

A Comparative Study of Integration Methods in A-Level Mathematics and Chinese Senior High School Mathematics Textbooks

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Abstract: Calculus serves as a key difficult module in senior mathematics and a critical bridge connecting elementary and advanced mathematics. Significant differences exist between the A-Level international curriculum and China's standard senior high school mathematics textbooks in terms of the knowledge framework of integration, systems of problem-solving techniques, examination priorities and orientation of mathematical thinking. Taking mainstream syllabuses of CAIE and Edexcel A-Level together with People's Education Press senior high school mathematics textbooks as research objects, this paper conducts a comparative analysis from four dimensions: scope of knowledge coverage, core integration approaches, examination logic and cultivation of mathematical thinking. It sorts out similarities and disparities between the two systems, explores the underlying curriculum orientations and educational rationales behind such differences, and proposes targeted learning strategies for trans-system learners preparing for examinations and building knowledge connections. This research reveals that integration teaching in domestic senior high schools emphasizes theoretical derivation, algebraic manipulation and in-depth critical thinking, while A-Level integration prioritizes formula application, standardized problem routines and scenario modelling. The two systems are highly complementary. Systematic mastery of their characteristics can effectively improve learners' comprehensive ability to solve calculus problems and develop core mathematical literacy.

Keywords: A-Level Mathematics; Chinese Senior High School Mathematics; Integration Methods; Curriculum Comparison; Calculus Teaching

1. Introduction

As the core component of calculus, integration is widely applied in calculating geometric areas, analysing physical motion and investigating function extrema. It constitutes a compulsory key content in mathematics examinations at home and abroad. In Chinese senior high school textbooks, integration is positioned as an introductory course to advanced mathematics, focusing on cultivating learners' awareness of limits, logical derivation of formulas and training on complex variant problems. In contrast, A-Level Mathematics, a British senior high school curriculum for global international students, covers far broader content of integration than domestic senior high school syllabuses. It incorporates fundamental university-level calculus knowledge yet adopts standardized, routinized problem-solving methods and simplifies complicated theoretical deductions.

With the integration of international education and domestic basic education, numerous students engage with both curriculum systems simultaneously. They frequently encounter obstacles including knowledge confusion, misaligned problem-solving logic and poor adaptation to examinations. Against such a backdrop, this paper systematically compares the knowledge frameworks and integration techniques stipulated in the two sets of teaching materials, clarifies the essence of their differences, and provides references for bilingual mathematics learning, international curriculum preparation and optimization of mathematics teaching.

2. An Overall Comparison of Integration Knowledge Systems

2.1 Scope of Knowledge Coverage: Broader Content in A-Level, Deeper Exploration in Domestic Textbooks

Chinese senior high school mathematics textbooks published by People's Education Press only contain fundamental indefinite integrals, basic definite integrals, the Fundamental

Theorem of Calculus and definite integral applications for planar graphical areas. The knowledge boundary is strictly confined within elementary mathematics. Advanced techniques such as integration by substitution, integration by parts, improper integrals and integral solutions to differential equations are excluded and reserved for university calculus courses.

As an independent core module in A-Level Pure Mathematics, integration boasts a complete and extended knowledge system covering all integration content taught in domestic senior high schools, supplemented by multiple introductory university topics. These include advanced integration techniques such as substitution and integration by parts, trigonometric integration, improper integrals, integration of rational functions via partial fractions, extended integral applications such as volumes of revolution and arc lengths of curves, and integral approaches to simple first-order differential equations. The curriculum forms a solid foundation for university calculus.

2.2 Logical Sequence of Knowledge Arrangement

Domestic textbooks follow a rigorous sequence: Limits $\rightarrow$ Derivatives $\rightarrow$ Definite Integrals $\rightarrow$ The Fundamental Theorem of Calculus. Great importance is attached to tracing theoretical origins. Teachers guide students to derive integration by reversing differentiation, establishing theoretical frameworks step by step and prioritizing mathematical rigour.

A-Level textbooks adopt an application-oriented logic centred on formulas. Standard integration formulas are presented directly, theoretical derivation processes are simplified, and learning objectives focus on memorizing formulas, adopting fixed methods and tackling practical problems. The arrangement of knowledge prioritizes practical problem-solving over theoretical exploration.

3. Detailed Comparison of Core Integration Problem-solving Approaches

3.1 Fundamental Formula Systems: Divergences in Derivation and Application Rules

3.1.1 Integration Formulas in Chinese Senior High School Courses

Domestic textbooks do not provide comprehensive formula sheets. Students are

expected to understand and memorize core integration formulas through reverse differentiation reasoning. Examination rules prohibit direct application of over-syllabus formulas without derivation. Only basic integrals for power functions, elementary exponential functions and simple trigonometric functions are covered. Examiners require full logical reasoning, and solutions using unproven advanced formulas will be deemed invalid.

3.1.2 Integration Formulas in A-Level Examinations

An official formula booklet is provided throughout all A-Level assessments. It contains complete basic and advanced integration formulas. Students are not required to memorize complex formulas or demonstrate their theoretical derivation. The primary competency assessed is identifying problem types, matching corresponding formulas and substituting values accurately. Apart from elementary integrals, the booklet directly includes formulas such as $\int \tan x dx$, integration by parts and integrals of composite functions, reducing burdens of memorization and theoretical derivation while emphasizing practical application.

3.2 Differences in Core Problem-solving Techniques

3.2.1 Solutions to Indefinite Integrals

Chinese senior high school syllabuses lack systematic advanced integration techniques. Only basic reverse differentiation methods are examined. Learners merely encounter elementary forms of integration by substitution. Advanced methods such as complex substitution and integration by parts are excluded. Students rely on elementary algebraic transformation and reverse deduction, with high requirements for algebraic manipulation skills.

A-Level establishes a standardized system of routines for integration:

Direct integration: Used for elementary functions by direct reference to formula booklets.

Integration by substitution (a core exam focus): Including linear substitution and substitution for complicated composite functions, following fixed operational procedures for most composite integrals.

Integration by parts: Applied to integrands consisting of products of power functions, exponential functions and trigonometric functions, solved by following a universal formula step by step.

3.2.2 Definite Integral Calculation and Practical Applications

Both systems adopt the Newton-Leibniz Formula as the core tool to evaluate definite integrals by substituting upper and lower limits into antiderivatives, and both examine basic geometric applications such as calculating planar areas.

Crucial distinctions lie in the following aspects:

First, domestic senior high school examinations limit integral applications to planar areas. Questions are highly flexible, frequently combined with function monotonicity, extrema, inequalities and parametric discussions. No universal problem-solving templates exist, and numerous variants are designed to test flexible analytical skills.

Second, A-Level covers diversified fixed application scenarios. Besides planar areas, it regularly examines volumes of revolution, displacement and work done in mechanics. All application problems follow fixed formulas and standard procedures with limited variants, leading to highly repetitive question patterns.

3.3 Strategies for Complicated Problems

The difficulty of integration in domestic senior high school education lies not in the range of available techniques, but in comprehensive question design and complicated algebraic transformations. Examination questions integrate functions, derivatives and inequalities, requiring independent analysis, flexible transformation and classified discussion without fixed templates, aiming to foster innovative problem-solving and logical reasoning.

In A-Level examinations, challenges originate from proficiency in standardized methods and computational precision. All difficult questions operate within fixed methodological frameworks. Once students master substitution and integration by parts and match appropriate formulas, they can proceed systematically. Comprehensive innovative final problems are rare, and computational errors constitute the primary source of lost marks.

4. Differences in Examination Design and Marking Criteria

4.1 Examination Focus

College entrance examinations in China prioritize logical thinking over pure computation, and theoretical reasoning over mechanical routines.

Assessment highlights awareness of limits, calculus logic and comprehensive applications of functions. Final challenging questions combine integration with derivatives and inequalities to distinguish candidates according to depth of logical reasoning, while computational difficulty remains relatively moderate.

A-Level integration assessments emphasize procedural routines and precise calculation with reduced emphasis on theoretical deduction and critical speculation. Test questions closely mirror textbook examples and past paper patterns with few eccentric problems. Student differentiation mainly comes from accuracy of arithmetic, rapid formula matching and standardization of working steps. Questions requiring in-depth logical derivation are scarce.

4.2 Question Structure and Marking Standards

Chinese senior high school integration assessments include multiple-choice items, fill-in blanks and proof or solution questions. Long questions carry high scores and strong comprehensiveness. Markers award partial credit based on correct analytical thinking; candidates can obtain procedure marks if their general reasoning is sound, valuing complete thought processes.

All A-Level integration questions are structured multi-step long questions. Sub-questions are progressive and interconnected with small allocated marks. Marks are awarded strictly according to each stage of working and proper formula application. Partial marks can still be obtained for correct procedures even if the final numerical answer contains errors, featuring highly standardized and objective marking rules.

4.3 Examination Preparation Characteristics

Preparation for domestic examinations requires thorough comprehension of theoretical principles, accumulation of question variants and training in comprehensive logical thinking. Exercise practice focuses on categorizing question types and developing flexible reasoning capabilities.

A-Level revision concentrates on mastering standardized procedures, improving formula recognition and eliminating computational mistakes. Candidates mainly practise past paper routines rather than exploring highly complex variants. The core objective is to enhance speed and accuracy in applying established methods.

5. Causes Underlying Differences Between the Two Integration Systems

5.1 Distinct Curriculum Objectives

Chinese senior high school mathematics is a core basic education subject designed to cultivate students' abstract thinking and rigorous reasoning capabilities. Integration acts as preliminary exposure to advanced mathematics, prioritizing the transmission of core calculus ideas rather than merely training instrumental problem-solving skills.

As an international standardized university entrance curriculum, A-Level Mathematics aims to provide foundational mathematical tools for undergraduate majors including engineering, economics and physics. Therefore, it broadens knowledge coverage, strengthens the instrumental value of integration, simplifies theoretical derivation and concentrates on practical problem-solving and scenario application.

5.2 Different Educational Orientations

Domestic education tends to cultivate elite critical thinking. Sophisticated comprehensive questions screen students' mathematical literacy through in-depth exploration of knowledge and knowledge transfer and innovation.

A-Level adopts an inclusive educational orientation suitable for learners with varied academic backgrounds worldwide. Modular and standardized curriculum design lowers barriers to abstract thinking, enabling students to master practical mathematical tools through systematic training and catering to diverse university admission requirements and academic disciplines.

6. Learning Adaptation Strategies for Students Transitioning Between the Two Systems

6.1 Transition from Chinese Senior High School to A-Level

First, fill knowledge gaps: focus on learning integration by parts, advanced substitution techniques, volumes of revolution and simple differential equations, which are absent from domestic textbooks.

Second, adjust learning mindsets: reduce excessive focus on theoretical derivation, strengthen the ability to identify formulas, memorize standard routines and guarantee computational precision to adapt to standardized problem-solving patterns.

Third, adapt to examination rules: practise fixed question patterns from past papers purposefully, avoid delving into overly complicated variants and prioritize computational accuracy and complete working steps.

6.2 Transition from A-Level to Chinese Senior High School Mathematics

First, reinforce theoretical foundations: thoroughly understand the derivation of integration formulas and the logical connection between limits and integrals to remedy deficiencies in theoretical learning.

Second, improve comprehensive reasoning skills: train intensively on integrated questions combining integration, derivatives and inequalities, adapting to flexible variants and classified discussion.

Third, abandon over-reliance on fixed routines: develop independent analytical skills and flexible transformation capabilities to tackle comprehensive final examination questions.

7. Conclusion

The integration systems of A-Level and Chinese domestic senior high school mathematics demonstrate complementary characteristics: breadth versus depth, instrumental application versus speculative reasoning, standardization versus flexibility.

Integration teaching in Chinese senior high schools features depth, rigour and comprehensiveness. Based on basic education thinking cultivation, it focuses on conveying calculus ideas, logical derivation and complex interdisciplinary applications, developing students' abstract reasoning and innovative problem-solving capacity. Nevertheless, its knowledge scope is limited without advanced instrumental integration techniques.

A-Level integration teaching prioritizes breadth, practicality and standardization. It establishes a complete system of advanced integration approaches and standardized routines alongside diversified application scenarios. However, it simplifies theoretical deduction and rarely assesses comprehensive critical thinking ability. Neither system holds absolute superiority; each bears unique educational value.

For cross-system learners, recognizing divergences in problem-solving logic, examination rules and thinking orientations is essential. Targeted improvement of weak capabilities and adaptation to examination

models allow learners to move beyond passive mechanical problem-solving toward systematic command of calculus knowledge, laying a solid foundation for advanced mathematics and disciplinary applications in university.

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