How to Cultivate Students' Core Literacy of Biology in New Lessons: A Case Study of the *Cell Nucleus*

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Keywords: cell nucleus; core literacy of biology; scientific thinking; integration of structure and function.

Abstract: Biological literacy is an important part of citizens' scientific literacy. Biological literacy refers to relevant knowledge on biology, the inquiry ability, as well as emotional attitudes and values that citizens need in their social life, economic activities, production practice and personal decision-making. Improving the biological literacy of every senior high school student is a basic task in the curriculum standard. This paper analyses how to cultivate students' scientific thinking ability and help them to understand the integration of structure and function through the classroom design of the Cell Nucleus.

1. Introduction

Core literacy of biology can bring lifelong benefit. It is one important component of citizens' basic literacy; it is one essential character and key ability when students solve biological problems in real situations. Biology core literacy mainly includes the life concept, rational thinking patterns, scientific inquiry ability and social responsibility.

The purpose of this lesson is to help students form core biological literacy, and provide them with scientific viewpoints, knowledge, ideas and methods which can be used to solve problems in real life. In order to achieve such objectives, we should pay close attention to the practical experience in the teaching process. The "practice-oriented" model emphasizes that students' learning process is a process of active participation. Teachers should not only let students participate in hands-on activities, but also encourage them to actively integrate into minds-on links. Through inquiry learning activities, students can deepen their understanding on biological concepts and enhance their ability to apply knowledge.

2. Brief Introduction to the Overall Idea and Background

In the compulsory biology textbook published by the Zhejiang Science and Technology Press, *Cell Nucleus* is the fourth section of the second chapter in textbook one for senior high school students. The specific requirement is "to clarify the structure and function of cell nucleus", which belongs to the level of understanding.

2.1 Guidelines

The guiding ideology and theoretical basis of this lesson are the value of content learning on the development of students' subject literacy. They include the life concept (structure and function view, relationship between the part and the whole), scientific inquiry ability (observation, questioning, the design of experiment, the scheme implementation, exchange and discussion of results), scientific thinking (induction and summary, critical thinking) as well as social responsibility (participate in discussions on personal and social affairs).

2.2 Teaching Model

According to characteristics of the content, the author adopts the concept construction teaching model in this section.

Firstly, through hot social events, the author leads in the lesson and puts forward the core issue

  DOI: 10.25236/acaelt.2019.393

of this section. Then the author provides students with sufficient and reliable facts or experiments, adopts the exploratory, heuristic and problem-solving teaching strategies, so as to guide students to find the answers to the core question. During that process, students are allowed to ask questions; the teacher organizes students to discuss and explain their doubts, pay attention to students' conceptual process, and find the answers to the core question. Finally, the teacher should clarify the important concepts and find evidence which shows that students have understood the concepts and realized the transfer and application of the concepts. So far, the teaching process of concept construction is completed.

3. Analysis of the Teaching Content

3.1 Analysis of the textbook

Students have learnt contents of the structure and functions of cell membrane before this section. Knowledge in this part enables students to have a more comprehensive understanding on cell's submicroscopic structure and function. It also paves the way for future study. For example, the relationship between chromatin and chromosome is the basis of studying chromosome changes during cell mitosis. It also enables students to further recognize the "unity of structure and function". In addition, the data analysis also enables students to experience the general methods and processes of biological research.

3.2 Analysis of difficulties

The teaching focus includes two points. First, through data analysis, students can truly recognize that the nucleus is the control center of cell metabolism and genetics. Second, students need to understand the structural characteristics of nucleus and its relationship with its functions.

Teaching difficulties include two points. First, Students need to think and analyze actively, and grasp the method of analyzing experiment results and drawing conclusions. Second, through the teaching of nucleus structure, students need to understand that the nucleus is a genetic information base; functions are suitable for the structure.

3.3 Textbook adjustment

Through the in-depth analysis of the textbooks, the author re-arranged the textbook contents. First, relevant contents in the junior high school textbook are reviewed; they are the basis of learning senior high school curriculum. Second, contents in textbooks published by the Zhejiang Science and Technology Press and the People's Education Press are integrated. Third, supplementary materials are provided.

4. Analysis of Learners

After learning in junior high school, students have a preliminary understanding on the overall structure of cells, the cell membrane, the cytoplasm as well as the nucleus. However, students' knowledge on biology is still very weak. They do not know how genes control the synthesis of proteins, and then control the metabolism of organisms and the cell division. Therefore, in the teaching of "nuclear structure", we should not mention too much difficult contents, so as to avoid unnecessary obstacles to understanding. In addition, they have a certain ability to analyze problems. It is feasible to carry out problem-based inquiry teaching. Their interests can be aroused by problems. The teacher needs to guide students to learn independently, and cultivate students' biological thinking ability as well as subject literacy.

5. Design of Learning Goals

Learning goals include following parts. First is the life concept: students need to understand the structure and function of the nucleus and the relationship between the structure and function. Second is the scientific inquiry: students should be able to conduct experiment analysis; the

experiment results should be exchanged and discussed. Third is scientific thinking: the teacher needs to enhance students' desire to explore new knowledge and cultivate their innovative consciousness through the analysis of experimental data; students should develop their thinking abilities of induction, generalization and modeling when reading the supplementary materials. Fourth is social responsibility. Facts are introduced into the discussion of social affairs; rational explanations and judgments are made. Students should germinate the consciousness and responsibility of solving the problems in life and work.

6. Overall Teaching Design for the Unit

Design teaching activities from the whole to the part is conducive to grasping viewpoints and core concepts of the subject.

6.1 The design thought

The overall teaching preparation at the unit level is the key link in implementation. The overall preparation should distinguish factual knowledge from important concepts. Teachers need to think about the teaching objectives of the whole unit, and design the core issues of the unit. The core issues should focus on important concepts and serve as the main line of teaching.

6.1.1 Teaching purpose

The teaching content of this module helps students understand that life is material (the essence of life); the structure and function of organisms are compatible; the unity of parts and whole of organisms (the viewpoint of system theory). It helps to form the dialectical materialist view of nature.

As for ability cultivation, the focus of this unit includes following parts. First, the structure and function of each part of the cell are unified; the structure of each part of the cell is coordinated, so that the cell can be a unified organic whole to carry out metabolic, genetic and other life activities, reflecting the unity of the part and the whole. Second, the viewpoint of system theory is established through learning knowledge about the cell. All systems have boundaries (membranes), components and structures; structures interact with each other.

6.1.2 Teaching structure

The teaching structure and important concepts of this unit are summarized as follows. First, cell membrane acts as the boundary of the system, which controls entry and exit of materials and detects environmental signals. The flow mosaic model can explain above functions. Second, DNA molecules in the nucleus store genetic information and guide protein synthesis to carry out various life activities of cells, such as the regulation of cell activity, catalytic function and the signal system as structural components. Third, cells are concentrated mixtures of tens of thousands of molecules that form specialized structures (such as organelles). They need to complete tasks such as the synthesis of new molecules, the energy generation, the molecular transport and the storage of genetic material. Fourth, cells are like small societies, in which various components and structures cooperate closely with each other to accomplish life activities such as cell metabolism through complex information exchange.

6.2 Design core

A central question throughout this unit is: how do the structures of eukaryotic cells realize their functions? The topic is not interesting. Students can evaluate the problem by building their own three-dimensional physical model or electronic model. It can also increase students' interest in learning.

This section is the penultimate section of this chapter. After this section, students can construct the complete, integrated cell structure. The contents of this section are not too much. Therefore, when design this lesson, besides helping students to construct basic concepts of cell nucleus, we hope to cultivate students' biological accomplishments such as scientific exploration and thinking

ability through experimental analysis and the material analysis.

7. Record of One Single Class

Teaching Process	The Teacher's Activity	Students' Activity	Evaluation of the link
Leading-in the new lesson combining with current events	Play the video of "Three Parents", hot news on nuclear transplantation in 2016 Put forward the core question of this section: Why we can manipulate the nucleus to influence and control biological manifestations?	Watch videos; Some tentative ideas on this issue are put forward.	The factual news related to social hot spots arouses students' interest; students' attention are drawn to the core issues of this section.
Learning the new lesson, analyzing materials	Blackboard writing: Function of nucleus Materials of four experiments are provided for students in the form of study plans: 1. Nuclear Transplantation of Black and White Ambystoma mexicanum 2. Transverse constriction of fertilized salamander eggs 3. Cutting Amoeba 4. Grafting acetabularia The experimental materials are given to students to experience the exploratory nature of biological science experiments. Students are divided into groups to analyze and discuss. After discussion, the conclusions are generated. The teacher participates in group discussions, and encourages students to ask question, and help groups with little progress. The teacher evaluates the results of students' discussion and carries out guided analysis on the controversial parts; most groups can basically draw standard conclusions. Following situations on the conclusions of the 1st, 3rd and 4th experiments happened: In the first experiment, the conclusion of the experiment can be given smoothly, but in the process of analysis, the students found and put forward: Can we set up another control group to introduce the nucleus of the white Ambystoma mexicanum into the cytoplasm of the black Ambystoma mexicanum? (The teacher seizes the opportunity to further ask students about his thinking process. Through the interaction between the teacher and students, students understand that independent variables are reflected by setting up control group and directly presented on dependent variables, as well as the necessity of setting up the control group.) In the third experiment, students conclude that cytoplasm and nucleus are interdependent and indispensable. (This conclusion is not the experimental conclusion expected in this lesson: the nucleus is the control center of cell life activities. However, the student analyzes the question with clear thinking and reasoning	Reading the learning materials on experiments in the study plan. Active group discussion. Some groups can quickly analyze and draw conclusions; some groups are fast, but the language of the conclusion is not rigorous while the analysis of independent or dependent variables is inaccurate; some groups have controversial opinions and heat discussion. They put up with more questions and have more achievements. In the process of presenting the results of the group discussion, some groups questions the conclusions of other groups, which effectively triggers the in-depth thinking of the whole class. When presenting the overall conclusions of 1, 3 and 4 experiments, students' keenness in the biology subject surprise the teacher!	The teacher does not lay any groundwork for students to analyze the experiment materials. The teacher worries about whether students could extract the materials comprehensively and accurately. However, the facts tell us that we should trust students and provide them proper space to exercise. The demonstration process exercises students' abilities of analyzing experiment, organizing language and questioning. This link cultivates students' academic attainments: 1. Scientific inquiry ability (observation, questioning, experiment design, scheme implementation, exchange and discussion of results); 2. Scientific thinking (induction and generalization, critical thinking).

	logic. The conclusion is rigorous. We can approve the conclusion and guide students to draw different conclusions.) In the fourth experiment, when a group of students comes to the conclusion that the nucleus could control the morphology of acetabularia, another group of students questions that the experiment is not rigorous: the experiment could not eliminate the interference of cytoplasm! The teacher takes the opportunity to inspire students: can we design a parallel experiment on that basis to eliminate cytoplasmic interference? Students' performances are gratifying; many groups of students are active. Finally, the “nuclear transplantation of acetabularia“ is presented. Students reach the conclusion that the construction of the morphological structure of organisms is mainly related to the nucleus.		
Learning the new lesson, function of nucleus	Blackboard: summary of nuclear function Teacher: Just now you have performed very well. We have reached the conclusion of four groups of experiments. So can we integrate them into one sentence to reflect the function of the nucleus? Conclusion: The nucleus controls the metabolism and inheritance of cells. By analyzing the experiments, we not only acquired knowledge about the function of the nucleus, but also improved our understanding on the design of the experiment. The homework after class is to complete the final content of each experiment on the study plan: experimental evaluation. For example, you can point out the shortcomings of the experiment and propose an improved scheme, or point out rigorous design ideas of the experiment.	On the basis of the previous link, students can summarize the functions of the nucleus smoothly. When the teacher assigns the homework of experiment evaluation, students are confident and eager to try. (Their homework really exceeded my expectations. Students’ perception of control variables in experimental design is surprising!)	Through the after-class experiment evaluation method, students are trained to analyze experiment, design experiment, and form preliminary understanding of biological experiment.
Learning the new lesson, structure of nucleus	Play 3D dynamic video Teacher: We have a preliminary sensory understanding of the space structure of the nucleus through this video, but there are still many doubts about the details. Next, please read the materials on our study plan carefully with the questions after the materials, and refine our nuclear structure model step by step. Then the teacher guides students to read three materials related to the nucleus, grades and analyzes the students' discussion, and gradually guides students to construct the concrete structure of the nucleus. Blackboard: nucleus, chromosome, DNA, genetic information At last, students browse the materials again, and realize that the structure of each part of the nucleus is compatible with its function.	Watch the video to form the first intuitive understanding of the nucleus. After reading materials prepared by the teacher, students discuss in groups, complete the question series, and further understand the structure of each part of the nucleus. This part is completed smoothly, but because the former part takes more time than planned, this part is compressed. In addition, the material is academic and the amount of information is large. Some students cannot complete the task on time.	Developing students' ability to extract information and analyze materials from reading materials. It cultivates students’ concepts of life: the relationship between structure and function, the unity of part and whole.
Summing up and upgrading; the unity of	On the basis of the general structure of the nucleus, sieve tube cells, skeletal muscle cells and mature mammalian red blood cells are given. Teacher: Who can tell me why	Reading analytical materials, thinking and answering questions: basically the absence of nuclei and the	Recognize the unity of nuclear structure and function, and further deepen the

structure and function	these cells have no nuclei or have many nuclei? What is the relationship between the numbers of nuclei and their functions? Combining with the old knowledge and providing related materials of red blood cells, the teacher can guide students to deepen their understanding on the unity of structure and function, and make students recognize that the nucleus is the control center of the cells' life system.	multiple nuclei of sieve tube cells and skeletal muscle cells are related to the transport function of sieve tube cells and cell fusion of skeletal muscle cells, but the absence of nuclei of mammalian red blood cells is hard to explain.	understanding of the unity of structure and function
Summing up and upgrading; explaining the doubts	blackboard writing; taking students as the main body to summarize knowledge learnt in this lesson and constructs the logical framework of knowledge. Teacher: Through this lesson, we have a certain understanding of the structure and function of the nucleus. Now let's go back to the beginning of this lesson. Can you explain why babies of three parents can avoid genetic diseases caused by genes of their parents?	Students follow the teacher to construct the knowledge framework of this lesson. When reviewing the lead-in question, students can explain this fact from the perspective of the function of the nucleus. Students are very happy and enthusiastic. The teacher cultivates students' scientific thinking quality, as well as induction and generalization abilities in the process of induction and summary.	Applying what we have learned in this section to solve factual scientific events. The teacher cultivates students' social responsibility and accomplishment: participating in discussions on personal and social affairs.
Homework	Students need to evaluate the four experiments in the study plan.	Most students can finish the homework. Some students still cannot understand the principle of experiment control and variable control.	Students are trained to transfer, use and design experiments. The scientific and rigorous thinking pattern is cultivated. The results are gratifying.

8. Conclusion

Through designing classroom activities properly, teachers can cultivate students' core literacy of biology in new lessons. On one hand, the problem-based inquiry design has good effects. The classroom efficiency is high; students can grasp key points of this lesson. The teacher can enlighten students' inquiry thinking and guide classroom activities through asking questions. Second, the teacher breaks the limitation of textbooks through integrate the contents of different versions of textbooks. Through appropriate selection, integration and adjustment, the contents are redesigned; the core of this section is refined. Rearranging typical cases and examples make the classroom design more conform to students' cognitive rules and can better improve students' literacy of biology.

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