

# iOS 上における離散数学の論理的な学習用アプリの開発に関する研究

## Logical Learning System of Discrete Mathematics on iOS

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### 1. Social Background

MEXT (Ministry of Education, Culture, Sports, Science and Technology) of Japan announced that textbooks in elementary school and junior high school are changed to electronic books in 2020 [1]. Therefore all paper textbooks are abolished and students will take the lessons using electronic terminal. There are many various learning applications in the world, for example, e-Text [4] [5], iTex viewer [6] and digital text in Japan [7] [8]. Furthermore there are many theses of learning system, for example, electrical engineering [9], electromagnetics [10], fusion of education, entertainment and training [11], computer science [12], distributed learning system [13], digital logic design [14], multilingual user interface [15] and online learning [16]. But these applications lack logicity. Thus, we implemented an logical learning application.

### 2. iOS

Apple smartphones of 6.5 million in the 1st quarter of 2016 and one of 8.5 million in the 1st quarter of 2017 were sold in Japan [17] [18]. These breakdowns are Figs. 1-2. Apple smartphone is the second most popular in the world(see Figs. 3-4) [19]. From these figures, we saw that smartphone of Apple is one of the most popular smartphones.

### 3. Sets of Discrete Mathematics

We can learn discrete mathematics, especially sets, using the Logical Learning Application. In mathematics, a set is a collection of distinct objects, considered as an object in its own right. For example, the numbers 2, 4, and 6 are distinct objects when considered separately, but when they are considered collectively they form a single set of size three, written  $\{2, 4, 6\}$ . The concept of a set is one of the most fundamental in mathematics.

Developed at the end of the 19th century, set theory is now a ubiquitous part of mathematics, and can be used as a foundation from which nearly all of mathematics can be derived. In mathematics education, elementary topics such as Venn diagrams are taught at a young age, while more advanced concepts are taught as part of a university degree [20].

## 4. Logicality

### 4.1 Venn Diagram

At first, we consider to proof by venn diagram, for example

$$A \cup (B \cup C) = (A \cup B) \cup C. \quad (1)$$

From Fig. 5, because the shadow of  $A \cup (B \cup C)$  is same as one of  $(A \cup B) \cup C$ , Equation(1) is true. This proof is venn diagram.

### 4.2 GeoGebra

GeoGebra [21] is dynamic mathematics software that made the geometry, the algebra, the spreadsheet, the chart, the statistics and the analysis one package which is easy to use. GeoGebra is a community which consists of millions of users of all over the world. GeoGebra is supporting innovation of STEM (scientific: Science, technological: Technology, engineering: Engineering and mathematics: Mathematics) education, learning and guidance all over the world. GeoGebra can operate easily by a GUI, can draw a chart of a numerical formula, can change the parameter, and can judge a movement by a slider. GeoGebra has the numerical formula process functions of the factorization and the differential and integral calculus.

### 4.3 What is proof

The proof of Section 4.1 cannot prove the cases of Figs. 6-7. Therefore this proof is not perfect. Everybody will agree to a logical proof which includes all cases. This time, we implemented the application that we can learn a logical proof.

## 5. Important Points of the Implemented Application

The application has five important points that we consider to be important. These are “What we need to show”, “Symmetric”, “Detective”, “Step by step” and “Interactive”.

### 5.1 What we need to show

When we do not know procedure of proof, we cannot solve. Thus, we need to know what we need to show. We can know how to solve a problem by making clear what is goal of a problem (see Fig. 10).

### 5.2 Symmetric

Discription is sometimes parallel. We can compare difference of proofs by making it symmetric visually. Fig. 11 shows the whole proof of Equation(1). This consists of two columns. One side shows “ $A \cup (B \cup C) \supset (A \cup B) \cup C$ ”. Other side shows “ $A \cup (B \cup C) \subset (A \cup B) \cup C$ ”. They are located symmetrically. As a result, learners can understand the parallelness of the description of the proof.

### 5.3 Detective

Detective is to expect and argue unknown things with known things. It is possible to make learners

consider what continue after by not giving all sentence of proof (see Figs. 12-15). For example, to stop only “(ii)  $x \in B \cup C$  のときさらに” in Fig. 14 then additional, “(ii-1)  $x \in C$  または (ii-2)  $x \in B$  となる。” in Fig. 14, they will think continuation of proof. So, to stop makes to think.

## 5.4 Step by step

We can obtain a solution to deduce gradually when we solve a problem. To give learners hints little by little, they can learn certainly stepwise(see Fig. 12).

## 5.5 Interactive

There are various methods to show solution of proof: For example, to show all of sentences, to show oneline sentence at a time, to show sentences parallely, etc. Thus, students can select a method as they can learn. Students can choose from several items that they want to learn (see Figs. 8-9). Students can choose a solution method they like to tap the buttons in Figs. 11-15. To tap the button “表示” in Figs. 11-15 every time, oneline sentence appears. When students want to know proof early they can see to tap the button “一括表示” in Figs. 11-15. If students still do not understand, they will be able to do to tap the button “概要/表示” in Fig. 11-15.

## 6. Result and Future Works

We have implemented the application about the notion of sets for discrete mathematics in iOS including “What we need to show”, “Symmetric”, “Detective”, “Step by step” and “Interactive”. First future work is to add animation and venn diagram to implemented application. Second future work, to make the application more interactivity, we would like to make it cooperate with systems, for example

Siri [22]. Xcode [23] [24] has a interactive system concerning a speech framework. Third future work is to be desired that the learning application includes items, for example, contraposition, proof by contradiction and clarity of definition. We will include the other fields of education in the application. Final future work is to get feedback of students that use the application.

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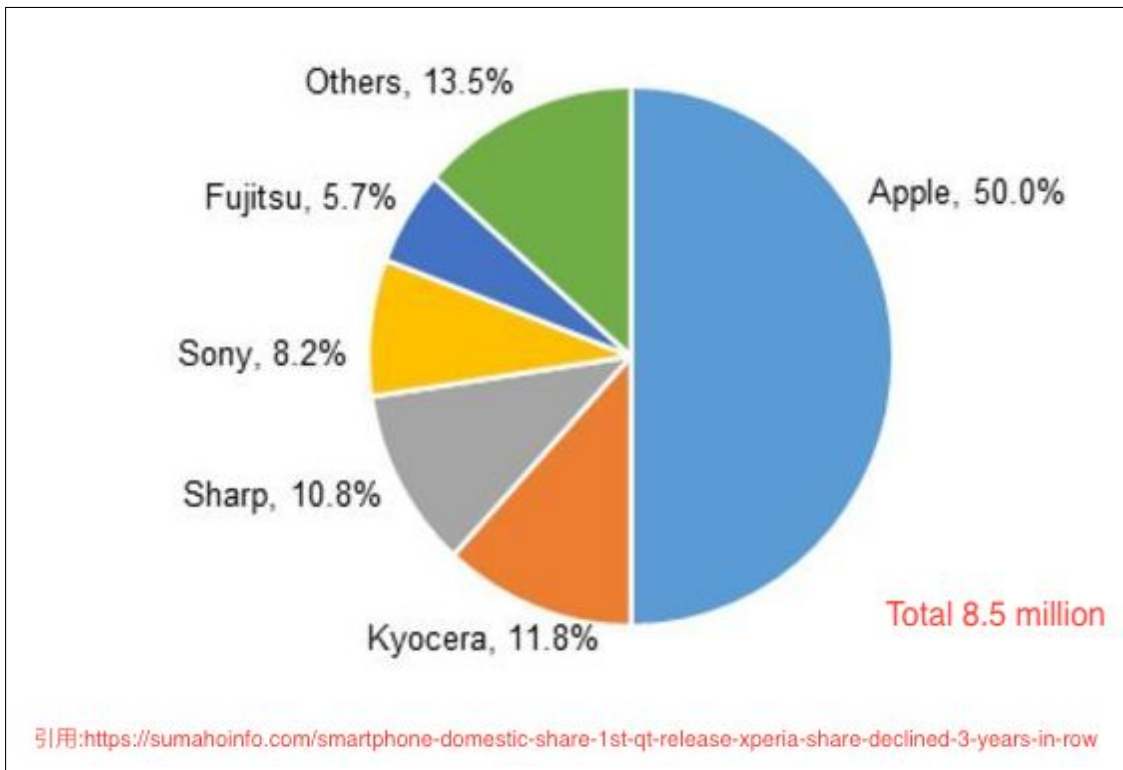


Fig. 1 Share in Japan 1st quarter of 2017

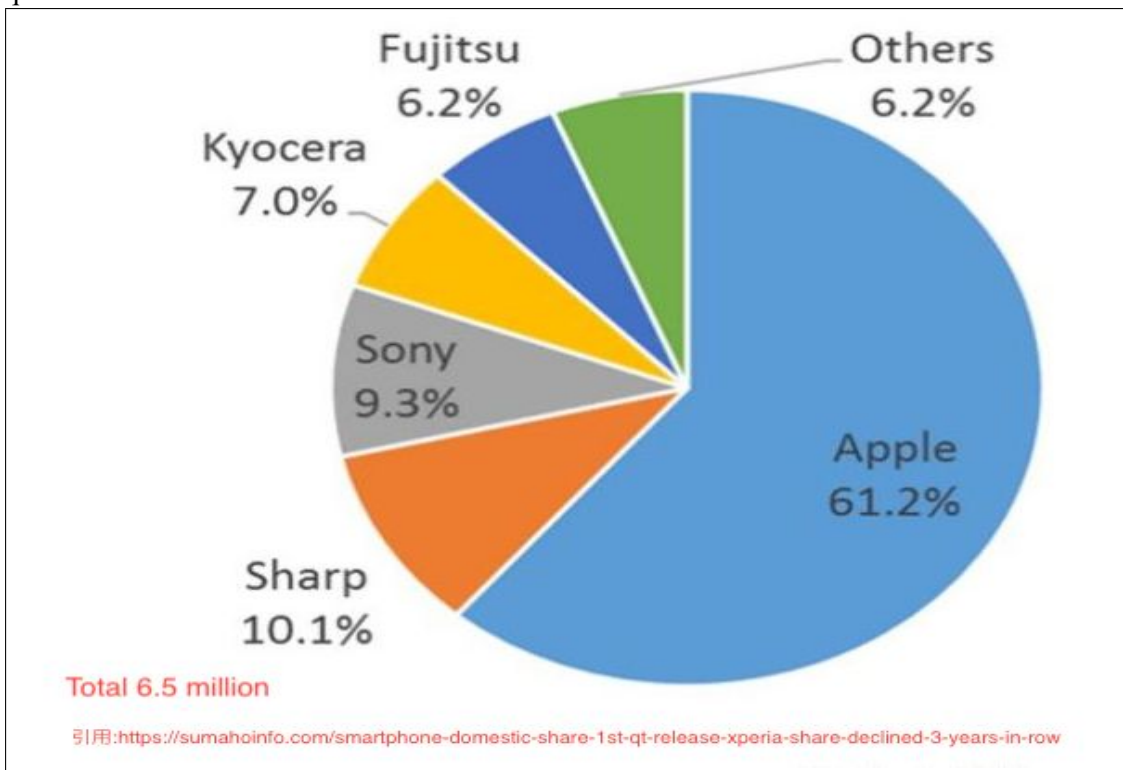


Fig. 2 Share in Japan 1st quarter of 2016

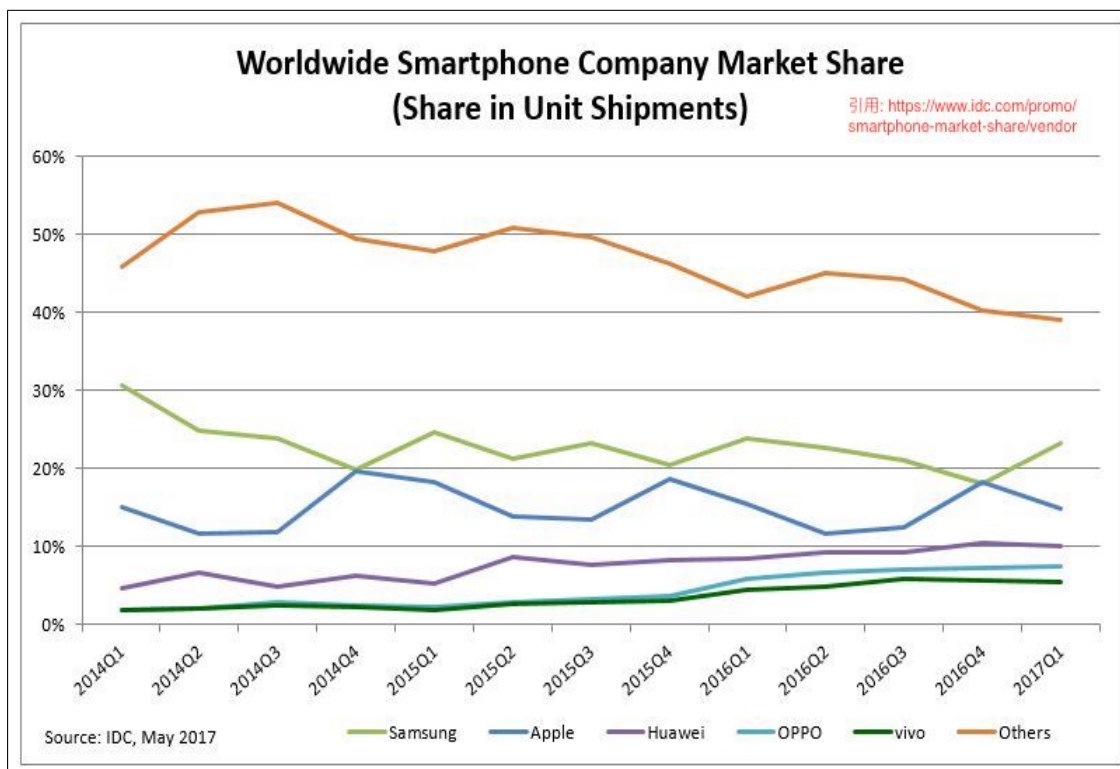


Fig. 3 Share in the world  
2014-2017

Period	Samsung	Apple	Huawei	OPPO	vivo	Others
2016Q1	23.8%	15.4%	8.4%	5.9%	4.4%	42.1%
2016Q2	22.7%	11.7%	9.3%	6.6%	4.8%	45.0%
2016Q3	20.9%	12.5%	9.3%	7.1%	5.9%	44.3%
2016Q4	18.0%	18.2%	10.5%	7.3%	5.7%	40.2%
2017Q1	23.3%	14.7%	10.0%	7.5%	5.5%	39.0%

Source: IDC, May 2017

引用: <https://www.idc.com/promo/smartphone-market-share/vendor>

Fig. 4 Share in the world  
2016-2017

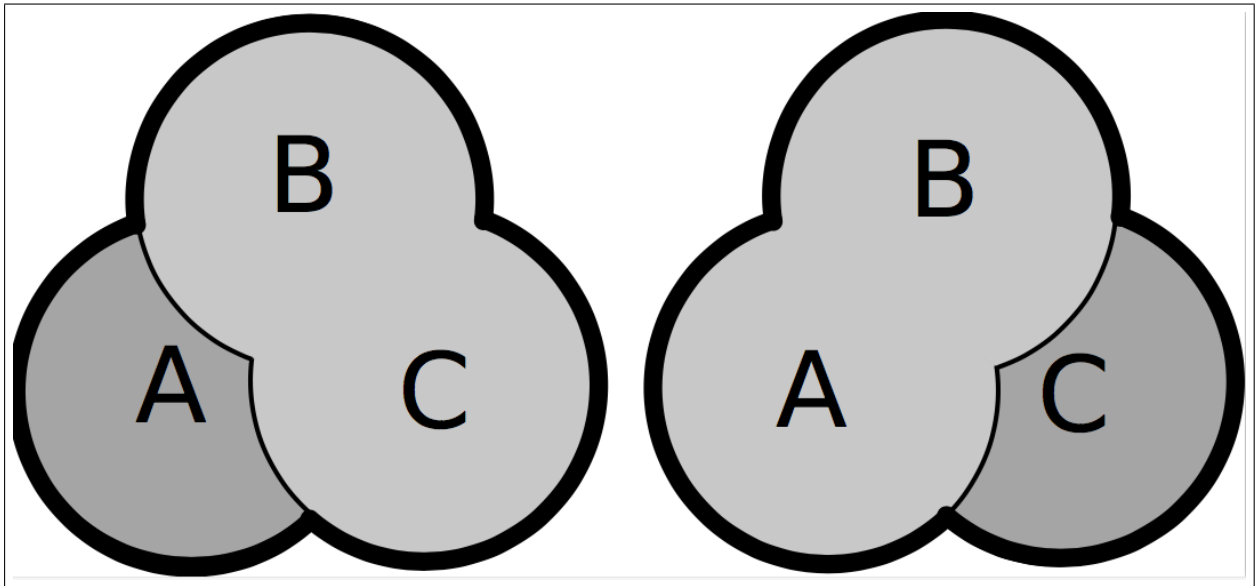


Fig. 5 Venn diagram 1

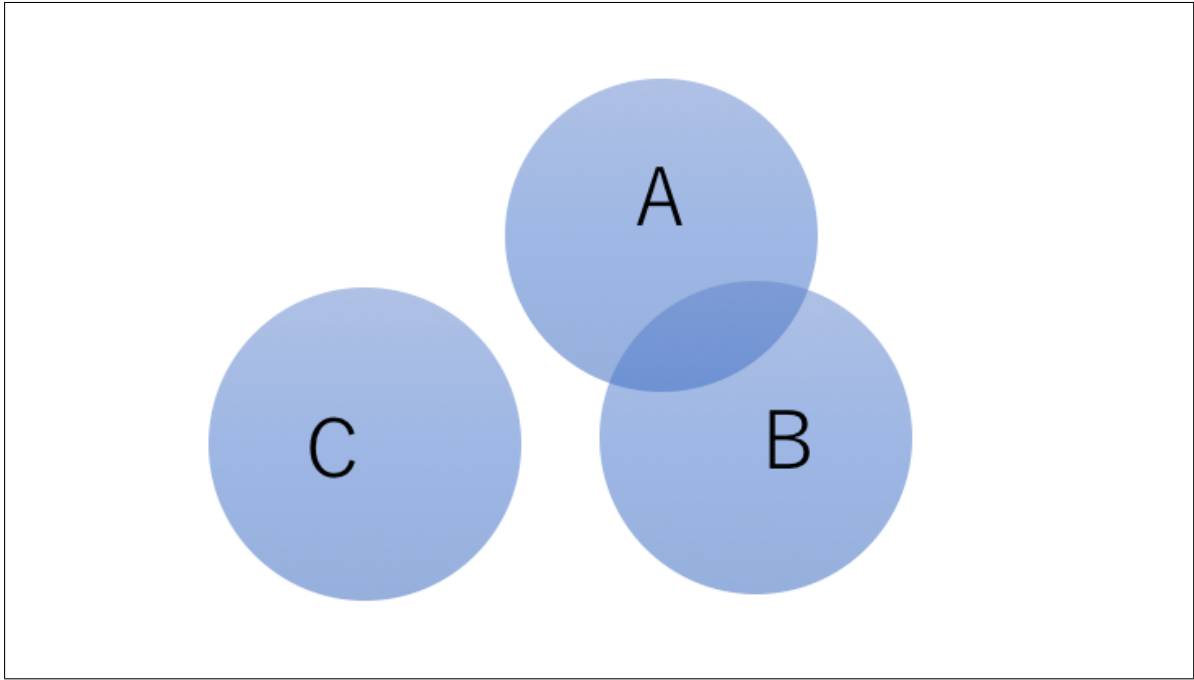


Fig. 6 Venn diagram 2

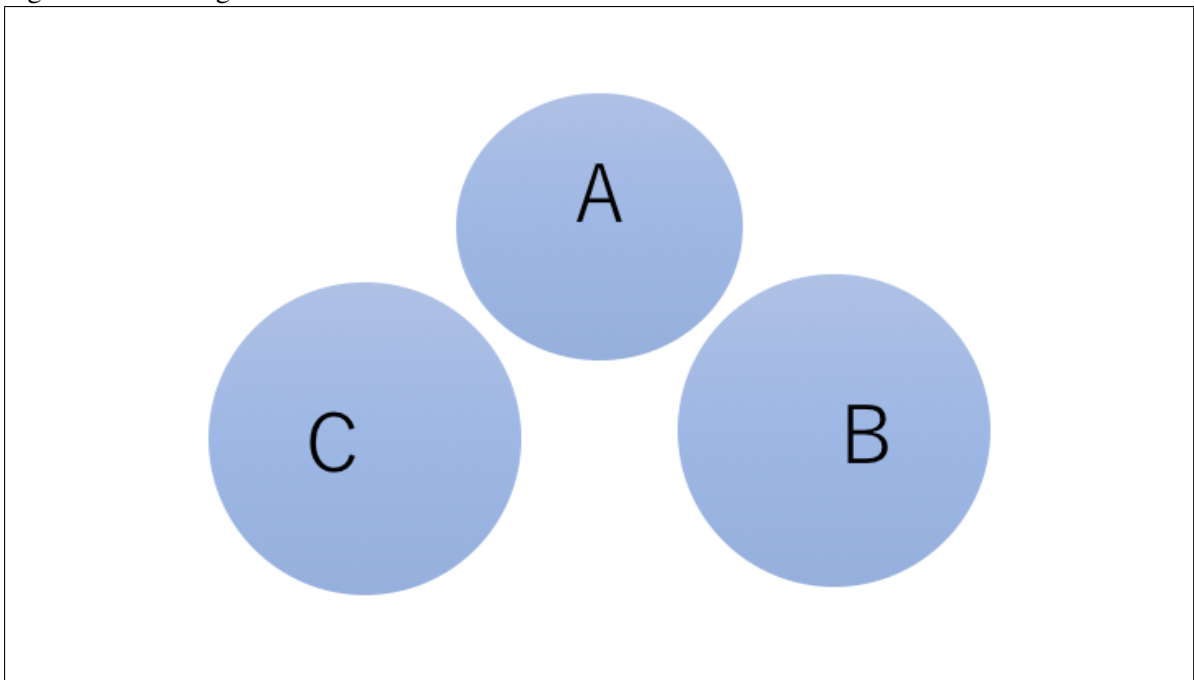


Fig. 7 Venn diagram 3



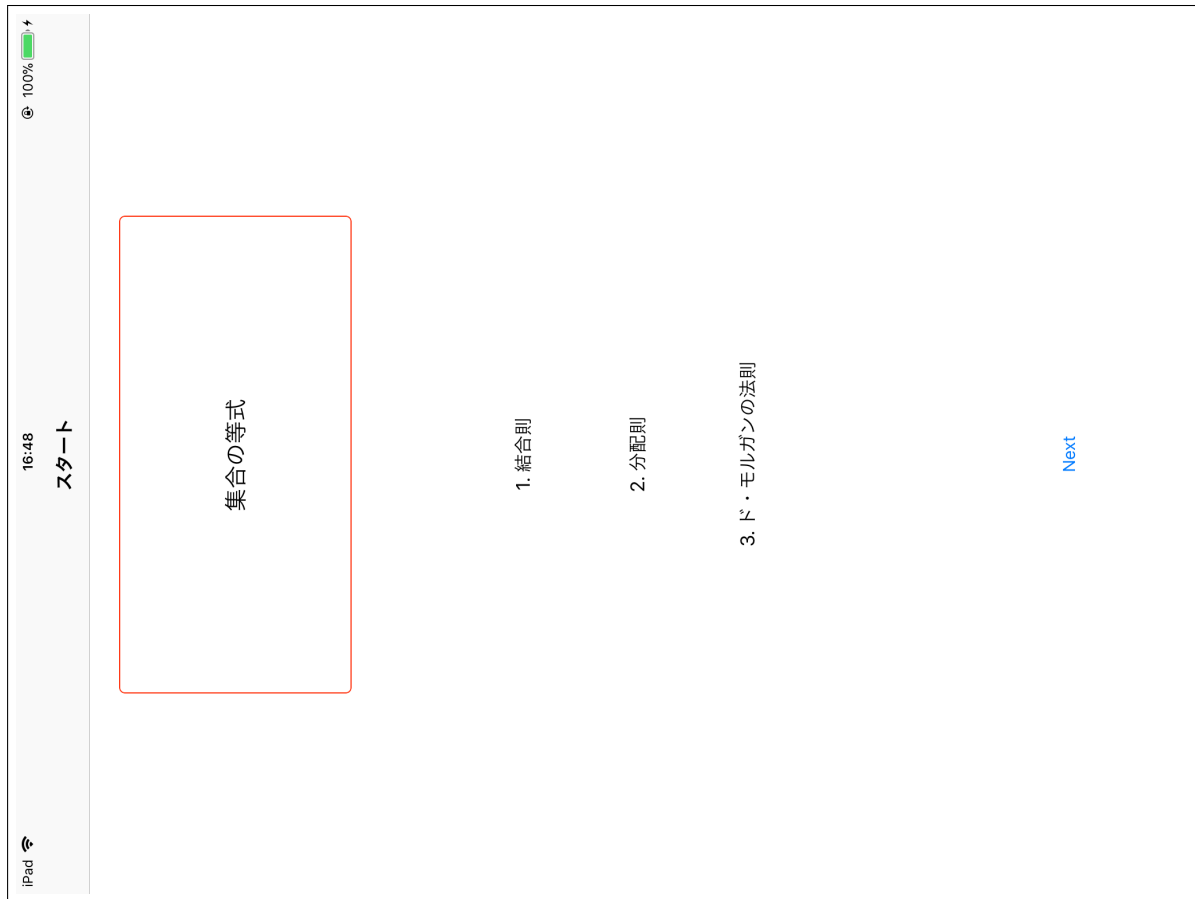


Fig. 8 Screen shot1 of Application



Fig. 9 Screen shot2 of Application



Fig. 10 Screen shot3  
of Application



Fig. 11 Screen shot4  
of Application



Fig. 12 Screen shot5  
of Application



Fig. 13 Screen shot6  
of Application



Fig. 14 Screen shot7  
of Application



Fig. 15 Screen shot8  
of Application