

Article

A Teaching Strategy Based on Observation, Experience and Inquiry Research on Promoting Students' Conceptual Change

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Abstract: The 2022 “Compulsory Education Primary School Science Curriculum Standards” clearly stipulates the specific requirements for students to conduct scientific inquiry in primary school science classes. Based on the experiential learning theory and the concept change theory, the “Observation-Experience-Inquiry” (OEI) teaching strategy was proposed. Taking cell-concept teaching as an example, this strategy guides students to revise their prior misconceptions driven by cognitive conflicts. With tools including structural diagrams and collaborative discussion, students can accomplish scientific conceptual change and develop scientific ideas.

Keywords: primary school science; concept change; experiential learning; observation-experience-inquiry

1. Introduction

The word “inquiry,” when used as a verb, means “to explore, investigate, or study.” When used as a noun, it refers to the exploration and study of natural phenomena and laws through scientific methods and processes. In everyday life, people often conduct investigations or practical activities, such as exploring the conditions under which iron rusts. In scientific research, when scientists discover phenomena that cannot be explained by their existing knowledge, they conduct investigations based on scientific hypotheses. This process is known as scientific inquiry. Scientific inquiry is a systematic and step-by-step process of exploration and practice based on scientific theories and a series of rigorous inquiry procedures directed toward research questions (Kunisch et al., 2023). Since China’s basic education curriculum reform in 2001, scientific inquiry has been included in the primary school science curriculum standards as an important component of science education. Scientific inquiry provides a general framework for raising questions, formulating conjectures and hypotheses, collecting evidence, and drawing conclusions, thereby providing students with a structured direction for scientific exploration (Dewey, 1910; Schwab, 1958).

On this basis, Klahr and Dunbar (1988) proposed the Scientific Discovery as Dual Search model, which conceptualizes scientific inquiry as coordinated searches within a hypothesis space and an experiment space. This model provides a theoretical explanation of the cognitive processes involved in scientific inquiry.

Pedaste et al. (2021) developed a scientific inquiry test for primary school students based on the inquiry-based learning framework proposed by Pedaste et al. (2015). The test encompassed the essential skills aligned with the different phases of inquiry-based learning. These included analytical skills, which are primarily required in the orientation, conceptualization, and investigation phases; planning skills, mainly needed in the investigation phase; and interpretation skills, primarily needed in the conclusion and discussion phases. Chen et al. (2025) examined the effects of ChatGPT- and argument map-supported online argumentation on students’ critical thinking skills



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and perceptions, providing insights into the cultivation of scientific reasoning and evaluation skills. These studies offer useful insights into scientific observation, experience, inquiry, and evaluation.

Previous research has established a close relationship between scientific inquiry and conceptual change. Zimmerman (2007) suggested that scientific thinking involves inquiry, experimentation, evidence evaluation, and inference, which contribute to the formation and revision of scientific concepts. However, existing studies provide limited guidance on how these processes can be organized into a coherent classroom sequence to promote primary school students' conceptual change. Therefore, drawing on experiential learning theory and conceptual change theory, this study proposes an Observation–Experience–Inquiry (OEI) teaching model. Specifically, literature analysis was used to clarify the theoretical foundations and construct the OEI model, while teaching case analysis was used to illustrate its classroom application in the teaching of cell concepts.

2. Theoretical Background

2.1. Experiential Learning Theory

The “experience” in pedagogy mainly includes two aspects: one is to regard experience as a way of learning for students, that is, the study of experiential learning; The second is the research on experiential teaching, which regards experience as the mode for teachers to carry out teaching activities.

Experiential Learning theory is a teaching strategy driven by experience and centered on students, which is suitable for students' “learning” (Kolb & Kolb, 2009). It places students' learning in real cognitive situations, helping them complete learning tasks by creating situations that conform to the learning content, thereby experiencing the process of knowledge construction, behavioral evolution, and dynamic emotional development. It is an important means to promote the occurrence of deep learning effectively. Experiential learning theory results from John Dewey's “experience learning” theory, and British educational practices initially adopted it as a way of independent learning and development.

On this basis, American scholar David A. Kolb systematically proposed A complete theory in “Experiential Learning: Making Experience the Source of Learning and Development” and pointed out the characteristics of the experiential learning theory: (1) Process-oriented learning experience. (2) The cognitive development of dialectical opposition. (3) Adaptive multilateral interactivity. (4) Build an integrated learning cycle. These characteristics provide scientific guidance for educational practice (Murrell & Claxton, 1987). Based on these characteristics, the application of experiential learning theory in teaching has gradually expanded, promoting the development of experiential teaching.

Experiential teaching, with the core of stimulating students' learning experiences, is a teaching strategy that guides students to engage in experiential learning (Luo et al., 2023). The research on experiential teaching abroad has a long history, traced back to Socrates' “midwifery”, Aristotle's theory of sensory cognition, and Rousseau's naturalistic education. With the continuous development of experiential teaching, its application scope is constantly expanding. For instance, Spiegel (1975) advocated the “role-playing method”, enabling students to experience and learn through interaction by simulating real situations. This greatly enriches the practical forms of experiential teaching.

2.2. Conceptual Change Theory

Conceptual Change is when learners (students) abandon their original incorrect or incomplete concepts during the learning process and accept and internalize new scientific concepts (Özdemir & Clark, 2007). Its essence is to replace the preconceptions or misconceptions with a scientific concept to achieve a more accurate and deeper understanding of a specific knowledge field or phenomenon. Conceptual Change Model (CCM) was proposed by Posner et al. (1982) from Cornell University in the United States. This model is based on epistemology, Kuhn's theory of scientific revolution (Kuhn, 1970), and Piaget's theory of cognitive development (Piaget, 1976).

(1) Cognitive conflict stage: The concept change begins when students realize a contradiction between their original and scientific concepts, generating cognitive conflicts (Limón, 2001). This conflict prompts students to re-examine and question their preconceived concepts, triggering conceptual change. Research shows that during the stage of cognitive conflict, cooperative communication is regarded as an effective means to trigger cognitive conflict (Zhang & Zhang, 2022). It reveals the irrationality of preconceptions through peer interaction and the collision of viewpoints, causing cognitive conflict.

(2) Concept reconstruction stage: Concept change is not merely a simple acceptance of new concepts, but requires students to understand and internalize them deeply. This process involves the guidance of non-intellectual factors such as emotional engagement and motivational stimulation. Learners (students) must integrate new concepts into their cognitive structure to form a complete knowledge system, achieving a deep understanding of

the concepts. Many researchers believe that through various concept change strategies, such as concept mapping (Amiruddin et al., 2025), analogy strategy (Handee et al., 2025), and dynamic evaluation strategy (Esmailzadeh, 2025), the in-depth understanding of concepts can be effectively promoted. After completing the concept reconstruction, students need to internalize the new concepts further to consolidate and deepen their understanding.

(3) Concept internalization stage: Concept change is continuous and gradual. After accepting new concepts, students must repeatedly apply and verify them in different situations and problems to consolidate and deepen their understanding of the new concepts (Alzheimer et al., 2025). Creating problem situations is an effective teaching strategy to promote the internalization of concepts. For instance, in physics teaching, teachers can design everyday problem scenarios, such as explaining why balloons rise or boats float on the water surface, to help students internalize the concept of buoyancy in solving practical problems (Stănescu et al., 2025).

3. The Design of a Teaching Strategy Based on Observation, Experience and Inquiry

The teaching strategy based on observation, experience, and inquiry is a conceptual teaching that drives students' independent exploration through cognitive conflicts. The teaching strategy constructed in this study is shown in Figure 1, which specifically includes the following three parts.

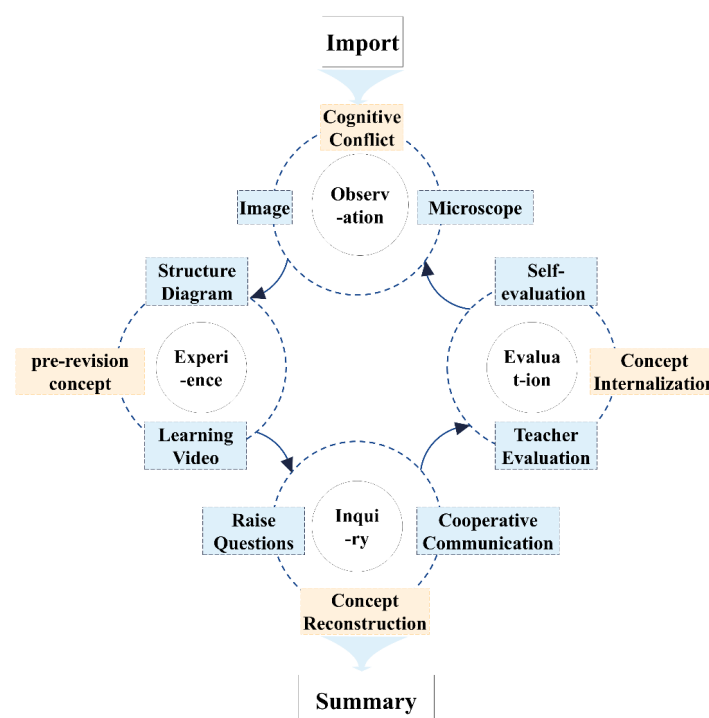


Figure 1. Teaching process of cell concepts.

(1) Import

Teachers first guide students to independently construct based on their initial understanding of knowledge (existing experience) to reveal the initial level of scientific concepts. Then, by creating problem situations that contradict students' experiences, students are made to doubt the new knowledge, form cognitive conflicts, and stimulate their desire to inquire. (Cognitive conflict)

(2) The “Observation-Experience-Inquiry” cycle

In this teaching session, students will carry out inquiry activities driven by cognitive conflicts, constantly revise and improve their existing knowledge structure (new concepts) based on the phenomena and conclusions of the inquiry, and further evaluate and test the construction of new knowledge (new concepts) in the “experience” and “inquiry” sessions. If the construction of new knowledge is consistent with the inquiry's conclusion and the problem situation, it indicates that the new knowledge is internalized with the existing knowledge. Conversely, it indicates that the new knowledge structure (concept) still has some imperfections and requires students to inquire further and correct it. In this cycle, while constantly revising the integration and matching degree of new and old knowledge, students experience the dynamic development process of knowledge construction, enhance their scientific thinking, promote their understanding of concepts, and achieve conceptual change.

(3) Evaluation

Students review the construction process of new knowledge (conceptual structure) and discuss their evaluation and understanding of the final integration/matching degree of new and old knowledge. This section mainly reflects students' understanding of the concepts to consolidate them. (Concept internalization)

4. Model Practice and Case Analysis

Based on the “Compulsory Education Primary School Science Curriculum Standards” and in combination with the core literacy of the subject, this study takes “Observing More Biological Cells” in the first unit of the sixth grade science textbook of the Education Science Edition as an example to further inquiry the application of the “Observation–Experience–Inquiry” teaching strategy in primary school science teaching. The teaching objectives of this course include: (1) Knowledge and skills objectives: Students can accurately describe the morphology, structure, and diversity of cells, including the similarities and differences between animal cells and plant cells, by observing cells under a microscope. (2) Process and Method Objectives: By repeatedly revising the cell structure diagram, students can master the cyclical process of scientific inquiry (observation–experience–inquiry), and enhance their scientific inquiry skills and critical thinking. (3) Emotional attitude and value goals: Recognize scientific knowledge's dynamic and developmental nature, have the courage to question and correct one's preconceived notions, and form correct scientific concepts.

Based on the above teaching objectives, the specific teaching activities designed are as follows:

4.1. Import

Students independently draw and construct cell structure diagrams based on their initial understanding of the knowledge to reveal their understanding of cell science concepts. (Cognitive conflict)

Design intention: Through a series of questions, guide students to construct the initial form of cells and expose their preconceptions. For instance, the shape of a cell is round, and the nucleus is drawn as a small dot. Then, presenting a real case of cell images under a real microscope triggers students' cognitive conflicts, making them question the rationality of the initial cell structure diagram, stimulating their desire to inquire, and laying a foundation for the smooth progress of subsequent teaching links.

Teacher: *“Students, please draw the shape of a cell based on your understanding of it and mark the parts you think are important.”*

Student: *(Draw a diagram of the cell structure. Draw a round cell, and simplify the nucleus to a small dot.)*

Teacher: *The cell structure diagrams you all drew are very interesting, but have you ever thought that the shape of a cell must be round? Is the cell nucleus really just a tiny dot? Next, let us observe the actual shape of the cells through the cell images under a real microscope.*

4.2. Cycle 1: Observation-Experience-Inquiry

- (1) Observation: Students establish connections between things by observing the morphology of various cells and promote conceptual change through practice.

Design intention: Through observation activities, enhance students' scientific inquiry abilities, such as observation and drawing, and provide an intuitive basis for correcting the initial cell structure diagram.

Teacher: *“Now, please observe the slices of animal and plant cells through the microscope, paying attention to their shapes, the positions of the cell nuclei, and other structures.”*

Student: *(Observe and record the cell structure.)*

Teacher: *“What are the differences between the cell structure you observed and the one you drew before?” Does the position and shape of the cell nucleus meet your expectations?*

Student: *“I found that the cell nucleus is not a small dot but has a distinct structure, and the shape of plant cells is quite different from that of animal cells.”*

- (2) Experience: Students gain in-depth experience and reflection on the structure and function of cells by watching videos. (Conceptual Reconstruction)

Design intention: Through students' independent questions after watching the learning video, guide them to think about the structure and function of cells deeply, reflect on the limitations of the initial cell structure diagram,

and complete the construction of a new cell structure diagram, understanding the preconceptions of the specific functions of structures such as the nucleus, cell membrane, and cytoplasm. Then, the students used the new cell structure diagram to explain the question of “how cells maintain life activities” to evaluate the rationality of the new cell structure diagram.

Teacher: *“When watching the video, please think: What is the function of the cell nucleus?” What is the function of the cell membrane?*

Student: *“Teacher, how does the cell nucleus control the activity of cells?”*

Teacher: *“The nucleus is the cell’s control center, and the cell membrane acts as a protective barrier that regulates the passage of substances.” Please correct your cell structure diagram according to the video content.*

Student: *“I added the internal structure of the cell nucleus and also drew the layers of the cell membrane.”*

Teacher: *“Now, please explain how cells maintain life activities with your new cell structure diagram?”*

Student: *“The nucleus controls activities, the cell membrane protects and controls the entry and exit of substances, and the cytoplasm is the site of life activities.”*

- (3) Inquiry: Students redraw and inquire into the cell structure and construct concepts with the teacher’s assistance. (Concept internalization)

Design intention: Create a problem situation with the “structure and function” theme of animal cells to guide students to inquiry in cooperative communication. Subsequently, a new problem situation was created again based on the “research findings of a certain interest group” to help students recognize the limitations of the cell structure diagram: the observation results of only animal cells cannot indicate that cells have similar functions and structures in different organisms, thereby triggering a new round of exploration and further internalization of the concept as well as revision of the cell structure diagram.

Teacher: *“Now, let us inquire into animal cells’ structure and function in groups.” Please discuss the functions of the nucleus, cell membrane, and cytoplasm based on the cell structure diagram you drew, and explain how they work together.*

Students: *(Discuss in groups and correct the cell structure diagram.)*

Teacher: *“A certain interest group discovered that the mitochondria in animal cells are energy factories. So, does a similar structure exist in plant cells as well?” Please further observe the plant cells and correct your cell structure diagrams.*

Student: *(Observe plant cells and correct the cell structure diagram, adding structures such as mitochondria.)*

4.3. Cycle 2: Observation-Experience-Inquiry

Design intention: By guiding students to observe independently, experience, inquiry, and draw diagrams of the structure of plant cells, further enhance students’ exploration abilities. By guiding students to apply the cell structure diagrams they have drawn to explain the structure and function of plant cells, their ability to analyze them is enhanced, enabling them to recognize the social value of biological knowledge.

Teacher: *“Next, we will observe the morphology of plant cells and compare them with animal cells.” Please consider: What are the similarities and differences in structure and function between plant cells and animal cells?*

Student: *(Observe plant cells and record them.)*

Teacher: *“You have found that plant cells have cell walls and chloroplasts, while animal cells do not.” What roles do these structures play in the functions of plant cells? Please explain it using the cell structure diagram you have drawn.*

Student: *“The cell walls of plant cells provide support, and chloroplasts are responsible for photosynthesis. These are all functions that animal cells do not have.”*

4.4. Evaluation: Students Review the Process of Cell Structure Construction, Evaluate and Understand the Final Cell Structure Diagram

Design intention: Review the process of constructing the cell structure diagram. Through students' responses, test their understanding of cell structure and their comprehension of the concept, guide them to consolidate the concept, apply what they have learned, and cultivate their observation, experience, and exploration abilities.

Teacher: *"Please review the cell structure diagrams you have drawn. What changes have occurred in your understanding of cells from the initial simple cell structure diagrams to the current complex ones?"*

Student: *"Initially, I thought the cell nucleus was just a tiny dot. Now I know it has many complex structures, and the cell membrane and cytoplasm functions are also essential."*

Teacher: *"Very good!" Through this learning experience, you not only corrected the previous concepts but also gained a deep understanding of the structure and function of cells. Next, we can use this knowledge to explain more biological phenomena.*

5. Teaching Summary and Strategy Refinement

The cell concept teaching case shows that Observation-Experience-Inquiry (OEI) is not a simple linear sequence of three independent activities, but a cyclical process in which students continuously examine and reconstruct scientific concepts. Observation provides direct empirical evidence and exposes the differences between students' preconceptions and actual cell morphology. Experience helps students interpret the observed phenomena through videos, discussion, and repeated revision of cell structure diagrams, thereby connecting perceptual experience with knowledge of cell structure and function. Inquiry further guides students to raise questions, compare animal and plant cells, explain evidence, and test and revise their existing ideas. The questions generated during inquiry then initiate a new round of observation and experience, promoting the progressive development of students' understanding. Based on this case, the OEI teaching strategy can be summarized as the following instructional path: diagnosing preconceptions, creating cognitive conflict through evidence-based observation, reconstructing concepts through meaningful experience, testing and applying concepts through problem-driven inquiry, and consolidating understanding through reflective evaluation. In this process, students move from passively receiving conclusions to actively observing evidence, explaining phenomena, and revising their ideas. The teacher's role also changes from directly transmitting knowledge to designing situations, providing scaffolding, organizing inquiry, and offering timely feedback. Thus, the value of the OEI strategy lies not only in helping students understand scientific concepts, but also in integrating concept learning with the development of observation, reasoning, inquiry, and reflection.

6. Teaching Reflection and Conclusions

The cell concept teaching case illustrates how the OEI strategy can be applied to primary science concept teaching. It connects the theoretical framework of observation, experience, and inquiry with specific classroom activities. Through microscope observation, students obtain direct evidence of cell structures. Videos, discussions, and diagram comparison then help them connect their observations with scientific concepts. Further questioning and diagram revision encourage students to explain evidence, correct misconceptions, and deepen their understanding. Therefore, the case supports the central idea that scientific concepts can be gradually constructed through the interaction of observation, experience, and inquiry. Several issues should be considered when implementing the strategy. Microscope operation, specimen observation, group discussion, and diagram revision require sufficient classroom time. Differences in students' operational skills and prior knowledge may also affect their participation. Teachers should therefore provide appropriate guidance, assign clear group roles, and use progressive questions to connect the three stages. Evaluation should not focus only on the final cell diagram but should also include students' observation records, diagram revisions, discussions, and explanations as evidence of conceptual development. In conclusion, observation provides empirical evidence, experience supports the interpretation and reconstruction of concepts, and inquiry promotes their application and further development. The interaction of these stages helps students gradually develop a more scientific conception of cells. Future teaching may further adapt the strategy to students' age, prior knowledge, and the characteristics of different scientific topics.

Author Contributions

Y.Z. (Youyou Zhang): Writing—original draft, Methodology, Investigation, Funding acquisition, Case analysis, Conceptualization. Y.Z. (Yu Zhao), X.L. and D.D.: Conceptualization, Writing—original draft,

Writing—review & editing. J.Y., J.L. and W.L.: Conceptualization, Methodology, Investigation. All authors have read and agreed to the published version of the manuscript.

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Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

The original data supporting the conclusions of this article are not publicly available because of the privacy requirements of the research participants, but may be available from the corresponding author upon reasonable request with the permission of the participants.

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Conflicts of Interest

The authors declare no conflict of interest.

Use of AI and AI-Assisted Technologies

During the preparation of this work, the authors used ChatGPT to improve language clarity and correct grammatical errors. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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