



# Comparison of the Content of Chinese and British Senior Secondary Mathematics Textbooks

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**Abstract.** This paper explores the differences between Chinese and British mathematics textbooks, mainly from three aspects: 1) Focus on the training object; 2) Comparison of content difficulty; 3) Comparison of mathematical culture and function. The textbooks this paper selected are Chinese People's Education Edition and Cambridge SMP textbooks. The main finding of this paper is that the UK has a different mathematical talent training focus, as well as the differences in the degree of penetration of mathematical culture. In addition, it is found the embodiment of the difficulty in mathematics teaching materials in both Chinese and English. Meantime, Chinese students' mathematics performance is better than British students. On the other hand, Britain has played more significance than China in some areas of advantage. Finally, this paper summarizes the above three aspects and put forward our own opinions on how to improve the mathematics teaching materials in the future.

**Keywords:** Comparative Education · Mathematics Textbooks · Senior Secondary School

## 1 Introduction

With the rapid development of science and technology, culture and economy, the accelerating process of globalization, and the international educational exchange has become a hot field of educational research.

According to THE times Higher Education (THE) 2022 World University Rankings, universities in the U.K. and the U.S. are still dominant, with the University of Oxford at the top for many years with 42% international students, while University of Cambridge has 39% of international students, and UK institutions account for 28% of the top 200 [1]. UK institutions have a relatively high International Outlook and a high proportion of international students. In the UK, the General Certificate of Education Advanced

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Level (GCSE) is the entrance examination for high school students in the UK to enter university. It is similar to the National College Entrance Examination in China and is open to all international students. It is highly recognized by the world and is also the focus of the educational exchanges between the two countries. At the same time, the curriculum reform in the world influence, its quality is widely recognized by international higher vocational colleges. As Chinese international student has been the UK's first major group in colleges and universities, a number of British policies will be more attractive to study in China. International students choose the UK to accept education, as the study of Britain's high school education is helpful to study and draw lessons from Chinese education business, for promoting the sustainable development of international educational exchanges.

Mathematics teaching materials have always been a heated topic in international mathematics education research. In July 2014, the First International Conference on Mathematics Textbook Research and Development (ICMT) was held at the University of Southampton, UK. The conference discussed the research, analysis, comparison, historical research, use, development, and penetration of other subjects of mathematics teaching materials, reflecting that the research of mathematics teaching materials has received extensive attention from the international mathematics education circle.

## 2 Comparing Math Education Between China and the U.K.

### 2.1 The Comparison of Educational Objectives

The educational objectives of mathematics changed with the teaching reform. Also, curriculum reform is carried out in response to the requirements of social development and the needs of individual development. Since the founding of New China in 1949, the development of mathematics curriculum standards in China has gone through a long process. China first adopted the Soviet Union's "Syllabus," which had a general statement of aims and a sub-subject statement of aims. This was followed by the refinement of the objectives with the three main directions of "Knowledge and Skills", "Ability" and "Affective Objectives" [2]. Among them, the "knowledge and skills" objectives went through the process of reform from "Basic Knowledge" to "Double Foundations," and from "Double Foundations" to "Four Foundations." In recent years, in response to the demand for innovative talents, China has completed the top-level design of the core literacy: the General Framework for Core Literacy, and the design of the curriculum standards for senior secondary mathematics with the theme of core literacy.

In the General High School Mathematics Curriculum Standards of China, which is revised in 2017 and 2020 [3]. It is stated that mathematics education aims to help students acquire the mathematical knowledge, skills, ideas, and methods necessary for modern life and further learning, to enhance students' mathematical literacy, to guide them understand math, and to promote students' mathematics education. These will play a unique role in the formation of students' correct outlook on life, values, and worldview.

The Curriculum Standards also explain the focus of the "Four Foundations" and "Four Capabilities": "Four Foundations" refers to that through the study of mathematics in the senior secondary curriculum, students will acquire the basic knowledge of mathematics, the basic knowledge of mathematics, the foundational skills, ideas and activities

necessary for the further study and future development. The “Four Skills” refer to the development of the ability to identify and formulate problems from a mathematical perspective, and the ability to analyze and solve problems. During the process of learning mathematics and applying mathematics, students will be able to develop core literacies in mathematics such as mathematical abstraction, logical reasoning, mathematical modeling, intuitive imagination, mathematical operations, and data analysis.

The Curriculum Standards also set out the following vision for teaching and learning: through the learning of mathematics in senior secondary school, students will be able to enhance their interest in learning mathematics, increase their confidence in learning mathematics well, develop excellent mathematical independent learning; develop students’ critical thinking ability; continuously improve their practical skills and enhance their senses of innovation; and recognize the scientific, applied, cultural and aesthetic values of mathematics.

In the Cambridge version of the textbook, the following teaching objectives are set out: the aims are to enable students to develop their mathematical knowledge and skills in a way that encourages confidence and provides satisfaction and enjoyment; to develop an understanding of mathematical principles and an appreciation of mathematics as a logical and coherent subject; to acquire a range of mathematical skills [2]. Learners then can acquire the mathematical background necessary for further study in mathematics or related subjects. They can apply these skills across a wide range of subjects and these skills equip them well for progression to higher education or directly into employment.

As can be seen, the development of mathematical knowledge and skills, and the ability to analyze and solve problems are reflected in both Chinese and British textbooks. Mathematical skills play a very positive role in further learning as well as in future development. The ability to identify and formulate problems from a mathematical perspective and analyze and solve problems, which also provide an important foundation for developing students’ creative and research skills. The development of mathematical knowledge and skills reflects the importance of mathematics as a fundamental subject for students at the stage of basic education.

In addition, China students are required to develop a sense of social responsibility and cultivate a correct outlook on life, values, and the world. The embodiment of moral education in the subject of mathematics is a feature of Chinese teaching materials. In mathematics textbooks, this is reflected in studies related to the history and culture of mathematics. For example, in the chapter on “The derivative of a function and its applications”, in addition to mathematical skills, the teaching of “The founding and development of calculus” is introduced, and it is stated that teachers “can organize students to collect and read historical information on the founding and development of calculus and to write short essays on the process, important results, major figures, key events and their contribution to human civilization.” A similar statement is proposed under the topic of “Functions”.

The importance attached to the teaching of Civics is a feature of Chinese textbooks. Civic education is given an important place in the teaching of all subjects. In the Chinese version of the Mathematics Curriculum, it is clearly stated that “teachers can organize students to collect and read research results on number sequences, especially the best ancient research results in China, and write short essays on the process of the development

of number sequences, important results, major figures, key events and their contributions to human civilization, and to appreciate the glorious achievements of our ancient mathematics" [4]. As can be seen, the content of Civic Education and History of Mathematics are well integrated into the introduction of ancient Chinese mathematicians.

Through the analysis of the teaching objectives, it can be seen that there is a general overlap between the UK and Chinese objectives for mathematics lessons, but the Chinese teaching materials are richer in terms of content and format, which can be seen as a focus on the development of 'core literacies'. At the same time, the integration of moral education into the subject content helps students to learn by presenting abstract subject knowledge in a more concrete context. Also, it has a positive effect on students' character building, which is a very effective practice.

## 2.2 The Comparison of Difficulty of Textbooks

In terms of international mathematics education, there are great differences about the difficulties between eastern and western mathematics courses. For example, China's high school mathematics teaching material teaches geometry, calculate the function such as the difficulty greatly higher than that of the difficulty of the British A-level mathematics teaching material. In the international mathematical Olympiad, 65% of Chinese students, performance is better than students in other countries, won the first prize in the competition, as well as the champions, also accounts for the proportion of the majority, 70% of the situation has improved in recent ten years, a growing number of foreign students with non-Chinese education backgrounds are also topping math competitions [6]. Many factors affected the mathematics ability of Chinese and British students, among which the difference in the difficulty of teaching materials cannot be ignored. Therefore, this part will focus on the details (e.g., function, sequence, probability, and statistics) to study and compare the difficulty differences between Chinese and British high school mathematics textbooks. Then several viewpoints will be proposed in this paper as below:

First of all, there are obvious differences between Chinese and English mathematics textbooks on probability and statistics. In terms of content breadth, the Chinese high school mathematics "probability and Statistics" version A contains 68 knowledge points; The SMP version of high school mathematics "Probability and Statistics" contains 35 knowledge points [7]. Chinese textbooks for human Education cover a wide range of contents, which pay more attention to the comprehensiveness of knowledge, while British textbooks attach importance to the practicability of knowledge points. Secondly, in terms of content depth, the depth of knowledge group of "probability and statistics" taught by Chinese high school math A version is 149; The depth of knowledge group of "Probability and Statistics" in English SMP is 75, while the total depth of knowledge group of Chinese Teaching A is much greater than that of British SMP [7].

Furthermore, in terms of the comprehensive difficulty of exercises, the comprehensive difficulty of "probability and statistics" in Chinese high school mathematics is 392; the British SMP textbook "probability and statistics problem synthesis difficulty is 320. In general, Chinese textbooks are "more and more difficult," while SMP textbooks are "less and easier". Finally, in terms of the total difficulty of teaching materials, the total difficulty of Teaching "probability and statistics" in Chinese high school is 3.16. The SMP version of high school maths of "probability and Statistics" has a total difficulty

**Table 1.** The Differences between Two Editions of Mathematics Textbooks on Probability and Statistics

	PEP edition	Cambridge edition
The breadth of knowledge group	68	35
The depth of knowledge group	149	75
The difficulty of exercises	392	320

**Table 2.** The Differences between Two Editions of Mathematics Textbooks on Function

	PEP edition	Cambridge edition
The breadth of knowledge group	53	22
The depth of knowledge group	76	45
The difficulty of exercises	75	59

of 2.64 [7]. In contrast, the Chinese teaching A version of high school mathematics textbooks “probability and Statistics” content is broad and deep, but many exercises are difficult. The SMP high school mathematics textbook “probability and Statistics” is narrow, with few and easy exercises.

As for functions, in terms of the breadth of knowledge group, the knowledge points of functions in the Textbooks of Chinese People’s Education edition, including functions and trigonometric functions, are 53 in total, while the knowledge points of functions in SMP textbooks published by The University of Cambridge are 22 in total [8]. Then, for the depth of knowledge group, the comprehensive depth coefficient of the function part in the Human Education edition of Chinese high school mathematics textbooks is 76, while the comprehensive depth of the function part in the British SMP textbooks is 45 [8]. For the comparison of the comprehensive difficulty of the exercises, the sum of the comprehensive difficulty of the knowledge group in the exercises in the Chinese textbooks is 75, and that of the knowledge group in the exercises in the British textbooks is 59 [8]. Moreover, according to Table 1 analysis, we can conclude that the Chinese high school mathematics textbook function of course comprehensive difficulty than the high school mathematics teaching material function part of the difficulty of the class, whether the mathematics knowledge breadth and depth, the problem sets are a kind of difficult too, but compared with the Chinese textbooks, the teaching material of lay particular stress on the knowledge discovery process, the application of knowledge in the actual production and life (Table 2).

On the contrary, in the contents of the sequence, the comparison results are opposite to those of the previous two sections. In terms of content selection, Chinese textbooks emphasize the main knowledge, while British textbooks have a wider range of knowledge. In terms of arrangement order, the contents of Chinese textbooks are continuously distributed in one chapter, while the contents of British textbooks are scattered in several chapters. There is little difference in knowledge structure between Chinese and British

**Table 3.** The Differences between Two Editions of Mathematics Textbooks on the Sequence.

	PEP edition	Cambridge edition
The difficulty of exercises	45	57

textbooks, but the internal connection of knowledge points in Chinese textbooks is weak [9]. In terms of presentation characteristics, Chinese textbooks have a better presentation of unit structure and explanation. In terms of concept establishment, Chinese textbooks attach more importance to introducing concepts by using life examples and problem situations, while British textbooks attach more importance to establishing connections between concepts. In terms of course difficulty, the serial content of British SMP textbooks is 57, which is more difficult than that of Chinese textbooks, while the serial content of Chinese A-edition textbooks is 45 [9]. In terms of the difficulty of exercises, the British SMP textbook is superior to the Chinese a-edition in both reasoning level and operation level, which is consistent with the comparison results of course difficulty (Table 3).

In summary, it is more difficult for learners to study in Chinese mathematics textbooks than that of British mathematics textbooks. In terms of the breadth and depth of content and the difficulty of courses and exercises, Chinese mathematics textbooks are slightly higher than that of British mathematics textbooks in most parts. However, although the difficulty and knowledge of Chinese mathematics textbooks are excellent, they are not as good as British mathematics textbooks in the practical application of knowledge and the process of exploring mathematical interests. The difficulty of mathematics teaching materials often represents the amount of homework after class and the pressure of examination. It is not advisable to reduce or increase the difficulty of mathematics teaching materials blindly, no matter in China or Britain. How to find a balance so that students will not bear excessive academic pressure while accepting mathematics knowledge, preventing students from thinking that maths is a boring subject is a problem that is not confined to education in China and the UK.

### 2.3 Comparison of Mathematical Culture and Its Role

Mathematical culture has always been a heated issue in education research, and its educational value has been recognized more and more. With the progress of global internationalization, the exchanges of mathematics education between China and Britain have become more frequent these days. Generally, textbooks are the primary materials on which teachers and students base their teaching and learning activities [10]. They can directly affect the development of teaching activities and students' learning. Therefore, there is a certain significance for the educational field to compare mathematical culture in Chinese and British high school mathematics textbooks. This section selects the Chinese A edition mathematics textbooks (2019) of the senior high school published by People's Education Press and the British AS&A-Level Mathematics textbooks (2018) by Cambridge University Press as the research objects, uses statistical software to quantify data results, divides the contents of mathematical culture in textbooks into three categories:

**Table 4.** The Proportion of Content related to Mathematics Culture in the Two Editions of Mathematics Textbooks

	PEP edition	Cambridge edition
History of mathematics	18.22%	20.90%
Mathematics and life	60.47%	48.51%
Mathematics and technology	21.32%	30.60%

mathematical history, mathematics, and real life, and mathematics and technology. The following content will provide a detailed comparison of these three categories.

First of all, the situation of the emergence of mathematical culture is compared as a whole. The following two graphs give visual data about the distribution of mathematical culture in two editions of the textbook.

As shown in Table 4, the content of the History of mathematics in the British Cambridge edition is relatively higher, accounting for 20.90%, while the content of the history of mathematics in the Chinese PEP edition is 18.22%, which is not much different in general.

The content of the history of mathematics in the Cambridge Edition of the UK mainly appears in the “Supplementary content” part, mostly in text narration, which is a small part of the explanation with pictures to supplement, short content with relatively small length.

The Chinese PEP edition of the history of mathematics teaching material contents of the presentation is more abundant. In addition to the column of reading and thinking, “there will be a bigger space on the outside, is still in” literature reading and writing “mathematics for students autonomous learning and the opportunity to think, to stimulate students’ interest in learning, thereby gradually cultivating students in mathematics study rigor and accuracy.

In the section of mathematics and real-life, its role is to integrate mathematical knowledge into the life situation, which is close to the reality of students, and cultivate students’ mathematical application ability. The Chinese PEP edition accounts for 60.47%, while the Cambridge edition accounts for 48.51%. The column of mathematics and real-life knowledge in The Chinese PEP edition is the exercise column, and the proportion of the remaining columns is evenly distributed. In the British Cambridge edition, mathematics and real-life knowledge are mostly combined with exercise and course introduction.

In the mathematics and technology section, the Cambridge edition has a higher proportion of 30.60%, while the Chinese PEP edition has 21.32%. Mathematics is an important foundation of natural science and is closely related to modern science and technology. It is necessary to introduce, understand and apply science and technology in teaching materials.

Overall, it is not difficult to see that ‘mathematics and life’ occupy the largest proportion in both PEP mathematics textbooks and Cambridge mathematics textbooks respectively, accounting for half of the data in both countries. In addition, there is a certain research gap in the proportion of ‘mathematics and technology’ between China and

Britain, which is more important in the Cambridge edition. For the history of mathematics, the comparison between the two countries is not very different, both accounting for the smallest proportion. It can be concluded that, compared with theoretical classes, Chinese and British mathematics textbooks pay more attention to training students to apply mathematics in real life.

### 3 Conclusion

This paper selects the Chinese People's Education Press edition of the high school mathematics textbook and the British SMP version of the senior school mathematics textbook as the research objects and conducts a comparative study from three aspects: teaching objectives, textbook difficulty, and mathematical culture and functions.

Firstly, the article analyzes the teaching objectives of the two editions of textbooks separately and finds out their respective advantages through comparison. It is found that there is an overlap between the teaching objectives of textbooks in China and the UK largely, but Chinese textbook is richer in content and format.

Secondly, the article discusses the difficulty of teaching materials. The authors provide a comparison of the content of probability and statistics, function, and sequence in two mathematics textbooks in terms of breadth, depth, and difficulty of exercises, which concludes that the overall difficulty of Chinese mathematics textbooks is still higher than that of British mathematics textbooks.

Lastly, the article concludes with an exploration of mathematical culture and its function. The researchers divide the content of mathematics culture in the textbooks into three categories: the history of mathematics, mathematics and life, and mathematics and technology.

Meanwhile, a comparative analysis of the data for the above three categories is also presented in the paper and the result finds that whether in China or the UK, the content of mathematics and life accounts for the largest proportion in the senior school mathematics textbooks, and this will help students to apply mathematical theories to the real life.

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