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Research on the Situation Consistency between New High School Mathematics Textbook Exercises and New Gaokao Questions

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Abstract: *The situation consistency between the New Gaokao math questions and textbook exercises is of significant importance for the collaborative development of students' core competencies. Taking the exercises from the People's Education Edition A of high school mathematics textbooks and the 2024 New Gaokao math papers I and II as the research objects, this study used the SEC model and the Porter consistency coefficient to construct a situation consistency analysis model, and combined it with MATLAB to draw research conclusions. Subsequently, the study put forward some suggestions on future high school mathematics teaching and learning, aiming to provide references and empirical evidence for improving the collaborative education mechanism of teaching and evaluation.*

Keywords: *SEC model; New textbook; New College Entrance Examination; Situation consistency*

1. Introduction

With the advancement and deepening of international curriculum reforms, the status of alignment among elements within curriculum systems has garnered increasing attention from educators. As a crucial vehicle for delivering knowledge content and realizing educational values in teaching practices, situation has been infused with a "new" dimension in the latest curriculum reforms, playing a pivotal role in these transformations. Research on situational consistency among curriculum system elements can not only provide evidence-based support for educational reformers to refine curriculum innovations, but also offer theoretical references for teachers to implement situational teaching effectively. However, current studies on situational consistency across curriculum system components remain scarce.This study innovatively optimizes the SEC consistency analysis model based on situational characteristics, and subsequently conducts pioneering research on the situational consistency between exercises in the People's Education Press A version high school mathematics textbooks and China's 2024 New Gaokao examination papers. The investigation demonstrates both theoretical significance and broad practical implications.

2. Research Design

2.1. Research Subjects

Since the promulgation of China's Mathematics Curriculum Standards for General Senior High Schools (hereinafter referred to as the New Curriculum Standards) in 2018, the country has progressively implemented the New Gaokao reform in regions such as Shanghai and Shandong, achieving nationwide adoption of new textbooks by the fall of 2022. Among these, the 2019 edition of the People's Education Press (PEP) A version high school mathematics textbooks and the New Gaokao Volume I and Volume II papers have become the most widely used and representative resources nationally. Furthermore, given that exercises and test questions serve as critical situational components in both textbooks and the Gaokao, this study selects the latest PEP A version mathematics textbook exercises and the 2024 New Gaokao Volume I and Volume II papers as research subjects. The aim is to investigate the latest characteristics of situational consistency among curriculum system elements.

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2.2. Research Instruments

The consistency analysis research model originated from the Webb model proposed by American scholar Norman Webb in the 1990s. Building on this foundation, Smith, Patte, and colleagues, with support from the Council of Chief State School Officers (CCSSO), collaboratively developed the more robust SEC consistency analysis model (Surveys of Enacted Curriculum) in 2001[1]. This model, designed as an authoritative tool for curriculum implementation monitoring, has been widely adopted in the United States. Its core framework is a two-dimensional matrix integrating "content topics × cognitive levels". The SEC model was selected for this study due to its strong adaptability in matrix construction,intuitive data quantification, and its capacity to derive precise consistency indices and critical thresholds through functional computations in MATLAB[2].

Based on this framework, the research outlines the following analytical procedures:(1) Encoding and Statistical Analysis: Under the "content topics × cognitive levels" matrix framework, the New Gaokao mathematics examination papers and curriculum standards are encoded and statistically analyzed.(2) The two-dimensional matrix data undergo normalization to derive ratio values, which are then substituted into the Porter alignment index formula to calculate the degree of consistency between the two datasets. The formula is expressed as follows:

$$p = 1 - \frac{\sum_{i=1}^{n} |X_i - Y_i|}{2}$$

In this formula, n denotes the total number of cells, i represents any individual cell ($1 \le i \le n$), and X_i and Y_i correspond to the ratio values of the respective cells in the two matrices. The alignment coefficient p is proportional to the degree of consistency ($0 \le p \le 1$), with higher p-values indicating stronger alignment between the datasets.

2.3. Research Procedures

2.3.1. Content Theme Classification

The New Curriculum Standards categorizes curricular content into five thematic areas: Preliminary Knowledge, Functions, Geometry and Algebra, Probability and Statistics, and Mathematical Modeling Activities and Mathematical Inquiry Activities[3]. However, since the fifth theme emphasizes student-led participation and its assessment in examination questions is typically integrated with knowledge from the first four themes, this study focuses exclusively on analyzing the first four thematic areas.

2.3.2. Cognitive Level Classification

Traditional research on SEC consistency has generally focused on the cognitive level classification corresponding to the themes of knowledge content, with relatively insufficient consideration of the characteristics of situations. The limitation of this research perspective lies in its difficulty in fully revealing the actual state of situational consistency in current educational practice. In view of this, this study takes Bloom's Taxonomy of Educational Objectives as the theoretical basis, and fully absorbs the descriptions of situational characteristics in the "New Curriculum Standards" and the "China College Entrance Examination Evaluation System Explanation", and has adaptively modified the cognitive level classification framework of SEC. This modification aims to make it more in line with the specific situations contained in the new textbook exercises and the new college entrance examination questions, so as to more accurately reflect the performance of situational consistency among the elements of the curriculum system. The specific classification of cognitive levels in this study is shown in Table 1.

Table 1: Cognitive Levels

Cognitive Levels	Classification Basis
Memory	Students are required to directly identify simple mathematical materials, recall existing knowledge, associate methods, and perform basic calculations according to the procedures and methods required by the textbook.
Understanding	Students are required to creatively interpret and transform complex mathematical materials, grasp the overall nature of related concepts and knowledge, and creatively transfer and apply methods.
Application	Students are required to abstract and acquire mathematical problems from simple real-life materials, identify mathematical models in real problems, and directly construct them with existing knowledge and methods.
Exploration	Students are required to abstract and acquire mathematical problems from complex real-life materials, innovatively transfer and apply the learned knowledge and methods to build corresponding mathematical models, and use the mathematical models to explain social phenomena and solve real problems.

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The two-dimensional matrix of SEC situational consistency constructed in this way is presented in Table 2.

Table 2: SEC Analysis Framework

Content Theme	Cognitive Levels				Total
	Memory	Understanding	Application	Exploration	
Preliminary Knowledge,					
Functions,					
Geometry and Algebra					
Probability and Statistics					
Total					

2.3.3. Subject Coding

By analyzing the situational context of textbook exercises, the 1,507 exercises in the textbooks were coded based on their situational cognitive levels. Subsequently, the raw data were subjected to standardization, resulting in their ratio values, as presented in Table 3.

Table 3: Coding of Textbook Exercises

Content Theme	Practice Item Ratio				Total
	Memory	Understanding	Application	Exploration	
Preliminary Knowledge,	0.007	0.042	0.019	0.002	0.070
Functions,	0.099	0.167	0.085	0.008	0.358
Geometry and Algebra	0.057	0.172	0.101	0.006	0.335
Probability and Statistics	0.030	0.109	0.088	0.008	0.235
Total	0.193	0.490	0.292	0.024	1.000

The content themes and cognitive levels examined in the new college entrance examination papers I and II in 2024 were coded, with the data then being standardized, resulting in the data presented in Tables 4 and 5, respectively.

Table 4: Coding of New Gaokao Paper I

Content Theme	Test Item Ratio				Total
	Memory	Understanding	Application	Exploration	
Preliminary Knowledge,	0.000	0.038	0.000	0.000	0.038
Functions,	0.000	0.269	0.232	0.000	0.501
Geometry and Algebra	0.038	0.269	0.077	0.000	0.384
Probability and Statistics	0.000	0.000	0.077	0.000	0.077
Total	0.038	0.576	0.386	0.000	1.000

Table 5: Coding of New Gaokao Paper II

Content Theme	Test Item Ratio				Total
	Memory	Understanding	Application	Exploration	
Preliminary Knowledge	0	0.04	0	0	0.04
Functions	0	0.4	0.04	0	0.44
Geometry and Algebra	0.04	0.2	0.12	0	0.36
Probability and Statistics	0	0.04	0.12	0	0.16
Total	0.04	0.68	0.28	0	1

2.3.4. Establishment of Statistically Significant Reference Values and Porter's Consistency Coefficient

In this study, utilizing the Unidrnd function in MATLAB software, 1,507 specific practice items from the textbook were randomly assigned to a 4×4 matrix A, while 25 test items were randomly allocated to another 4×4 matrix B. After normalizing matrices A and B, corresponding p-values were derived. By iterating the above procedure 2,000 times via a for loop, a normal distribution curve of the p-values was generated. A critical threshold for the consistency coefficient (p-value) was set at the 95% confidence level. When the p-value reached this threshold, it indicated statistically significant consistency, thereby supporting the conclusion that the examination aligns well with curriculum standards. As calculated by MATLAB, the contextual consistency coefficients and reference values between the textbook exercises and the two sets of National College Entrance Examination (Gaokao) test items are presented in Table 6.

Table 6: Situational Consistency Coefficients and Reference Values

Test Paper	Consistency Coefficient	Reference Value
2024 New Gaokao Volume I	0.654	0.668
2024 New Gaokao Volume II	0.688	

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3. Data Analysis

3.1. Overall Consistency Analysis

As shown in Table 6, both test papers of the 2024 New Gaokao exhibit favorable situational consistency with textbook practice items. However, only Volume II of the New Gaokao demonstrated a consistency coefficient exceeding the reference value of 0.668. This result indicates that only the 2024 New Gaokao Volume II test items achieved statistically significant situational consistency with textbook exercises.The surface plots illustrating the situational alignment between the textbook and the 2024 New Gaokao test papers are presented in Figure 1.

Figure 1: Overall Distribution of Situations in Textbook Exercises and Gaokao Questions

Analysis of Figure 1 reveals distinct differences in color gradation between textbook practice items and the New Gaokao test papers (Volumes I and II): the assessment rigor of both New Gaokao papers is generally higher than that of textbook exercises, though the latter demonstrates a more balanced distribution across content domains. Specifically, the situational assessment rigor for thematic content such as "Functions," "Geometry and Algebra," and "Probability and Statistics" in the New Gaokao significantly exceeds the requirements of textbook exercises. Conversely, the rigor for "Foundational Knowledge" in the New Gaokao falls below textbook benchmarks. This discrepancy indicates that the New Gaokao prioritizes core, high-complexity knowledge in situational assessments while allocating less emphasis to basic, low-difficulty content, leading to its overall elevated difficulty compared to textbook materials. Subsequent sections will analyze the alignment between the New Gaokao test items (Volumes I and II) and curriculum standards through two dimensions: cognitive levels and content themes.

3.2. Content Theme Consistency Analysis

This study utilizes a combined bar and line chart (Figure 2) to intuitively present a comparative analysis of the situation distribution of content themes between two sets of New Gaokao test papers and traditional textbook exercises. The data indicates that the situation construction of the 2024 New Gaokao test questions shows significantly differentiated thematic assessment characteristics compared to traditional textbooks.

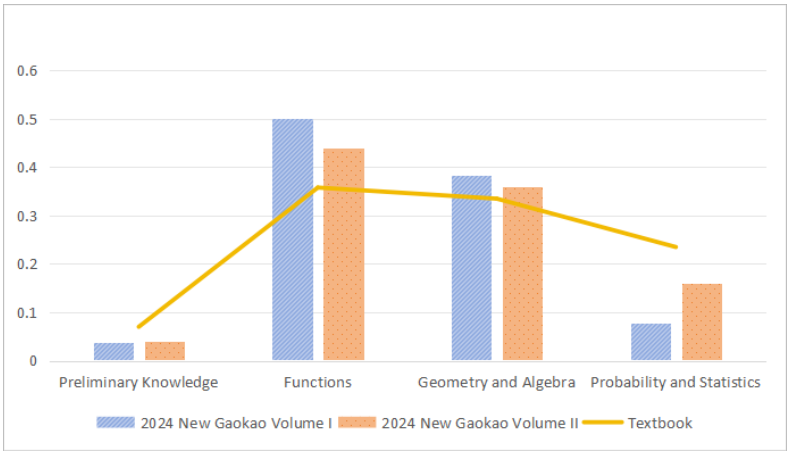

Figure 2: Comparison of Content Themes in Situations

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In terms of specific theme distribution, the assessment intensity of the preparatory knowledge module in both New Gaokao test papers is weaker than that in traditional textbooks, with the absolute value of the assessment ratio decrease stably in the range of 0.030 - 0.032. The function theme shows a significant strengthening trend, with the New Gaokao test papers' assessment ratio increasing by 0.081 - 0.142 compared to the textbooks. Notably, the function assessment proportion in New Gaokao Paper I reaches 0.501, highlighting the important status of this theme in the new curriculum standard system. Regarding the geometry and algebra theme, the assessment proportion in both New Gaokao test papers (with the highest reaching 0.384) is slightly higher than the textbook benchmark, but the difference amplitude is only 0.024 - 0.048. It is worth noting that the probability and statistics theme shows an inverse trend, with the assessment ratio in New Gaokao test papers decreasing by 0.075 - 0.158 compared to the textbooks, and the proportion of 0.160 in New Gaokao Paper II is already the highest value.

The gradient difference in this theme distribution reveals the shift in the assessment of disciplinary core literacy under the background of the New Gaokao reform: strengthening the in-depth understanding and application ability of function concepts, moderately adjusting the weight configuration of traditional knowledge modules, and reducing the assessment intensity of applied themes such as probability and statistics. This structured adjustment reflects the emphasis on the cultivation of students' mathematical modeling and logical reasoning abilities in the new curriculum standard system.

3.3. Cognitive Level Consistency Analysis

The comparative analysis of cognitive level distribution between New Gaokao test papers and traditional textbook exercises in situational contexts is visually presented in Figure 3. The data reveals that the assessment trends of cognitive levels in the 2024 New Gaokao question situations align with those in textbook exercises, though their proportional distributions exhibit distinct characteristics.

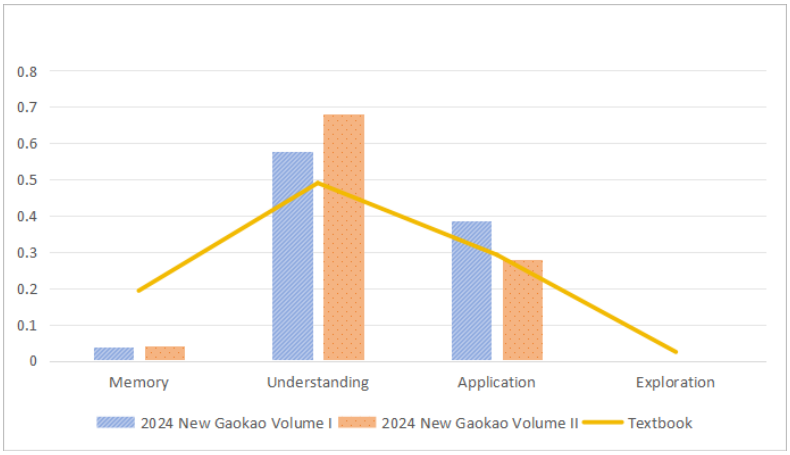

Figure 3: Comparison of Cognitive Levels in Situations

At the “memory” cognitive level, the ratios of the 2024 New Gaokao Paper I (0.038) and Paper II (0.04) are nearly equal and both significantly lower than that of the textbook exercise situation, with the absolute difference ranging from 0.153 to 0.155, and no significant consistency exists. Furthermore, at the “understanding” cognitive level, the differences between the two sets of papers and the textbook are both positive, with a deviation range of 0.086 - 0.19. Among them, New Gaokao Paper I has the highest fit with the textbook, while Paper II significantly exceeds the textbook, but neither of them is consistent with the textbook. Furthermore, at the “solving” cognitive level, the ratio difference between New Gaokao Paper I and the textbook is positive (0.054), while that between New Gaokao Paper II and the textbook is negative (-0.012). This result indicates that New Gaokao Paper II shows higher consistency with the textbook, while the consistency of Paper I is relatively lower. Finally, in the analysis of the “exploration” cognitive level, the ratio deviation between New Gaokao Paper I and the textbook is 0.014, indicating strong consistency between them; whereas the weight of the question situation in New Gaokao Paper II is zero, indicating that it does not show consistency with the textbook.

The distribution differences in cognitive levels reveal a structural shift in the assessment of disciplinary core literacy under the New Gaokao reform: significantly weakening the memory level and strengthening the ability of understanding and application. The situation assessment focuses on

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innovative problem-solving ability and the permeation of inquiry literacy.

4. Prospects for Future High School Mathematics Education and Pedagogy

4.1. Expanding Comprehensive Knowledge Integration and Optimizing Assessment Equilibrium

The study found that there are significant differences between the situations of textbook exercises and college entrance examination questions in terms of assessment focus and knowledge coverage. Specifically, the proportion of each theme in exercise situations is more balanced than that in test questions, which is the key factor leading to the significant difference in situation consistency between the two. In view of this, it is suggested that the design of situations should moderately expand the coverage of knowledge and optimize the balance of assessment content. First, we can carefully construct theme - based situations to promote the cross - integration of knowledge. Due to the limitation of space, test questions cannot cover all the secondary content themes like exercises, resulting in some knowledge examination blind spots. The introduction of theme - based situation questions can effectively make up for this assessment deficiency. By integrating the content knowledge of different or similar themes into the same situation, it not only deepens the assessment of students' thinking process but also further promotes the display of their innovative abilities. Second, by designing open - ended situation questions, we can further expand the scope of knowledge assessment. Developing open - ended situation questions can not only promote the comprehensive integration of students' knowledge, greatly expanding the breadth of knowledge coverage, but also effectively assess students' innovative thinking and critical thinking abilities. How to judge and preset students' answers, and carry out reasonable scoring and grading, is undoubtedly a higher requirement for teachers' mathematical teaching knowledge level and teaching wit.

4.2. Aligning with Curriculum Standard Orientation and Facilitating Tripartite Synergy in New Reforms

In 2018, the Ministry of Education of China issued the "Guiding Opinions on the Implementation of New Curriculum and Textbooks in General High Schools". According to these opinions, all teaching links in general high schools should integrate the concepts of the new curriculum and new textbooks to realize the goals of the "Three New Initiatives" (new curriculum, new textbooks, and new teaching models). In the context of these "Three New Initiatives", every aspect of high - school teaching, including curriculum design, classroom instruction, assessment, and extracurricular activities, should be infused with the innovative ideas put forward in the new curriculum and textbooks. This integration aims to improve the quality of high - school education, enhance students' comprehensive abilities, and better adapt to the needs of modern society. It requires teachers to update their teaching concepts, adjust teaching methods, and promote the all - around development of students in knowledge acquisition, skill development, and value formation.

5. Conclusion

In the context of the new curriculum reform, the consistency between teaching and testing is crucial for achieving educational goals and accurately assessing students' abilities. This study analyzed the situation consistency between the exercises in the People's Education Edition A of high school mathematics textbooks and the 2024 New Gaokao questions. It was found that the New Gaokao papers have good situation consistency with the textbook exercises, but only the second New Gaokao paper reached significant consistency with the textbooks in a statistical sense.Specifically, the New Gaokao questions focus on "functions" and "geometry and algebra" in terms of content themes, and place more emphasis on the assessment of understanding and application abilities in terms of cognitive levels, with a higher cognitive difficulty than the textbook exercises. Based on this, this study proposes relevant suggestions for teaching and learning. It is hoped that the research conclusions and suggestions of this study will provide beneficial theoretical references and empirical evidence for the future improvement of high school mathematics teaching and learning, and promote the in-depth development of the new curriculum reform.

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