A Study and Implications of the Interdisciplinary Unit of the Integrated Science Textbook "Science Explorer"-----Taking Electricity and Magnetism subsection as an example

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Abstract: Abstract The author has repeatedly studied the interdisciplinary unit in Science Explorer - Electricity and Magnetism (China Edition), based on the textbook itself, focusing on the analysis of the characteristics of the interdisciplinary unit of the textbook, so as to summarize what the textbook crosses in the interdisciplinary unit? How? We try to provide a new style for the writing of interdisciplinary units in secondary school science textbooks in China, and help promote interdisciplinary learning.

Keywords: interdisciplinary; textbook column; science textbook

DOI:10.12417/3029-2328.24.12.013

Today's world of science and technology is changing rapidly, the popularization of new media on the Internet, young people's learning, lifestyle is also changing. In April 2022, the Ministry of Education issued the "Compulsory Education Curriculum Program (2022 Edition)" (hereinafter referred to as the "new program"), which points out that it is necessary to "coordinate the design of integrated curriculum and interdisciplinary thematic learning", and for the first time, it is clear that interdisciplinary learning has been included in the national curriculum system for the first time. The status of interdisciplinary learning in the national curriculum system, the new program clearly puts forward that, in principle, each course uses no less than 10% of the class time to design interdisciplinary thematic learning[2]. The Science Curriculum Standards for Compulsory Education (2022 Edition) (hereinafter referred to as the "new standards") explicitly puts forward four interdisciplinary concepts, emphasizing the understanding of interdisciplinary concepts and the development of core literacy through the study of 13 core concepts of disciplines[3]. This is used to realize the integration between different subject areas. It can be predicted that interdisciplinary thematic learning is a key topic in the implementation of the new curriculum reform and a persistent problem.

As an important component of the education system, textbooks bear the dual functions of knowledge dissemination and shaping students' thinking. Whether the textbooks are interdisciplinary or not is the key to the success of interdisciplinary programs. Accordingly, the current textbooks in China are still relatively traditional in terms of the layout of knowledge structure, with obvious division of knowledge points in various disciplines and lack of interdisciplinary integration and application, which makes it difficult to meet the requirements of rapid development of the society for talent cultivation. There is an urgent need to conduct in-depth research on the content of textbooks from the perspective of interdisciplinarity, and to sort out the internal logical relationship between its disciplinary concepts and interdisciplinary concepts. What is interdisciplinary? How to cross? This study repeatedly reads the interdisciplinary units in the comprehensive science textbook "Science Explorer - Electricity and Magnetism" (China edition), based on the textbook itself, focusing on the analysis of the characteristics of the interdisciplinary units in the textbook, so as to summarize what is interdisciplinary in the interdisciplinary units of the textbook? We will summarize what and how the textbook is interdisciplinary in the interdisciplinary unit. We try to provide a new style of interdisciplinary unit writing for secondary school science textbooks in China, and help promote interdisciplinary learning.

1. What does the interdisciplinary unit span? This is the question of its knowledge system

How to integrate other disciplines into a textbook that is based on the logical knowledge of a discipline to form an interdisciplinary unit. One of the keys to this problem is the "choice of interdisciplinary concepts". What is "interdisciplinary"? How much? This is the question of interdisciplinary knowledge system. For the discipline of physics, physical concepts are its core content. Therefore, the first thing is to clarify the core concepts of physics and

interdisciplinary concepts of the intrinsic connection between. The author was greatly inspired by the re-viewing of "Science Explorer".

From the overall organization of the textbook, interdisciplinary units are set in 2-3 sections of the subject knowledge learning, most interdisciplinary units appear at the end of the chapter, the number of interdisciplinary disciplines is "1" (as Table 1). The reason for this is that the learning of any interdisciplinary concepts should be based on the knowledge of the discipline, and interdisciplinary concepts should be integrated on the basis of the core concepts of the discipline. For example, after learning magnetic poles and magnetic fields, it is synthesized with earth sciences, and then geomagnetic poles and geomagnetic fields are learned. If the logic of the original subject knowledge is removed from the design of interdisciplinary units, at the level of teaching materials, exacerbating the fragmentation of subject knowledge, at the level of student learning, increasing the burden of their learning. Interdisciplinary is not the more the better, multi-disciplinary "hodgepodge" is likely to cause the students' learning to become a pile of knowledge of various disciplines, resulting in only see the trees, not see the woods. In short, in the process of fusion of disciplinary concepts and interdisciplinary concepts should emphasize the "quality" rather than "quantity", not in the number of interdisciplinary subjects, but in the "fine", the selected disciplines can be It is not about the number of disciplines, but about the "essence" of the selected disciplines, which can establish a connection with the knowledge points of the discipline. Although "1" is small, it is actually enough.

Chapter name	Name of interdisciplinary module	physical knowledge	Other disciplines	Other subject knowledge
convection	Integration with Earth Sciences - Magnetic Earth	Magnetic poles, magnetic fields	Earth Sciences	Geomagnetic poles, geomagnetic field
electronic	Integration with Chemistry - Batteries	electrical engineering	Chemistry	chemical battery
electronic	Integration with Health Sciences - Safe Electricity	Circuits and electric power	Health Sciences	Short circuit, electric shock, ground wire
Utilization of electricity and magnetism	Technology and Design - Magneto-electricity	Electromagnetic induction, direct current, alternating current	Technology & Design	Generators
electronics	Technology and Design - Information Superhighway	electronics	Technology & Design	Computer Networks Network \ Intellectual Property

Table 1 Science Explorer chapter names, interdisciplinary unit names, units contain knowledge of physics, other disciplines, other disciplinary knowledge

2. How to cross the interdisciplinary unit? This is the realization of the path of the question.

Interdisciplinary unit how to cross? This is the question of interdisciplinary realization path. Through the qualitative analysis of the interdisciplinary unit of Science Explorer, it is concluded that the interdisciplinary unit has the following two characteristics: first, the setting of comprehensive columns; second, a clear knowledge organization framework oriented to the chain of questions.

2.1 Setting up comprehensive columns

The image system, together with the text system and the homework system, are listed as the subsystems of the textbook, and together they constitute the surface system of the textbook [4]. As a supplement to the text system, the

columns serve different functions to deepen students' understanding of knowledge. In terms of the organization of the interdisciplinary unit of Science Explorer, the textbook alternates different types of columns to present the content of the textbook in the design of the unit that implements the concept of interdisciplinarity.

2.1.1 Reading Columns

The reading columns in Science Explorer are systematic and consistent. The reading points at the beginning of the text not only set up a target for students at the beginning of the study, but also set up a "reading scaffold" for students to read independently, give students reading guidance, cultivate students' reading skills, and let students read the text with questions, which puts students in a learning atmosphere of inquiry at the beginning. Among them, the main concepts and main terms together build up the knowledge system of the whole interdisciplinary unit. The "Reading Test" and "Post-assessment", "Target Reading Skills" and "Review of Key Concepts" in the lesson are in the form of questions. The questioning approach facilitates self-testing during independent study. To a certain extent, it provides students with opportunities for self-diagnosis and remediation, and is conducive to students' testing, reflecting and refining their views and positions on issues. The "Review Key Concepts" section after class poses questions in the form of "behavioral verbs + key concepts", listed in order of a, b, and c, with increasing difficulty. On the one hand, the design of this question chain strengthens learners' understanding of core concepts, and on the other hand, it can guide learners to complete the corresponding skill requirements.

2.1.2 Activities

The most obvious feature of Science Explorer is the variety of activities, starting from "Exploration Activities" and ending with "Family Activities", which form a chain of activities from beginning to end. The activities in the textbook are based on real-life situations, and specific steps are given to develop students' practical ability of inquiry. Various types of activities have different functions depending on the location of the textbook. Before the lesson, "exploration activities" enable students to lead the subject through real tasks, and experience inquiry through practical hands-on operation. The "Experimental Area Skills Training" and "Experimental Area Trial" in the middle of the lesson are compiled with the content of the textbook to consolidate and strengthen students' understanding of the basic concepts, and fit in with the students' real-life exploratory activities. The "family activities" after the lesson are diversified and simple to further strengthen students' understanding of the core concepts.

2.1.3 Tools

The tools section, provides "tools to support" students' understanding of core concepts. The tools section of the textbook includes "Mathematical Analysis" and "Scientific Writing". The "Math Analysis" section teaches students how to apply mathematical tools to visualize and quantify knowledge by giving them data and steps to analyze the data, reinforcing their mathematical and logical skills to interact with the science concepts. The "Science Writing" section utilizes a text-based format that integrates science and language arts. The prompts in this section are clear, and instead of the usual stereotypical writing, they are role-played in a fun way.

2.2 Establishment of a problem-chain and oriented knowledge organization framework

One of the unique features of Science Explorer is that the training of various skills is infiltrated throughout the textbook in the form of closed-ended questions, forming a chain of questions that promotes the development of students' scientific thinking and practical skills of inquiry. Closed-ended questions are suitable for the cognitive structure of students, and students are able to reach the other side of cognition guided by the activity[9]. Before the lesson, the main concepts of the lesson are presented in the form of questions; students are trained in scientific thinking and practical skills of inquiry in various types of activities, and questions are used to inspire students to think about the phenomenon of the activity; illustrations in the text are embedded in the text in depth to form a unified whole.

2.3 Implications for the development of science teaching materials in China

2.3.1 Selecting interdisciplinary concepts and realizing horizontal links between concepts

What is “interdisciplinarity”? How to cross? One of the simplest principles is not to “cross for the sake of cross”, cross-disciplinary is not a simple addition of knowledge from different disciplines, cutting and splicing, and finally become “a pot of stew”. Instead, we should select interdisciplinary concepts based on the ontological knowledge of the discipline, according to the order of students' cognitive development and the logical order of knowledge points. The core of the selected interdisciplinary concepts lies in their ability to establish an intrinsic connection with the knowledge of the discipline. Selection of interdisciplinary concepts is the first and most important step in the preparation of interdisciplinary teaching materials. The editors of our textbook should pay attention to the consistency of conceptual choices and the value of integration, and optimize the content of the textbook with horizontal content integration as well as vertical learning progression[8].In the process, understanding the relationship between science, technology, society and the environment, developing strategies and habits of mind for scientific inquiry and technological problem solving, as well as understanding the basic concepts of science and technology are made the general objectives of interdisciplinary content integration and compilation of teaching materials. Thus, effective coverage of the three domains of STSE (science, technology, society, and environment), scientific inquiry, and science concepts, as well as mutual support and enrichment among the domains, are achieved[8].

3. Utilizing multi-type columns to promote the development and enhancement of students' diversified abilities

It is pointed out in the new curriculum standard that the teaching materials should be presented from the perspective of students' observation of the world in the form of independent learning activities, leaving sufficient space for students' independent learning, so that students can construct new knowledge through inquiry and practical activities[3]. Compared with the flat presentation, the setting of multiple types of columns can visually stimulate students' interest in learning, enrich the learning of core concepts in terms of content, which is more conducive to the occurrence of students' independent learning and inquiry learning, and realize the change of learning styles. By setting up multiple types of multi-functional columns, students can trigger high-quality thinking in specific contexts supported by subject knowledge to ensure the development of independent learning in interdisciplinary thematic learning.

4. Setting up a chain of questions and activities based on real situations

Inquiry is the soul of science education What is “real” scientific inquiry? One is that the inquiry questions are scientific questions suitable for students' cognitive structure, and the other is that the inquiry process should diffuse students' scientific thinking [9].In addition, the author believes that scientific inquiry needs to be driven by authentic tasks in authentic contexts. In the setting of interdisciplinary units, our textbook designers need to consider combining real-world situations with disciplinary knowledge, so that students can learn how to use theoretical knowledge to decode reality and how to apply abstract concepts in books to concrete situations in the process of exploring real-world problems. According to relevant research, students can understand knowledge more comprehensively and deeply when faced with real-world situation simulation and problem-solving tasks, and gain innovative thinking and cross-border collaboration skills in practice.

The ice of interdisciplinary curricula has been broken, and it is of great significance to implement interdisciplinary curricula in the context of advocating the curriculum concept of “fewer but better”, and in the light of the overall goal of cultivating students' core qualities. With the deepening of the new curriculum reform, the importance of interdisciplinary learning has become more and more prominent. Textbooks are an important carrier of interdisciplinary courses, and the establishment of interdisciplinary units in textbooks will provide strong support for the implementation of the fundamental task of cultivating moral integrity and the goal of cultivating core literacy.

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