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学　位　論　文　要　旨

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題　目　A Study of Mathematical Approaches in Educational Psychology Based on Physical Concepts

In the educational interface, one of the most important issues is to know the mental condition of each student. Also, to see the behavior of students' group is significant. These issues have been researched by means of psychology and social science. For the quantitative analysis of psychology and social science, many approaches have been associated with physics, so that the measurement and theoretical modelling in human behavior have been done as similar as those in physics.

In the mid-nineteenth century, psychology and physics were combined, and the realm was named "psychophysics" which was the study of quantitative relations between psychological events and physical events. The method of measurement and modeling in psychophysics has been developed in imitation of experiment and theory in physics. On the other hand, the behaviors of human crowds have been researched by the method of statistical physics since the nineteenth century, which is called "social-physics". In social-physics, the idea of describing society is that the laws in the social are similar to ones in the physical and biological sciences.

In the present thesis, we develop mathematical approaches to apply for educational psychology based on the concepts of physics, in which the philosophies of psychophysics and social-physics have been succeeded. The core of the present thesis is constructed by mathematical models described in chapters 3, 4 and 5.

Chapter 1 is introduction which describes the structure of the present thesis.

In chapter 2, we compare the physical world to the human world. By the comparison, we clarify different points between physics and psychology/sociology to prepare constructions and interpretations of models in the following chapters.

In chapter 3, we propose a mathematical model on the development of creativity. The present model is an approximated one related not only to nonlinear dynamics but also to quantum theory, reflecting the complicated phenomena of creativity. To construct a specific model, the investigations of the creative attitudes and the related factors based on the statistical surveys for lower secondary school students are reviewed. Two chief factors of the creative attitudes are abstracted; that are "efforts and durability" and "independence and originality". Both the two chief factors are shown to be influenced by impressed experiences which correspond to internal force. The internal force contains discontinuous effects which relates to sudden appearance of idea, expressed by the Dirac delta function. The developments of creative attitudes are expressed by differential equations, that are constructed by means of analogy with the motion of equation in Newtonian mechanics. By the simulations in the model, we can discuss many situations in education of creativity, and predict the growth in terms of creativity. Also, divergent thinking and convergent thinking are discussed in this model. These arguments well explain the transition of education policy in Japan which gradually converted the education from cramming into pressure-free education in the 1970s, but it was modified in the 2000s to increase the amount of knowledge to be attained.

In chapter 4, we propose a novel method to know the classroom conditions by utilizing the concept of entropy which expresses the order or disorder in the system, and a mathematical model called "Weidlich model" which has not used in educational psychology so far. In order to obtain the entropy of classroom, we combine the formula of differential entropy which is the extended quantity from ordinary entropy for continuous random variables, and the Weidlich model which is constructed by an analogy between human decision-making mechanism and the ferromagnetic spin model in statistical physics. We investigate the validity of our approach by using the data of students' lives in school, which are photos on the arrangement of desks after lunch and questionnaires on the school life. By numerical simulations, the classroom conditions are simply expressed by entropy and two parameters which are a measure of interaction of each member and a measure of moral in the classroom. These quantities are invisible ones in the raw data but can be deduced by analyzing with the present method. Thus, we can numerically argue various conditions of the classroom. Comparing the calculated results with the real classroom conditions, we can

find good correspondences, and suggest the usefulness of the present method to know the classroom conditions by rather simple investigations of photographing and questionnaires. In addition, we can find that the entropy analysis of the system in the Weidlich model has different significance against the standard statistical approaches. Namely, the differential entropy and the variance of probability distribution show different behavior, and they should have different meaning. So, calculating of the differential entropy, we can expect to find different viewpoints of the system, which can be find from variance of probability distribution. Thus, focusing on the entropy in the Weidlich model, we can expect to see another aspect that is the order and/or disorder in the classroom conditions. Also, we propose the extended version of prototype of Weidlich model, which can treat many opinions (or attitudes) case.

In chapter 5, we attempt to explain the quantum brain description of our models which are constructed in chapters 3 and 4. For this purpose, the quantum measurement theory and quantum brain dynamics are applied. First, we describe the discontinuous nature in creativity. Namely, the force of the delta function type is explained in the quantum brain level. By this explanation, we have a clue to construct more fundamental model of creativity. Second, we construct a quantum brain model in social science, so that it reduces a candidate of the Hamiltonian by means of incorporating with the Weidlich model which is treated in chapter 4. In particular, we concentrate on a simple phenomenon that one opinion is decided between two opinions in human mind. In order to determine the form of Hamiltonian, we assume a simple process on the propagation of information in the brain. In this model, we propose a new approach on the determination of the Hamiltonian as combining psychological model and quantum brain model.

Chapter 6 is conclusions of the present thesis.

Thus, in this thesis, we propose the novel mathematical models based on the physical concepts and the measuring methods of students' minds in educational psychology.