Journal of Research in Science and Engineering (JRSE)
ISSN: 1656-1996 Volume-7, Issue-10, October 2025
DOI: 10.53469/jrse.2025.07(10).04

Research on Inequality Solving in College Entrance Examination Mathematics—Take the National Test from 2 018 to 2022 as an Example

Mingjie Wan, Gang Xiao*, Siqiang Yang

School of Mathematics and Physics, Yibin University, Yibin, Sichuan, China
Correspondence Author

1. Introduction

The essence of mathematics lies in studying quantitative information and spatial transformations, serving as an essential tool for exploring modern advanced technologies. In mathematics education, inequalities not only form a crucial component of high school curricula but also represent challenging areas where students often struggle to grasp concepts like advanced algebra when learning other subjects. This paper analyzes inequality problems in college entrance examinations (Gaokao), revealing through literature review that high school students predominantly employ two problem-solving approaches: directly applying theorems for solutions and integrating numerical analysis with graphical representation. As a core compulsory subject, high school inequalities serve as fundamental knowledge that bridges the entire mathematical system, facilitating students mastery of new concepts. Through literature analysis, we examine common error patterns in recent Gaokao inequality questions, propose targeted solutions based on exam requirements and textbook content, and ultimately provide concrete implementation strategies aligned with high school mathematics curriculum standards, enabling students to effectively apply their acquired knowledge in problem-solving.

2. Study Design

2.1 Methodology

The research methods used in this paper are mainly literature research method, text research method, statistical analysis method and Polya problem solving theory method. In Dai Lingfeng [14]. The published paper “Problem-Solving Techniques for Inequalities in High School Mathematics” provides theoretical foundations through content analysis in inequality teaching research. By employing textual analysis, it examines the application of inequality-related content in high school mathematics and investigates various unique properties of inequalities, aiming to precisely grasp problem-solving strategies for inequality-related issues. Utilizing statistical analysis, the study compiled statistics on inequality-related questions from college entrance examination papers over the past five years, analyzed corresponding data, and subsequently used data to examine key question types and their assessment of core competencies. Based on the research by Bao Jiansheng...[21]The comprehensive difficulty model is used to study the difficulty coefficient of the statistical test questions. Finally, the Polya problem solving method is used to analyze the typical college entrance examination questions.

2.2 Research Content

This thesis conducts a systematic study of inequality-related questions in Chinas National College Entrance Examination (Gaokao) over the past five years. During the research process, I meticulously analyzed mathematical problems containing inequalities from these five-year Gaokao papers and performed comprehensive data analysis. The statistical findings revealed that inequalities were applied in functions, sequences, and conic sections, demonstrating examiners emphasis on this subject area. However, literature review indicated that most domestic studies on Gaokao inequalities are published in academic journals with incomplete coverage. Despite inequalities central role in high school mathematics and Gaokao, recent years have seen relatively limited academic research from university faculty. Moreover, while the examination points for arts and science streams share some overlap, their difficulty levels differ significantly. Therefore, this study focuses on inequality-related questions in science mathematics Gaokao papers from 2018 to 2022. In accordance with the “Senior High School Mathematics Curriculum Standards (Experimental)” and Sichuans recent Gaokao syllabus requirements, we categorized these questions into three aspects through qualitative and quantitative methods: 1. Analysis of inequality assessment in science Gaokao; 2. Classification and solution approaches for inequality-related questions in science Gaokao; 3. Suggestions for problem solving and teaching.

3. Findings

3.1 Frequency Analysis of Each Test Point of the Inequality

The high school mathematics curriculum contains distinct sections on inequalities, yet the national college entrance examination (Gaokao) maintains a limited scope. Analysis of Gaokao questions from the past five years reveals discernible patterns in inequality-related assessments. This chapter systematically categorizes examination points according to curriculum standards while tracking their frequency, thereby mapping the evolving trends in inequality-related content. Our research identifies six primary assessment categories: application of inequality properties, problem-solving through inequalities, inequality proofs, linear programming, maximization problems, and range determination.

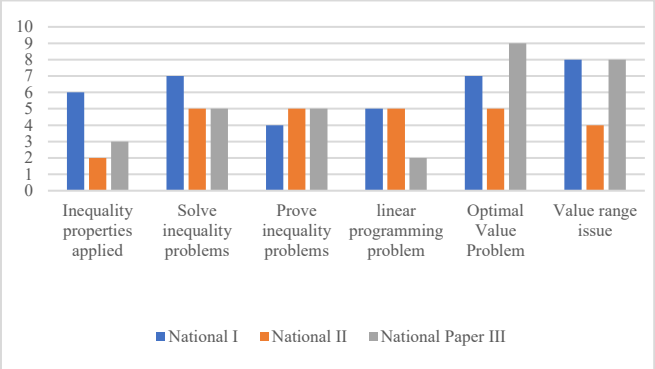

Figure 1: Frequency statistics of inequality test points in science test papers of college entrance examination in recent five years

The table clearly shows that the National Paper II demonstrates balanced distribution across question types, with relatively fewer applications of inequality properties. In contrast, the National Paper I primarily focuses on value range problems, while the National Paper III mainly examines extremum issues with limited emphasis on linear programming. Overall, extremum problems and value range questions remain key knowledge points emphasized in the examinations.

3.2 Statistical Analysis of the Form of Questions Related to Inequality

It is well-established that the National College Entrance Examination (Gaokao) mathematics paper comprises three question types: multiple-choice questions, fill-in-the-blank questions, and problem-solving questions. Inequality-related content appears across all three categories, particularly in problem-solving questions where it is consistently included in every exam. Through statistical analysis of inequality-related questions from the past five years, we have compiled data on the distribution of question types and their relative proportions in the examination.

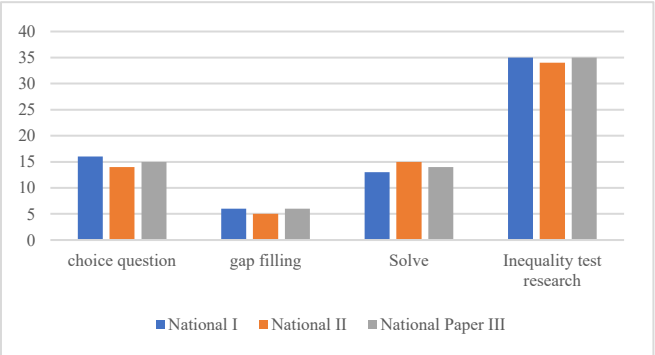

Figure 2: Statistical table of inequality related questions in college entrance examination mathematics in recent five years

Combined with this bar chart, we can see that in the different knowledge tests of the National College Entrance Examination, the national I, II and III papers mainly examine the questions in the form of multiple choice questions and answer questions, while the fill-in-the-blank questions are relatively less examined, because the integration difficulty of the fill-in-the-blank questions is relatively moderate.

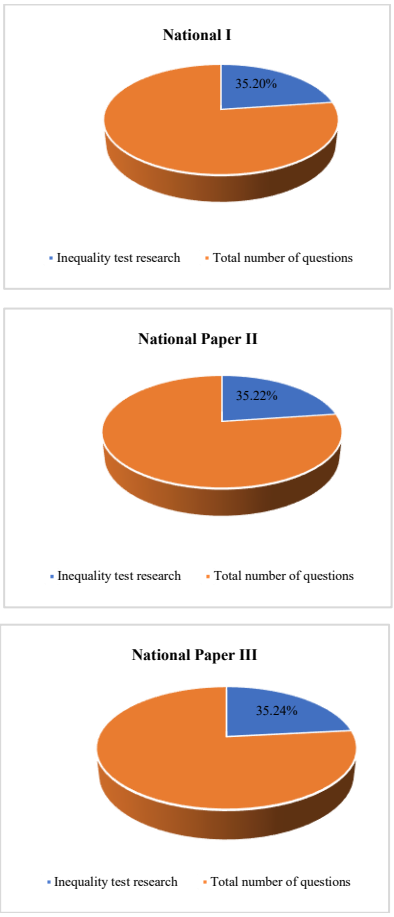

Figure 3: Pie chart

From this pie-shaped statistical chart, we can see that the questions containing inequality knowledge in the college entrance examination questions account for about 3 5% of the total number of college entrance examination questions, which is an important knowledge in the whole high school stage.

3.3 Statistical Analysis of College Entrance Examination Inequality Questions Based on Core Literacy

Our preliminary analysis of inequalities and core competencies revealed that students development of these essential skills is inseparable from their study of inequalities, as they complement each other. Through comprehensive data analysis of the past five years college entrance exam papers, we identified patterns in how inequality-related questions are assessed. Our research shows that while some multiple-choice questions focus on specific types of core knowledge, comprehensive problem-solving questions demand higher-level abilities, often integrating various core competencies with diverse problem-solving skills.

Table 1: Statistical analysis of inequality questions in college entrance examination based on core literacy

	National Paper 1	National B Volume	National Trilevel
Mathematical abstraction	0	2	8
logical reasoning	24	23	18
mathematical modeling	3	2	1
arithmetical operation	33	29	30
Visualizing the idea	6	6	10
DA	5	5	3

Table 1 reveals that core mathematical competencies have been the most frequently assessed component in Chinas National College Entrance Examination (Gaokao) papers over the past five years. Specifically, the National Paper I demonstrates zero emphasis on mathematical abstraction, while both logical reasoning and computational skills receive significant attention. In contrast, the National Paper III places greater emphasis on mathematical abstraction, whereas mathematical modeling remains underrepresented in overall assessment criteria.

3.4 Comprehensive Difficulty Analysis of Inequality Questions

3.4.1 Comprehensive difficulty model

Table 2: Comprehensive difficulty level division

Difficulty factors	Level 1	Level II	Level 3	Level four
operation	not have	Numerical operations	Simple arithmetic symbols	Complex context
inference	not have	Simple reasoning	Complex reasoning	
Knowledge content	one	two	Three or more	
exploration	memorize	understand	exploration	
background	No practical background	Chastnaya zhizn	Common sense	Scientific context

After reading a lot of literature, I based on Bao Jiansheng [21] Model of comprehensive difficulty of analytical mathematics test and Cui Yunliang [10] Professors "Research on Inequality Problems from the Perspective of College Entrance Examination" was revised according to the actual circumstances of this thesis, resulting in the following updated difficulty level table. This model comprises five difficulty factors: "Computational Skills", "Inferential Reasoning", "Knowledge Content", "Exploration", and "Contextual Background". Each factor corresponds to multiple difficulty levels while maintaining connections with the curriculum objectives we aim to achieve. For instance, the three factors — "Computational Skills", "Inferential Reasoning", and "Knowledge Content" — demonstrate the content of "Basic Knowledge" and "Fundamental Skills", whereas the two factors "Exploration" and "Contextual Background" highlight "Core Concepts" and "Essential Activity Experiences".

We then assign specific weight coefficients to each of the five difficulty factors in the comprehensive difficulty coefficient model based on their respective levels. Typically, we conduct natural assignment of values for each level using natural numbers. The formula is used to calculate the difficulty coefficients for each factor in the test paper. Here, represents the weight assigned to the nth level within the fifth dimension, where n denotes the total number of dimensions. $1,2,3\cdots d_i = \sum n_{ij} d_{ij} \left(\sum n_{ij} = n, i = 1,2,3 \ldots\right) (i = 1,2,3,4,5)\, n_{ij}\, i\, j$

3.4.2 Comprehensive difficulty analysis

Using a comprehensive difficulty coefficient model, we analyzed the five core elements of the National College Entrance Examination (Gaokao) from 2018 to 2022 — computation, reasoning, knowledge content, inquiry, and contextual application—to identify patterns in inequality proposition difficulty coefficients. Given the fixed number of exam questions each year, a thorough study of these five-year test papers reveals discernible trends that can be systematically identified.

1) Operational level

As shown in Table 3, the difficulty coefficients for computational skills in National Paper I, II, and III are 2.67,2.58, and 2.67 respectively, indicating nearly identical levels. The proportions of basic arithmetic operations, simple symbolic calculations, and complex symbolic computations show comparable differences. However, National Paper II demonstrates a notably smaller proportion in numerical computation proficiency.

Table 3: Statistical table of inequality operation level in mathematics in the 2018-2022 College Entrance examination

Difficulty factors	No operation		Numerical operations		Simple symbolic operations		Complex symbolic operations		degree of difficulty
Level of expertise	Volume of questions	percentage	Volume of questions	percentage	Volume of questions	percentage	Volume of questions	percentage	
National Paper I	2	0.03	20	0.37	24	0.50	5	0.10	2.67
National Paper II	3	0.08	15	0.33	20	0.50	4	0.08	2.58
National Paper III	2	0.04	16	0.37	22	0.48	5	0.11	2.67

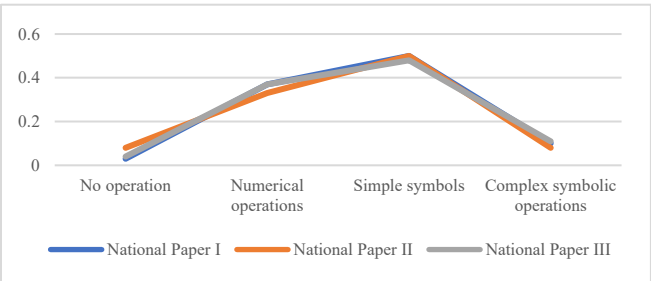

Figure 4: 2018-2022 statistics of inequality operation level in mathematics in the National College Entrance Examination

It can be clearly seen in the figure that numerical operation and simple symbol operation account for a large proportion in the three sets of paper rolls. The proportion of complex symbol operation is relatively small, and no operation is almost zero. Moreover, the level of operation examination in the three sets of paper rolls is extremely similar.

2) Level of reasoning

Table 4 clearly shows that the difficulty coefficients of these college entrance exam papers range between 2.2 and 2.4, with values of 2.32,2.24, and 2.23 respectively. Notably, the National Paper I does not cover reasoning-level questions, while complex reasoning questions account for the largest proportion. This indicates that in terms of reasoning difficulty, the National Paper I has the highest coefficient.

Table 4: Statistical table of inequality reasoning level in mathematics in the National College Entrance Examination from 2018 to 2022

Difficulty factors	No reasoning		Simple reasoning		Complex reasoning		degree of difficulty
Level of expertise	Volume of questions	percentage	Volume of questions	percentage	Volume of questions	percentage	
National Paper I	0	0.00	3 4	0.67	1 5	0.33	2.32
National Paper II	2	0.04	2 5	0.67	1 0	0.29	2.24
National Paper III	2	0.04	3 0	0.70	1 0	0.26	2.23

Table 5: Statistical Overview of Inequality Knowledge Points in the 2018-2022 Gaokao Mathematics Exam

Difficulty	Single knowledge point		Two knowledge points		Three or more knowledge points		degree of difficulty
Level	Question Count	percentage	Question Count	percentage	Question Count	percentage	
National I	5	0.14	2 0	0.44	2 0	0.44	2.31
National II	1 5	0.34	1 0	0.28	1 5	0.38	2.05
National Paper III	4	0.12	30	0.71	1 0	0.18	2.06

Table 6: Statistical table of inequality exploration level in mathematics in the National College Entrance Examination from 2018 to 2022

Difficulty factors	memorize		understand		exploration		degree of difficulty
Level of competence	Volume of questions	percentage	Volume of questions	percentage	Volume of questions	percentage	
National Paper I	6	0.14	3 0	0.61	1 4	0.28	2.14
National Paper II	0	0.00	2 9	0.70	1 3	0.29	2.30
National Paper III	4	0.08	3 1	0.69	1 2	0.23	2.16

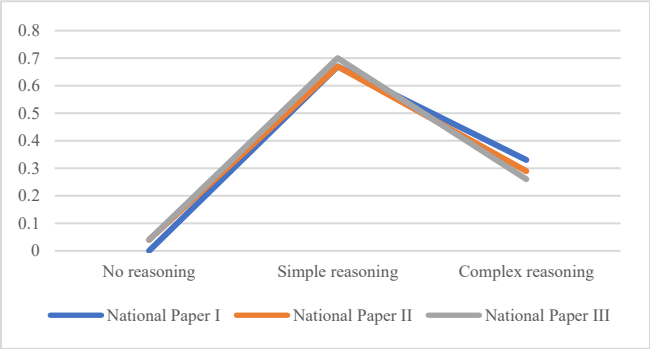

Figure 5: 2018-2022 Statistical Chart of Inequality Reasoning Proficiency in College Entrance Mathematics

By analyzing Figure 5, we observe that the exam primarily assesses basic reasoning skills. Simple reasoning constitutes 60% of all questions, while complex reasoning accounts for approximately 33%, with virtually no questions requiring no reasoning. The assessment types for reasoning skills in these three test sets show minimal variation.

3) Knowledge points

The data in Table 5 shows that the knowledge content and difficulty coefficients of these three college entrance exam papers are 2.31,2.05, and 2.06 respectively. It is evident that the National Paper I has a higher difficulty coefficient under this level factor compared to the other two. Meanwhile, the difference in difficulty coefficients for inequality-related knowledge between the other two papers is negligible.

Figure 6 reveals that both the “Two Knowledge Points” and “Three or More Knowledge Points” sections in National Paper I consistently account for approximately 40% of the total difficulty level. While National Paper II maintains a relatively balanced distribution with three tiers averaging around 30%, National Paper III predominantly focuses on the “Two Knowledge Points” section, which makes up a whopping 70% of the total. Overall, when assessing the quality of knowledge point content, the “Two Knowledge Points” category demonstrates the highest concentration of high-level questions.

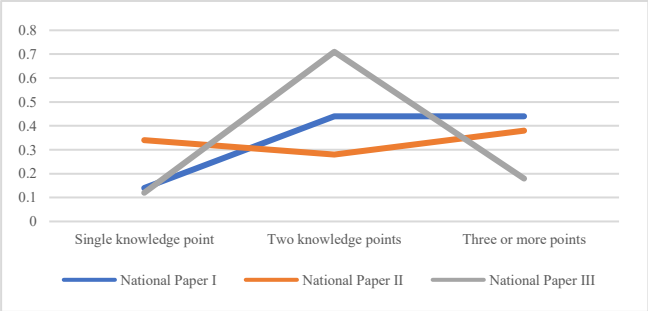

Figure 6: 2018-2022 statistics of inequality knowledge content in mathematics in the National College Entrance Examination

4) Level of inquiry

Table 6 reveals that the three college entrance exam papers have difficulty coefficients of 2.14,2.30, and 2.16 respectively in terms of inquiry level. These papers demonstrate the highest emphasis on understanding-based assessment. Notably, the National Paper II has not included any questions testing memorization elements over the past five years, focusing instead on evaluating comprehension and inquiry capabilities. This approach explains why it also boasts the highest difficulty coefficient among all papers.

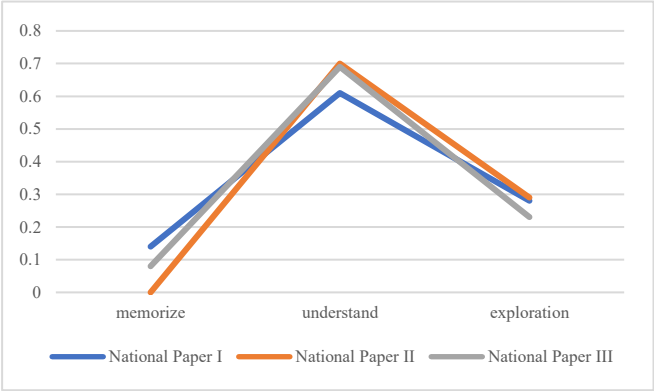

Figure 7: 2018-2022 statistics of inequality exploration level

in mathematics in the National College Entrance Examination

It is obvious from the figure that understanding this factor is the most important among all the inquiry levels. It accounts for more than half of all the factors in the inquiry level, and the proportion of each level in the three sets of papers is almost the same.

5) Background level

Analysis of Table 7 reveals that the three national college entrance exam papers demonstrate varying background-level difficulty coefficients: 1.28,1.03, and 1.10 respectively. Notably, all papers primarily assess theoretical knowledge without real-world contextual elements. While Paper I incorporates public affairs and scientific scenarios, Papers II and III completely exclude such elements, making Paper I the most challenging in terms of difficulty level.

Table 7: 2018-2022 statistics of inequality background level in mathematics in college entrance examination

Difficulty factors	No practical background		Chastnaya zhizn		Common sense		Scientific context		degree of difficulty
Level of expertise	Volume of questions	percentage	Volume of questions	percentage	Volume	percentage	Volume of questions	percentage	
National Paper I	45	0.86	2	0.04	3	0.08	1	0.03	1.28
National Paper II	39	0.96	2	0.05	0	0.00	0	0.00	1.03
National Paper III	40	0.89	5	0.12	0	0.00	0	0.00	1.10

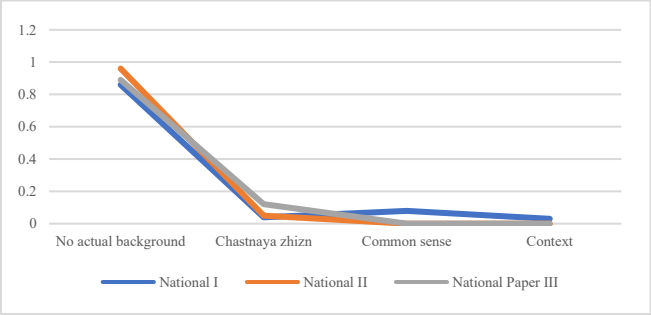

Figure 8: 2018-2022 statistics of inequality background level in mathematics in the National College Entrance Examination

The chart clearly shows that over 80% of questions lack practical background levels. The trend of the line in the graph indicates that other factors account for an insignificant proportion. Furthermore, both National Paper II and National Paper III exams only include questions with either no practical background or personal life-related contexts.

6) Overall difficulty

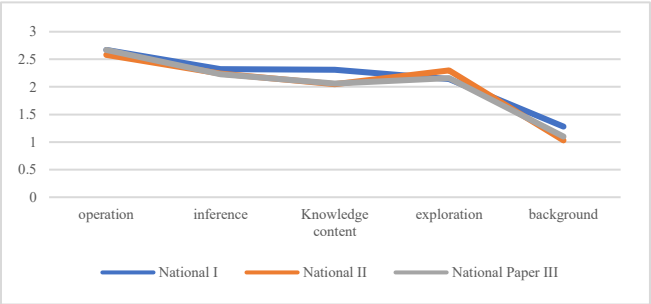

Figure 9: Statistical chart of inequality background level in mathematics in the National College Entrance Examination from 2018 to 2022

A closer examination of this chart reveals that among the five difficulty factors in college entrance exam questions, computational complexity demonstrates the highest difficulty coefficient. In contrast, contextual complexity shows the opposite trend. This data analysis indicates that when assessing inequality-related knowledge points, four key elements—computation, inference, knowledge content, and exploration—require particular attention.

3.4.3 Summary

Through a detailed analysis of five years worth of college entrance exam inequality questions, we can clearly observe that the test primarily covers six types of inequality-related questions 1) including property applications 2) solving inequalities 3) linear programming 4) inequality proofs 5) maximum/minimum value 6) and range determination. In terms of question formats, problem-solving questions dominate, followed by multiple-choice questions, with fill-in-the-blank questions occasionally appearing. Notably, inequality-related knowledge consistently accounts for 30% to 50% of total exam questions across all years. Regarding comprehensive difficulty assessment, the four key elements are “computation,” “deduction,” “knowledge content,” and “inquiry.” The “contextual background” element is only occasionally mentioned in National Paper I exams.

Project Fund

1) Supported by the Open Research Fund of Computational Physics Key Laboratory of Sichuan Province, Yibin University (No. YBUJSWL-JX-2025-05);

2) Supported by the Open Research Fund of Computational Physics Key Laboratory of Sichuan Province, Yibin University (No. YBUJSWL-YB-2024-06);

3) Yibin University School of Mathematics and Physics Teaching Reform Project (No. 156-24089001-003).

References

[1] Xu Tianbao. Application of inequalities in high school mathematics problem-solving [J]. Mathematical Problem-Solving Research, 2022(16):53-56.
[2] Sheng Long. Analysis of Inequality Problem-Solving Methods in High School Mathematics [J]. Mathematical Problem-Solving Research, 2021(25):43-44.
[3] Ding Xiaojun. Application of Mathematical Thinking in Inequality Problem Solving Teaching at High School [J]. Mathematics and Physics Problem Solving Research, 2020(30):12-13.
[4] Zhou Liang. Problem-solving strategies for constant parameter inequalities in high school mathematics [J]. Test and Research, 2020(18):24.
[5] Hu Xia. On the clever use of the mean value inequality in high school mathematics problem solving [J]. Mathematics Learning and Research, 2019(02):107.