A Method to Understand Psychological Factors Needed to Improve Learning Behavior

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***Abstract*— Learning behavior is influenced by psychological factors. Therefore, if teachers desire to improve the learning behavior of their students, they need to know the relevant psychological factors and their role in improving learning behavior. From this point of view, this paper reports a method to quantitatively understand the psychological factors needed to improve learning behavior and their shortages by using a decision tree. Our proposed method is expected to effectively utilize adaptive learning for class design to improve students' learning behavior.**

Keywords-Psychometrics; Data mining; Learning behavior.

I. INTRODUCTION

We propose a method to quantitatively understand psychological factors related to improving learning behavior.

In cognitive psychology, knowledge is categorized as procedural or declarative [1]. "Procedural knowledge" is knowledge about performing various actions (e.g., a calculating ability such as addition, subtraction, division or multiplication). It is acquired by repetition of its action. "Declarative knowledge" has a network structure that regards knowledge as a "node" and the relations of knowledge as "edges". One node connects to another along an edge [1]. To acquire declarative knowledge, the learner needs to learn while thinking about the meaning of each bit of knowledge. From the above, if the teacher wishes students to acquire procedural knowledge, he/she has to assign a task or homework involving exercise with repetition (e.g., in the case of calculating ability, the teacher assigns many numerical calculations to students). In contrast, for students to acquire declarative knowledge, the teacher must both assign an appropriate task and appropriate learning while thinking about the meaning.

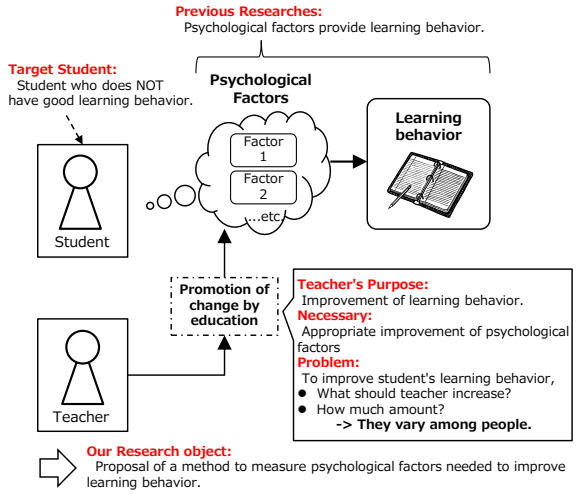

Figure 1. Problem to occur when teacher improves student's learning behavior.

However, Teranishi pointed out that the number of people who learn without thinking about it is increasing [2]. If the teacher wishes for them to acquire the appropriate declarative knowledge, he/she has to improve their learning behavior. However, changing learning behavior is difficult [3]. Thus, we consider that teaching students declarative knowledge is more difficult than teaching them procedural knowledge. For the above reason, our research target is to improve learning behavior needed to acquire declarative knowledge.

Horino mentioned the importance of improving the psychological factors that provide learning behavior [3]. Previous research [3][4][5] also mentioned that the effective factors related to learning behavior are psychological factors. Therefore, to improve a student's learning behavior, it is necessary for the teacher to improve the student's psychological factors. Figure 1 illustrates a problem that occurs when a teacher improves a student's learning behavior. The teacher is going to improve the student's learning behavior by his/her education. According to previous research on improving learning behavior, it is necessary to improve the psychological factors. However, the required psychological factor to improve learning behavior and its shortage vary among people. Teachers need to understand the missing psychological factors and their shortages. However, there is presently no method to measure a psychological factor to improve students' learning behavior. Because of this, the following problem occurs. The teacher cannot understand what he/she should change in the student's psychological factors and by what amount it should increase to improve the student's learning behavior. To solve this problem, this paper proposes a method to quantitatively understand the psychological factors required to improve a student's learning behavior.

In Section II, we present the necessary strategies to achieve our purpose and an outline for it. In Section III, we detail the results of a survey about psychological factors affecting learning behavior. In Section IV, we explain a

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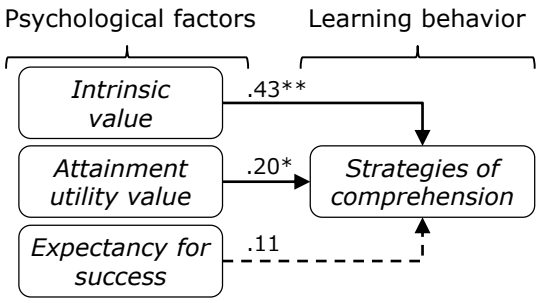
TABLE I. TECHNICAL TERM

Psychological factors
Intrinsic value means fun and interest about learning contents.
Attainment utility value means recognitions of merit about acquiring and using knowledge of learning contents.
Expectancy for success means confidence about learning contents.
Learning behavior
Strategies of comprehension are learning behavior such as study with understanding meaning.



	Mean	SD
Intrinsic value	0.50	0.29
Attainment utility value	0.64	0.22
Expectancy for success	0.57	0.21
Strategies of comprehension	0.57	0.20

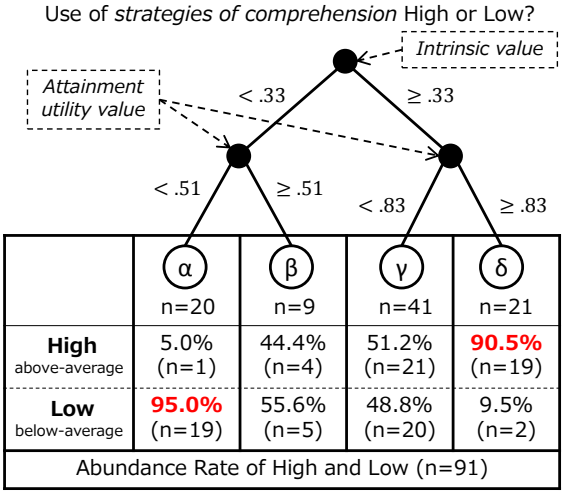
Figure 2. SEM of psychological factors and learning behavior. Dashed line is NOT statistically significant.

method to quantitatively measure the psychological factors needed to improve learning behavior. In Section V, we provide this paper's summary and the prospects for future work.

II. OUTLINE

We focus on mathematics as the subject of our method because Ichikawa says that many learners are weak in this area [6]. We adopted *strategies of comprehension*, which are effective learning strategies for knowledge acquisition in mathematics (defined in Learning Behavior in Table I) [2]. Ichihara tried to explain that the use of *strategies of comprehension* is influenced by the elements in Eccles's expectancy-value theories (*Intrinsic value*, *attainment utility value*, and *expectancy for success*) [4][7]. In imitation of this, we adopted *intrinsic value*, *attainment utility value*, and *expectancy for success* as our psychological factors (Psychological Factors are defined in Table I). Based on the above discussion, this paper focuses on learners who use few *strategies of comprehension*. Here, we describe our method to understand quantitatively the psychological factors needed to increase the use of *strategies of comprehension*. In order to do this, we need to address the following two points.

(1) Understanding the kind of psychological factor that provides use of *strategies of comprehension*.



Dependent variable (Binary variable, "High" or "Low") :
→ *"Strategies of comprehension"*
Independent variable (Quantitative variable, [0,1]) :
→ *"Intrinsic value", "Attainment utility value"*

Figure 3. Decision tree.

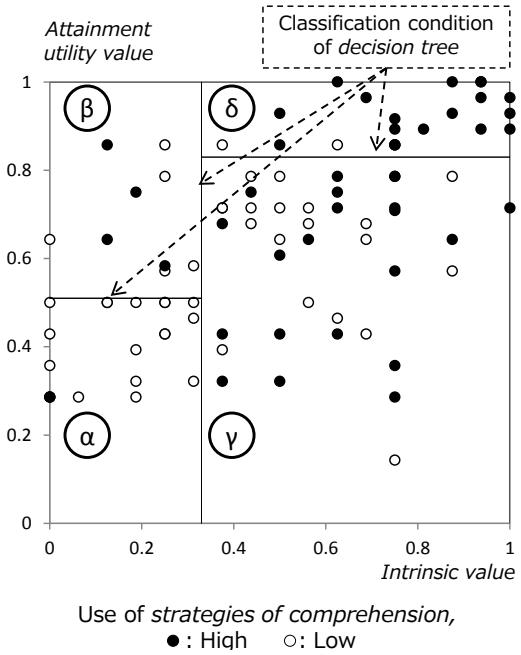


Figure 4. Scatter plot to be classified by decision tree.

(2) Understanding the conditions (in the form of the *Decision Tree* discussed in Section III) of the psychological factors selected in (1) to encourage use of *strategies of comprehension*.

Item (1) is covered in previous research [4]. Thus, we re-inspect it using *Structural Equation Modeling* (*SEM*). We apply item (2) to the result of clustering by *decision tree* based on the result of (1). We then consider conditions connected to improving the use of *strategies of comprehension*. To get the full picture of items (1) and (2), we surveyed 91 students of high school to score items on their *intrinsic value*, *attainment utility value*, *expectancy for*

TABLE II. AN EXAMPLE OF USED QUESTIONNAIRE. THERE ARE ALL ITEMS IN [4].

***Intrinsic value* (Total 7 items)**
(1) I think mathematics is interesting. (2) I like mathematics. (3) I enjoy studying mathematics. (In addition, there are 4 items.)
***Attainment utility value* (Total 8 items)**
(1) It is important for me to be good at mathematics. (2) I think the knowledge of mathematics will be useful in future. (3) The knowledge of mathematics is important for learning other subjects. (In addition, there are 5 items.)
***Expectancy for success* (Total 7 items)**
(1) I have confidence about being good at mathematics. (2) I have confidence about understanding learning contents in mathematics lesson. (3) I have confidence about getting good score in the mathematics tests. (In addition, there are 4 items.)
***Strategies of comprehension* (Total 7 items)**
(1) When I study mathematics, I prove a theorem. (2) When I read mathematics' textbook, I use critical thinking (e.g., Why is this theorem proved by this proof process?). (3) When I solve mathematics' problem, I think specific image. (In addition, there are 4 items.)
Answer Form (6-Likert-Scale)
About the above question items, please choose one : 1: Very **Negative** 2: **Negative** 3: Little **Negative** 4: Little **Positive** 5: **Positive** 6: Very **Positive**

success, and *strategies of comprehension*. We created the survey questions based on Ichihara's items, generated by a factor analysis (Table II shows some of them. The answer form is on a 6-Likert scale).

III. RESULTS AND DISCUSSIONS

We standardized *intrinsic value*, *attainment utility value*, *expectancy for success*, and *strategies of comprehension* to range from 0 to 1. Figure 2 presents the result of (1), along with the mean and standard deviation. The partial regression coefficients of *intrinsic value* and *attainment utility value* were statistically significant. This result is similar to previous research [4]. We thus determined that *intrinsic value* and *attainment utility value* could be used to categorize the amount of *strategies of comprehension* used. For the above reason, we performed clustering in the form of a *decision tree*. To do this, *strategies of comprehension* was classified into above average (High) and below average (Low). We then regarded *strategies of comprehension* as the dependent variable and *intrinsic value* and *attainment utility value* as independent variables. Based on these conditions, we performed clustering in the form of a *decision tree* (see Figure 3 and the corresponding scatter plot in Figure 4). We set the horizontal axis as the *intrinsic value*, the vertical axis as the *attainment utility value*, and the density of colors as the abundance ratio of *strategies of comprehension* state in terms of "High (Black)" and "Low (White)", and

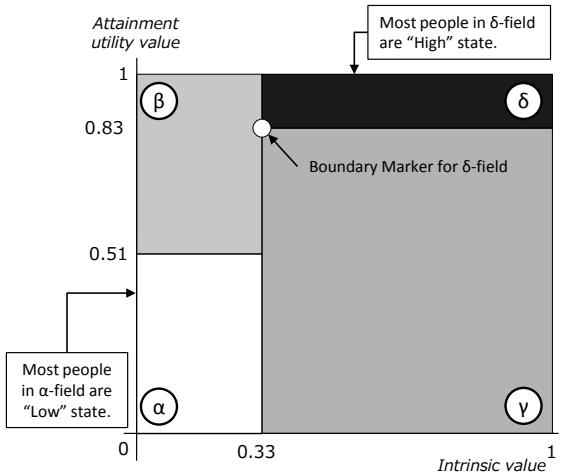


Figure 5. 2D Map of Psychological Factors and Learning Behavior. The density of color means High and Low rate. Black=High, White=Low.

constructed a *2D Map of Psychological Factors and Learning Behavior* (Figure 5). The map has four fields according to the abundance ratio ("High" or "Low") of the amount of *strategies of comprehension* used and the value of the psychological factors.

- **α-field (White)** Most of the subjects are in a "Low" *strategies of comprehension* state. *Intrinsic value* and *attainment utility value* are low.
- **β-field (Grey)** The abundance ratio of the *strategies of comprehension* state: ("High" or "Low") is nearly half-and-half. *Intrinsic value* is low.
- **γ-field (Grey)** The abundance ratio of the *strategies of comprehension* state ("High" or "Low") is nearly half-and-half. *Attainment utility value* is low.
- **δ-field (Black)** Most of the subjects are in a "High" *strategies of comprehension* state. *Intrinsic value* and *attainment utility value* are high.

If a student's *strategies of comprehension* state is "Low," it is desirable to move the point of their *intrinsic value* and *attainment utility value* into the δ-field to improve their use of *strategies of comprehension*.

IV. PROPOSED METHOD

Based on the result in Section III, we determined that the shortages of *intrinsic value* and of *attainment utility value* to improve the use of *strategies of comprehension* represent the difference between "Student Marker" and "Boundary Marker for δ-field" (Figure 6). The teacher can understand the shortage of these psychological factors, which vary from person to person, to improve learning behavior by following five steps.

Step 1. Measure *strategies of comprehension* of students using the questionnaire in Table II.

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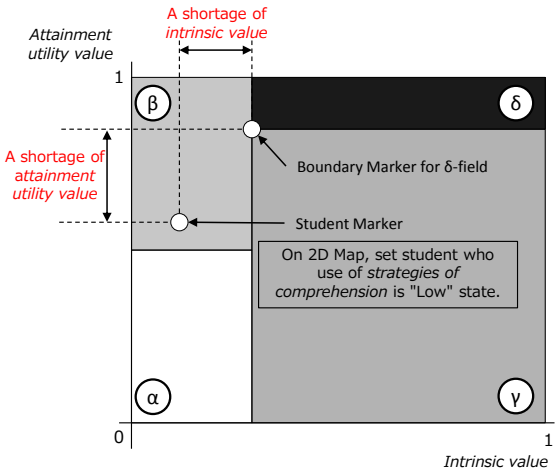

Figure 6. Definition of the degree of psychological factor needed to improve use of strategies of comprehension.

Step 2. Sample students in the "Low" state for *strategies of comprehension*.

Step 3. Measure *intrinsic value* and *attainment utility value* of these students (using the questions in Table II).

Step 4. Understand the shortages of *intrinsic value* and/or *attainment utility value* by calculating the difference between Student and Boundary Marker for the δ-Field on a 2D Map (Figure 6).

Step 5. If the teacher wants to know the average shortages for his/her own class, he/she calculates them from the individual shortages.

We applied our proposed methods to two classes (*a* and *b*). Table III presents the results of Steps 1 to 5. The insufficient psychological factors of *a-Class* were *intrinsic value* and *attainment utility value*. However, the only insufficient psychological factor of *b-Class* was *attainment utility value*. With this method, we can quantitatively understand the psychological factors needed to improve the use of *strategies of comprehension*.

V. SUMMARY AND FUTURE WORK

There presently is no method to measure the psychological factors needed to improve learning behavior. Thus, this paper proposed a measuring method for these factors. The adopted psychological factors were *intrinsic value* and *attainment utility value*. The adopted learning behavior was *strategies of comprehension*. We proposed a method to understand the shortage of each psychological factor in order to improve learning behavior using these factors. This paper described the research process as follows.

(1) Re-inspect the causal relationship reported in previous research (Figure 2) [4].

(2) Construct a *2D Map of Psychological Factors and Learning Behavior* using a *decision tree* (Figure 5).

(3) Determine the shortages of the psychological factors needed to improve the use of *strategies of comprehension* (Figure 6). (The procedures to achieve this are given as Steps 1 to 5 in Section IV).

TABLE III. RESULT OF STEPS 1-5

	Average shortage amount	
	Intrinsic value	*Attainment utility value*
a–Class (*n*=22)	0.16	0.36
b–Class (*n*=25)	0.01	0.35

From (2) and (3), a teacher can quantitatively understand the shortages of psychological factors that vary among people to improve students' learning behavior. We applied this method in two classes (Table III). In the results, the shortages of the psychological factors were different in each class (Table III). By using this result, teachers will be able to design adaptive learning approaches based on improving learning behavior using psychological factors.

As future work, we will perform education to increase *intrinsic value* and *attainment utility value* in two classes (*a* and *b*, Table III) while monitoring their psychological factors on a *2D Map of Psychological Factor and Learning Behavior* time-serially. Based on this, our next step will be to improve their use of *strategies of comprehension*.

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