

Comparison of the Writing Characteristics of "Statistics and Probability" in Chinese and American Junior High School Mathematics Textbooks

Abstract: This paper selects junior high School mathematics textbooks from the Zhejiang Education Edition in China and the Glencoe Edition in the United States, and conducts a comparative study on the writing characteristics of "Statistics and Probability" content in the textbooks of the two countries by comparing the breadth, depth, and content connections of knowledge points. The paper employs content analysis to count the number of knowledges points and assesses the curriculum coverage using a difficulty model. Building on Bloom's taxonomy of educational objectives and integrating the connotations of target behavior verbs from mathematics curriculum standards, the cognitive domain is categorized into four levels: awareness, understanding, mastery, and application. The depth of the two textbooks is quantitatively analyzed by considering the presentation methods of content. Variance and Markov sequence analyses, facilitated by Matlab software, are used to compare the transitions and connections of knowledge points, revealing the characteristics of difficulty distribution and structural design. The findings indicate that the Zhejiang Education Edition emphasizes the theoretical and foundational aspects of statistics, with content depth primarily at the awareness and understanding levels, and knowledge points are often introduced through examples. In contrast, the Glencoe Edition has broader coverage in data analysis and practical applications, with cognitive levels reaching mastery and application.

Keywords: Junior High School, Mathematics Textbooks; Statistics and Probability; Comparative Study; Variance Analysis; Markov Sequence Analysis

1 Introduction

Statistics and probability, as a subject that cultivates students' abilities in data collection, processing, analysis, and the study of random phenomena, has become increasingly important due to the growing demand for data analysis skills in society, and has attracted the general attention of mathematics basic education in various countries. In China, the Mathematics Curriculum Standards for Compulsory Education (2022 Edition) has outlined the content requirements for the "statistics and probability" domain in junior high school around two key themes: "sampling and data analysis" and "probability of random events". Students learn simple sampling methods, methods of inferring overall characteristics from sample data, and methods of quantitatively describing the likelihood of random events to form and develop a concept of data [1].

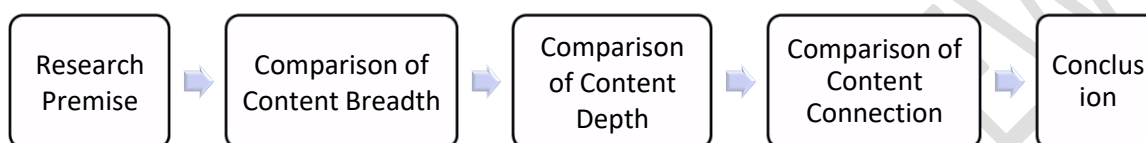
Mathematics textbooks, as an important basis for teachers' teaching and students' learning, are both the embodiment of curriculum standards and the source of inspiration for teaching practice, playing an important role in mathematics education [2-5]. Yang Chan [6] has highlighted that research on mathematics textbooks both domestically and internationally is increasingly focusing on the development of students' core competencies, with particular emphasis on data literacy and mathematical thinking skills. Domestic research has shifted from single textbook analysis to comprehensive comparison, emphasizing the role of textbooks in students' ability training, while integrating the concepts of inquiry-based learning and project-based learning; foreign research focuses on interdisciplinary integration and practical application, using quantitative and qualitative methods to explore the cultivation of statistical thinking by textbooks [7-9]. Wang Jianpan[10] proposed a framework for the comparative study of mathematics textbooks, systematically comparing and analyzing high school mathematics textbooks from various countries from the perspectives of the organization and presentation of core content, the design of teaching tasks, textbook characteristics, and the application of information technology, providing theoretical support and methodological reference for this study.

Methodology:

This paper selects the Zhejiang Education Edition (hereinafter referred to as Zhejiang Education Edition) and the Glencoe Edition (hereinafter referred to as Glencoe Edition) of junior high school mathematics textbooks to conduct a comparative study on the writing characteristics of the "statistics and probability" content. This paper adopts a combination of quantitative and qualitative methods, based on the analytical framework proposed by Wang Jianpan[10], to compare the breadth, depth, and connections of the "statistics and probability" knowledge points in Chinese and American textbooks. This paper uses content analysis to count the number of knowledge points and assesses the coverage of the content of the two editions of textbooks based on the curriculum difficulty model by Shi Ningzhong[11]. In the comparison of content depth, based on Bloom's educational classification theory and combining the connotation of target behavior verbs in the mathematics curriculum standards[12], the cognitive field is divided into four levels: awareness, understanding, mastery, and comprehensive application. Combined with the content presentation method classification proposed by Yue Zengcheng[13], each level is scored and weighted to calculate the cognitive level of the two editions of textbooks, and the depth of the two editions of textbooks is quantitatively analyzed. In the comparison of content connections, variance analysis[14] and Markov sequence analysis[15] are employed to examine the differences in the linkage and transition of knowledge points between the two editions of textbooks. This approach helps to uncover their distinct characteristics in terms of difficulty distribution and structural design.

By comparing the writing characteristics of "statistics and probability" knowledge points in Chinese and American junior high school mathematics textbooks, this paper analyzes their similarities and differences and their impact on teaching practice, aiming to provide references for the compilation of Chinese textbooks, promote teaching reform, and cultivate students' statistical thinking. The research focuses on two parts: first, the differences in content presentation between the two editions of textbooks; second, the specific manifestations of the writing characteristics of knowledge points in Chinese and American textbooks. The specific research approach is shown in Figure 1.

Figure 1 The Research Approach of This Paper



Results and Discussion:

Comparison of Content Breadth

Content breadth refers to the scope and extent of knowledge content in textbooks, usually quantified by the number of knowledge points[11]. The "knowledge points" here are divided according to the standards or reference content of China's mathematics curriculum. In Shi Ningzhong's curriculum difficulty model, content breadth is represented by G.

The specific knowledge points included in "statistics and probability" in the two editions of textbooks are as follows:

Table 1 Knowledge Points in Chinese and American Textbooks (Excerpt)

Zhejiang Education Edition	Glencoe Edition
class width, frequency, relative frequency	Concepts of statistics
Certain Event, Impossible Event, Random Event	Application of Box Plot
...	...
Estimating Probability Using Frequency	Stem-and-Leaf Plot Construction
A total of 43	A total of 53

As shown in Table 1, in terms of the presentation of statistical content, the Zhejiang Education Edition places more emphasis on the comprehensiveness and rigor of basic statistical knowledge, focusing mainly on how to collect, organize, and present data, with a total of 31 knowledge points,

accounting for about 72.1%. For example, it includes the definitions and drawing methods of frequency, relative frequency, class interval, and frequency histogram, and also introduces methods of data collection and organization, including comprehensive surveys and sampling surveys. This type of content tends to emphasize the quantitative understanding of data, enabling students to possess basic data processing skills. The Glencoe Edition covers a wider range of statistical knowledge points, with content focusing more on data analysis and practicality, including 44 knowledge points, accounting for about 83.0%. For example, it displays data through different charts such as stem-and-leaf plots, bar charts, scatter plots, and frequency tables, helping students understand data distribution and visualization, focusing on cultivating students' practical operation skills. It includes knowledge points such as "identification of misleading charts" and "application of scatter plots and linear prediction," aiming to help students analyze and understand the meaning behind data in real life. It can be seen that the Zhejiang Education Edition focuses more on basic knowledge and data processing skills in statistical teaching, while the Glencoe Edition emphasizes the practicality of data analysis and the cultivation of operational skills.

At the same time, in terms of the presentation of probability content, the Zhejiang Education Edition focuses on theoretical foundations, including 11 knowledge points, accounting for about 25.6%. The content mainly focuses on basic probability concepts such as "certain events, impossible events, and random events", and introduces the method of using frequency to estimate probability to calculate the probability of events. The content of the textbook involves the possibility of events and the relationship between a large number of repeated events and probability, helping students understand the basic knowledge of probability at the theoretical level. The Glencoe Edition has a greater breadth in the presentation of probability knowledge, including 9 knowledge points, accounting for about 17.0%. For example, it adds knowledge points such as "experimental probability and theoretical probability" and "compound events: the difference between independent and dependent events," and also provides detailed explanations on the application of permutations and combinations, tree diagrams, and the basic counting principle. These contents not only expand students' understanding of probability concepts but also enable them to perform probability calculations and reasoning through specific cases. It can be seen that the Zhejiang Education Edition focuses more on theoretical foundations in probability content, while the Glencoe Edition pays more attention to breadth and practical application, being closer to real life.

3 Comparison of Content Depth

3.1 Comparison of Cognitive Level Distribution of Knowledge Points

Based on the classification method in [12], the knowledge points of "statistics and probability" in the two editions of textbooks in Table 1 are divided into four levels: understanding (imitation),

comprehension (awareness), mastery (application), and integrated application, which are denoted as a_1 , a_2 , a_3 , and a_4 , respectively. The corresponding weights are assigned values of 1, 2, 3, and 4, respectively. The cognitive level distribution of the knowledge points of "statistics and probability" in the two editions of textbooks is shown in Table 2.

Table 2 The Distribution of Cognitive Levels of "Statistics and Probability" Knowledge Points in the Two Editions of Textbooks

Teaching material	a_1	a_2	a_3	a_4
Zhejiang Education Edition	6 (27.3%)	15 (68.2%)	1 (4.5%)	0 (0.0%)
Glencoe Edition	8 (27.6%)	13 (44.8%)	4 (13.8%)	4 (13.8%)

As shown in Table 2, the cognitive levels of the knowledge points of "statistics and probability" in the two editions of textbooks are mainly concentrated in the two cognitive levels of "understanding (imitation)" and "comprehension (awareness)".

This paper uses the method of scoring and weighting knowledge points[12] to calculate the cognitive levels of knowledge points in the Zhejiang Education Edition and the Glencoe Edition, denoted as S_{11} and S_{21} , respectively:

$$S_{11} = \frac{6 \times 1 + 15 \times 2 + 1 \times 3 + 0 \times 4}{22} \approx 1.77, \quad (1)$$

$$S_{21} = \frac{8 \times 1 + 13 \times 2 + 4 \times 3 + 4 \times 4}{29} \approx 2.14. \quad (2)$$


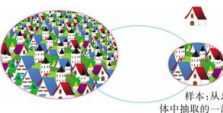


From the above data, it can be seen that the cognitive level distribution of "statistics and probability" in the Zhejiang Education Edition and Glencoe Edition textbooks is similar, mainly concentrated in the two levels of "understanding (imitation)" and "comprehension (awareness)," with the most knowledge points at the "comprehension (awareness)" level. Through calculation, it is found that in the Zhejiang Education Edition textbook, the number of knowledge points at the "mastery (application)" level in "statistics and probability" is 9.3% lower than that in the Glencoe Edition, and it does not reach the "integrated application" cognitive level. It can be seen that both editions of textbooks focus on students' understanding of the basic knowledge of "statistics and probability," but the cognitive level requirements are not high, with the Zhejiang Education Edition being slightly lower than the Glencoe Edition.

3.2 Comparison of the Distribution of Knowledge Presentation Methods

The research in reference [13], the knowledge points of "statistics and probability" in the two editions of textbooks in Table 1 are divided into four presentation methods: "direct presentation," "introduction through examples," "explanation through language," and "introduction through examples

+ explanation through language," denoted as b₁, b₂, b₃, and b₄, respectively. Based on this classification, the presentation methods of the knowledge points of "statistics and probability" in the two editions of textbooks are analyzed and counted below. For better understanding, examples of the four presentation methods are provided first, see Table 3.

Table 3 Examples of Content Presentation Methods in Chinese and American Textbooks

Identification Number	Presentation Method	Zhejiang Education Edition	Glencoe Edition
b ₁	directly given	<p>在选取样本时,样本中的个体要有代表性,样本容量要合适.如果在抽样时,每一个个体被抽到的机会都相等,这样的抽样方法叫做简单随机抽样(simple random sampling).</p>	<p>Theoretical probability is the chance that some event will occur. It is based on known characteristics or facts. You can use a ratio to find probability.</p>
b ₂	introduced by example	<p>人们根据研究自然现象或社会现象的需要,对所有的考察对象作调查,这种调查叫做全面调查.例如,国家的人口普查是全面调查;为了防控甲型H1N1流感,对从境外来的旅客逐个进行体温检测也是全面调查.但在许多情况下,因为不方便,不可能或不必要对所有的对象进行调查,所以从所有对象中抽取一部分作调查分析,这就是抽样调查(sampling survey).</p>	<p>It is equally likely to select any one of the five cards. The player hopes to select a card numbered 3. The five cards represent the possible outcomes. The specific outcome the player is looking for is an event, or favorable outcome.</p> 
b ₃	explained by language	<p>样本,样本中个体的数目叫做样本的容量.在统计中,我们也经常把要考察的全体对象的数据整体叫做总体,把从中取出的一部分个体的数据集体叫做样本.</p> 	<p>In the Mini Lab, the outcome of rolling the number cube does not affect the outcome of choosing a marble. Two or more events in which the outcome of one event does not affect the outcome of the other event are independent events.</p>
b ₄	introduced by example + explained by language	<p>观察图 6-8,并回答下面的问题: (1) 这种快餐中,脂肪占百分之几? 有多少克? (2) 这种快餐中,哪一种营养成分最多? 哪一种最少? 最多的营养成分是最少的多少倍? (3) 表示蛋白质的扇形的圆心角是多少度? 你是怎样计算的?</p>  <p>图 6-8</p> <p>像图 6-8 这样,用圆和扇形分别表示关于总体和各个组成部分数据的统计图叫做扇形统计图(pie chart).扇形统计图的特点是能直观、生动地反映各部分在总体中所占的比例.</p>	<p>The set of all possible outcomes is called the sample space. The list you made above is the sample space of choices at the concession stand. The sample space for rolling a number cube and spinning the spinner are listed below.</p>  <p>A tree diagram can also be used to show a sample space. When you make a tree diagram, you have an organized list of outcomes. A tree diagram is a diagram that shows all possible outcomes of an event.</p>

Next, analyze all the knowledge points of "statistics and probability" in the two editions of textbooks, classify them according to the distribution of presentation methods, and the statistical results are shown in Table 4.

Table 4 The Distribution of Presentation Methods of "Statistics and Probability" Knowledge Points in the Two Editions of Textbooks

teaching material	b ₁	b ₂	b ₃	b ₄
Zhejiang Education Edition	7 (31.82%)	6 (27.27%)	3 (13.64%)	6 (27.27%)
Glencoe Edition	14 (36.84%)	8 (21.05%)	6 (15.79%)	10 (26.32%)

As shown in Table 4, the "statistics and probability" in the Zhejiang Education Edition is mainly presented in a direct manner, the Glencoe Edition is mainly presented in two ways which are "direct presentation" and "introduction through examples + explanation through language". In terms of specific proportions, the two versions have similar proportions in "introduction through examples + language elaboration,"but the Zhejiang Education Edition has a slightly lower proportion in "direct presentation" than the Glencoe Edition.

Next, we calculate the presentation level of the knowledge points of "statistics and probability" in the two editions of textbooks. Let the presentation level of the knowledge points of "statistics and probability" in the Zhejiang Education Edition and the Glencoe Edition be denoted as S_{12} and S_{22} , respectively, then

$$S_{12} = \frac{1 \times 7 + 2 \times 6 + 3 \times 3 + 4 \times 6}{22} \approx 2.36, \quad (3)$$

$$S_{22} = \frac{1 \times 14 + 2 \times 8 + 3 \times 6 + 4 \times 10}{38} \approx 2.32. \quad (4)$$

The calculation shows that in the presentation of "statistics and probability" content, the two editions of textbooks mainly adopt a combination of "direct presentation" and "introduction through examples + explanation through language", avoiding the simple and direct presentation of knowledge content or the use of only abstract language for explanation. Through the guidance of examples and language elaboration, students are gradually helped to understand the knowledge points. Both editions of textbooks focus on helping students understand the basic knowledge of statistics and probability through specific examples and explanations, but there are differences in detail. The Zhejiang Education Edition tends to introduce through examples, helping students to gradually grasp the concepts, while the Glencoe Edition has a higher proportion of "direct presentation", emphasizing the direct transmission of knowledge.

Integrating the cognitive level and presentation method level of "statistics and probability," the content depth S_1 of the Zhejiang Education Edition and the content depth S_2 of the Glencoe Edition are as follows,

$$S_1 = \frac{S_{11} + S_{12}}{2} = \frac{1.77 + 2.36}{2} = 2.07, \quad (5)$$

$$S_2 = \frac{S_{21} + S_{22}}{2} = \frac{2.14 + 2.32}{2} = 2.23. \quad (6)$$

It can be seen that the presentation methods of "statistics and probability" in the Zhejiang Education Edition mainly focus on "introduction through examples" and "introduction through

examples + language elaboration". In comparison, the Glencoe Edition has a slight advantage in the diversity and richness of presentation methods. Specifically, the Glencoe Edition has a higher proportion of "direct presentation" and "language elaboration," indicating a more diverse content organization strategy. While the Zhejiang Education Edition is more concise and direct in its presentation, its depth in the "statistics and probability" section is not as strong as that of the Glencoe Edition.

4 Comparison of Content Connections

This section compares the differences in the connection and transition of knowledge points between the two editions of textbooks through variance analysis and calculation of transition probability matrices, using Matlab mathematical software, revealing the characteristics of difficulty distribution and structural design.

4.1 Analysis of Variance (ANOVA)

Analysis of variance, abbreviated as ANOVA, is mainly used to study the relationship between qualitative variables or ordinal variables and quantitative variables. Using Matlab mathematical software, this paper conducted an analysis of variance on the difficulty of the two editions of textbooks, resulting in Tables 5 and 6:

Table 5 ANOVA Table for Difficulty of Zhejiang Education Edition

Source	SS	df	MS	F	p-value (F)
Group	0.7873	2	0.39367	0.25	0.7837
Error	30.3036	19	1.59492		
Total	31.0909	21			

Table 6 ANOVA Table for Difficulty of Glencoe Edition

Source	SS	df	MS	F	p-value (F)
Group	0.5767	2	0.28833	0.18	0.8349
Error	55.6339	35	1.58954		
Total	56.2105	37			

In the ANOVA of the Zhejiang Education Edition, since $p \gg 0.05$, it indicates that there is no significant difference in the difficulty of knowledge points across different grades in the Zhejiang Education Edition. Similarly, in the ANOVA of the Glencoe Edition, since $p \gg 0.05$, it shows that there is no significant difference in the difficulty of knowledge points across different grades. From the data, it can be seen that there is no obvious trend in the difficulty of knowledge points across different grades in both the Zhejiang Education Edition and the Glencoe Edition.

By comparing the results of the analysis of variance of the two textbooks, it can be found that the p-value for the Zhejiang Education Edition is $p_1 = 0.8394$, and for the Glencoe Edition is

$p_2 = 0.7837$, both of which are much greater than 0.05. This indicates that in these two versions of textbooks, the difficulty level of knowledge points has not been significantly adjusted with the change of grade, suggesting that they are relatively consistent in the setting of knowledge point difficulty, or the increase in difficulty is relatively small.

4.2 Transition Probability Matrix

The core of the Markov chain is the transition probability matrix, which describes the probability of transitioning from one state to another. At each step, the system can only transition from the current state to the next state, without considering the previous states (i.e., the "memoryless" property).

The transition probability matrix $P = (P_{ij})$ is a square matrix, where P_{ij} represents the probability of transitioning from state i to state j . The sum of the elements in each row is 1, i.e.,

$$\sum_{j=1}^n P_{ij} = 1.$$

Using Matlab mathematical software, the transition probability matrices for the two editions of textbooks are obtained, see Tables 7 and 8.

Table 7 Transition Probability Matrix for Zhejiang Education Edition

		Next Knowledge Point Type			
		1	2	3	4
Current Knowledge Point Type	1	0.5714	0.2857	0.1429	0
	2	0	0.6667	0.3333	0
	3	0	0	0	1
	4	0.4	0	0	0.6

As shown in Table 7, in the Zhejiang Education Edition, knowledge points of difficulty level 1 and 4 are the main areas where students linger. From the transition probability matrix, it can be seen that knowledge points of difficulty level 1 are more likely to transfer to levels 2 and 3, showing a natural transition from simple knowledge to medium difficulty. Level 2 has a probability of 0.6667 to remain at itself and a probability of 0.3333 to progress to level 3, indicating that knowledge points of difficulty level 2 have a certain continuity in the students' learning process. Level 3 is characterized as the endpoint of difficulty jumps; once students enter level 3, they will directly transfer to level 4, with no possibility of returning to lower difficulty levels. For level 4, the probability of transferring back to level 1 is 0.4, indicating that some students review simple knowledge after reaching high difficulty knowledge, and there is a 0.6 probability of continuing to stay at this difficulty level.

Table 8 Transition Probability Matrix for Glencoe Edition

		Next Knowledge Point Type			
		1	2	3	4
Current Knowledge Point Type	1	0.7857	0.2143	0	0
	2	0	0.625	0.375	0
	3	0	0	0.5	0.5
	4	0.2222	0	0	0.7778

As shown in Table 8, in the Glencoe Edition, knowledge points of difficulty level 1 account for a larger proportion, with a transfer probability of 0.7857, higher than the 0.5714 in the Zhejiang Education Edition, indicating that students spend more time at difficulty level 1. For difficulty level 2, the Glencoe Edition shows that students have a 0.625 probability of continuing to stay at this difficulty level and a 0.375 probability of entering difficulty level 3, reflecting a steady progression from simple to medium difficulty. Knowledge points at difficulty level 3 also have a 0.5 probability of further entering difficulty level 4, which is similar to the high-difficulty transition pattern in the Zhejiang Education Edition, but more inclined to gradual increase rather than direct jump. Difficulty level 4 shows the high stability of American students staying at this difficulty level, with a 0.7778 probability of remaining at difficulty level 4 and only a 0.2222 probability of returning to difficulty level 1.

4.3 Comparison of Steady-State Probability Distributions

The steady-state probability distribution π is a vector that represents the long-term proportion of each state after the system has been running for a long time. In the steady state, the distribution of states will no longer change.

Table 9 Steady-State Probability Distribution

Difficulty Level	1	2	3	4
Zhejiang Education Edition	0.29787	0.25532	0.12766	0.31915
Glencoe Edition	0.33735	0.19277	0.14458	0.3253

From the steady-state probabilities in Table 9, it can be seen that the Zhejiang Education version has higher distributions at difficulty levels 1 and 4, while levels 2 and 3 have relatively lower distributions. This suggests that students spend more time on both simple and high-difficulty knowledge points, with fewer points at the intermediate difficulty levels. It can be inferred that the Zhejiang Education version emphasizes both mastery of basic knowledge and in-depth exploration of high-difficulty topics.

In the Glencoe version, the probabilities of staying at difficulty levels 1 and 4 are relatively balanced, while levels 2 and 3 have shorter durations. This indicates that the Glencoe version offers a more gradual transition in difficulty levels, with students tending to distribute their time more evenly

between simple and high-difficulty knowledge points, but with relatively fewer intermediate difficulty topics.

5 Conclusions and Implications

Chinese and American junior high school mathematics textbooks show significant differences in the breadth, depth, and presentation methods of "statistics and probability" content, reflecting the different teaching concepts and goals of the two countries. The Zhejiang Education Edition focuses on the systematization and logic of basic statistical knowledge, emphasizing the construction of a solid knowledge framework; in contrast, the Glencoe Edition has a broad coverage, from data collection to analysis and application, with a particular emphasis on the application of charts and the combination with context, highlighting the cultivation of data literacy and practical ability. The Zhejiang Education Edition is mainly focused on basic and intermediate levels, emphasizing solid foundations, but is relatively lacking in contextual application; the Glencoe Edition has a balanced distribution of knowledge points, covering content from basic to advanced levels, improving students' application and reasoning abilities through cases and contexts, but lacks attention to basic knowledge. In terms of presentation methods, the Zhejiang Education Edition mainly uses clear examples to guide, strengthening knowledge memory and systematicness, while the Glencoe Edition encourages students to explore independently through diverse designs.

Overall, the Zhejiang Education Edition focuses on the depth and structure of knowledge, while the Glencoe Edition is more prominent in cultivating innovative thinking and practical abilities. In the future, the two countries can learn from each other's strengths. The Zhejiang Education Edition can add more practical and contextual content to enhance students' comprehensive application abilities; the Glencoe Edition needs to strengthen systematic design to provide students with a more comprehensive knowledge framework. This kind of mutual learning is not only helpful for textbook reform, but also provides valuable insights for teaching practice under the background of globalized education.

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Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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