure and function of living things and reveals the phenomena, laws and essence of life [3]. Life science related courses are rich in dialectical materialism ideas. Teachers' integration of dialectical thinking in teaching plays an important role in improving students' philosophical literacy, especially in the cultivation of dialectical materialism quality. It is helpful for students to grasp the essential law of life phenomena, form correct world outlook, outlook on life and values, improve their ability of analyzing and solving problems, and develop their innovative thinking and innovation ability [4]. It lays a good foundation for engaging in life science research and improving of life science theory and application in future. To cultivate students' dialectical thinking, it is necessary to improve teachers' ability of dialectical thinking and their understanding of the importance of integrating dialectical thinking into teaching, excavate the elements of dialectical thinking in the curriculum, innovate teaching methods and optimize the teaching model. Molecular biology is a subject that studies the essence of life at the molecular level, and it is the most rapidly developing subject in the field of life science. Molecular biology is an important compulsory course for life science-related majors [5, 6]. Students should not only master solid molecular biology theory knowledge and skills, but also have dialectical thinking and ability of analyzing and solving problems. Taking the course of molecular biology as an example, this paper innovated the teaching method of integrating dialectical materialism thinking into the course, and expounded the specific teaching paths, so as to provide references for integrating dialectical thinking into the teaching of other related courses.

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II. The Problems Existing in the Integration of Dialectical Thinking into the Teaching of Molecular Biology

A. Teachers' Awareness Is Inadequate

Firstly, in the process of their personal growth, teachers often attach more importance to the development of basic teaching skills, but do not have a deep understanding of the importance of cultivating teachers' own dialectical thinking ability. Secondly, the teaching process is an organic whole composed of teachers, students, curriculum and environment. However, most teachers do not look at the teaching process in a dialectical way, and their understanding of the teaching lacks integrity and comprehensiveness. They treat teaching problems in isolation and separate teacher activities from student activities, only pay attention to change their own teaching methods, and lack the overall consideration on a variety of teaching factors.

B. The Integration of Dialectical Thinking is Insufficient

In general, teachers did not attach enough importance to the integration of dialectical materialism elements in the curriculum. In the course of preparing lessons, teachers focus their energy on the preparation of professional basic theories, and don't dig into the dialectic elements in the course. They do not integrate dialectical thinking and the teaching contents of molecular biology course, and do not fully realize that dialectical thinking can enhance students' understanding of the phenomena and essence of life, and improve the teaching effect of professional courses.

C. Teaching Strategies aren't Systematic

At present, there is little research on the integration of

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dialectical thinking into the teaching of molecular biology, and there is no mature strategy and scheme for the integration of dialectical thinking that can be used for reference. Teachers lack the experience of integrating dialectical thinking into the teaching, and can' t carry out careful design of integrating dialectical thinking into teaching, so that the integration of dialectical thinking is not systematic and natural. Therefore, how to construct an effective path of integrating dialectical thinking into the teaching of molecular biology course to achieve better teaching results and adapt to the all-round education mode is a problem to be solved.

III. The Main Content of the Integration of Dialectical Thinking in the Course of Molecular Biology

A. Dialectical Relationship between Practice and Cognition

The research results of molecular biology are made by scientists through numerous experiments. The history of molecular biology is the process and history of discovering problems, putting forward hypotheses and exploring experiments. Integrating the history of scientific development into the teaching of molecular biology can help students to deeply understand that we need to go through the arduous process of constant repetition of practice and cognition to reach the correct conclusion, which help students develop a dialectical materialism world outlook and innovative thinking. For example, when talking about the content of genetic material, teachers introduce the history of genetic material research. In the early days of molecular biology, protein was considered as the carrier of genetic information. Avery's transformation experiment in Streptococcus pneumoniae in 1944 [7] and Hershey and Chase's phage infection experiment in 1952 [8] proved that DNA was the carrier of genetic information. In 1957, Heinz Fraenkel-Conrat and B. Singre's tobacco mosaic virus experiment proved that RNA could also be used as genetic material [9]. Another typical example is the proposed process of the semi-conservative DNA replication hypothesis. Before the double helix model of DNA was proposed, many scientists thought that the replication of DNA might be conservative replication. In 1953, when Watson and Crick proposed the double helix model of DNA [10], they proposed the semi-conservative DNA replication hypothesis, which was confirmed by Meselson and Stahl in 1958 [11]. Molecular Biology was born in practice, and constantly developing through constant repetition of practice and cognition. The whole development history of molecular biology fully embodies the organic unity of practice and cognition. Through the introduction of the development history of molecular biology, teachers enable students to have a more comprehensive and profound understanding of the phenomenon and essence of life, guide students to understand the dialectical relationship between practice and cognition, and encourage students to practice, explore and innovate constantly.

B. Dialectical Thinking of the Unity of Opposites

The Law of unity of opposites holds that everything is made up of contradictions. Contradiction has two aspects of opposition and unity, which are closely related and inseparable [7]. The course content of molecular biology includes a wide range of examples of unity of opposites. For example, the genome of an organism is stable to a certain extent, and the organism has a whole set of DNA damage repair mechanisms to maintain genome stability, which ensures the stability of the biological species, so that the species can be reproduced from generation to generation. But this stability is relative. Organisms adapt to changes in the environment through the variations such as genetic recombination and mutation. It is these variations that allow species to evolve. Therefore, this stability and variability of the genome is two aspects of a contradiction, which develop harmoniously in the dynamic equilibrium, and promote jointly the evolution of organisms. Another example is that the lac operon of E. coli has both positive and negative regulatory mechanisms. These two regulatory mechanisms are also two aspects of the unity of opposite. They are opposite to each other, but co-regulated the expression of lac operon according to the properties and levels of c-source present in the medium. In addition, proto-oncogene and anti-oncogene, transcription and reverse transcription, enhancer and silencer, sense RNA and antisense RNA, phosphorylation and de-phosphorylation all contain the law of unity of opposite. In the teaching of molecular biology, teachers should adhere to the contradictory viewpoint, guide students to analyze problems using the law of unity of opposite, make students recognize that everything is a dialectically unified whole with both opposite and unified aspects, and cultivate students' dialectical thinking of unity of opposite.

C. Dialectical Thinking of Quantitative Change and Qualitative Change

The law of quantitative change and qualitative change means that everything changes from quantitative change to qualitative change [7]. Quantitative change to a certain extent will cause qualitative change and produce new quality. Then, the new quality will start a new quantitative change. Quantitative change is the foundation and necessary preparation for qualitative change, and qualitative change is the inevitable result of quantitative change. For example, polygenic diseases such as asthma and cleft lip are associated with abnormal changes in multiple genes, and abnormalities in any one of these genes can increase the risk of the disease. The accumulation of this danger is the process from quantitative change to qualitative change. In the regulation of eukaryotic gene expression, the expression of some genes depends on the concentration of transcription factors. For example, the high transcription of the kyphosis gene hun depends on the concentration of the transcription factor Bcd in Drosophila. The hun gene can initiate high level of transcription when the concentration of Bcd exceeds a certain threshold. The concentration gradient of Bcd becomes the switch of hun gene expression, which is also a typical example from quantitative change to qualitative change. In addition, cell signal transduction is accompanied by quantitative changes to qualitative changes. In the teaching process of molecular biology, we should fully explore these typical examples of quantitative changes and qualitative changes, guide students to accumulate quantitative changes in the process of learning and scientific research, actively create conditions for qualitative change, and cultivate students' dialectical thinking of quantitative changes and qualitative changes and scientific quality of courage to innovate.

D. Dialectical Thinking of the Negation of Negation

The law of the negation of negation means that the development of anything is accompanied by the negation of the old by the new, which is the process of the self-development of things and reveals that the development of things is both tortuous and progressive [7]. Many discoveries and understandings in molecular biology are accompanied by the process of the negation of negation. The establishment of the central law is a typical example. Scientists originally thought that genetic information could only be passed from DNA to RNA to proteins. In 1970, Temin *et al.* discovered reverse transcriptase in oncogenic RNA viruses [13]. The fact that reverse transcriptase can synthesize DNA using RNA as a template proves that RNA can also be used as genetic material in some organisms, negating the traditional central law and making up for its shortcomings. Another example is P53, which is an important tumor suppressor gene. P53 was first identified as an oncogene in the Simian vacuolating virus 40 (SV40) in 1979. But subsequent research found that P53 was actually a tumor suppressor gene, which is also a denial of early knowledge, and it is this denial that drives science forward. The integration of these examples in teaching enables students to have a deep understanding of the law of development of things, to understand that any theory and conclusion of predecessors should not be absolutely believed and accepted, and to adopt a scientific analytical attitude. These teaching contents are helpful to cultivate students' dialectical thinking of negation of negation.

E. Dialectical Thinking of Connection and Development

Two basic viewpoints of Materialist Dialectics are general connection and eternal development [7]. Molecular biology itself is a connected and developing discipline. Firstly, the various molecules in life are closely connected to each other. Genes are expressed to proteins, and some proteins can regulate the expression of genes. The regulation of gene expression is connected and restricted each other. Various cell signal transduction pathways for cell proliferation and apoptosis are interconnected and interwoven, forming a huge signal network. Secondly, molecular biology is a multi-disciplinary discipline, and has a wide range of links with other disciplines, which provides many new technologies and new means for the exploration of the mysteries of life. With the rapid progress of science and technology, this connection has become more and more closely linked, forming bioinformatics, biomedical, biophysics and many other emerging disciplines. Modern molecular biology is both highly differentiated and highly integrated.

At the same time, molecular biology is also a developing discipline. From gene cloning, gene mutation, transgene to gene editing, molecular biology has become the most rapidly developing discipline in the field of life science. With the development of molecular biology, many new problems, new concepts and new research fields have been put forward to other disciplines, which promoted the development of the whole natural science. Therefore, molecular biology fully embodies the two principles of connection and development. These teaching contents can help us to guide students not to analyze problem in a single, isolated, one-sided way, but in a connected and developing way, and to cultivate students' dialectical thinking of connection and development.

IV. The Path of Dialectical Thinking Teaching in the Course of Molecular Biology

A. To Improve Teachers' Ability of Dialectical Thinking

The dialectical thinking ability and level of teachers directly affect the effectiveness of teaching. Firstly, teachers should enhance philosophical literacy and improve the ability of dialectical thinking through training, teaching seminars, teaching conferences, to do a demonstration of dialectical thinking. Secondly, teachers should be able to analyze molecular biology curriculum and teaching activities in accordance with dialectical laws, and follow consciously the relevant logic laws. Teachers should use a comprehensive, connected, and developing perspective to analyze teaching problems, and treat teachers, students and teaching activities as a connected whole. Thirdly, teachers should carry out teaching design carefully from the aspects of teaching objectives, teaching contents, teaching models and teaching assessment, and exploit fully the materialistic dialectic elements such as unity of opposites, quantitative change and qualitative change, and the negation of negation in the course of molecular biology. It is necessary to set up the philosophy of the whole and the part, the macro and the micro to guide and train the students' dialectical thinking ability. In addition, teachers should pay attention to personalized teaching. The thinking modes of college students are very different because of different personality, experience and growth environment. Teachers should take different ways to guide and inspire different students according to the characteristics of students, and teach students in accordance with their aptitude. Finally, teachers should take the dialectical thinking as the guidance to carry on the teaching reflection, make a comprehensive and development summary on teaching activities, and constantly optimize and improve the teaching.

B. To Use the Information-Based Teaching Platform

In the age of Internet, we should make full use of information-based teaching tools to promote the integration of dialectical thinking into the teaching. On the one hand, we push high-quality learning resources especially typical cases on dialectical thinking to students through various information-based learning platforms. We use easy-to-understand video, audio, text, pictures and other means to guide students to excavate the materialist dialectics elements contained in the case, which can expand students' learning channels and broaden students' knowledge. On the other hand, we use information-based means to carry out diversified interaction, including online discussion, debate and other activities. We organically combine activities such as pre-class preparation, in-class discussion and after-class exercises to stimulate the enthusiasm and initiative of students and improve the teaching effect of integrating dialectical thinking into the curriculum.

C. To Construct "1 + 3" Innovative Teaching Method

In order to cultivate students' dialectical thinking, teachers must change the original inculcation teaching concept to guide students to actively explore knowledge. In the teaching of molecular biology, we combine the traditional lecture-based learning (LBL) method with three modern teaching methods of problem-based learning (PBL), case-based learning (CBL) and research-based learning (RBL), and construct the "1 + 3" innovative teaching method to improve the teaching effect.

1) PBL is a problem-oriented, student-centered teaching method [14]-[15]. Firstly, teachers should not explain the truth at once, but inspire students' in-depth thinking and discussion step by step on molecular biology issues and modern molecular biology technologies through typical questions. Nowadays, modern molecular biology technology develops rapidly and is widely used in agriculture, medicine, food, energy and environmental protection. It has great influence on social progress and economic growth. While seeing the benefits modern biotechnology has brought to mankind, teachers should guide the students to think deeply about a series of problems caused by their application. For example, food safety problems caused by genetically modified foods have been the focus of controversy. Some people suspect that the new protein produced by genetically modified food may trigger a violent immune response and even lead to tumors. Some people believe genetically modified food may produce toxins that cause a toxic reaction in the body. Another people think that antibiotics commonly used in screening for genetically modified organism may increase the risk of drug resistance in the body or produce drug-resistant strains. In view of these problems, teachers can guide students to discuss the issues of toxicity, allergy, drug resistance, beneficial ingredient and immunity of genetically modified food to stimulate students' ability to analyze problems dialectically and activate the classroom atmosphere.
2) CBL is a case-based teaching method [16]. Teachers carefully design the case and let students to explore the materialist dialectical thought contained in the case. The combination of materialist dialectics and typical cases can make students understand the theory more comprehensively, thoroughly and deeply, and cultivate students' abilities of combining theory with practice and dialectic thinking. Gene editing is a very hot technology in the life science field in recent years. Gene editing baby event can be introduced in the content of gene editing. In 2018, Jiankui He from Southern University of Science and Technology genetically edited a pair of human embryos to knock out their CCR5 genes using CRISPR-Cas9 technology. He claimed that the babies would be able to resist AIDS after birth, which has drawn strong condemnation from academics around the world. Teachers can inspire the students to discuss gene editing baby event from the technical level, the genome cognition level and the ethical and moral level, so that the students can view the modern biological technology dialectically. Through the discussion, students can realize that science and technology is not an isolated system, and it must be restricted and influenced by many factors such as politics, law, morality, and so on. Students can also understand that scientific and technological innovation must adhere to the correct value orientation.
3) RBL is a research-based teaching method. Teachers excavate the elements of dialectical thinking in scientific research, and combine scientific research and teaching to improve the teaching effect. Firstly, teachers can put scientific research results, scientific research cases and scientific research problems into the classroom teaching, create suspense, and guide students to discuss, which can enrich the content of lectures, broaden students' horizons, improve the quality of teaching, exercise students' thinking ability, and make scientific research more meaningful. Secondly, teachers can select classic scientific research literature into the teaching, which make students learn scientists' research ideas and methods, close the distance between students and scientific research, follow the forefront of the subject, extend students' theoretical knowledge and train the students' thinking ability. In addition, dialectical thinking is a kind of rational thinking based on practice. Through research projects, teachers guide students to design experiments in groups to explore scientific problems, improving students' understanding of the world of life and enhancing students' practical ability, thinking ability and innovative ability.

V. Conclusion

Dialectical thinking is a scientific world outlook and methodology. Improving students' ability of dialectical thinking meets the overall requirements of cultivating innovative talents in the new era. The curriculum of life sciences, represented by molecular biology, is loaded with rich dialectical materialism views. We explored the elements of materialist dialectics in the teaching contents, made full use of information-based means and tools, innovated "1 + 3" teaching methods, and constructed the teaching mode in which the philosophy of dialectical materialism was incorporated into the course, which has achieved good teaching effect. The molecular biology course was awarded as an excellent demonstration course of Harbin Institute of Technology at Weihai in 2022. Students' learning ability, thinking ability and innovation ability have been improved obviously. Students can use philosophical thinking to interpret the law of life phenomena, forming a "theory-thinking" combined learning model. Practice has proved that the integration of dialectical thinking into classroom teaching is an innovation in teaching reform, and it has a good reference for other related courses.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Xiaofei Wang wrote the paper; Jie Jiang conducted overall teaching design; Hong Zhang explored the elements of materialist dialectics in the teaching contents; Yanxiao Jiang built the online learning platform; Guangfeng Kan and Yingying Wang innovated "1 + 3" teaching methods; all authors had approved the final version.

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