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Designing an Educational System Using a Model of Clinical Reasoning to Support Novice Physiotherapists' Learning

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The aim of this study is to support the learning of novice physical therapists. When treating a patient, the physical therapist makes clinical reasoning to grasp the patient's intrinsic problems that cause disability. The clinical reasoning is highly logical thinking that deals with complex, ambiguous and unstructured knowledge and the experience of a physical therapist contribute to handling such knowledge. Accordingly, for novice physical therapists, making clinical reasoning appropriately is a challenging problem. To support such novices, this paper proposes a model of clinical reasoning by focusing on the logical structure and provides an educational method with the model. This educational method is designed as a form of problem-based learning (PBL). In this system, a novice determines the patient's situation and therapeutic strategy based on the model, gets an exemplary model created by an experienced physical therapist as feedback. The usability test conducted for incumbents revealed that the proposed system enables novices to create a model in a simple task, leading to a deeper understanding of the cases.

1. Introduction

Advances in medicine have led to lower mortality and longer lives for humans. We have been given more time and we can spend more time realizing our well-being. At the same time, the number of elderly people who are bedridden owing to their age and who cannot live comfortably without receiving care is increasing. These changes have highlighted the importance of not only the quality of life but also the value of life.

Enabling people to live independently without requiring any help improves their quality of life. In particular, physiotherapists commonly help patients who are unable to live independently owing to age, injuries, or illnesses. Although appropriate physiotherapy requires specialized knowledge and experience, this know-how is not systematized because of its complexity and vagueness.

Physiotherapy generally involves the following steps.

(1) Collect patient information.

(2) Use this information to evaluate the patient's condition based on medical evidence.

(3) Based on the evaluation, extract the problems to be addressed.

(4) Develop an appropriate treatment plan for solving the problems.

(5) Perform physical therapy based on the devised treatment plan.

Here, steps (2)–(4) are called clinical reasoning and require advanced logical thinking.

2. Logical thinking for clinical reasoning

Physiotherapy in clinical settings is given to patients with diverse backgrounds, including physical issues such as muscle weakness in the lower limbs and restricted range of motion as well as social issues such as wanting to walk from home to a supermarket to go shopping. However, physiotherapy students cannot experience this variety of backgrounds in medical school; typically, they deal with them only in the field.

Many novice physiotherapists recognize the difference between the clinical reasoning learned in the medical school curriculum and the clinical reasoning performed in actual clinical settings [Sole 2019]. This is because, in physiotherapy, personal experience in clinical settings plays an important role. Indeed, there is a difference in the quality of clinical reasoning between beginners with little clinical experience and experts with much experience. Although such differences are recognized as "clinical sense" or "experience." they have not been clarified.

The systematization of physiotherapy knowledge supports inexperienced beginners and effectively improves the quality of their clinical reasoning. Such systematization involves using ontology to extract physiotherapy knowledge from multiple experienced experts. However, because clinical reasoning knowledge differs with each ward and individual unit, it is difficult to obtain a consensus between the systematic knowledge and the knowledge used in actual clinical settings [Castilho 2009].

This study aims to systematize clinical reasoning knowledge to support novice physiotherapists' education. As noted above, it is difficult to formulate clinical reasoning because the recognition in each ward and individual unit is different. However, it is thought that the logical structure of clinical reasoning can be expressed in a unified way through a thought model. Therefore, this study uses the Toulmin model, which formulates the logical structure of logical reasoning using six elements, to propose a model to formulate clinical reasoning. In addition, an educational system is implemented using this model and a platform is constructed to collect clinical reasoning data.

3. Toulmin model

The Toulmin model provides a layout for visualizing logical arguments [Toulmin 2003]. It contains three basic elements—conclusion, ground, and warrant—and three extended elements—backing, rebuttal, and qualification. The advantages of using the

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Toulmin model to visualize an argument are that it clarifies problems in the logic of the argument and makes it easier for others to properly explain the argument. The Toulmin model has been applied in various fields such as social studies and educational situations related to logical thinking. David et al. claimed that good reasoning can be performed using the Toulmin model [Hitchcock 2005]. To perform good reasoning in the present study, we propose the items to be considered in each element of the Toulmin model.

Studies have tried to improve students' logical thinking ability with an educational system using the Toulmin model. Kitamura et al. proposed a triangular model of logic with the three basic elements of the Toulmin model: conclusion, ground, and warrant [Kitamura 2017]. In this study, we developed a system that allows users to create a triangular model that combines the basis, reasoning, and conclusion for logical thinking. In this system, the user performs reasoning by allocating a card on which a proposition is written to each element of the triangular model. In experiments, students who learned using the proposed system got high scores in a written test, suggesting that the activity of constructing a triangular model of logic using this system improved their logical thinking ability.

4. Formulation model of clinical reasoning

As discussed earlier, clinical reasoning is difficult to formulate because perceptions differ for each ward and individual unit [May 2010]. Few studies have actually provided a specific methodology for clinical reasoning. However, the logical structure of clinical reasoning can be formulated because it is considered to be the same as that of general reasoning.

This study focuses on the logical structure of clinical reasoning and proposes a model formulated as a clinical reasoning model. The clinical reasoning model is defined using the Toulmin model. The Toulmin model consists of three basic elements—conclusion, grounds, and warrant—and three extended elements—backing, rebuttal, and qualification. Because physiotherapy requires clinical reasoning based on medical evidence, a clinical reasoning model contains four elements: conclusion, ground, warrant, and backing (Figure 1). An example in which medical reasoning is represented by a clinical reasoning model is presented below.

> He needs penicillin treatment (conclusion) because he has pneumonia (ground). Penicillin treatment is effective for pneumonia (warrant). Previous medical studies have demonstrated the efficacy of penicillin treatment for pneumonia (backing).

Here, the present study defines clinical reasoning as follows: "extract problems (conclusion) of a patient based on medical evidence (warrant and backing) based on the collected data (ground) of the patient."

The advantages of using this clinical reasoning model are that (1) physiotherapists can organize their thoughts and make it easier to reflect on their logicality and (2) physiotherapists can easily pass on each other's thoughts. By doing so, we hope to support knowledge sharing.

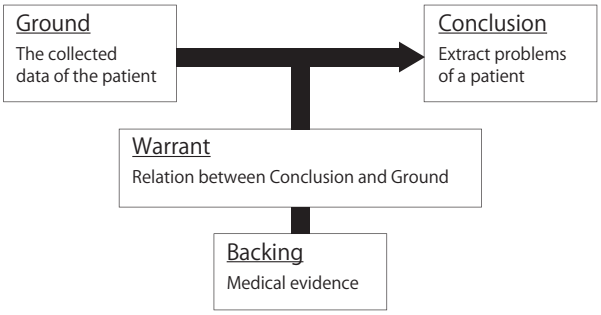

Figure 1: Clinical reasoning model

5. Education system

We design an educational system that enables instructors and learners to interact with each other using a clinical reasoning model. During learning, both the instructor and the learner create a clinical reasoning model. The instructor creates a clinical reasoning model for the purpose of transmitting his/her own thoughts to the learner, and the learner creates a clinical reasoning model for the purpose of organizing and reflecting on his/her own thoughts. To create a clinical reasoning model using the proposed system, the Kit-Build method that assembles parts prepared in advance is adopted. However, a free description is used only for the reasoning element.

First, before learning, the instructor inputs the components necessary for creating a clinical reasoning model into the system (e.g., simulated patient settings and literature information). The instructor then creates a clinical reasoning model of the model answer to be used as feedback to the learner.

In the learning interaction, the system presents the learner settings and literature information to the learner. The learner uses these to create a clinical reasoning model. When the learner creates a model, the system returns a clinical reasoning model of the model answer as feedback. Learners learn by comparing their own clinical reasoning model with this clinical reasoning model. In addition, the system counts the number of uses of two elements—ground and backing—in the model created by the learner and presents it to the instructor in a histogram. The instructor gives feedback to the learner based on this information.

6. Implementation

The proposed education system is implemented as a web application using HTML, CSS, JavaScript, Python 3.7.3, and Django 2.2. It is assumed that the user will use this system through a smartphone.

Figure 2 shows the interface through which the instructor inputs the settings of the simulated patient. We asked an experienced physiotherapist what items were needed in advance and accordingly created this web form. Figure 3 shows the interface for creating a clinical reasoning model as a model answer for a leader and a clinical reasoning model for a learner. A clinical reasoning model is shown at the top of the screen. The parts of the clinical reasoning model are listed at the bottom of the screen. Users can assemble a clinical reasoning model by tapping the checkbox next to the part they want to use. Figure 4 shows the feedback screen after model creation. The model answer,

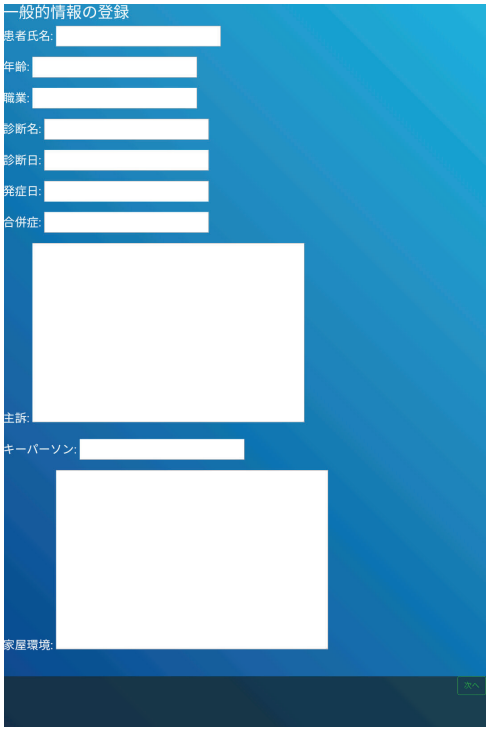

Figure 2: Input UI for settings of simulated patient.

commentary, and learner's clinical reasoning model are arranged in order from the top of the screen. Figure 5 shows a histogram of the number of uses of two elements—ground and backing—in the model created by the learner.

7. Experiment

As a preliminary step to evaluate whether the proposed system is effective for beginner physiotherapists to learn clinical reasoning skills, we evaluated its usability in actual clinical settings. In the experiment, the instructor was one experienced physiotherapist, and the learners were seven physiotherapists with 2–6 years of clinical physiotherapy experience. The evaluation was performed using a questionnaire on the usability.

First, participants accessed the web application through their smartphone. Then, they entered their name and number of years of experience into the system. The system presented simulated patient data to the participants, and the participants created a clinical reasoning model based on these data. After they created this model, the system gave them feedback; further, at the end of learning, the instructor gave verbal feedback.

8. Usability evaluation

Of the seven participants, five responded to the questionnaire. The system was evaluated based on four items with a three-point scale (good, normal, and bad). Of the five respondents, four (80\%) said that "placement of models, selection columns, buttons, etc." and "operation method" were normal; three (60\%) said that the "ease of operation" was normal; and three (60\%) said that the "ease of work" was good.

Of the five respondents, three (60\%) answered "I was able to create the model easily" when asked "Is it easy to create a model

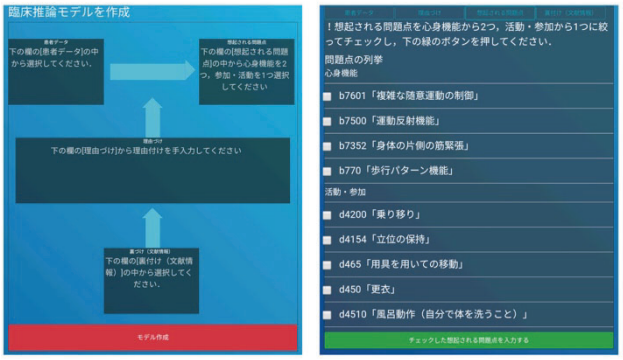

Figure 3: Input UI for creating a clinical reasoning model

using this system?"; three (60\%) answered that the feedback was useful when asked "Is the feedback provided by using this system useful?"; and three (60\%) answered "Explanation was effective for understanding the case deeply" when asked "Did you think that the explanation of the leader using the analysis results was effective for understanding the case deeply?"

9. Discussion

The questionnaire results for the items "ease of work" and "Is it easy to create a model using this system?" suggest that the proposed system provides users with an environment in which they can easily create a clinical reasoning model. The questionnaire results for the item "Is the feedback provided by using this system useful?" suggest that the feedback provided by the system was useful to users and that presenting the instructor's clinical reasoning model to the learner may have helped pass on the instructor's thinking to the learner. The questionnaire results for the item "Was the leader's explanation using the analysis results effective for understanding the case deeply? suggest that users could effectively understand cases deeply using the proposed system. One user summarized the advantages of the proposed system as follows: "I can see the information I see and think about, and I can organize it. I could organize my thoughts by formulating with a focus on the logical structure of reasoning."

The questionnaire results for items such as "arrangement of models, selection columns, buttons, etc.," "operation method," and "ease of operation" suggest that the user interface could be improved further. With regard to the shortcomings of the proposed system, users provided comments such as "difficult to press buttons" and noted some usability issues.

10. Result

This study proposed a clinical reasoning model that focuses on the logical structure for formulating clinical reasoning and designed and implemented an educational system using this model. The proposed system was used in actual clinical settings, and experiments were performed to evaluate its usability. The experimental results suggested that the proposed system enables users to easily create a model and to understand cases deeply. At the same time, the results suggested a need to improve the user interface and usability of the proposed system.

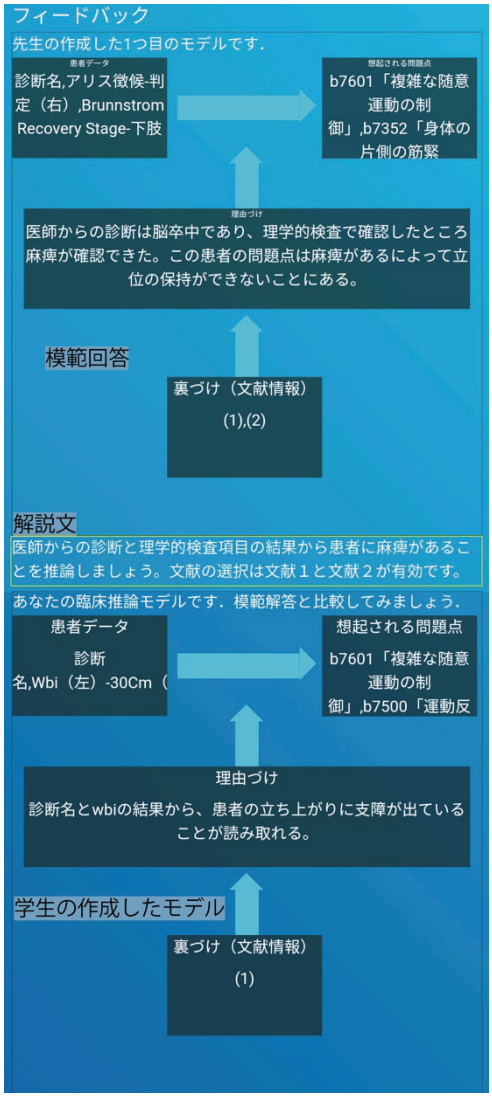

Figure 4: Feedback screen.

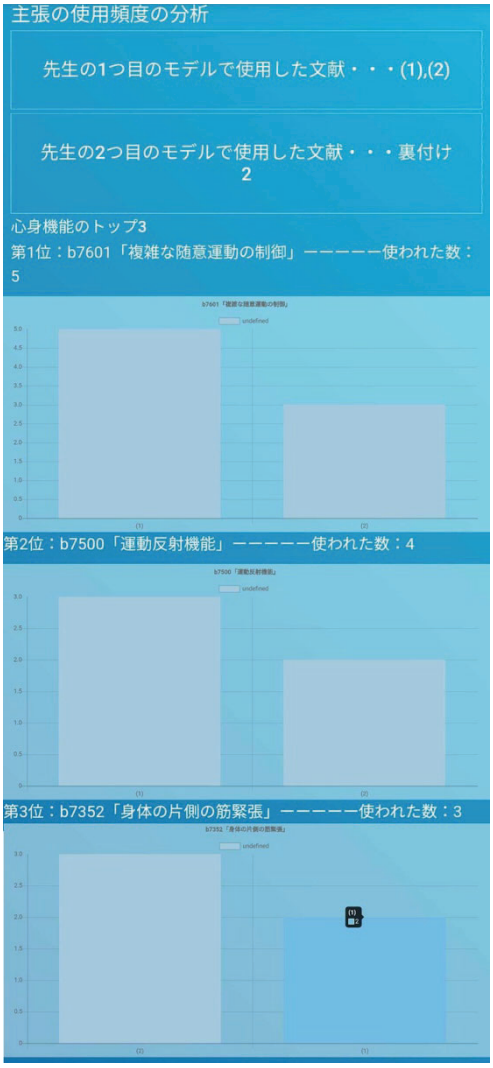

Figure 5: Histogram screen.

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