Integrate STEM Education into Biology Teaching

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ABSTRACT
As an interdisciplinary education, STEM emphasizes the authenticity of the teaching context and requires secondary school teachers to conduct teaching activities in a real-world context. Secondary school biology teachers can develop students' comprehensive abilities such as critical thinking, problem-solving ability and innovation ability by carrying out teaching activities based on STEM education concepts. This paper explores the development of integrating STEM education with biology teaching in schools in China. Many examples of STEM teaching that can be used in targeted biology teaching are given.

Keywords: *STEM education, Science teaching, Biology teaching.*

1. INTRODUCTION

When students learn science in secondary schools, some of them are influenced by the testing education and appear to have high scores with low ability, which is very unfavorable to students to improve their comprehensive ability and get integrated development. Based on the concept of STEM education, biology teachers in secondary school integrate the knowledge of biology with technology, engineering and other fields, which can strongly promote students' operational ability, innovation ability and other noticeable improvements. Teachers in secondary schools in China should encourage their students to open their minds and actively engage in various learning activities, which will lead to better comprehensive ability of students.

STEM education helps cultivate students with key competencies for the future which are likely to last in their future lives and work. STEM education makes up for the shortcomings of traditional education by being more student-needs-based, not just aiming at the short-term acquisition of knowledge, but at long-term competency development, with the ultimate goal of developing students into well-rounded, capable learners. The new education reform requires cultivating of students' scientific literacy as the main objective of biology teaching, which has often been overlooked by Chinese teachers in the past. The integration of STEM education in biology teaching helps to achieve this goal by helping students change their test-taking mindset and apply what they have learned about biology to solve real-world problems. Thus, it is of considerable practical and theoretical importance for Chinese biology teachers to integrate STEM education into their classes.

2. SELECT TEACHING CONTENT BASED ON STEM CONCEPT

2.1. The principle of integration

The principle of integration requires teachers to integrate the knowledge of science, technology, mathematics and engineering as much as possible in the teaching process so that students can integrate the knowledge of biology to solve real-world problems in the process of learning scientific knowledge. Integrating can broaden students' minds and effectively improve their problem-solving skills [1].

For instance, when demonstrating the function of the plasma membrane, teachers can give some examples from students' life, such as why the liquid turns red after the edible amaranth is well-cooked? In order to explain that the plasma membrane has the function of protecting the cell, and then analyze what structure of the plasma membrane determines this function. In other words, students can have a deep cognition of the microscopic plasma membrane and form a scientific concept that "structure determines the function".

2.2. The principle of practicability

The practicality principle means attaching importance to students' practice and extending the theory into practice. In line with this principle, teachers in

secondary school should guide students to participate in hands-on practice so that students can boldly imagine and explore independently. Students can deepen their understanding of scientific knowledge through practical exploring, which will not only make students' mindset not limited to textbooks but also deeply explore students' potential and make their hands-on practical skills develop more rapidly [2]. Written assignments are not conducive to constructing abstract concepts and developing students' interest in learning biology, so designing hands-on activities elaborately in teaching is essential. Letting students try something by themselves often leads to more profound memories, because students may spend more time and remember the knowledge they get better by figuring it out by themselves. It is evident that students are more willing to spend time building scientific models than copying knowledge points.

For example, in high school biology lessons, when teaching the formation and extinction of species, glass bottles and glass beads can be used to model the bottleneck phenomenon of populations. When explaining the free combination of sweet corn and fruit fly chromosome gametes' crossbreeding, plasticine or ultralight clay can be used to build models to simulate the process of meiosis and free combination. When simulating natural selection, teachers can use black and white paper and beans to simulate the different environments and two types of peppered moths. Then let students play the role of predators, grab the black and white beans and put them in the corresponding boxes, and count the genotype frequency at the end of this game.

In addition, computer programs are gradually gaining prominence in biology teaching. Using computer programs to simulate the effects of natural selection on the genotype frequency of the population can help students understand abstract biological phenomena more intuitively.

For instance, teachers in secondary and high schools in China can also use the website "Phet" to simulate natural selection in rabbits, where imposing artificial conditions can change the proportion of various phenotypes in the population. Software simulations output more scientific results than homemade materials, and the experiment process is more straightforward and more understandable due to the fine animation.

Therefore, to become a biology teacher who teaches based on the STEM concept, one must also learn to continuously improve one's educational technology and learn to use a variety of computer programs to assist in teaching and learning to increase students' interest in learning.

2.3. The principle of sociality

The principle of sociality means that teachers should conduct teaching based on the STEM concept, stretch the practice tasks to some topics related to real society, and lead students to think and care about the community, which is important for strengthening students' sense of social responsibility and applying scientific knowledge to social practice. It can effectively help students apply what they have learned to solve social problems better, thus developing their problem-solving skills rapidly [3].

To give you an idea, when teaching chapters on transgenic technology, human genetic diseases, abuse of antibiotics, grain breeding and so on, teachers can let the students make posters to promote science knowledge to their families and friends around them, popularizing professional biological knowledge learned in school while strengthening students' sense of social responsibility. Promoting China's achievements in grain breeding and cultivating national sentiment and mission is also very important.

3. ENGAGE STUDENTS BY CREATING TEACHING CONTEXTS

Based on the STEM education concept of hands-on practice, teachers need to engage students in learning activities in the class spontaneously, in order to encourage students to explore actively and deeply effectively. In this part, teachers need to impart the teaching content in a more vivid form to students so that their attention is entirely focused on the lesson and be curious about the practical practice, which can motivate students to investigate and seek evidence actively. This will effectively improve students' overall ability and application ability.

For example, when teaching the structure of the cell, teachers can use software such as 3DMax to create 3D models in the PPT to show students 3D animal and plant cell models, using them as an introduction to the lesson will make students feel interested, and then they will actively focus their attention on the class. After that, teachers should guide students to build models by themselves when integrating the knowledge of biology with other subjects by assigning STEM-based tasks, such as making models of cells using various materials in their homes. Moreover, teachers should remind students to be aware of the differences and similarities between animal and plant cells.

By letting students create multiple modeling solutions, teachers will effectively expand students' minds and develop their problem-solving skills. At the same time, it will also effectively stimulate students' interest in scientific inquiry activities and exploration. The actual production will also allow students to put theory into practice, and encourage students to explore and analyze the relevant scientific knowledge in the context of the actual situation actively, which make students focus on the implementation of knowledge and solutions, and will effectively accelerate students'

understanding and cognition of science knowledge. The "teaching by units" concept in the new curriculum reform placed great emphasis on establishing authentic situations, requiring students to be able to complete large learning tasks in a large context, and then refine them into teaching objectives for each unit. In the process of contextualized teaching, students' comprehensive ability can be improved.

To illustrate, teachers can use a big context like grain breeding to build the big context of the whole unit, and then subdivide the smaller contexts under this big context to design various learning activities. The teaching context can be created in a variety of ways, using current events such as Shenzhou 13 spaceship, or situations from the textbook, such as colon cancer and sicklemia. Teachers can create the context by themselves through various media materials. Teachers can also process materials from the textbook into elaborate teaching contexts.

The scenario design should be innovative and close to students' lives so that students' interest in learning can be mobilized. The new education reform emphasizes the need to deepen students' understanding of biological concepts in real-life situations to enhance students' ability to solve real-life problems. However, the real situations designed by teachers that students have not personally experienced, such as urban students, have not been to the field and have not been exposed to plant and animal diseases. Therefore, scenario's design should choose from the students' life experiences to generate personal feelings. The big social situation needs to be transformed into a classroom situation through the teacher's design. After, learning the knowledge content, the classroom situation should be sublimated into a social situation to apply the theoretical knowledge learned to solve practical problems.

4. TEACHING REQUIRES CONSTANT INNOVATION

Only creative teachers can genuinely put themselves in their students' shoes and find ways to help them learn and master their science knowledge better. Although biology courses in secondary school and high school are all examination-oriented subjects, it is difficult for teachers who only teach by the book to let students understand some abstract concepts of biology. Rote memorization cannot be regarded as understanding, so instruction should be designed in terms of "how core concepts are formed".

To give you an idea, the "invisible" DNA is the key point of the biology exam in high school. Some teachers only let students memorize the base principle of complementarity is "A-T, C-G", while some teachers will demonstrate the pairing process of base, transcription and translation process to their students by playing animated videos. In contrast, other teachers will let students try to use various bases to build DNA models by themselves, and then use the built models to do further transcription and translation processes. This is a good example of how different levels of teachers' creativity can make a significant difference in their teaching methods and effectiveness.

To give another example, for the same teaching of the history of science, some teachers turned it into a role-play activity, asking students to create groups of different scientists and to relive the experimental process as scientists. This allows students to discover and solve problems in the process of independent exploration and to fully understand the principles of how scientific knowledge is formed. In contrast, some teachers turn the history of science into a story and teach it in a storytelling way.

The types of activities are very rich and can be roughly divided into experimental operation, data analysis, problem discussion, investigation and research, model construction and program design, which fully reflect the teachers' creative thinking and different teaching styles.

5. PAY ATTENTION TO THE ROLE OF INSTRUCTIONAL EVALUATION IN STEM EDUCATION

5.1. Solo classification evaluation method

Piage's stage theory of cognitive development points out that children's cognitive development is stage-specific in the process of growing up, and there are qualitative differences in cognitive levels between different stages. Biggs and his colleagues found through their research that human cognition is characterized by stages not only in general, but also in the process of cognition of specific knowledge. People's stages of thinking in learning new knowledge are observable so the term SOLO refers to "Structure of the Observed Learning Outcome" [4].

5.2. Presentation method

Teaching science based on the concept of STEM, not only follows certain principles to encourage and attract students to participate in innovative practices actively, but also needs to measure and improve the performance of students' practice after they have completed the integrated application of knowledge followed by teachers' guidance, in order to expand the depth of cognition and the level of comprehensive ability [5]. Thus, maximize the integration of science, technology, and other subjects and effectively promote the students' overall development and level of thinking. In this process, teachers should encourage students to take the initiative to present their achievements and to analyze and interpret

them in-depth, thereby enhancing students' scientific awareness and expanding their thinking further.

Still taking cell structure modeling as an example, after students designing and making their own models, teachers need to conduct a comprehensive assessment for the results of students' productions. Teachers can divide the students into small groups and let them discuss and share in the groups, so that they can absorb different ideas and expand their thinking. As a result, their creative thinking ability can be further improved and their designs can be optimized. Afterward, the teacher should allow students to present their results to the whole class, and explain the factors they considered when choosing the materials, and the evaluation by themselves. This will lead to an increased depth of understanding and memory of the cell structure. Students will actively integrate their knowledge of science, technology, mathematics, and engineering, while developing their comprehensive ability in various ways. It also positively contributes to stimulating students' enthusiasm for exploration in biology courses and increasing their self-confidence and motivation to study.

6. CONCLUSION

The integration of the STEM education concept in secondary school biology teaching is vital for subject education and the overall development of students. At the same time, it will drive students to explore more actively and apply multidisciplinary knowledge to solve practical problems in the real world and improve their overall ability. Teachers should select curriculum content based on STEM principles, and engage students' active participation and divergent thinking. Besides, teachers must pay attention to assessment, so that students can better use integrated knowledge to deepen their understanding and knowledge of biology and other science courses, effectively promoting their overall development.

To integrate STEM education with biology teaching, teachers should focus on the formation process and the application of the core concepts of life sciences. Teachers can train their students to use scientific methods to solve life science problems, and develop their social responsibility in the discussion of hot topics in society on biology issues, like the Covid-19. These measures can be regarded as ways to guide, stimulate, and promote the development of students' core capabilities.

The current study illustrates many examples that Chinese biology teachers can apply in their classes, which can help teachers gain an initial understanding of the use of STEM education and inspire them to design colorful and effective teaching activities.

A follow-up study could explore several in-depth types of activities mentioned in this study: experimental operation, data analysis, problem discussion, investigation and research, model construction, and solution design, finding out the role they play in science teaching.

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