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Effects of collaborative learning on a complex doubly structured network

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Abstract

The purpose of this research is to clarify the actual conditions of understanding of teaching done in a classroom. As a means to do so, we propose a simulation for in-class learning processes with consideration given to academic capability, learning material structure, and collaborative relationships. We build an internal network by estimating the understanding probability network by the use of Item Response Theory (IRT) and estimating the learning material structure model with the use of the Bayesian network. The influence of teaching strategies on learning effects is analysed in the model. Moreover, the influence of the seating arrangement of learners on collaborative learning effects and ability groups are discussed. As a result of the simulation, the following points were found: (1) the learning effects depend on the difference in teaching strategies; (2) a teaching strategy where learning skills, material structure, and collaborative learning are integrated is the most effective; and (3) seating arrangements affects collaborative learning.

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1. Introduction

In education, it is important to understand the status of the understanding of each learner and design instruction content according to their understanding status. Digitalization of learning environment, called e-learning, has enabled the accumulation of records containing a vast amount of information concerning the learning history of students. Many technologies to gain an understanding status of each learner sequentially have been produced¹⁻⁴.

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Additionally, there exist relationships between knowledge and the content to be instructed, and it is important to consider the structural dependency relationship when teaching is done. The effectiveness of the collaborative effect among learners has also been clarified.

In the research field of network models, recently, a new model building method, referred to as a complex doubly structured network model, has been proposed⁵⁻⁷.

By using this complex doubly structured network model in this research, we tried to integrate the understanding status, knowledge structure, and collaborative effect of each learner in order to simulate the actual conditions of the learners' understanding for instructions given in a classroom based on previous studies⁸⁻¹⁰. Moreover, we set and examined the issues described below by applying the simulation method.

1. What kind of influence could teaching strategies have on learning effects?
2. What kind of influence could the seating arrangement of learners have on collaborative learning effects?
3. What kind of influence could ability groups and mixed-ability groups have on collaborative learning effects?

2. In-Class learning process simulation

In this research, we tried to build a simulation with a class consisting of 30 learners, where it was assumed that five instructions, from X1 to X5, are used when teaching them. This simulation was to estimate what material should be taught, in what order and how many times, until all learners in the classroom could give the correct answer. In this simulation, we used two criteria, the attainment degree and the average time of teaching. The attainment degree indicates the proportion of correct answer given so that the status where all learners give the correct answer reached 1. The average time for teaching indicates the time until the attainment degree has reached 1, which averages 10 simulation sessions.

To build the teaching simulation, we used correct answer history data for model estimations, correct answer data in the class, and seating data. Correct answer history data for model estimation has two values, correct/incorrect answers, of all 300 learners for five questions that correspond to the instructions taught from X1 to X5. The history data was gathered from a school in Japan.

2.1. Definition of the internal network

The internal network is composed with multi-layers combined the understanding probability model of knowledge according to the academic capability of each learner and the learning material structure model. When certain knowledge is taught, based on the understanding probability model, the understanding probability according to the academic capability of each learner is calculated. As for knowledge items, the understanding probability propagates along with the material structure model. In this way, the internal network is defined.

2.2. Understanding a probability model

When it comes to the understanding probability model of all knowledge that corresponds to the academic capability of each learner, the item parameter is estimated by conducting the marginal maximum likelihood estimate based on the quasi-Newton's method and the EM algorithm¹¹⁻¹⁸. The ability parameter is estimated by using the experience Bayesian method. By using these estimated values, the understanding probability model is built. Specifically, this estimation is done by using the correct answer history data for model estimation and the "ltm" package on software R¹⁹. The result of this estimation is quantified as the form of Ability. The estimated Ability parameter (item characteristic curve) is set according to the knowledge and the understanding status for all knowledge of each learner at the point in time before teaching, in order to estimate the understanding probability of knowledge of each learner.

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