

Statistics in Junior High Schools Textbooks: A Comparative Study Between People's Republic of China, the United States and Australia

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The content of statistics in current mathematics textbooks used in junior high schools of China, the United States and Australia, are chosen as the objects in this study. The paper conducts a comparative study in light of content, content proportion, presentation, and content width and depth. The study analyzes characteristics of the content of statistics in the textbooks of these three countries and provides enlightenment for the statistical content in China's textbooks.

Key words: Mathematics Textbooks, Statistics, Comparative Study, Enlightenment

Research Background

Statistics is gaining more weight in mathematical courses. In *Full-Time Compulsory Education Mathematics Curriculum Standards* (Experimental Version) promulgated by the Ministry of Education of China (2001), “statistics and probability” is granted higher proportion and identified as a content area in mathematical courses in various stages of compulsory education, just as “numbers and algebra”, “space and graphics” and “practice and comprehensive application”. *The Compulsory Education Mathematics Curriculum Standards* (2011) and (2012) list “data analyzing sense” as one of the important aims of mathematical courses, data analysis is specified as the core of statistics. Many countries incorporate statistics as an important part of mathematical courses in junior high schools (Cao, 2012).

The content of statistics in mathematics textbooks used in junior high schools of China, the United States and Australia, are chosen as the objects in this study. The paper conducts a comparative study in light of content, content proportion, presentation, and content width and depth, so as to provide enlightenment for the statistical content in China's textbooks.

Methods

Selection of Mathematics Textbooks

The paper studies textbooks issued or recommended by educational administrative bodies in three countries, which are introduced in detail as follows.

People's Republic of China: *Mathematics (for Junior High Schools)*, which are written according to *The Compulsory Education Mathematics Curriculum Standards* (2011 Edition) and were published by Beijing Normal University Publishing Group in 2012. Designed for students of grade seven to nine, the textbooks comprise of six books, and two books are used every year.

The United States: *IMPACT Mathematics*, which were published by McGraw-Hill Companies in 2009. Designed for students of grade six to eight, the textbooks include three books, namely *IMPACT Mathematics (Course 1)*, *IMPACT Mathematics (Course 2)* and *IMPACT Mathematics (Course 3)*.

Australia: There are no universal mathematics textbooks in Australia, so the paper studies *Heinemann Maths Zone 7 (8, 9, 10) VELS Enhanced* published by Pearson Publishing Group and are widely used in Victoria. The textbooks consist of four books.

The number of semesters for junior high schools varies from country to country, for instance, the junior high schools in China comprise of three grades for three years namely grade seven to nine, while junior high schools in Australia comprise of four grades for four years namely grade seven to ten. In the United States, grade six, seven and eight are equivalent to grade seven, eight and nine in China and Australia. Considering this, the textbooks for grade seven, eight and nine in China and Australia, and the textbooks for grade six, grade seven and grade eight in the United States are studied.

Comparison Dimensions

The paper analyzes tables of contents in mathematics textbooks used in junior high schools of these three countries and compares the chapters and sections concerning statistics. Through comparing the number of pages concerning statistics (mainly the main body, excluding the preface, the table of contents, the postscript), the paper conducts a quantitative description of the proportion of statistics in these three countries' junior high school mathematical textbooks. The study compares the style, columns and statistical activities of these three countries' junior high school mathematical textbooks. Content width refers to the coverage of textbooks. Considering that the paper studies statistics in these three countries' junior high school mathematical textbooks, it represents content width by knowledge points of statistics. Content depth is mainly concerned with the presentation mode of knowledge points' concepts.

There are three ways of presenting concepts, namely direct description, induction and deduction, and they are granted of the value 1, 2 and 3

respectively.

a. **Direct description:** Only one case is introduced to present relevant concepts.

b. **Induction:** A general result is derived through making inductions out of at least two cases.

c. **Deduction:** A method of logical reasoning, which adopts common mathematical theoretical knowledge to explore particular or irregular mathematical concepts.

The content depth of each knowledge point is represented by the formula

$$S_i = \frac{1 \times A + 2 \times B + 3 \times C}{A + B + C} .$$

In the formula, i refers to knowledge point, A refers to the sum of i 's concepts presented through "direct description", B refers to the sum of i 's concepts presented through "induction", and C refers to the sum of i 's concepts presented through "deduction". Content depth is represented by the

$$S = \frac{\sum_{i=1}^n S_i}{n} .$$

In the formula, n refers to the number of knowledge points, and S_i refers to the content depth of the knowledge point i .

Results

Content Layout

By studying the content layout of statistics in junior high school mathematical textbooks used in China, the United States and Australia, we can conclude that statistics in China's textbooks is introduced in the order of "data collecting, assorting and analyzing", including two chapters, eight sections and three "combination and practice". In textbooks of the United States, statistics is introduced along the line of "investigation", including three chapters, five sections and eighteen "investigation". In textbooks of Australia, it is introduced along the line of knowledge, including three chapters, eighteen sections, four "investigation" and three "design task".

Content Proportion

An international study comparing content proportion in junior high school mathematical textbooks in ten countries finds that in average, the proportions of "numbers and algebra", "measurement and geometry" and "statistics and probability" are 56%, 32% and 12% respectively, showing that the share of "statistics and probability" is the lowest (Wu & Cao, 2013). In the mathematics curriculum standards of Australia, statistics and probability accounts for a relatively small part, yet relevant titles appeared fifty-eight times, demonstrating its importance. In addition, as the grades increase, no visible change of these contents' proportion is found in textbooks of various grades (Kang, 2011).

The study calculates the page number of statistics in each grade's mathematical junior high school textbooks used in China, the United States and Australia, and the total page number of each grade; then it divides the total page number by the page number of statistics. The result is shown in

Table 1
Proportion of Statistics in Textbooks

	China	United States	Australia
Grade 7	37/370=0.1	39/657=0.0594	49/513=0.0955
Grade 8	26/370=0.07	36/555=0.0648	50/592=0.0845
Grade 9	4/304=0.0132	20/657=0.0304	56/560=0.1
Total	67/1044=0.0642	95/1869=0.0508	155/1665=0.0931

Table 1 shows that with a proportion below 10%, statistics accounts for a relatively small part in textbooks of these three countries. The share of statistics in textbooks of all grades is fairly even in Australia and the total share is the highest among these three countries. Difference in the share of statistics is the most obvious in China's textbooks of all grades. The total share of statistics in textbooks of the United States is the lowest among these three countries.

Mode of Presentation

Textbooks in three countries all follow the order of chapters and sections, with theme pictures, introductions and study aims in each chapter's beginning, review exercises in each chapter's end, and examples and exercises in sections. In textbooks of China and the United States, each section starts with problem situation or problem investigation, and the content of statistics is introduced by question strings or investigation activities which prompt students to think. There are columns like "let's do it" "let's think" "let's discuss" in textbooks of China, columns like "think & discuss" "develop & understand" "share & summarize" in textbooks of the United States, while in textbooks of Australia important statistics knowledge and concepts are presented with direct description, analogies, induction, etc. In China's textbooks, there is a "review and reflection" column in the beginning of review exercises, so that students can review what they have learned and develop a knowledge structure which suits their own cognitive stage. In textbooks of Australia, there is a "prep zone" at the start of chapters, so as to help students review all the knowledge relevant to this chapter.

A comparison of the statistics activities in these countries' textbooks shows that in textbooks of the United States, the knowledge of statistics is integrated into statistical activities, and investigation activities lead students to experience the process of discussion, comprehension and summary. In textbooks of Australia, two statistical activities named "investigation" and

“design task” are designed parallel with sections. These statistical activities prompt students to think and design in the form of questions and tasks respectively, and help students apply statistical knowledge and methods into the process of solving problems and completing tasks. In China’s textbooks, a column named “combination and practice” is designed parallel with chapters, enabling students to experience the whole process of “starting from specific problems, raising valuable statistical questions, collecting data, assorting data, analyzing data and making reasonable induction”.

Content Width and Depth

Content width is represented by the number of knowledge points in these countries’ junior high school mathematical textbooks. Using the formula introduced in previous texts, the content depth of statistics in these three countries’ textbooks can be calculated and listed in Table 2.

Table 2
Content Depth of Statistics in Textbooks of China U.S. and Australia

	China	United States	Australia
Content width	16	22	26
Content depth	1.1875	1.8636	1.0769

From Table 2, it can be inferred that the number of knowledge points concerning statistics are sixteen, twenty-two and twenty-six respectively in textbooks of China, the United States and Australia. In terms of content width, textbooks of Australia ranks first, followed by that of the United States and China. In terms of content depth, textbooks of the United States ranks first, followed by that of China and Australia.

Discussion

The Content of Statistics

American textbooks emphasize developing students’ problem awareness by integrating statistical knowledge into statistical activities and the process of problem-solving. Through inviting students to think, to discuss and to comprehend problem situations and guiding students to exchange ideas and make summaries, textbooks of the United States help students grasp relevant statistical knowledge and develop statistics awareness in the process of problem-solving. By comparison among these three countries, the content of statistics in American textbooks ranks third in terms of share in the whole book, second in width and first in depth. American textbooks raise high demands on students’ thinking capability and the content is typically “precise and deep”.

Textbooks of Australia emphasize the concepts and skills concerning statistics. They present important statistical knowledge and concepts through

direct description, analogies, induction and so on, and enforce students' understanding with many examples, while giving exemplary steps and methods of solving general problems. Besides, there are many exercises for review and enforcement in Australian textbooks. By comparison among these three countries, the content of statistics in Australian textbooks ranks first in terms of its share in the whole book, first in width and last in depth, and coupled with a relatively low demand on students' thinking capability, statistics in Australian textbooks is typically "wide-ranging and plain".

China's textbooks follow the process of "data collecting, assorting and analyzing" in overall designing, and emphasize grasping basic statistical methods in the process of data analyzing, so that students can comprehend the role of statistics in decision-making and develop statistics awareness. By comparison, the content of statistics in China's textbooks ranks second in terms of its share in the whole book, third in width and second in depth, and the demand on students' thinking capability is lower than textbooks of the United States and higher than textbooks of Australia.

Recommendations for the Textbooks Development

According to the research findings and analysis listed above, it can be found that by comparison, the coverage of China's textbooks is the lowest with the smallest number of knowledge points. For instance, apart from circle graphs, bar graphs, line graphs and histograms which appeared in textbooks of all these countries, there are double bar graphs, stem-and-leaf plots and box-and-whisker plots in textbooks of the United States and Australia. It is advised that China's textbooks increase relevant knowledge points accordingly, so that students can know more statistical knowledge and methods. Naturally, the content should not be presented simply with definitions of statistics, the making of statistics graphs and calculations of numerical characteristics; rather, it should be presented with comparing each method in terms of deriving information, so as to let students know their applicable conditions and help students select the right method accordingly. In this way, the basics of statistics are embodied in the acquiring of statistical knowledge and method.

The statistical process should be given particular importance to, that is, to let students experience the whole process of "data collecting, data assorting, data analyzing and making inductions". That's because the thinking mode for statistical problems is different from traditional mathematical problems in that the latter emphasizes deduction, while the former emphasizes induction since statistics concerns generalizing concrete items. To help students build statistics awareness, the most effective way would be to let them actually engage in statistical activities (Zhang, Lv, & Zhang, 2002).

Statistical activities are integrated with statistical knowledge in textbooks of the United States, while statistical activities and knowledge are interwoven in textbooks of Australia. In textbooks of China, statistical activities and subjects concerning "combination and practice" are designed as a whole,

so that after learning statistical knowledge of all chapters, students can experience a relatively whole statistical process. It is advised that while retaining the characteristics of their own, China's textbooks can learn from textbooks of the United States or Australia by designing some relatively easy statistical activities while presenting statistical knowledge and methods. Limited by prior knowledge, maybe students can only experience part of the statistical activities, but letting students gradually experience the whole statistical process in various stages of statistics learning and giving particular emphasis on each stage are already improvements. These improvements would play a better role in helping students grasp the method of using statistics to solve problems and develop the sense of data analysis.

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