



# “Backward Design of Primary School Science Based on UbD Theory: Taking the Unit Teaching of ‘Environment and Us’ as an Example”

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**Abstract.** This design is based on the “Understanding by Design” (UbD) theory, and adopts the backward design method to make a detailed teaching design for the “Environment and Us” unit of the science course in the fifth grade of primary school. By clarifying the Big Ideas and expected learning results, determining appropriate assessment evidence, and arranging corresponding learning experiences and teaching activities, it aims to cultivate students’ environmental awareness and scientific literacy. In the design process, a variety of assessment methods such as Performance Tasks, investigation reports, observation, self-assessment and reflection are comprehensively used around the Big Ideas to ensure that students can deeply understand and effectively apply the knowledge they have learned. The design results are expected to provide an effective reference and practical guidance for future teaching design.

**Keywords:** UbD theory; backward design; primary school science; unit teaching; “teaching-learning-assessment” integration

## 1 Introduction

With the increasing severity of global environmental problems, environmental protection has become one of the core issues of concern to the whole society. The Global Resources Outlook 2024 released by the United Nations Environment Programme pointed out that the world is currently facing a “triple planetary crisis” caused by climate change, biodiversity loss, pollution and waste, and the overuse of resources has further increased the pressure on ecosystems [1]. In recent years, frequent extreme weather, serious air and water pollution, ecosystem degradation and other problems have constantly reminded people that the importance of environmental protection cannot be ignored. Education plays an important role in cultivating students’ environmental awareness, and it is very important to cultivate students’ environmental awareness and sense of social responsibility through scientific education.

According to the requirements of the Compulsory Education Science Curriculum Standards (2022 Edition), modern science courses should not only teach students scientific knowledge, but also pay attention to cultivating students’ environmental awareness and practical ability [2]. Through systematic science education, students should

understand the close relationship between the environment and human life, and be able to apply scientific knowledge in daily life, actively participate in environmental protection actions, and propose effective solutions. Based on this background, this design adopts the UbD (Understanding by Design) theory for backward design. By clarifying learning goals, designing assessment evidence and planning teaching activities in three stages, it systematically helps students achieve deep understanding, aiming to improve students' environmental awareness and sense of responsibility.

## 2 Overview of UbD Theory

The core structure of UbD theory includes three stages: clarifying the expected learning results, determining appropriate assessment evidence, and arranging learning experiences and instruction [3]. The first thing is to clarify the expected learning results. Teachers need to determine the understandings and abilities that students should have at the end of the course, which not only includes specific knowledge points, but also involves higher-order thinking skills and mastery of key concepts. At this stage, teachers guide students' learning by designing Essential Questions and identifying Big Ideas. These questions and concepts are open and can stimulate students' desire for exploration and thinking ability. At the same time, the six facets of understanding (Explanation, Interpretation, Application, Perspective, Empathy, Self-Knowledge) provide students with multi-level learning goals, ensuring that students can understand and apply the knowledge they have learned from multiple angles.

The second is to determine the appropriate assessment evidence. Teachers design various assessment methods to verify whether students have achieved the expected learning results. These assessments are not limited to traditional quizzes and exams, but also include Performance Tasks. As shown in Figure 1, the GRASPS model (goals, roles, audience, situation, performance or products, standards) requires students to apply what they have learned in real situations, complete challenging tasks, and fully reflect students' understanding and ability. Teachers can also help students reflect and improve themselves through self-assessment, rubrics and other ways, so as to achieve deep learning.

Finally, the learning experiences and instruction are arranged. Based on the goals and assessments of the first two stages, teachers design specific teaching activities and learning experiences to ensure that students continue to deepen their understanding and apply knowledge in the process of participation, and can transfer what they have learned in different situations. At this stage, teachers need to consider the WHERETO elements. The WHERETO elements in the teaching design proposed by the UbD theory are shown in Table 1. Clarify learning goals and the importance of learning (Where and Why), arouse interest and maintain attention (Hook and Hold), provide exploration, experience and necessary tools and support (Explore, Experience, Equip and Enable), reflect, rethink and revise (Reflect, Rethink, Revise), evaluate learning effects (Evaluate), tailor according to students' needs (Tailor), reasonably organize and arrange teaching activities (Organize). These elements ensure the systematicity and coherence of

teaching design, help students constantly reflect and improve in practical operation, and finally achieve deep understanding and lasting memory.

**Table 1.** WHERETO Elements

| Element | Meaning                                                                                                                                               |
|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| W       | learning direction (Where) and reason (Why), to ensure that students understand the goals and reasons of the unit being studied.                      |
| H       | arouses interest and keeps attention (Hook and Hold), attracting students from the beginning and keeping their attention.                             |
| E       | provides students with exploration, experience and necessary tools and support (Explore, Experience, Equip and Enable).                               |
| R       | reflects on the progress, rethinks the Big Ideas and revises their own design work (Reflect, Rethink, Revise).                                        |
| E       | evaluates the learning effect (Evaluate), providing students with the opportunity to evaluate the progress of their work and conduct self-evaluation. |
| T       | Tailor reflects personal talents, interests, style and needs.                                                                                         |
| O       | Organize and arrange teaching activities reasonably for students to gain a deep understanding.                                                        |

**3 Backward Design of Primary School Science based on UbD theory — the Design Process of Taking the Unit Teaching of “Environment and Us” as an Example**

**3.1 Preparations Before Design**

In this design, the entry point of the backward design is first determined, that is, we hope to appeal to everyone to protect the environment through education. Environmental protection is closely related to the science curriculum, so the unit “Environment and Us” in the second volume of the fifth grade of primary school science has been determined, and the “Compulsory Education Science Curriculum Standards (2022 Edition)” has been studied to clarify the core concepts of the science curriculum, and the Big Ideas of this unit design have been extracted according to the relevant requirements of the disciplinary core concepts in the curriculum standards.

**3.2 Determine the Theme of the unit and Clarify the Big Ideas**

In actual teaching, the themes of teaching units are diverse. According to different organizational logic, the theme of the unit will be different, and the main content of the teaching unit will also be different [4]. The selection of the theme of the teaching unit can be roughly based on two logics, one is disciplinary logic and the other is learning logic. For example, the units in the textbook, or the units based on an important concept as the theme, are generally based on disciplinary logic; the units with the theme of

learning projects, problem solving and special ability cultivation are generally organized according to learning logic [5]. The main body of this design unit is selected according to the disciplinary logic, and the following is the basis for selection:

The topic of environmental protection is closely related to the science curriculum, so this design chooses the third unit of the second volume of the fifth grade of primary school science, “Environment and Us”, and determines that the theme of the large unit is “Protecting Our Earth”.

After determining the specific learning unit, start to study the curriculum standards of this discipline. The primary school science curriculum standards put forward 13 disciplinary core concepts from the field of physical science, the field of life science, the field of earth and space science, the field of technology and engineering, and the field of environmental protection, as shown in Figure 1. The core competencies of the subject emphasize the connection and application of knowledge, and require teaching to break through the fragmented organization of knowledge points and form a more holistic learning structure [6]. In the objectives for grades 5–6 in the primary school science curriculum standards, the disciplinary core concept “human activities and the environment” involves three main concepts: natural resources, natural disasters, and the impact of human activities on the environment. Among them, there are three sub-concepts closely related to the content of the “Environment and Us” unit: ① Correctly understand the relationship between human activities and ecological environment protection. ② Correctly understand the relationship between economic development and ecological environment protection, combine examples, explain the impact of unreasonable human development activities on the environment, put forward suggestions for environmental protection, and participate in environmental protection actions. Therefore, according to the relevant requirements of the disciplinary core concepts in the curriculum standards, the Big Ideas of this unit design are: ① ecological balance ② human responsibility ③ sustainable development.

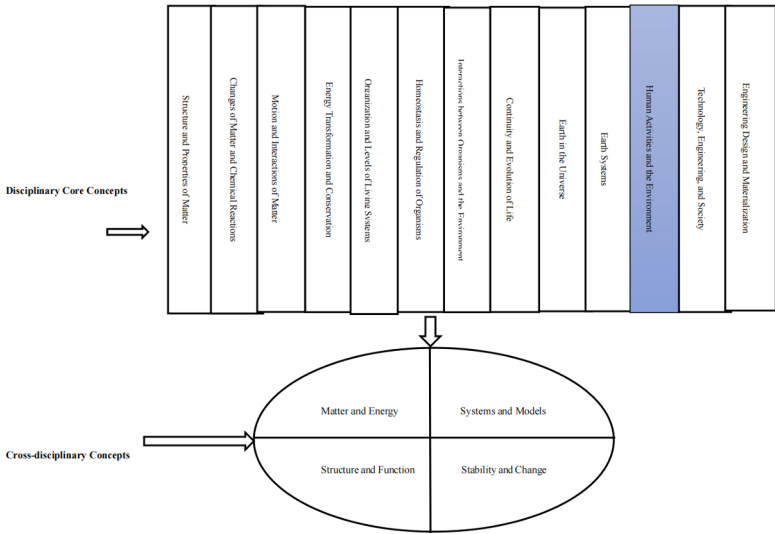


Fig. 1. Disciplinary Core Concepts of the Science Curriculum

3.3 Build a Unit Knowledge System with the Big Ideas as the Core

3.3.1 Stage 1 — Clarify the Expected Learning Results.

Under the framework of UbD theory, clarifying the expected learning results is the first step in teaching design. The goal of this stage is to ensure that students can understand and master key concepts at the end of the course and be able to apply this knowledge to solve practical problems. The elements that designers need to consider in stage 1 are shown in Figure 2. In the design of this stage, the specific learning results in Table 2 are set in combination with the “Compulsory Education Science Curriculum Standards (2022 Edition)” and the Big Ideas of the subject.

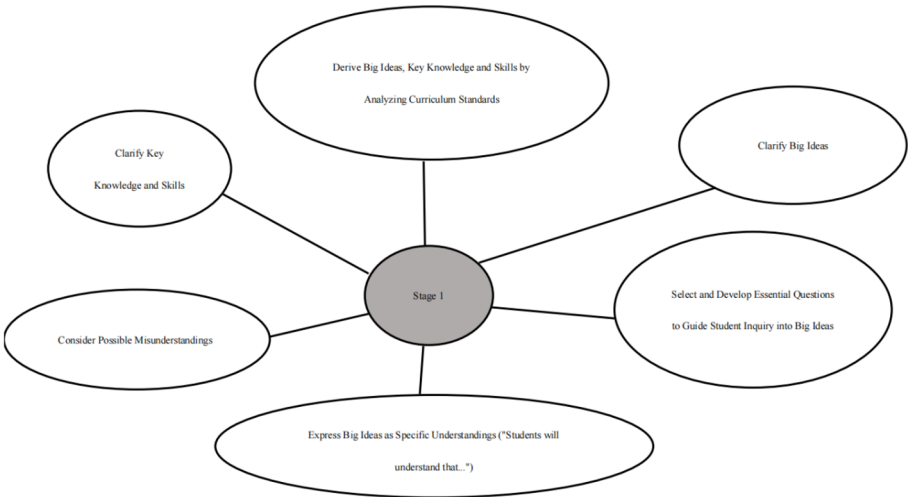


Fig. 2. Design Elements in Stage 1

Table 2. Determining Expected Learning Results

| Predictable Misunderstandings                                                                                                       |                                                                                 |
|-------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
| Environmental protection is only the responsibility of scientists; art cannot effectively convey environmental protection messages. |                                                                                 |
| Essential Questions to Consider                                                                                                     | What is the expected understanding?                                             |
| ① Why should we protect the Earth?                                                                                                  | Students will understand that...                                                |
| ② What is environmental pollution?                                                                                                  | ① The importance of environmental protection.                                   |
| ③ How does it affect us and ecosystems?                                                                                             | ② The concept of sustainable development.                                       |
| ④ How do human activities cause environmental pollution?                                                                            | ③ The proper way for humans to coexist with the Earth.                          |
| ⑤ How can we reduce environmental pollution?                                                                                        |                                                                                 |
| ⑥ What is the significance of sustainable development for the present and future?                                                   |                                                                                 |
| Students will know (K)                                                                                                              | Students will be able to (S)                                                    |
| ① The types of environmental pollution and their specific causes and impacts.                                                       | ① Create environmental protection artworks using recycled materials.            |
| ② The role of environmental protection art in promoting environmental protection.                                                   | ② Organize and hold environmental protection art exhibitions.                   |
| ③ The methods and steps for solving environmental pollution problems.                                                               | ③ Conduct environmental pollution surveys, write reports, and propose solutions |

In today’s society, many people are not aware of environmental protection, and littering and wasting water resources are the most common. Water resources shortage is now a major problem facing the world, and most of them still think that this is just the duty of sanitation workers and scientists, and their own recklessness is not included

in the consequences. Therefore, the predictable misunderstanding that “environmental protection is only the responsibility of scientists, and art cannot effectively convey environmental protection information” is designed to guide students to realize that environmental protection is not only the responsibility of scientists, but also the responsibility of ordinary people to participate in it, and to improve environmental awareness through artistic means and correct students’ misunderstanding of environmental protection responsibilities. Through the correction of this misunderstanding, students will understand the important role of art in promoting environmental protection, realize that they can also raise their environmental awareness through creativity and artistic means, and stimulate their initiative and enthusiasm for environmental protection actions.

In the expected understandings, students will understand the importance of environmental protection, the concept of sustainable development, and the correct way people get along with the earth. This echoes the requirements proposed in the “Compulsory Education Science Curriculum Standards (2022 Edition)”: “Requiring students to recognize the impact of unreasonable human development activities on the environment, establish the awareness of recycling resources, put forward suggestions for environmental protection, and participate in environmental protection actions”. These understanding goals aim to help students form a comprehensive and deep understanding of environmental issues. Students will understand why environmental protection is crucial to the health of human beings and ecosystems, as well as the roles and responsibilities of individuals and collectives in protecting the environment. Recognize the importance of sustainable development to the present and future, so as to establish the concept of sustainable development and develop good habits of saving resources and loving the environment. And realize that they can maintain the ecological balance and sustainable development of the earth through the rational use of resources, reduction of pollution and participation in environmental protection activities.

In order to guide students to think and explore deeply and promote the transfer and application of knowledge, the design of Essential Questions is indispensable. In combination with the disciplinary core concepts of the science curriculum sorted out in the previous article, the question system of this teaching unit is compiled. Design Essential Questions according to the disciplinary core concepts, and then decompose them into sub-problems to promote specific thinking, guided by general concepts, factual knowledge and basic skills, as shown in Table 3.

**Table 3.** Unit Question System

| Essential Questions                        | Sub-questions                                                                                                                                                                                                         |
|--------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Why should we protect the Earth?        | 1. What is an ecosystem?2. In what ways do humans depend on the Earth?3. How do the finitude and non-renewability of the Earth’s resources affect us?                                                                 |
| 2. What is environmental pollution?        | 1. What are the main types of environmental pollution?2. What are the specific manifestations of environmental pollution?3. How can we determine whether an area is affected by environmental pollution?              |
| 3. How does environmental pollution affect | 1. How does air pollution affect the human respiratory system?2. What are the harmful effects of water pollution on aquatic organisms and human health?3. How does soil pollution affect crop growth and food safety? |

|                                                                                    |                                                                                                                                                                                                                                                         |
|------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| our ecosystems and human health?                                                   |                                                                                                                                                                                                                                                         |
| 4. How do human activities cause environmental pollution?                          | 1. How do industrial emissions and wastewater discharge pollute the environment?2. How do vehicle exhaust emissions affect air quality?3. How do agricultural activities (such as the use of pesticides and fertilizers) cause environmental pollution? |
| 5. How can we reduce environmental pollution?                                      | 1. What habits in daily life can reduce pollution?2. What actions can communities and schools take to reduce pollution?                                                                                                                                 |
| 6. What is the significance of sustainable development for the present and future? | 1. What are the basic principles of sustainable development?2. How can the sustainable use of resources benefit future generations?<br>3. How can public awareness of sustainable development be raised through education and promotion?                |

Under the framework of expected understandings and Essential Questions, students will master the types of environmental pollution (such as air pollution, water pollution, soil pollution and noise pollution), the main causes and specific manifestations, the ways and steps to solve the problem of environmental pollution, and recognize the role of art in promoting environmental protection, and how to save resources effectively in daily life. These knowledge goals ensure that students have the necessary scientific knowledge foundation and are contained in the Essential Questions, pointing to the exploration of the Essential Questions.

Through the study of the above knowledge, students will be able to use recycled materials to create environmental protection works of art, use community survey data to analyze environmental pollution, and use creative and artistic means to promote the concept of environmental protection to improve public environmental awareness, and organize and hold environmental protection art exhibitions. Through practical operation and participation in the exhibition, students can not only deepen their understanding of environmental issues, but also exercise their organizational and coordination skills, and improve teamwork and communication skills.

### 3.3.2 Stage 2 — Determine Appropriate Assessment Tasks.

On the basis of determining the expected understandings in stage 1, stage 2 should provide evidence clue support for assessing whether the student has achieved the expected understandings, including the design of Performance Tasks and various other evidence (such as tests, prompts, observations, etc.) and the student's self-assessment and reflection to prove that the student has achieved the expected understandings. The UbD theory focuses on the process and diversity of assessment. It not only uses traditional tests to test students' knowledge and skills, but also pays great attention to the design of Performance Tasks, so that students are in real problem situations, and multi-dimensionally assesses students through the process of students' problem solving and the final product results. In stage 2, the following elements (Figure 3) are mainly considered as evidence to determine the degree of achievement of the expected results (stage 1). According to the main design elements of Stage 2 described in Figure 3 and in combination with the "Compulsory Education Science Curriculum Standards (2022

Edition)”, the design of appropriate assessment tasks for Stage 2 is carried out. The assessment methods involved are shown in Figure 4.



Fig. 3. Main Design Elements in Stage 2

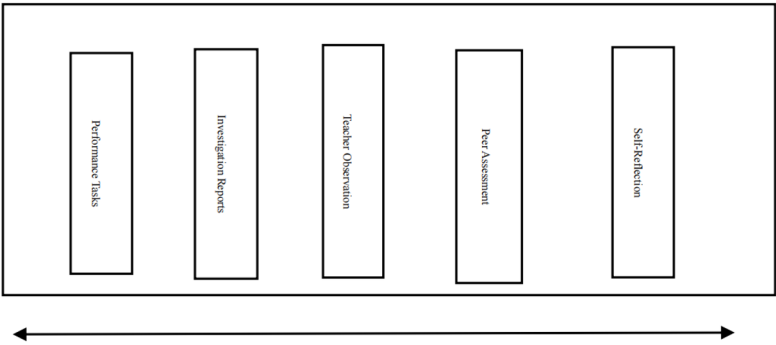


Fig. 4. Assessment Methods

Rubrics play a key guiding and normative role in various assessment methods. By clarifying specific assessment standards, rubrics help students understand the expected learning goals and behavioral performance standards in various aspects such as Performance Tasks, survey reports, observation records, peer assessment and self-reflection. When assessing students’ works and performance, two general rubrics (holistic and analytical) are widely used. Since the analytical rubric evaluates each identified feature separately, each feature has a score. In this design, the design of rubrics mainly selects analytical rubrics, and each assessment method corresponds to an analytical rubric, as shown in Table 4.

**Table 4.** Rubrics for Assessment Methods

| Assessment Methods    | Indicators                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Performance Tasks     | ① Creativity and artistic expression. ② Effectiveness in using recycled materials. ③ Interpretation of and reflection on the environmental protection theme. ④ Organization and execution of the exhibition.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Teacher Observation   | <p><b>Preparation Stage:</b> ① Level of attentiveness while watching environmental documentaries. ② Frequency of active participation in discussions. ③ Level of detail in the investigation plan.</p> <p><b>Creation Stage:</b> ① Initiative in collecting materials. ② Creativity in artistic creation. ③ Cooperation and division of labor in group discussions.</p> <p><b>Exhibition Stage:</b> ① Level of participation in exhibition planning and setup. ② Performance in exhibition introduction and interaction. ③ Performance in group discussions.</p> <p><b>Assessment and Reflection Stage:</b> ① Performance in peer assessment. ② Depth of self-reflection. ③ Completion of the reflection essay.</p> |
| Investigation Reports | ① Level of detail in the investigation plan. ② Comprehensiveness of data collection. ③ Accuracy of data analysis. ④ Clarity of report structure. ⑤ Accuracy of language expression. ⑥ Feasibility of solutions. ⑦ Performance in teamwork.                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Peer Assessment       | ① Feedback is detailed and specific. ② Improvement suggestions are practical and feasible. ③ Language is positive and constructive.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Self-Reflection       | ① Specificity of discoveries and gains. ② Improvement in understanding of environmental protection. ③ Feasibility of future action plans. ④ Self-critical awareness in the reflection process. ⑤ Clarity and logic of language expression.                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

### 3.3.3 Stage 3 — Arrange Learning Experiences and Instruction.

After completing the expected learning results and assessment evidence design, stage 3 further transforms the learning goals into specific learning experiences and teaching activities. UbD theory emphasizes that teaching activities should be carried out around the Big Ideas and Essential Questions, and should be consistent with learning goals and assessment tasks. Therefore, this design plans the learning process based on the learning goals determined in stage 1 and the assessment evidence designed in stage 2, combined with the WHERETO elements, and promotes students' deep understanding through continuous assessment and adjustment. The key design elements of stage 3 are shown in Figure 5.

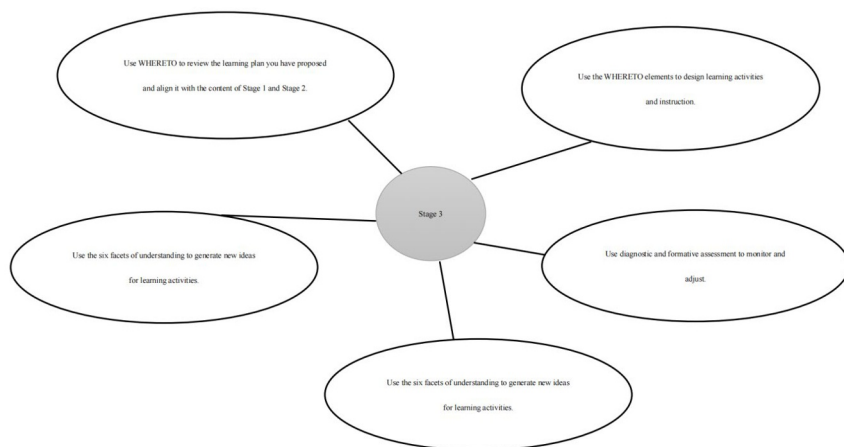


**Fig. 5.** Key Design Elements in Stage 3

In the process of specific teaching implementation, this design divides the learning process into four stages: “preparation–creation–exhibition–assessment and reflection” around the theme of “Protecting Our Earth”. Combined with the actual situation of primary school science classes, if students lack preliminary observation and investigation, it is often easy to keep environmental protection art creation at the level of work production. Therefore, in the preparation stage, through environmental information learning and campus and community investigation, students should be guided to discover real environmental problems and accumulate materials for subsequent creation. On this basis, enter the creation and display of works, so that students can transform the understanding gained in the early stage into concrete expressions; after the exhibition, through peer assessment and self-reflection, help students summarize the findings and shortcomings in the activity, and further form an understanding of environmental protection responsibility and sustainable development.

## 4 Conclusion

Through this teaching design, it can be found that the biggest inspiration of UbD theory for teachers is to first think about “what students will finally understand” and then decide what activities to arrange in the classroom. In the actual design, if you start from the activity first, it is easy to have the problem of rich content but scattered goals; and working backward from the expected understandings and assessment evidence to design the teaching process is more conducive to linking the unit goals, learning tasks and assessment requirements in series, so that each activity has a clear orientation.

At the same time, teaching design should not only pursue the integrity of the activity form, but also consider the real learning process of students. Especially in primary school science classes, students are often prone to stay at the level of “completing tasks”, so teachers need to judge whether students really understand the scientific meaning behind the activities through observation, questioning, display and reflection. For

teachers, UbD is not only a design program, but also reminds us to constantly check “what students have learned” in the teaching process, not just “what has been accomplished in the classroom”.

## References

1. United Nations Environment Programme. (2024). *Global resources outlook 2024: Bend the trend—Pathways to a liveable planet as resource use spikes*. International Resource Panel. <https://www.unep.org/resources/Global-Resource-Outlook-2024>
2. Ministry of Education of the People's Republic of China. (2022). *Compulsory education science curriculum standards (2022 edition)*. Beijing Normal University Press. [http://www.moe.gov.cn/srcsite/A26/s8001/202204/t20220420\\_619921.html](http://www.moe.gov.cn/srcsite/A26/s8001/202204/t20220420_619921.html).
3. Wiggins, G., & McTighe, J. (2017). *Understanding by design* (2nd ed.; H. Yan, X. Song, & P. Lai, Trans.). East China Normal University Press. (Original work published 2005) <https://www.sinobook.com.cn/b2c/scrp/bookdetail.cfm?iBookNo=1087921>.
4. Zhang, Z., & Huang, X. (2026). Structuring learning experiences: The logic and strategies of large-unit content organization. *Journal of the Chinese Society of Education*, (7), 79–84. <https://www.aisixiang.com/data/180870.html>.
5. Harlen, W. (2011). *Principles and big ideas of science education* (Y. Wei, Trans.). Popular Science Press. (Original work published 2010). <https://xzx.shnu.edu.cn/9e/25/c18445a499237/page.htm>.
6. Cui, Y. (2019). Disciplinary core competencies call for large-unit teaching design. *Journal of Shanghai Educational Research*, (4), 1. <https://doi.org/10.16194/j.cnki.31-1059/g4.2019.04.001>.

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