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A Study on Calculus Examination in Japanese Top University Entrance Exams and Educational Enlightenment for Gifted Students in Mathematics

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Abstract: ***Calculus is the cornerstone of many branches of modern mathematics and a crucial component of mathematics education. This article conducts in-depth qualitative and quantitative research and analysis on the calculus questions in the entrance exams of three top universities in Japan (University of Tokyo, Kyoto University, and Tokyo Institute of Technology). It is found that the calculus questions in the entrance exams of the three universities cover a wide range of knowledge and are highly comprehensive, with comparable difficulty in testing calculus knowledge. At the same time, the examination of calculus emphasizes the characteristics of students' comprehensive mathematical literacy.***

Keywords: Japanese universities, Entrance exams, Calculus, Selection of gifted students.

1. Introduction

In the present, competition between the comprehensive strength and science and technology of various countries is becoming increasingly fierce, and in the final analysis, it is the competition for talents. Therefore, all countries in the world attach great importance to the selection and training of talents. Among many disciplines, mathematics, as one of the important basic disciplines of scientific and technological innovation, has attracted special attention from education in various countries.

In China, in addition to the college entrance examination, the main ways to select and cultivate talents for mathematics subjects at the middle school level are the national high school league and the mathematics test in the "Pilot Reform Program of Enrollment for Basic Subjects" (hereinafter referred to as "plan" in the article). However, looking at the high school math league exam questions in the past decades, there are almost no requirements for the calculus part. At the same time, the author found that in the past few years, there were relatively few calculus questions in the tests of the "Plan". In addition, the International Mathematical Olympiad does not include calculus. In this regard, many mathematicians said that this is a deficiency in the selection of mathematical talents - the famous mathematician Mr. Qiu Chengtong pointed out clearly in an interview that if you do not understand calculus, then most of the content in modern mathematics is not understood [1].

Calculus is the cornerstone of many branches of modern mathematics, eye on the world, developed countries in the world attach great importance to the teaching of calculus in talent training, such as AP calculus AB/BC course opened in the United States at the high school level, A-level calculus course for high school students in the United Kingdom, and so on [2]. At the same time, some countries also attach great importance to the content of calculus in the selection of gifts; Among them, the examination of calculus in the second entrance examination of Japanese top universities has important reference significance of mathematics education system in China.

2. Overview of Mathematics Test Questions for Entrance to Top Universities in Japan

The talent selection system in Japan and China have similarities: there is both a unified national college entrance examination and an independent entrance examination for colleges and universities. Similar to China, the second entrance examination of Japanese universities is also implemented by each university independently, and candidates are tested for specific ability, but the difference is that candidates who wish to apply for the university must take the second entrance examination. Therefore, compared to China's independent admission examination, the secondary entrance examination of Japanese universities has a long history.

Whether it is a public or private university in Japan, mathematics is an important subject in the second entrance examination. This article examines the entrance exams of three of Japan's top universities (the University of Tokyo, Kyoto University, and Tokyo Institute of Technology). Among them, the University of Tokyo and Kyoto University are the two most comprehensive institutions of higher learning in Japan, and their academic level and innovation ability lead the vigorous development of various fields in Japan. Tokyo Institute of Technology is a world-class polytechnic university specializing in engineering technology and natural science research.

As a comprehensive university, the University of Tokyo and Kyoto University entrance examination questions are generally divided into liberal arts papers and science papers, and the examination time is 2.5 hours. Since only science majors are enrolled, Tokyo Institute of Technology entrance mathematics test questions are not divided into arts and sciences, 5 questions are examined every year, and the exam duration is 3 hours. In addition, the mathematics entrance test questions of these universities are solution questions, generally involving elementary number theory, elementary algebra, elementary geometry, probability and calculus [3], of which calculus content accounts for a high proportion [4].

This article will explore the calculus test questions of the above three universities in Japan in the past five years (2018-2022), and provide a new perspective for the selection of mathematical talents in China.

3. An Analysis of Calculus Examination for Entrance Exams in Top Japanese Colleges and Universities

3.1 Overall Examination

The Mathematics Entrance Test for Public Universities in Japan mainly examines solution questions. In the past five years, the University of Tokyo and Kyoto University of Technology have had a total of 85 science questions in the entrance examination, of which 34 questions involve calculus (including 15 questions at the University of Tokyo, 11 questions at Kyoto University, and 8 questions at Tokyo Institute of Technology), accounting for 40%.

3.2 Content Analysis

In order to deeply study the content of calculus questions in three universities, the author analyze the content examined in the above calculus questions based on the "High School Study Guidance Guidelines (Rational Mathematics)" [5] (hereinafter referred to as the "Guidance Guidelines") issued by the Ministry of Education, Culture, Sports, Science and Technology in 2019 (This document is similar to Chinese high school mathematics curriculum standards), and analyzes the content examined in the above questions involving calculus, which is mainly divided into three aspects: limit theory, differential calculus and integral calculus.

(1) Limit theory

Regarding the limit theory, the "Guiding Essentials" mainly puts forward the following requirements: First, understand the convergence conditions of the limit of the series and master the method of finding the limit of the series. Such as finding the limit of the sequence $a_n = \frac{(2n+1)(n-1)}{n(n+2)}$ (it can be deformed into $a_n = \frac{(2+\frac{1}{n})(1-\frac{1}{n})}{1+\frac{2}{n}}$ and then solved);The second is to understand the convergence and divergence of infinite series, and find the sum of infinite series, for example, from the point of view of limit $0.\dot{9} = 1$; The third is to understand the limit of the function and find the limit of the simple function.

In the second entrance examination for Japanese universities, the examination of limit theory knowledge points is no longer a single or simple evaluation, but is combined with other knowledge points. For example, question 5 of Tokyo Institute of Technology in 2018 synthesizes the monotonicity of functions with the zero point and the limit of the series (see example 1), and the calculation of infinite series $\sum_{n=0}^{\infty}\left(\frac{1}{2}\right)^n cos\frac{n\pi}{6}$ in question 3 of Kyoto University in 2021 is essentially related to complex numbers, and so on.

Example 1 (Tokyo Institute of Technology Question 3, 2018) Knowing the equation $e^x(1 - sin\,x) = 1$, answer following questions:

Proof: There is no negative real solution to this equation, but there are infinitely many positive real solutions.

Arrange the positive real solutions of the equation from smallest to largest as $a_1, a_2, a_3, \ldots$ Let $S_n = \sum_{k=1}^{n} a_k$, solve for $\lim_{n\to\infty}\frac{S_n}{n^2}$.

(2) Differential calculus

In the Guiding Essentials, differential calculus mainly deals with: the sum, difference, product, and derivative of the quotient of functions; derivatives of trigonometric, exponential, and logarithmic functions; Tangent equation of curve, monotonicity of function, maximum minimum, drawing of function image. In the second entrance examination of Japanese top universities, the content examination of differential calculus is also closely related to the requirements of the "Guidance Essentials", but the comprehensive difficulty has been improved. For example, in 2021, Kyoto University Question 2 of Kyoto University fused tangent equations with the maximum value of a function (see Example 2), and the existential problem in Question 5 of the University of Tokyo in 2021 required the third derivative of a function (see Example 3), and so on.

Example 2 (Kyoto University Question 2, 2021) The tangent line of the point P on the curve $y = \frac{1}{2}(x^2 + 1)$ intersects the x-axis, and the intersection point is Q. Let the length of the line segment PQ be L, and find the minimum value of L.

Example 3 (Tokyo University Question 5, 2021, excerpt) It is known that α is positive real number, and the coordinates of the two points A and P in the plane are $A(-\alpha, -3)$, $P(\theta + sin\,\theta, cos\,\theta)$ $(0 \le \theta \le \pi)$. Let the square of the distance between two points of AP be $f(\theta)$. Proving that when $0 < \theta < \pi$, there exists a unique θ such that $f'(\theta) = 0$.

(3) Integral calculus

In the "Guiding Essentials", the content learning requirements of the integral calculus mainly include understanding and solving the basic properties of indefinite integrals and definite integrals; understanding and application of partial integration method and commutation integral method; Using the definite integral, the area of the irregular figure, the volume of solid shapes, the length of curves, etc. are obtained. In the secondary entrance examination of Japanese top universities, the examination of the integral science part also focuses on three aspects, but the questions are more comprehensive. For example, the Question 2 of Tokyo Institute of Technology in 2019 involves a more complex integral equation, and the Question 5 of Tokyo University combines the trajectory of points in space and the volume of a space rotating body (see

Example 4), and so on.

Example 4 (Tokyo University Question 5, 2022) It is known that A and B are two points in the spatial coordinate system, and S is the surface obtained by the rotation of line segment AB around the Z axis. It is known that the moving point P on S and the moving point Q on the XoY plane satisfy PQ=2, and the range formed by the midpoint M movement of the moving line segment PQ is recorded as K, and the volume of K is calculated.

According to the above classification, among the 34 calculus questions, the three schools examined a total of 11 questions in limit theory, 21 in differential calculus, and 20 in integral science (Because some calculus questions are more comprehensive, in the actual classification, there will be a phenomenon that the same question involves multiple contents, so the sum of the three here is greater than 34.); Among them, the University of Tokyo examines the largest number of various types of questions (see Figure 1).Common knowledge of three universities includes derivation of elementary functions and composite functions, monotonicity of functions and extreme (maximal) values of functions, application of definite integrals in geometry (finding the length of curves, area and volume of irregular figures), finding the limits of functions or series, and commutation and partial integration methods, which appear at frequencies of 23, 15, 11, 10 and 9 in turn; Some contents such as tangent equations, infinite series, etc. are less covered (see Figure 2).

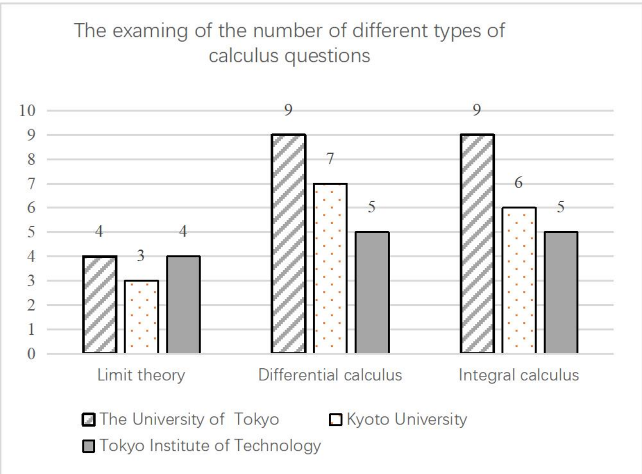

Figure 1: The number of calculus test items in three universities

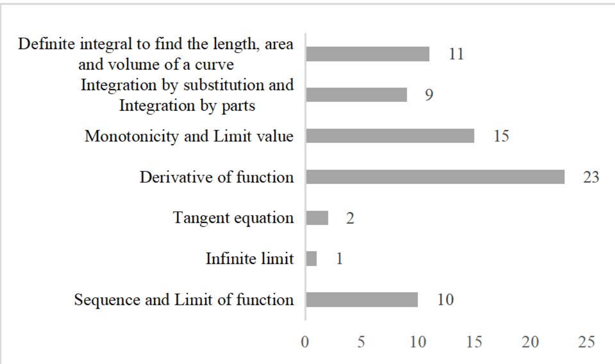

Figure 2: The knowledge points statistics of three universities calculus to examine

To sum up, as for calculus, the secondary entrance examination of top universities in Japan not only requires students to master the application of differential (monotone of functions, extreme value, etc.), simple definite integral, and area by integral method, which are required to be learned in Chinese high school courses. It is also required to master such knowledge as limit of number series and function, summation of series, integration by substitution, integration by parts, length of curve by integration, and volume of rotation by integration, which only appear in advanced mathematics courses of science and engineering in Chinese universities.

3.3 Difficulty Analysis

The difficulty model originated from the report that Nohara submitted to the National Center for Education Statistics in 2001 [6]. Based on Nohara's overall difficulty model, Bao Jiansheng proposed a comprehensive difficulty model that included five factors: "exploration", "background", "operation", "reasoning" and "knowledge amount" [7]. On the basis of this model, scholars combined with the characteristics of their own subject courses, appropriately increased the corresponding difficulty model factors [8-10], and built a comprehensive difficulty model suitable for analysis needs. In mathematics test questions, in addition to factors such as reasoning and calculation that affect the difficulty of test questions, the presence or absence of parameters in the test questions often also affects the difficulty of the test questions. In the examination questions of Japanese secondary entrance examination, many questions include the discussion of parameters. Therefore, the factor of "whether it contains parameters" is added here, and the comprehensive difficulty model is revised into six aspects: "exploratory level", "background factor", "operational level", "reasoning ability", "knowledge content" and "whether it contains parameters", and the level of each factor is specified. See Table 1 for details.

According to the comprehensive difficulty coefficient framework established in Table 1, the following difficulty coefficient model is established:

$$d_i = \frac{\sum_j n_{ij} d_{ij}}{n} \left(\sum_j n_{ij} = n; i = 1,2,3,4,5,6; j = 1,2,\ldots\right)$$

Where $d_i (i = 1,2,3,4,5,6)$ respectively represent the values of six difficulty factors: "background factor", "exploratory level", "operational level", "reasoning ability", "knowledge content" and "whether it contains parameters"; d_{ij} is the weight of the jth level of the ith difficulty factor (1,2,3 are assigned respectively according to the level); n_{ij} represents the number of questions belonging to the jth level of the ith difficulty factor in this group of questions, the sum of which is equal to the total number of questions in this group n. In addition, in order to maintain the objectivity of the division, we analyzed the difficulty indexes of the calculus questions in these three schools according to the detailed solution process provided by the Japanese website of the same question answer.

3.3.1 Integrated difficulty model coding paradigm

The following is an example of Kyoto University 2022 Entrance exam number 5 (see Example 5) to illustrate how to code according to the different level connotations described in Table 1 for each difficulty factor.

Table 1: Comprehensive difficulty coefficient frame structure and connotation

Factor	Level	Code	Connotation	weights
Exploratory level	Use	A1	There is no need to dig deep into the hidden conditions of the test, and fewer steps are required to complete the solution	1
	Analyze	A2	It is necessary to analyze one or several mathematical knowledge or the hidden conditions behind it, and the subsequent solution is simpler or programmatic	2
	Comprehensive exploration	A3	It is necessary to deeply analyze the hidden conditions behind it, synthesize the obtained conditions or hidden conditions behind it, and need a more complex process or flexible mathematical method to solve the problem	3
Background factor	No background	B1	There is no specific background in the test questions, and the questions are developed on the mathematical knowledge itself, and the logical reasoning and calculation of pure mathematics are examined.	1
	With background	B2	Mathematical problems are integrated into specific life, common sense situations, or use other scientific knowledge such as mathematical images and other background to develop problems	2
Operation level	Simple Symbolic Operations	C1	Operations include simple mathematical logic reasoning, such as binomial calculations, trigonometric transformations, simple limit calculations, simple derivatives and their addition, subtraction, multiplication and division operations, simple integrals, etc.	1
	Complex Symbolic Operations	C2	There are complex logical reasoning in the test questions, such as complex reasoning and proof, seeking limits, derivation of complex compound functions, integral operations, etc.	2
Reasoning ability	Non-reasoning	D1	No reasoning, just arithmetic	1
	Simple reasoning	D2	Relatively simple mathematical knowledge background reasoning, reasoning steps within 3 steps	2
	Complex reasoning	D3	More abstract mathematical knowledge background reasoning, reasoning steps in 3 or more steps	3
Knowledge content	1 knowledge point	E1	The answer to the question requires 1 knowledge point	1
	2 knowledge points	E2	The answer to the question requires 2 knowledge points	2
	More than 3(≥3) knowledge points	E3	The answer to the question requires 3 knowledge points	3
Whether it contains parameters	No parameter	F1	The solution is not affected by the change of parameter(s)	1
	Contained parameter(s)	F2	The questions contain parameter(s), and the solutions involve the classification and calculation of parameters	2

Example 5(Tokyo University Question 5, 2022) The area of the figure enclosed by the curve C: $y = cos^3 x\,(0 \le x \le \frac{\pi}{2})$, the X-axis and the Y-axis is denoted as S. If $0 < t < \frac{\pi}{2}$, and the area of the rectangle OPQR with point $Q(t, cos^3 t)$ on C, origin O, and points $P(t, 0)$ and $R(0, cos^3 t)$ as vertices is denoted as $f(t)$. Answer the following questions:

Find the value of S;

If $f(t)$ reaches its maximum at only one t ($t = \alpha$), proof: $f(\alpha) = \frac{cos^4 \alpha}{3 \sin \alpha}$;

Proof: $\frac{f(\alpha)}{S} < \frac{9}{16}$.

According to the comprehensive difficulty model constructed, from the perspective of exploration level, this problem requires irregular graph integration, derivative of complex function, monotonicity and maximum value, and requires comprehensive knowledge points to be analyzed. However, the solution is more programmed, so it belongs to the analysis level, namely A2. From the perspective of background, there is no background condition in this question, namely B1; Integrals and derivatives involved in solving this problem are relatively simple without too many complex operations, which belong to simple symbolic operations, namely C1; The reasoning steps to solve this problem are more than 3 steps, which belongs to complex reasoning, namely D3; This question examines five knowledge points, namely, E3, including area by definite integral, derivative by elementary function, derivative algorithm, monotone and extreme value. This question has no parameters and belongs to F1. So this question is coded as A2B1C1D3E3F1.

According to this example of comprehensive difficulty model, calculus examination questions from three top universities in Japan during 2018-2022 are analyzed question by question, and specific quantitative indexes of difficulty are obtained, as shown in Table 2:

Table 2: Quantitative Index of Calculus Knowledge Difficulty Factors in three Japanese Universities (2018-2022)

Factor	Level	Question quantity & percentage	Tokyo University	Kyoto University	Tokyo Institute of Technology
Background factor	No background	quantity	15	11	8
		percentage	100%	100%	100%
	Have backgrounds	quantity	0	0	0
		percentage	0	0	0
	Weighted average		1	1	1
Exploratory level	Use	quantity	1	2	1
		percentage	6.67%	18.18%	12.5%
	Analyze	quantity	11	7	0
		percentage	73.33%	63.64%	0
	Comprehensive exploration	quantity	3	2	7
		percentage	20%	18.18%	87.50%
	Weighted average		2.133	2	2.75
Operation	Simple Symbolic Operations	quantity	5	5	2

level		percentage	33.33%	45.45%	25%
	Complex Symbolic Operations	quantity	10	6	6
	Non-reasoning	percentage	66.67%	54.55%	75%
	Weighted average		1.667	1.636	1.75
Reasoning ability	Non-reasoning	quantity	0	0	0
		percentage	0	0	0
	Simple reasoning	quantity	4	2	2
		percentage	26.67%	18.18%	25%
	Complex reasoning	quantity	11	9	6
		percentage	73.33%	81.82%	75%
	Weighted average		2.733	2.818	2.75
Knowledge content	1 knowledge point	quantity	2	1	0
		percentage	13.33%	9.09%	10
	2 knowledge points	quantity	2	3	1
		percentage	13.33%	27.27%	12.5%
	3 knowledge points	quantity	11	7	7
		percentage	73.33%	63.64%	87.5%
	Weighted average		2.6	2.545	2.875
Whether it contains parameters	No parameter	quantity	10	8	4
		percentage	66.67%	72.73%	50%
	Contained parameter	quantity	5	3	4
		percentage	33.33%	27.27%	50%
	Weighted average		1.333	1.364	1.5
Comprehensive difficulty			11.466	11.363	12.625

3.3.2 The results of comprehensive difficulty analysis

(1) Background factor

As can be seen from Figure 3, the calculus questions of the three universities in recent 5 years did not appear in the background of life and science, so the students' calculus knowledge mastery and comprehensive application ability were tested directly from the mathematical knowledge itself.

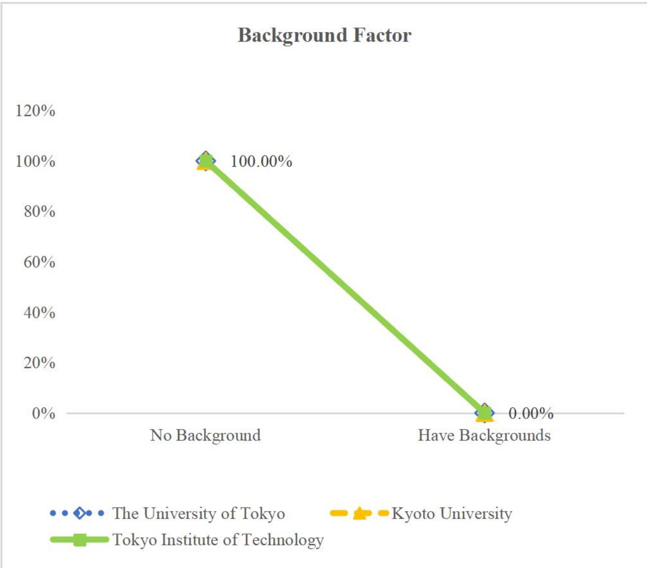

Figure 3: Comparison of Background Factors in Calculus Topics in Three Universities

(2) Exploratory level

In terms of exploratory level factor, there is a big difference among the three universities. The University of Tokyo and Kyoto University account for more questions at the level of analysis, both accounting for more than 60%, while the Tokyo Institute of Technology accounts for more questions at the level of comprehensive exploration, accounting for 87.5%. The sum of analysis and comprehensive exploration in these schools is more than 80%, and that in the University of Tokyo is more than 90%. It can be seen that calculus questions in Japanese top universities have very high requirements on students' exploratory level and attach great importance to the examination of the depth of knowledge.

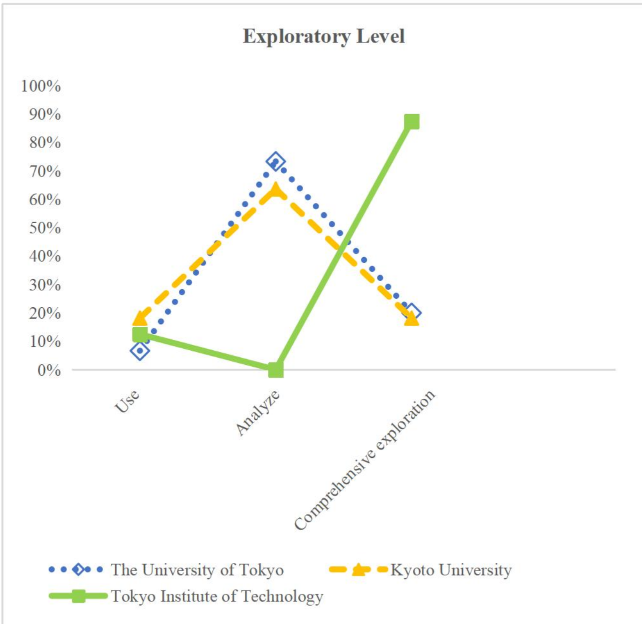

Figure 4: Comparison of the Inquiry Levels of Calculus Topics in Three Universities

(3) Operation level

As can be seen from Figure 5, among the test items of calculus, the level of complex symbol operation (derivative of complex function, complex integral operation and complex limit value, etc.) accounts for 75% in Tokyo Institute of Technology, which is about 3 times that of simple symbol operation (derivative of simple function, simple integral calculation and simple limit). At the University of Tokyo and Kyoto University, the proportion of complex symbol arithmetic questions is about 2/3 and 1/2, respectively.

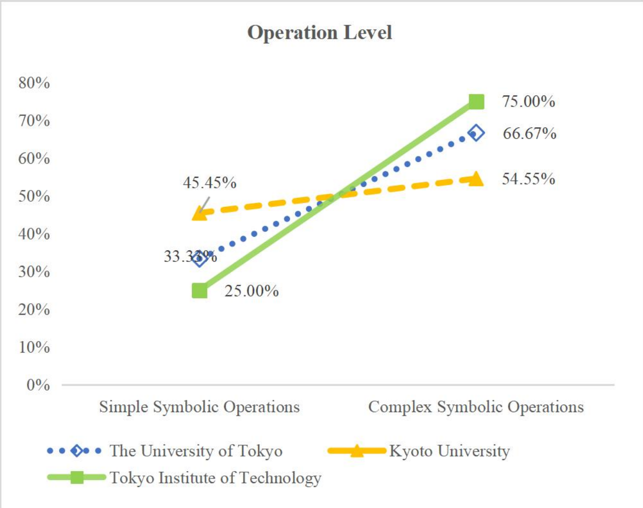

Figure 5: Comparing the Computational Levels of Calculus Topics in Three Universities

(4) Reasoning ability

As can be seen from Figure 6, there are no non-reasoning questions in the calculus examination of the three universities, and complex reasoning questions account for a significant proportion. Complex reasoning questions in the three universities all account for more than 70%, about 3-4 times the number of simple reasoning questions. Thus, the calculus questions in the three universities focus on students' logical reasoning ability.

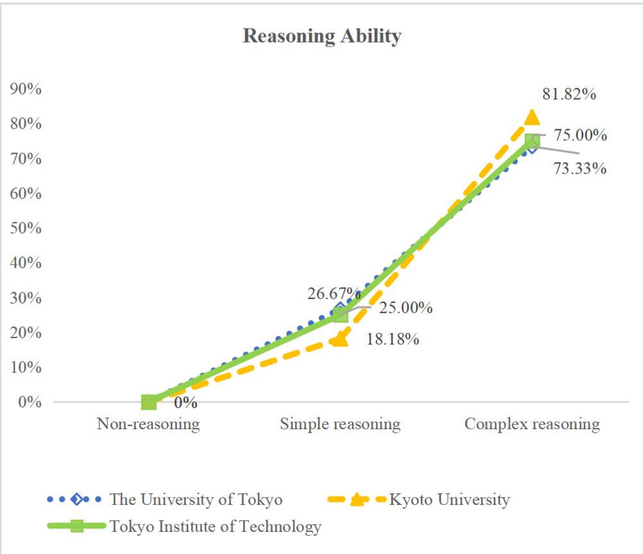

Figure 6: Comparison of Reasoning Levels of Calculus Topics in Three Universities

(5) Knowledge content

As shown in Figure 7, most of the questions in the three universities examined two or more knowledge points, and about 2/3 or more of the questions examined three or more knowledge points, especially in Tokyo Institute of Technology, the proportion of the questions examined three or more knowledge points accounted for 87.5%, indicating that the mathematics entrance examination of the three universities covered a wide range of calculus knowledge, so students should have a strong calculus comprehensive knowledge reserve.

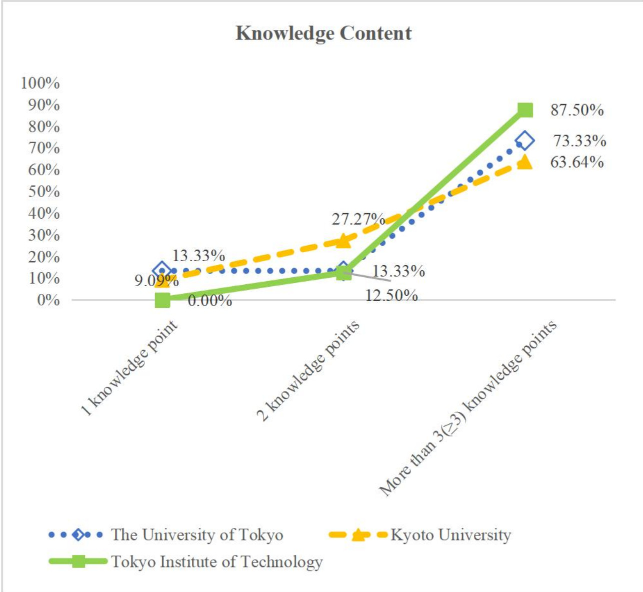

Figure 7: Comparison of Knowledge Content of Calculus Topics in Three Universities

(6) Whether it contains parameter(s)

As can be seen from Figure 8, Tokyo Institute of Technology has the largest proportion of calculus questions with parameters, followed by the University of Tokyo and Kyoto University. The comprehensive calculus test is already difficult for most students, and the inclusion of parameters undoubtedly makes the test more challenging.

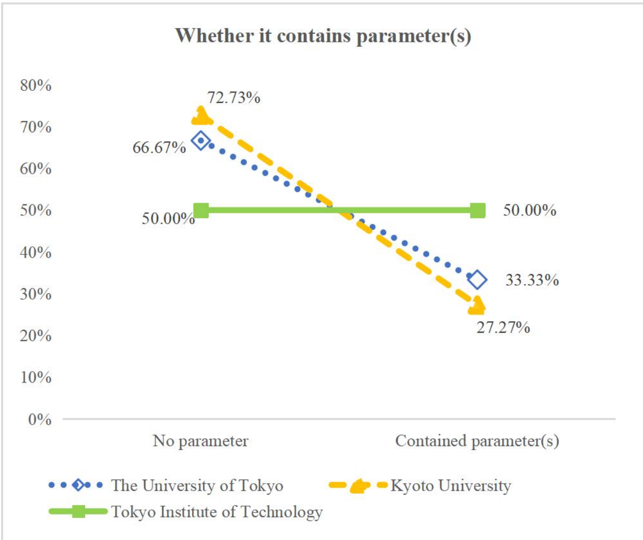

Figure 8: Comparison of whether it contains parameter(s) of Calculus Topics in Three Universities

Based on the six difficulty factors, including background factors, inquiry level, knowledge content, reasoning ability, the comprehensive difficulty radar map of calculus knowledge test questions of three universities in recent five years was obtained (see Figure 9) according to their weighted average value. The comprehensive difficulty coefficients of each school are calculated separately [the bold numbers in Figure 9 represent the 6 difficulty coefficients of the University of Tokyo, the 6 numbers in italics correspond to Kyoto University, and the remaining 6 numbers correspond to Tokyo Institute of Technology]. It was 11.466 in the University of Tokyo, 11.363 in Kyoto University and 12.625 in Tokyo Institute of Technology. The weighted average of inquiry level, knowledge content and reasoning ability is equal to or higher than 2, indicating that the calculus questions of these three universities pay attention to the examination of students' inquiry level and reasoning ability. The content of knowledge is large, there is no background test questions, and the proportion of questions involving exploration level is large, which indicates that the test questions not only test the breadth of students' calculus knowledge, but also test the depth of understanding of calculus knowledge.

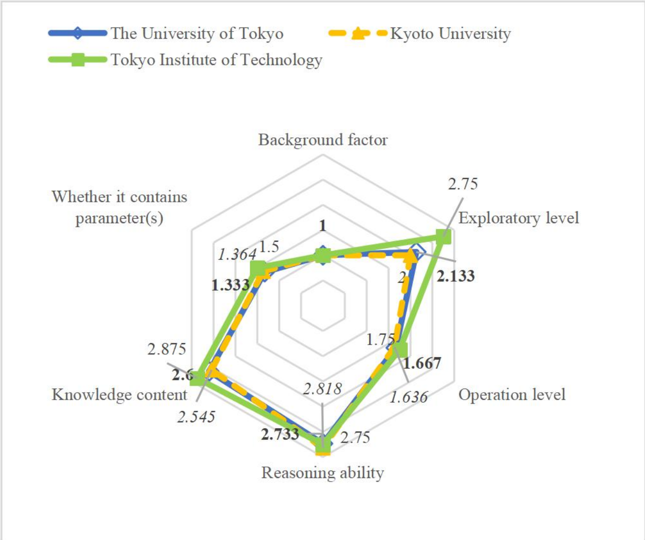

Figure 9: Comparison of comprehensive difficulty of calculus questions in three colleges and universities in recent 5 years

The numbers in bold in Figure 9 represent the 6 difficulty factors of the University of Tokyo, the 6 numbers in italics correspond to those of Kyoto University, and the remaining 6 numbers correspond to those of Tokyo Institute of Technology.

4. Conclusion and Suggestion

4.1 Conclusion

(1) Calculus examination content of three colleges and universities has a wide range of knowledge and comprehensive strength

The University of Tokyo, Kyoto University and Tokyo Institute of Technology have 40% of the test questions in the past 5 years, including limit, differential calculus, integral, the examination content basically covers the knowledge points required in the "High School Study Guide" every year, including series limits, function limits, infinite series, higher-order derivatives, definite integral applications (finding curve length, curved edge graphic area, solid volume) and other calculus knowledge learned during Chinese universities. At the same time, these calculus questions are often combined with other knowledge points such as analytic geometry, vectors, number theory, etc., which puts forward high requirements for students' comprehensive mastery and application of mathematical knowledge.

(2) The entrance exams of the three colleges and universities are equally difficult to test calculus knowledge

Through the quantitative analysis of the weighted average results of six comprehensive difficulty factors, it can be seen that the weighted average of the three schools in background factors, whether they contain parameters, knowledge content, reasoning ability, and computing level is not much different, and the exploration level factor of Tokyo Institute of Technology is higher than that of the other two schools. In general, the three universities in Japan have a similar comprehensive difficulty in calculus questions, not only focusing on the examination of students' arithmetic level, but also paying special attention to testing students' knowledge accumulation, logical reasoning and inquiry level.

(3) The calculus examination of the entrance examination of the three universities focuses on students' comprehensive mathematical literacy

The second entrance examination for Japanese colleges and universities is similar to the self-enrollment examination in China. The purpose is to select gifted students to enter universities for high-level learning. Therefore, the examination of calculus knowledge not only requires students to understand this part of knowledge, but also requires in-depth exploration of knowledge. The knowledge points and question types tested in the calculus type test every year do not change much, but the complete solution requires students to have excellent mathematical comprehensive literacy such as analysis, calculation, spatial imagination and logical reasoning. For example, Kyoto University's question 6 of 2020 to find the volume of a rotating body requires students to be proficient in the method of using the integral method to find the volume of a rotating body, and also requires a high spatial imagination ability, considering the rotation of the curve in space to form a surface, and then calculating the volume of the three-dimensional figure formed by the rotation of the surface around coordinate axis, which has a strong comprehensiveness.

4.2 Suggestion

(1) In the selection of gifted students, the examination of calculus should be strengthened and the difficulty of the examination should be appropriately increased

As an important force in the country's future cutting-edge scientific and technological research, gifted students in mathematics and science often learn more deeply and comprehensively than other students. At the same time, in the gifted selection questions, calculus, as one of the basic contents of university science and engineering learning, is widely used in scientific and technological innovation and other fields, and should become one of the important contents of the examination. Therefore, in the selection of gifted students in mathematics such as the High School Mathematics League and the "Plan", the examination of calculus should be strengthened, and the comprehensive examination of test questions should be paid attention to, so as to further improve the efficiency of the selection of gifted students.

(2) Depending on the specific situation of the student, the calculus course is divided into classes or different difficulty materials are selected

At present, China is implementing the "3+1+X" college entrance examination reform, and students have a clear understanding of the direction of their future majors in high school subject selection. Therefore, at the high school level, according to the student's own learning ability and the major to be studied, students who have outstanding performance in mathematics and science or who need more solid basic knowledge of mathematics and science in the future will be taught in different classes or choose teaching materials with different difficulty than students who choose to study literature and history or majors that do not have high requirements for basic knowledge of mathematics and science in the future. In this case, students who have outstanding interest in mathematics or need a solid foundation of mathematical knowledge, teachers can choose textbooks with more rigorous logical order of calculus system to learn calculus theory and application more systematically; For students who choose to study majors that do not have high requirements for mathematical knowledge, teachers can choose less difficult textbooks to teach the preliminary knowledge of calculus, and truly teach according to aptitude to meet the learning needs of different students.

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