

Original Research Article

Reflections on the Design of Junior High School Science Homework Pointing to the Core Literacy under the Background of "Double Reduction"

ABSTRACT

Science homework is an important part of junior high school science teaching and learning, playing an important role in the whole subject curriculum teaching system. How to design homework scientifically, reasonably and effectively according to the teaching contents and learning conditions is the key exploration of junior high school science teaching under the background of "double reduction". Based on the understanding of the core literacy of science and the analysis of the current status of science homework in junior high schools, we combined with the teaching practice of science homework design, and considered the improvement path for the design of junior high school science homework that points to the core literacy under the "double reduction" policy. Teachers can proceed with the following four aspects to improve the quality of homework design: designing conceptual homework from scientific concepts to consolidate basic knowledge; designing upgraded homework from scientific thinking to improve the quality of assignments; designing hands-on homework from inquiry and practice to enrich the form of assignments; designing value-oriented homework from attitude and responsibility to bring out the value of educating people, so as to truly help students achieve "quality improvement, efficiency increase, and burden reduction" in learning, and cultivate students' core literacy.

Keywords: core literacy; homework design; junior high school science; double reduction.

1. INTRODUCTION

Junior high school science curriculum is a fundamental and inquiry-oriented subject. Its teaching content and teaching process can well stimulate students' interest in natural inquiry, prompt them to form good scientific research spirit and quality and publicize their personality in experiencing the changes of scientific phenomena. Science education is a kind of education by imparting basic scientific knowledge as a means, quality education as the basis. It allows students experiencing the scientific method of thinking and inquiry, cultivating scientific spirit and scientific attitude, establishing a complete view of scientific knowledge and values, conducting the basic scientific research ability training and the application of science and technology.

In the process of science education, it is particularly important to cultivate students' scientific core literacy. How to cultivate students' scientific core literacy in limited school or classroom time has become a problem that every science educator has to face, especially the after-school homework, it should not only achieve the goal of teaching and learning, but also occupy less of the students' after-class time.

In July 2021, the general office of the Central Committee of the Communist Party of China and the general office of the State Council issued the "opinions on further reducing the burden of students' homework and off-campus training in compulsory education stage" (hereinafter referred to as the "double reduction" policy), which clearly stated to comprehensively reduce the total amount and duration of homework, so as to reduce the excessive homework burden on students [1]. The "double reduction" policy also proposed to classify and clarify the total amount of homework, and the average completion time of written homework in junior high schools should not exceed 90 minutes.

How can we effectively reduce the burden of homework on students, but also to ensure the quality and quantity of teaching tasks? Homework is an important part of teaching, and many schools focus on both "quantity control" and "quality improvement". "Quantity control" is relatively easy to achieve, while "quality improvement" puts forward higher requirements on the homework design of classroom teachers. Only when teachers increase the quality of homework can the assigned homework promote students' academic and thinking growth in a small amount of high-quality situations. Under the current situation of "double reduction", the design of homework should keep pace with the times.

2. SCIENCE CORE LITERACY

2.1 What is the core scientific literacy

Combining the definitions of core literacy by international organizations and countries around the world, taking into account the research on core literacy in different subjects, as well as our definition of core literacy for student development in our country [2], China defines core literacy in science subjects as: the necessary character and key abilities that students gradually form in the process of receiving science education to adapt to the needs of personal lifelong development and social development, it is the qualities with science subject characteristic that the student internalizes through the scientific study, and is the concentrated embodiment of education value of science subject.

According to the core literacy of students' development and the nature of science subject, after systematically analyzing the scientific curriculum standards in major developed countries and the current situation and trends of international science education research, and summarizing the practice and research of science education in China, the connotation of core literacy of science subject in our national "science curriculum standards for compulsory education (2022 edition)" is expressed as follows: the core literacy of students to be cultivated in science curriculum, mainly refers to the correct values, necessary characters and key abilities that students gradually form in the process of learning science curriculum to adapt to the needs of personal lifelong development and social development, and is the concentrated embodiment of the education value of science curriculum, including science concepts, scientific thinking, inquiry and practice, attitude and responsibility and so on [3].

2.2 The significance of cultivating students' core literacy in science

Under the macro background of the continuous and in-depth development of the education system reform, core literacy, as a key part of the reform, has become the direction and ideology of teaching in many subjects. As an important subject in junior high school teaching, science core literacy is not only of great significance for students in the study of science, but also for students to form a good habit of thinking and strong logical thinking ability in the study of other subjects, and promote the overall improvement of their comprehensive quality.

At the same time, junior high school is an important transition stage for students to learn science, so abandoning the previous teaching philosophy of "filling students with knowledge" in the process and supplementing it with the development of core literacy skills is not only conducive to cultivating students' enthusiasm and initiative for learning science, but also conducive to students' use of creative thinking habits to make significant achievements in their future studies of physics, chemistry, biology, and other disciplines at a higher level.

Among the four elements of core literacy in science, scientific inquiry is a process, a way of learning and scientific research, a means and a way of learning science concepts, developing scientific thinking, forming scientific attitudes and responsibilities, and it is also a kind of comprehensive ability. Science concepts, scientific thinking, scientific attitudes and responsibilities are the core literacies that are formed through science learning [4].

3. THE CURRENT SITUATION OF SCIENCE HOMEWORK IN JUNIOR HIGH SCHOOL

Reducing the homework burden of elementary and middle school students has always been a key task of the education administration. However, in the process of vigorously promoting quality education, the "inertia thinking" of exam-oriented education and the short-sighted behavior of pursuing temporary educational "achievements" have not been completely eliminated. Therefore, in junior high school, students' science homework is often seen to be heavy in written assignments, mainly review and consolidation orientation, and neat and tidy homework requirements. This brings students a sense of tedium and boredom in their assignments and at the same time greatly reduces the efficiency and quality of the completed assignments. Typical problems are as follows [5]:

3.1 Large amount of homework

In traditional homework assignments, teachers always assign the massive exercise questions and try to use "question sea tactics" to strengthen the learning effect in class. Some experts pointed out that the time spent on homework is one of the indicators of students' homework burden. The homework time is closely related to the quantity of assignments, and the homework time is usually too long when the quantity of assignments is too large, and the homework burden generally will be too heavy [6].

With the increasing pressure of the senior high school entrance examination, the amount of written assignments for students has remained high for a long time. First of all, the front-line teachers feel that the amount of homework should be reduced, but on the other hand, they feel that if the amount of written assignments is not enough, the effect of consolidation and review will not be achieved. In order to improve students' test scores and academic standards, teachers of various subjects have assigned a large number of written assignments.

3.2 The quality of homework is not high

"The quality does not work, the quantity wins", which is a status quo of the current homework assignment that emphasizes quantity over quality.

As an indicator of homework quality, homework validity is also one of the performance indicators of homework burden [6]. Homework validity can be viewed from the content, structure, and type of homework. Unreasonable homework content and structure design and arrangement will generate homework burden, and the type or form of homework exercises

will also be related to homework burden. An invalid or ineffective homework will undoubtedly cause direct or indirect burden on students.

3.3 The homework is not well targeted

There are differences and variances between each student. If the differences among students are ignored, the homework assigned by the teacher is uniform, and the design of the homework does not take into account the learning situation and differences of the students, this will lead to some students have more than enough to learn on the hungry, and some underachievers are afraid of homework because they cannot complete the homework assigned by the teacher, and are afraid of learning science subjects.

From the literature research, students' emotional experience of homework is also an indicator of homework burden [6]. Students' emotional experience of homework can be reflected in their attitude to homework, their emotion of homework, etc. For example, assigning uniformity of homework demotivates struggling students to learn and makes them have a dislike for homework psychology.

3.4 Single form of homework

At present, written assignments is still the main body of homework. Most of the junior high school science homework questions are mainly based on choice, fill-in-the-blank, calculation questions. However, there are very few generative homework such as experimental exploration and thinking expansion, which inevitably forms a situation of mechanical brushing questions.

The single form of homework is also an important factor that causes the heavy burden of students' homework. In the long run, the core literacy of students can not be promoted, and even stifles the enthusiasm of students to learn.

4. IMPROVEMENT PATHS FOR JUNIOR HIGH SCHOOL SCIENCE HOMEWORK DESIGN

Homework activities are an important carrier for developing students' core literacy. In response to the problems of the current situation, some studies have argued that the design of homework that points to core literacy should focus on the appropriateness, richness, structure and selectability of homework tasks in terms of content [7], and explored the key issues of homework design [8] and strategies for optimal design of junior high school science homework [9]. Some scholars took the design of homework for junior high school chemistry [10-14], junior high school physics [15-17], junior high school biology [18], and junior high school geography [19] as examples, combined with the teaching content of each subject, and explored the strategies of the design of homework for each subject.

In the light of the situation under the policy of "double reduction", for the junior high school science homework design, we can combine the cultivation of students' science core literacy. We think that the following measures should be taken:

4.1 Starting from science concepts, design conceptual assignments and consolidate basic knowledge

The concept of professional terminology is the basis of junior high school science knowledge. When junior high school students are learning, they need to understand and memorize some basic concepts and theories, so as to conduct in-depth learning. Therefore,

when designing science homework, teachers should incorporate relevant content of science concepts, guide students to memorize and apply concepts, and enable students to analyze and differentiate in the process of completing the homework. This will help students to clarify the knowledge system, deepen the learning of basic knowledge, reduce the probability of mistakes due to conceptual confusion, help teachers cultivate students' scientific viewpoints, and lay a good foundation for in-depth teaching.

For example, when learning about "biology and biosphere", we can take the conceptual knowledge of biology, biosphere and ecosystem, and the theoretical knowledge of basic characteristics of biology and composition of ecosystem as the content of the post-class homework, and design exercise questions such as "The life of biology requires (▲)" "Biology can (▲) and (▲)" "Ecosystem refers to a certain area, (▲)". The students are asked to write out the contents in parentheses according to their memory, in order to strengthen the students' memory of the basic concepts and theories related to biology. In this way, teachers can enhance students' ability to analyze and distinguish the concept of "biosphere" and "ecosystem", and train students' ability to summarize and sort out the basic knowledge of science.

4.2 Starting from science thinking, design improving assignments and enhance the quality of homework

Only the homework that fits the student's nearest developmental zone is the real homework, and only the wrong questions that fit the student's nearest developmental zone are the real wrong questions. So you can start from two aspects:

First, the content of homework is stratified. The learning content based on memorization and simple understanding is mainly done in the form of oral assignments; the learning content based on ability improvement is mainly done in the form of written assignments; the learning content based on application and creativity can be completed in the form of practical assignments.

Second, the difficulty of homework is stratified. According to the wrong questions in the nearest developmental zone of students, corresponding two-fold variation is designed for students to strengthen training and carry out scientific remedies, so as to ensure that each student chooses an assignment that is equivalent to or slightly higher than his or her ability level. When teachers design assignments, they should first have a comprehensive understanding of students' learning situation through classroom observation, daily communication, questionnaires and other forms, so as to grasp students' willingness to learn, divide students in the class into scientific levels, combine the nearest development zones of students at different levels, and design assignments with hierarchical content so that students can pick the "fruit" by "jumping around".

In terms of question type design, the homework can be designed into two parts: A-level and B-level. The A-level homework is the basic consolidation type, and the B-level homework is the ability-improving question to meet the learning needs of different students. Students can choose the content of the homework according to their own ability and interest, mobilize the enthusiasm and initiative of the students to learn, and then improve the students' performance and core literacy.

For example, when teaching the "carbon cycle in nature" section, teachers can design hierarchical homework content according to students' learning ability when assigning homework. Our country has proposed the goal of "carbon peaking by 2030 and carbon neutrality by 2060", which is a commitment to the world as a responsible major country. The

greatest value of science education lies in the ability to use what we have learned to solve real and challenging problems, and we can compile assignments based on the educational value orientation of "carbon peaking, carbon neutrality".

The required basic A-level assignment can be a single-choice question: "Carbon peaking" and "carbon neutral" is a key content of the government's work. Carbon peaking refers to a certain moment when carbon dioxide emissions reach the highest value in history and then gradually fall back. Carbon neutrality refers to offsetting the carbon dioxide or greenhouse gas emissions generated by itself through afforestation, energy saving and emission reduction, and achieving positive and negative offsets to achieve relatively "zero emissions". Which of the following measures is not in line with the "carbon peaking" and "carbon neutral" development concepts (▲): A. Take public transportation as much as possible when going out; B. Turn off lights with your hands; C. Use disposable tableware for convenience; D. Use new energy such as hydrogen.

The optional B-level assignment for the upgrading question can be designed with reference to a question in the 2022 Zhejiang Zhoushan senior high school entrance examination science paper, which incorporates the carbon sequestration and sink function of the ocean: China is committed to achieving carbon neutrality by 2060, for which it is crucial to both control carbon emissions and increase carbon absorption. Research has found that in addition to carbon sequestration by land plants, the ocean is also an important place for carbon sequestration, as shown in the figure 1, which shows three ways in which the ocean absorbs carbon dioxide.

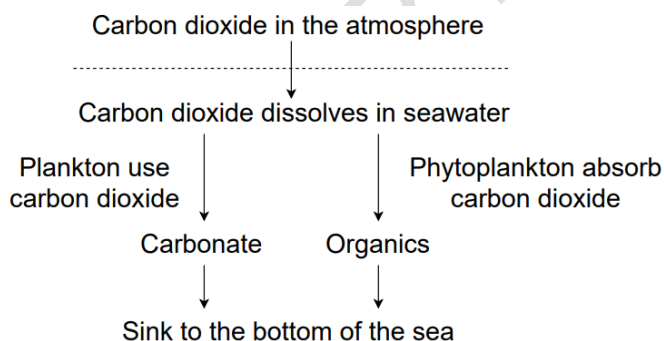


Fig. 1. Three ways the ocean absorbs carbon dioxide

Please answer: (1) Natural dissolution: carbon dioxide in the atmosphere can be continuously dissolved into seawater. Studies have shown that the lower the seawater temperature, the more carbon dioxide dissolved per unit volume. In the four seasons of the year, the most dissolved carbon dioxide per unit volume of seawater is the (▲) season.

(2) Carbon sequestration by plants: Mangroves on coastal beaches and marine phytoplankton absorb carbon dioxide through photosynthesis, and eventually these carbon elements are deposited to the seafloor along with plant residues. Carbon sequestration by plants can only occur in the shallow layers of the ocean, and can not occur beyond a certain depth, the reason is (▲).

(3) Carbonate pump: Marine organisms such as shellfish and coral deposit carbon in the form of calcium carbonate. A certain shell embankment stores about 400 million tons of shells, 95% of which are calcium carbonate. How many million tons of carbon are fixed in the shell embankment?

Above three questions is designed based on three ways of carbon sequestration in the ocean. It examines "temperature affects the water solubility of carbon dioxide" "photosynthesis conditions", which are based on information-based reasoning ability, and "calculation based on chemical equations (law of mass conservation)", which is based on the concept of conservation of elements before and after chemical reactions, and the carbonate pump is a new concept.

4.3 Starting from inquiry and practice, design practical assignments and enrich the form of homework

Teachers can design practice-based homework in combination with science teaching content, so that students can complete after-school homework through independent operation or cooperative operation. This will help students improve their interest in doing homework, experience the joy of science learning, and help students deepen their understanding and experience of knowledge in the process of practice, learn scientific research methods in the process of practice, develop science thinking habits, and achieve the goal of cultivating students' comprehensive science literacy.

When designing practical assignments, we can start from daily life, engineering practice and social hotspots, study and design comprehensive practical tasks, highlight problem solving in real situations, reflect comprehensiveness, practicality and openness, and guide students to use multi-disciplinary knowledge and methods to solve problems, develop students' problem-solving ability and practical skills.

We can encourage students to do homework in the form of experiments using objects around them. For example, when studying the "acidity and alkalinity of solutions" section, we can arrange for students to make their own acid-base indicator using daily items such as purple cabbage, or we can arrange for students to go home and design an acid-base neutralization reaction with items in the kitchen. In this way, teachers can promote students to deepen their understanding of the concepts of acid and alkali and the essence of neutralization reactions in the process of completing homework, improve students' ability to design and complete experiments independently, and enhance students' science inquiry literacy. At the same time, students can feel the connection between science and life.

Teachers can also guide students to carry out practice activities such as "raising and observing the life of silkworms" and "planting and observing the life of soybeans", so that students can truly experience the beauty of life and make science learning more vivid and meaningful.

While observing plants, teachers can also assign assignments for plant science painting, so that students can objectively record the morphological and structural characteristics of the plants themselves in a visual way. In addition to interpreting rational science concepts vividly and intuitively, science drawing can also intermingle the beauty of the senses with true knowledge, and students' perception of the beauty of the biological world can be reflected in the form of hand-drawing.

For another example, in the "melting and solidification" section, students can be assigned a reading practice assignments: consulting information to investigate how the frost in the refrigerator is formed, share and discuss. This assignment not only uses the knowledge learned in the classroom, but also needs to consult some extracurricular information through the Internet to obtain more knowledge to solve the problem. This kind of homework design of reading practice can open up students' knowledge horizons and enhance students' learning effect.

4.4 Starting from attitude and responsibility, design value-oriented assignments and bring out the value of educating people

In addition to checking core knowledge and key competencies, assignments also need value orientation. Good homework can not only help students master and consolidate knowledge, but also contribute to the perfection of their emotional structure. Only when students' social emotions are perfected can they truly perceive the meaning of learning itself.

In the design of junior high school science homework under the literacy intention, teachers can integrate the essence and value of science subjects into real situations, prompt students to transform problem situations into scientific situations for solving problems, and gradually form the awareness of relating situations to science knowledge to promote the development of students' core literacy in science subject.

We can present the real scientific research world in the homework, and use this as a context to test the relevant knowledge and abilities of students. For example, we can draw on a question in the 2022 Zhejiang Hangzhou senior high school entrance examination science paper, introduce students to a science and technology frontier research context of synthetic organic matter with far-reaching relevance and philosophical implications, and deal with it as the following:

In 2021, Ma Yanhe's research team made a major breakthrough in the artificial synthesis of starch, which is the first time in the world to achieve the total laboratory synthesis from carbon dioxide to starch. The production of starch by green plants through photosynthesis involves more than 60 steps of metabolic reactions and complex physiological regulation, while the artificial starch synthesis technology of Ma Yanhe's team requires only 11 steps, and the technical route is shown in the figure 2. The comparison of photosynthesis of green plants (take corn as an example) and the synthesis of the same amount of starch using the artificial starch technology of Ma Yanhe's team is shown in table 1.

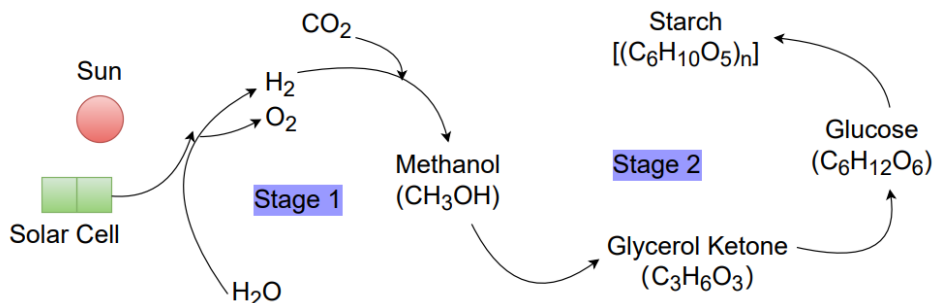


Fig. 2. The synthetic starch technology route of Ma Yanhe's team

Table 1 Comparison of photosynthesis of green plants (take corn as an example) and the synthesis of equivalent starch using the artificial starch technology of Ma Yanhe's team

	Corn Starch	Synthetic Starch
Efficiency of energy conversion	2%	7%
Production conditions and modes	Sunlight, irrigation, fertilization, dosing, harvesting	All-day workshop production
Production cycle	4-6 months	1-2 days
Land area	5 acres of land	1 m ³ reactor

Answer the following questions: (1) The artificial starch synthesis technology of Ma Yanhe's team can be divided into the following two stages: Stage 1: From x energy→electric energy→hydrogen energy→methanol. Stage 2: Multi-step enzyme-catalyzed synthesis of starch using methanol as raw material through the strategy of " $C_1 \rightarrow C_y \rightarrow C_6 \rightarrow \text{starch}$ ". According to the analysis of the figure 2, in stage 1, x energy is (▲) energy, and the reactants to synthesize methanol using hydrogen energy are (▲) and (▲); in stage 2, C_y is glycerol ketone ($C_3H_6O_3$), then the value of y is (▲) (fill in the number).

(2) The artificial synthesis of starch by Ma Yanhe's team and the process of photosynthesis by green plants both require a variety of (▲) as catalysts. Starch is a carbohydrate substance, and its important role in the human body is (▲).

(3) Although the starch synthetic technology of Ma Yanhe's team is at the laboratory stage, it is of great significance to solve the food crisis and reduce carbon emission. According to the analysis of the table 1, the advantage of this technology over traditional agriculture in solving the food crisis problem is (▲).

The pioneering work of Ma Yanhe's team has the significance of a philosophical and ideological turn in blurring the boundary between the changes in the biological and non-biological fields, which may be more significant than the practical significance. The first sub-question above involves the knowledge of energy conversion, the second sub-question is an examination of the functions of important substances such as enzymes and starches, and the third sub-question is a comprehensive analysis of the information provided by the materials, as well as an understanding of the meaning of scientific and technological events themselves, playing a value-oriented role, and making the educational function of homework play a practical effect.

5. EXPECTED RESULTS

Homework is an effective implementation and extension of classroom teaching. In addition to its role in consolidating knowledge, it is also necessary to consider cultivating students' core literacy in the process of completing homework. Scientific and rational design of science homework can meet the needs of students' personality development. In the process of completing homework, students can not only train their scientific thinking ability, but also acquire the scientific method of cognizing the science world, the ability of analyzing and solving problems, thereby improving the core literacy of science subject. So it is very important for the design of junior high school science homework, which requires the attention of every science educator.

Under the background of "double reduction", with the core literacy peer, after carrying on the optimization design to the junior high school science homework, first of all, the burden of students is significantly reduced, most students can complete their homework in time and have their own time to spend on other aspects of learning. Secondly, because of the personalized design for the homework, the content is more in line with the development needs of each student, and there is no lack of content to enhance the science core literacy, which can effectively improve the teaching and learning effect. Finally, the satisfaction of parents is significantly increased. After students complete their homework efficiently, parents and children can communicate better, which can effectively improve the parent-child relationship. At the same time, students are more focused, efficient, and more confident in their learning in class.

CONSENT

All the interviewees consent the use of their views for analysis and publication purpose of the study.

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