Introduction to University Calculus for "Bunkei'' Students in Waseda

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Abstract. *In these days, mathematics is one of the most important tools for any person. However, in Japan, many students hate and avoid mathematics in their high school age. In Waseda University, one of the biggest and oldest private universities in Japan, special curriculum is constructed for such "Bunkei'' students who major in social or human science.*

Keywords: *math education, economy, commerce, "Bunkei" students, high school math, higher school math, curriculum for «Bunkei», social science, Humanities, "Rikei", natural science*

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Introduction

First, we shall discuss about background and our aim in this paper.

"Bunkei" and "Rikei". In Japan, in many cases, each senior high school is divided into 2 courses, "Bunkei" and "Rikei" for the preparation of the entrance examination of universities. In "Bunkei" course, they study social and human sciences, mainly. In "Rikei", they study natural science, mainly. At the end of first grade of senior high school (=tenth grade), they have to choose one of them. Teachers recommend "Rikei" to excellent students, not after their interest but the score of mathematics. So, almost all "Bunkei" students hate or avoid mathematics. Yes, they do not need math for their entrance examination at university. Hence, at the entrance of university, many "Bunkei" students have very few (or sometimes no) knowledge of mathematics.

New plan in math education as liberal arts in 21st century. Waseda university, one of the oldest, biggest and strongest private universities in Japan, has constructed a new plan on liberal arts[1]. It has five divisions – academic writing, English, information (and communication) technology, statistics and mathematics. In our math division, we teach in four parts: 1) calculus, 2) linear algebra, 3) mathematical structures, 4) mathematics, logic and communication.

Such "Bunkei" students, 80 percent of Waseda's students, need to learn high school math again, but we decided that we DO NOT give "high school math" itself. It should be some kind of "university math".

In 2007, the second author S. Takagi started to plan the course, especially, parts 1 and 2. He named them as "Introduction to University Math" and planned that we teach not only high school math but also some application to economy or commerce. So, in part 1, we teach calculating interest and its preparation in high school/university math, and linear algebra and

[1] In Waseda university, that plan is named "Waseda Next 125" after the 125th anniversary year in 2007 [1].

linear programming, in part 2. Later, the third author H. Uesu reinforced such application in part 1 after his knowledge of math education. The first author, T. Sobukawa has constructed part 4 in 2014 and other version of part 1 in 2017. Part 3 is just in preparation.

In this paper, we shall introduce the history of part 1, as a new suggestion on math education in university.

Main part: On calculus – Basic policy

They say math is an important tool for "Bunkei" studies. So, classes of basic mathematics, calculus and linear algebra in many cases, have been organized at each university. However, in general mathematics classes, emphasis is often placed on solving mathematical problems without the point of contact with the real world. Hence, the motivation for learning mathematics is reduced for "Bunkei" students who wish to use mathematics as a tool.

Therefore, we decide the goals of this course are the following: 1) simple and compound interest, 2) install deposit, 3) repayment of loan, 4) mini/max problems of 2 variable functions, used in mathematical economy.

In high school in Japan, they learn the following topics in calculus and related fields:

1) linear and quadratic function, 2) exponential functions, 3) logarithmic functions, 4) trigonometric functions, 5) other functions, 6) sequence and series (arithmetic, geometric etc.), 7) recursive relation in sequence, 8) limit, 9) derivative/differentiation, 10) integration.

We pick up useful topics of them to study our goal. So, we have constructed 3 courses.

Version 1.0, Takagi's plan (2008–2014)

A basic plan of the course is "prepare first, then apply".

Course A. Takagi created the elementary level "Course A" for "Bunkei" students who especially hate or avoid mathematics until now. In 2008, as the first version 1.0, he put the following units of this course:

1) concept of numbers and sets,
2) exponential and logarithmic functions,
3) sequence and series,
4) limit,
5) binomial theorem,
6) Napier's number and proof of existence the number,
7) concepts of interest, simple and compound interest, continuous compound interest, calculation of simple and compound interest.

The flow of learning that deals math and economics separately is as usual.

He also wrote a textbook dedicated to these learning contents [2], and made video lectures based on it. The main feature of this textbook is that the notations of University Math are explained as the first section for elementary "Bunkei" students. After the first quarter, most students felt hard to study especially the proof of existence of Napier's number. Therefore, he revised the course units each year. Finally, he arranged this course as version 1.4 with the following units:

1) exponential functions,
2) logarithmic functions,
3) sequence and series,
4) binomial theorem,
5) limit and Napier's number,
6) concepts of interest, simple and compound interest, continuous compound interest,
7) calculation of simple and compound interest.

This revised textbook [3] contains the appendix that deals with not only economics but other applications, pyramid scheme, magnitude of earthquake, hydrogen-ion exponent (pH), equilibrium state of heat etc. Recurring decimal, the ε-N method of limit, the continuity of real line are also discussed in appendix. Another feature of this revised textbook is used square root, exponential and logarithm tables. These would support that students understand math deeply.

Course B. In 2009, Takagi set up a new intermediate level "Course B" for those who took the elementary level "Course A". This "Course B" has the following units:

1) concepts of interest, revisited,
2) useful functions (revisited),

3) limit and continuity of functions
4) recursive definition of arithmetic and geometric sequences,
5) recursive definition by affine transform,
6) equal principal/total payment,
7) annual rate and real annual rate.

One of the features of this course is that the concepts of interest are explained in detail that depends upon the Japanese language. He wrote a textbook dedicated to this course [4]. In this textbook, recursive definition between 3 terms is not treated in the main course. Fibonacci sequence is considered in appendix, only. As to this course, there are few revisions of contents [5].

For the "Bunkei" students with some mathematics skills, Takagi also put a pretest which can judge which course should be taken. Even if the "Bunkei" students do not take the elementary level "Course A", they can take the intermediate level "Course B" without taking "Course A" if they pass the pretest. The pretest consists of the following five questions of five alternatives[2]:

1. Which one is correctly calculated $\left(\sqrt[12]{2}\right)^{36}$?

2. When expressing $1{,}1^x = 2$ using logarithm, which one is correctly represented?

3. What is the limit value $\lim_{n\to\infty}\left(1+\frac{1}{n}\right)^n$?

4. When a person who always walks at 4 km/h is walking y km for x hours without rest, which one does correctly represent the relationship between x and y?

5. Which is the correct limit as $x \to 0$ of the function $f(x) = -1(x < 0), 0(x = 0), 1(x > 0)$?

Course C. As the advanced class, for introduction to calculus, the followings were given[3]:

1) functions,
2) definition of derivative,
3) derivative of polynomial functions,
4) (local) maximum and minimum, convexity and concavity,
5) partial differential of 2 variable functions,
6) extreme problems of 2 variable functions,
7) utility function method.

There three courses have a big feature that trigonometric functions and integrations are NOT treated.

Minor version up has been given every year. Finally, we got version 1.4.

Version 2.0, Uesu's plan (2014–)

The plan of this version is "studying math among economy".

H. Uesu arranged Takagi's version (ver.1.4) and rewrote the textbook of calculus [6–8]. The big difference between ver.1.4 and ver. 2.0 is the introduction of each learning content. Takagi wrote textbooks (like ordinary mathematical textbooks) in the order of "definition, theorem, proving". Uesu had considered that such textbook style would be very tough for mathematics learning for "Bunkei" students who are not used to studying mathematics. Therefore, he wrote mathematical contents after introducing economic examples so that the mathematical meaning can be understood smoothly. In other words, he wrote examples of economics and the mathematics used there, rather than suddenly introducing mathematical concepts.

In addition, he composed Course A and Course B as a series of courses. As with ver.1.4, Course A is an elementary level and Course B is an intermediate level, but Uesu wrote a textbook with the aim of learning "Napier's number" through Courses A and B. For that reason, he advised "Bunkei" students to take Courses A and B in order.

Course C is for students who wish to learn mathematics more. The difference from ver.1.4 is that the first concrete examples are placed in the middle of the course. As with Courses A and B, he wrote students to make understand basic mathematical concepts through concrete examples.

The contents of each course are as follows.

Course A. Course A's subject goal is "to acquire important basic knowledge of calculus". We explained the fundamental of the sequence,

[2] Here, we omit the choice of five alternatives.

[3] This course was given by Dr. R. Shinjo, Associate Professor of Kokushikan University, former Assistant Professor of Waseda University.

exponential function, and logarithmic function, by taking an example of the compound interest calculation. It consists of the following 7 lectures:

1) simple interest and sequence;

2) simple interest and arithmetic series. Through these 2 lectures, students learn about the basis of a sequence (general term of sequence, sum of sequence, etc.) and arithmetic progression;

3) compound interest, then geometric progression and series;

4) annual/half year compound interest, then exponential function;

5) quarterly or shorter compound interest and comparison of simple/compound interest. As an example of compound interest in the length of the period, students learn about the mathematical characteristics of exponential functions and linear functions;

6) compound interest and logarithmic function. Students learn about logarithmic function after an example of number of years reaching target amount in compound interest;

7) loan repayment, then recursive definition of sequence.

Course A includes important items of basic mathematics. Students can acquire useful knowledge in real life such as simple/compound interest calculation and loan calculation.

Course B. Course B's subject goal is "to understand Napier's number". We explained the recurrence relations of the sequence, the limit, and Napier's number, by taking an example of the loan calculation. The following lectures are included:

1) simple and compound interest (revisited);

2) the system of repayment of loan, equal principal/equal total repayment, add on repayment;

3) equal total repayment and recursive definition of sequence, real annual rate;

4) monthly equal total repayment. In these two lectures, student also learns how to solve the recurrence relations of a sequence;

5) limit of sequence to consider continuous compound interest;

6) binomial theorem, as an example of total amount in compound interest calculation;

7) Napier's number and continuous compound interest.

We explain about the knowledge for advanced students such as loan calculation and loan repayment.

Course C. Course C's subject goal is "method of Lagrange multiplier". We explained the differentiation of one variable and the differentiation of two variables, by taking an example of the utility maximization problem. The course includes the following lectures:

1) definition of derivative, exponential/logarithmic functions;

2) formulae of derivative and mean value theorem;

3) higher derivative and graph of functions;

4) application to economy I, utility function and budget constraint and maximization problem;

5) function of 2 variables, definition, continuity and partial derivative;

6) implicit function theorem and conditional extremal problems of 2 variable functions, then, the method of Lagrange multiplier;

7) utility limit, indifference curve and utility maximization, an example of multivariable calculus.

We composed Course C as ver.1.4 redesign. The goal of the subject is to learn the representative solution of the conditional maximization problem "method of Lagrange multiplier". As an example, we explain the utility maximization problem, etc.

We consider that there are two significances of learning these courses as follows: 1) mathematical economy is studied deeply; 2) every mathematical tool is explained among economy. So, this course is, so to say, good for the "Rikei" students, because they have no chance to study such topics.

About the former, mathematics is necessary to model the problem and to clarify its mechanism and to suggest a solution. From these courses, students are able to learn it with reasonable pace.

About the latter, in general "Rikei" mathematics classes, emphasis is often placed on solving mathematical problems without much emphasis on the point of contact with the real world. Therefore, it is very meaningful for students to learn the application of mathematics.

Version 1.5, Sobukawa's plan in English (2017–)

After the policy of Japanese government, Waseda is preparing many lectures in English. Some students, educated in foreign countries, need such math courses. They have each math-history. Therefore, it is difficult to construct in the method of version 2.0, depending on the education in Japan or Japanese language.

Therefore, T. Sobukawa has constructed the course NOT after Uesu's idea but Takagi's.

Course A. This course consists of:

1) exponential functions,
2) logarithmic functions,
3) sequence and series,
4) binomial theorem,
5) limit and Napier's number,
6) simple and compound interest,
7) install deposit.

This course has several features. Before the version 1.4, notation of university math was explained [3], because the student who has studied in Japan does not use it. However, it is closely related to the expression in English. This version is given for the students studied abroad. So, we omit it. Moreover, many mathematical concepts are treated slightly, e.g. the definition of limit. We need it for pure math but not in economy. On the other hand, we add the theory of install deposit in lecture 7 to use the theory of arithmetic/geometric series. In the version before 1.4, we cannot find the reason why they study them. We DO NOT treat the definition of limit of sequence/function rigidly than other versions.

Course B. This course consists of the following lectures:

1) useful tools, exponential/logarithmic functions, sequence and series, revisited;
2) install deposit, revisited;
3) linear and quadratic approximation of data;
4) sequence, recursive definition by affine transform;
5) recursive definition among 3 terms;
6) equal principal payment;
7) total equal payment.

This course has several features: in the lecture 3, we treat Lagrange (linear and quadratic) interpolation (approximation). It is just the preparation to correlation coefficient on statistics. Recursive definition among 3 terms of sequence has treated in the lecture 5. It is a preparation to numerical analysis.

Sobukawa claims these courses have to give such preparation for other studies.

Conclusion

We have offered three courses on math education for "Bunkei" students at university. They are also useful for "Rikei" students for their study.

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Введение в курс математики для гуманитариев в Университете Васэда

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Аннотация. *В наши дни математика является важным инструментом для любого человека. Между тем в Японии многие студенты ненавидят математику и избегают ею заниматься со времен обучения в средней школе. В Университете Васэда, одном из старейших и крупнейших частных высших учебных заведений Японии, для студентов-гуманитариев («Bunkei»), специализирующихся в социальных и экономических науках, разработано три специальных практико-ориентированных курса по математике. В статье представлено содержание каждого курса.*

Ключевые слова: *преподавание математики, курс математики для студентов-гуманитариев, Bunkei, Университет Васэда*

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