Advances in Economics, Business and Management Research, volume 96
2019 3rd International Conference on Education, Management Science and Economics (ICEMSE 2019)

Comparison and Analysis of Physics Textbook Structure in Junior Middle School between China and America

—Taking "Electricity and Magnetism" as an Example

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***Abstract*—In order to compare the characteristics of the physical textbook structure between China and America, this paper takes the subject of "electricity and magnetism" as an example, and provides a useful reference for the writer and the user of the comprehensive science textbook for junior high school in China. This work firstly analyzed the textbooks' surface structure quantificationally, then discussed the deep structure, and finally put forward the qualitative analysis based on the complex network.**

Keywords—junior middle school; textbook structure; complex network

I. INTRODUCTION

The structure of textbooks can be divided into surface structure and deep structure due to the influence of social structure, students' psychological structure and subject structure. In the textbook structure, we should not only show knowledge and skills, process and method horizontally, but also run through the emotional attitude and values vertically, so that deepen the development of three-dimensional goals and construct the core literacy model of the system.

This paper takes the *Compulsory Education Textbook-Physics* published by the people's education press in 2013 [1] and the theme "electricity and magnetism" of the mainstream American textbook *Science Explorer* translated and published by Zhejiang education press in 2013 [2] as the research object, compares the surface structure and deep structure of the textbooks between the two countries, and analyzes the characteristics of the textbook structure of the two countries.

II. AN ANALYSIS OF PHYSICS TEXTBOOKS STRUCTURE IN CHINA AND AMERICA

The structure of the textbook is to understand the relationship between the components in the textbook from a macroscopic point of view, which is mainly composed of the introduction, the text preparation and the section arrangement and so on. This paper mainly analyzes the surface structure of the "electricity and magnetism" content from the section arrangement and the content relationship. According to the knowledge logic of the "electricity and magnetism" content, the content can be divided into four dimensions: "electricity", "magnetism", "electrical and magnetic relationship" and "electrical and magnetic application". The content relationship diagram shown in Fig. 1 is constructed by combing the relationship between the "electricity and magnetism" contents in the specific section.

Through the comparison of the relationship between the "electricity and magnetism" content of the Chinese and American junior middle school physics textbooks, it can be found that the similarities and differences between the two textbooks are mainly reflected in the following aspects:

A. Section Assignment

From the point of view of the chapter distribution of "electricity and magnetism", Chinese textbooks are divided into 7 chapters, a total of 29 sections. American textbooks are divided into 4 chapters, a total of 16 sections. The number of chapters in Chinese textbooks is obviously more than that in American textbooks.

B. Content Arrangement

As far as the four dimensions are concerned, the content of the "electricity" part of Chinese textbooks is abundant and it is obviously more than that of American textbooks. "Electricity" is behind "magnetism" in Chinese textbook, while "magnetism" is after "electricity" in American textbook. It reflects the differences in the content arrangement between the two countries. Furthermore, for the relationship between "electricity and magnetism", the textbooks of the two countries are arranged in the order of "magnetism from electricity" is before "electricity from magnetism".

C. Application Expansion

Moreover, textbooks in both countries have made a great deal of introduction to "electrical and magnetic application", showing the broad prospect of the application of electricity and magnetism in life.

This research was supported by the excellent graduate course of Yanbian university in 2017 ("education measurement and evaluation theory and practice").

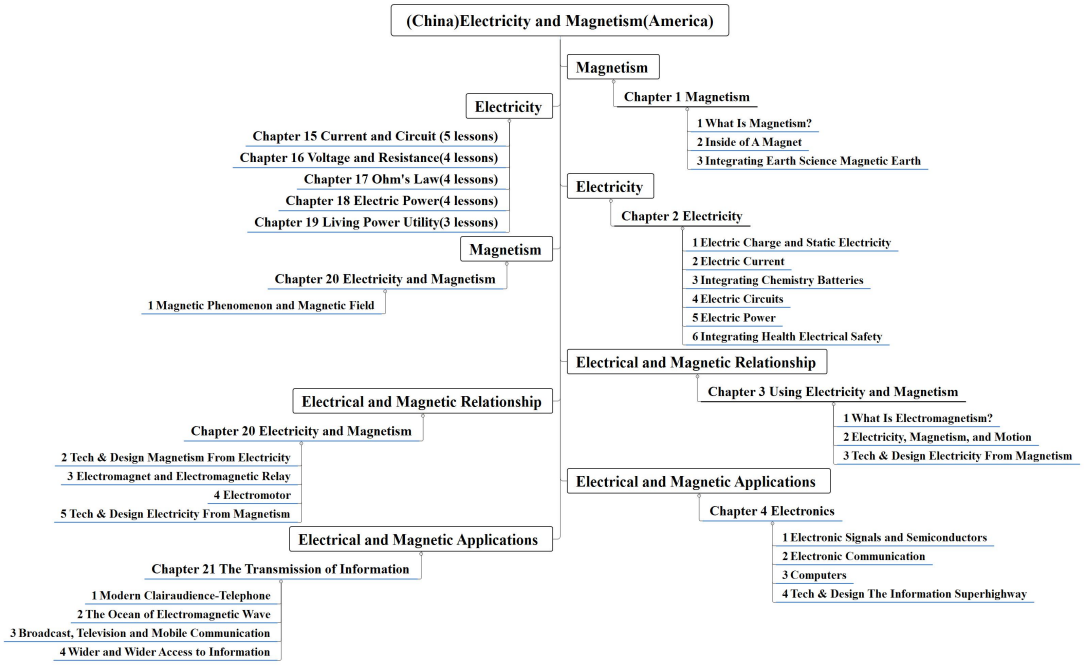


Fig.1. Relationship between "electricity and magnetism" in Chinese (left) and American (right) physics textbook.

III. The Analysis of the Deep Structure of Chinese and American Textbooks

Afterwards, the deep structure of textbooks refers to the analysis of a certain part of the structure from a micro point of view, including knowledge elements, ability elements and emotional elements [3]. As the most basic structure of the subject, knowledge structure occupies a vital position in the textbook structure. In this paper, the knowledge structure of electrical and magnetic content is qualitatively and quantitatively analyzed by knowledge network in complex network theory. As a kind of network which can connect knowledge, knowledge network can show the structural characteristics of knowledge. Therefore, this paper uses the complex network method to construct the physical knowledge network between China and America, and makes a clearer analysis of the deep structure of the two countries' textbooks.

A. Construction of Physical Knowledge Network

In this paper, the physical terms in the textbook text are used as the node to establish the relationship between the physical terms that appear at the same time in the same sentence, and it is the way to construct knowledge network of Chinese and American textbooks. The specific method of constructing a sentence knowledge network in the textbook is shown in Fig. 2. The physical terms in the sentence are "conductor", "electricity", "voltage" and "resistance". When these four physical terms appear in the same sentence at the same time, they can be connected to each other to represent the relationship between the terms.

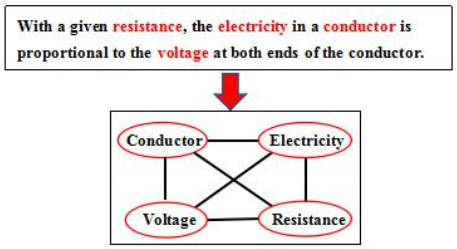


Fig.2. Construction method of binary knowledge network.

Based on *Oxford Dictionary of Physics with Chinese Translation* [4] and *Practical Physics Dictionary of Middle School Teachers* [5], according to all the contents of textbooks, physical terms are extracted from each sentence, and the knowledge network of textbooks between China and America is constructed by using complex network method. In the process of extracting physical terms, when there are two or more physical terms composed of two or more words, the words that make up the compound words are no longer extracted twice. For example, "electric energy": the "electric" is no longer extracted twice. Based on the analysis of surface structure, it can be seen that there are a mass of physical terms with different capacity and less frequency in applying of "electricity and magnetism" in textbooks between China and America, so in order to compare the textbooks of the two countries more evenly, the physical terms with frequency of more than 10 times (including 10 times) are selected for statistical analysis. There are 58 physics terms in Chinese junior middle school physics textbook and 78 physics terms in American textbook.

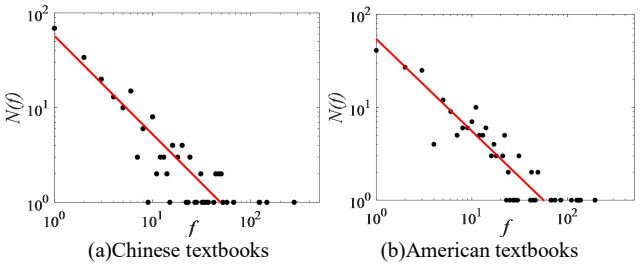
B. Comparison of Statistical Characteristics of Physics Textbooks between China and America

The statistical characteristics of textbooks presented by complex network theory can quantitatively reveal the internal structure of textbooks. In order to realize the frequency of the use of physical terms in textbooks, Table I lists the top 15 physical terms used in textbooks in the two countries. It can be found that the most frequently used physical term in junior middle school physics textbooks in China and America is "electric current", and the terms "electricity", "voltage" and "wire" all occupy a high frequency of use, which indicates that the "electricity" part occupies an important position in the whole knowledge system of "electricity and magnetism" in both Chinese and American textbooks.

TABLE I. 10 MOST FREQUENT PHYSICS TERMS IN 2 TEXTBOOKS

Rank	China	*f*	America	*f*
1	electric current	277	electric current	194
2	voltage	146	electric charge	137
3	electricity	123	electron	132
4	resistance	122	electricity	129
5	bulb	67	magnetic field	125
6	wire	57	computer	110
7	power supply	52	wire	85
8	I	50	motion	74
9	signal	50	voltage	68
10	R	47	conductor	67
11	magnetic field	47	resistance	49
12	V	44	magnetic pole	49
13	conductor	44	iron	46
14	amperemeter	42	magnetism	44
15	U	37	electric energy	42

Based on the frequency of the use of physical terms in the two countries' textbooks, the distribution map of the frequency of use of physical terms as shown in Fig. 3, in which the horizontal axis represents the frequency of the use of physical terms, *f*, and the longitudinal axis represents the number of physical terms in which this frequency occurs $N(f)$. It can be seen from the graph that the two distribution are in accordance with the power-law distribution $N(f) \propto f^{-\alpha}$ and fewer physical terms are used more frequently. The frequency of most physical terms is between 1 and 10, and the index α is close to 1, which is consistent with the previous study [6-7], which indicates that the textbooks of the two countries are similar in terms of the frequency of the use of physical terms.



(a)Chinese textbooks (b)American textbooks

Fig.3. Distribution of physics terms using frequency *f* for 2 textbooks.(log-log plot)

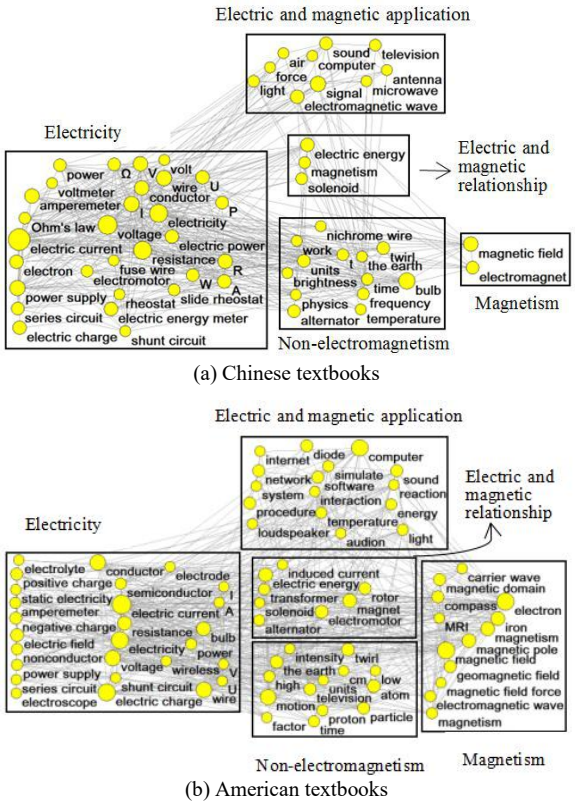
The sum of all the connected edges of a node *i* is called degree, which is represented by k_i, while the average value of the degree of all nodes in a knowledge network is called the average degree, which is represented by $\langle k \rangle$ [8]. The average degree can reflect the compact density between nodes in knowledge network.

$$\langle k \rangle = \sum_{i=1}^{N} k_i \Big/ N \tag{1}$$

Through calculation, the average degree of knowledge network of Chinese physics textbook is $\langle k_C \rangle$=19.00. The average degree of knowledge network in American physics textbook is $\langle k_A \rangle$=20.18. This shows that the density of connections between nodes in Chinese textbook knowledge network is slightly lower than that in American textbooks.

C. Comparison of Physical Knowledge Network Structure

In order to intuitively reflect the deep relationship between the contents of "electricity and magnetism" in each dimension, the following physical knowledge network diagram is drawn by Pajek software [9]. The physical terms in the content of "electricity and magnetism" are divided into five sections: "electricity", "magnetism", "electric and magnetic application", "electric and magnetic relationship" and "non-electromagnetism". Five different categories of physical terms are outlined with five frameworks to construct a binary knowledge network. The density of the line represents the compact degree of the relationship between the physical terms, as shown in Fig. 4.



(a) Chinese textbooks

(b) American textbooks

Fig.4. Binary knowledge network of the theme of "electricity and magnetism"

By comparing and analyzing the binary knowledge network of physics textbooks between China and America, we can find that there are significant differences in the deep structure of textbooks between the two countries in the following aspects:

1) The richness of terms

The terms of Chinese textbooks in "electricity" and "non-electromagnetism"' are similar to those in America. However, the number of physical terms and species in the other three parts of "magnetism", "electrical and magnetic relationship" and "electrical and magnetic application" are significantly lower than those in American textbooks.

2) The compactness of content

In the connection between "electricity" and other parts, Chinese textbooks are comparable to America. In addition, the connections between the other parts are sparser from the American textbooks, and on the whole, the contents of the American textbooks are more closely related.

IV. Conclusion and Suggestion

A. Conclusion

Through the qualitative and quantitative analysis of the surface and deep structure of textbooks in the two countries, the following conclusions can be drawn:

There are differences in the surface structure of "electricity and magnetism" content in the two textbooks. As a set of comprehensive curriculum textbooks, *Science Explorer*, with quite a few important themes as the core, organizes and develops the teaching contents, the layout design and column setting are rich and diverse. It tends to explore the physical laws from the physical phenomena in life and emphasize on the cultivation of students' independent and cooperative inquiry ability. The other one is based on the knowledge structure of physics, and the content of teaching material is carried out step by step. "electricity" in front, "magnetism" in the back, this mode truly presents the sequence of human understanding of electricity and magnetism.

There are similarities and differences in the deep structure of the contents of "electricity and magnetism" in textbooks of the two countries. The similarity is that the statistical characteristics of the physics knowledge network of Chinese and American textbooks are basically the same, the difference lies in the structure of the physics knowledge network: the content of "electricity and magnetism" in Chinese textbooks belongs to the first level scientific theme "movement and interaction" of *Compulsory Education Physics Curriculum Standard (2011 edition)*; Based on the *American National Standard for Science Education*, American textbooks are arranged according to the core concepts of the subject. The content of "electricity and magnetism" belongs to the core concepts of material science: movement and stability, force and interaction. Chinese textbooks strengthen the part of "electricity" with the principle-"less but better", it can highlight the key points of knowledge in a clear logical order. American textbooks pay more attention to make the knowledge "wide and complete" and can effectively integrate it.

B. Suggestion

On the basis of the above analysis, the following suggestions can be put forward for the compilers and users of textbooks in China:

1) Strengthen the degree of convergence between knowledge.

The relationship between "electricity and magnetism" in Chinese textbooks is not close enough. We should strengthen the transition from "electricity" to "magnetic", lay a solid foundation for the following important content of "the electric and magnetic relationship", and realize a coherent and complete teaching system.

2) Pay attention to the systematicness of content.

The content of "electricity" in Chinese textbooks is obviously more than that of "magnetism", which can be properly expanded and extended to facilitate the study of the content of "electricity and magnetism" in senior high school.

3) We will appropriately expand the scope of textbook knowledge.

The proper expansion of the scope of textbook knowledge can not only reflect the breadth of knowledge, but also facilitate the effective integration of physical knowledge and other subject knowledge. American textbooks end with the chapter of "electronics", which not only undertakes the content of "electricity and magnetism", but also highlights the teaching thought of STSE.

To a certain extent, the compiling level of physics textbooks reflects the development level and present situation of physics education, so we should draw lessons from the merits of textbooks in other countries to perfect the physics education system of our country. In this paper, the differences between the surface structure and the deep structure of the textbook "electricity and magnetism" between China and America are compared and analyzed, and we hope that the research methods used can be extended to the study of the teaching material structure of other disciplines.

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