

Knowledge Modeling of the Inquiry based Learning Instructional Process in Japanese High Schools

Ontology model of Instruction Based on the PPDAC Cycle

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Abstract

The development of problem-solving skills has gained importance worldwide. Japanese high schools are aiming to develop problem-solving skills through inquiry based learning to discover and solve problems. However, there is a lack of instructional methods for inquiry based learning have not been established. This study proposed the Problem-Plan-Data-Analysis-Conclusion cycle (PPDAC cycle) ontology as a knowledge model that facilitates the standardization of instructional methods in inquiry based learning. First, knowledge regarding the states of understanding in inquiry based learning were extracted and systematized. Next, Consequently, a knowledge model was constructed by structuring the systematized knowledge based on the PPDAC cycle. As a result, by extracting knowledge about the details of the problem-solving process and systematizing the knowledge, we made explicit the implicit teaching method using the PPDAC ontology.

Keywords

High school Education, Inquiry based learning, PPDAC Cycle, Ontology, Knowledge Modeling

1. Introduction

Inquiry based learning along the problem-solving process has been popular in Japanese high school education in order to cultivate problem-solving skills[1]. The Japanese high school education curriculum contains a course referred to as "Period for Inquiry-Based Cross-Disciplinary Study" which is designed for students to conduct inquiry based learning.

The other side, prior research[2][3] has indicated that the ability to teach inquiry based learning is difficult without master level academic experience. Therefore, although inquiry based learning are becoming increasingly important for developing problem-solving skills, teachers capable of teaching inquiry based learning in high schools are limited.

This study aimed at the standardization of the teaching method for inquiry based learning using the problem-solving process. The proposed ontology is a heavyweight one, and each concept definition has rich properties. By using the ontology, we plan to support inexperienced teachers by inferring instructional strategies for inquiry based learning in high schools and to

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build a system that outputs instructional plans according to the teachers' abilities, students' abilities and their learning environments.

2. Related Works

2.1. Ontology Engineering

In this study, an ontology engineering tool suitable for making implicit information explicit, systematizing knowledge, and standardizing knowledge in a certain domain was used. Ontology engineering, as proposed by Mizoguchi[4], is a theory and technology for representing essential conceptual structures that exist in reality on computers.

2.2. PPDAC cycle Overview

The five phases of the PPDAC cycle are Problem-Plan-Data-Analysis-Conclusion. In mathematics in the high school curriculum guidelines[5], the five phases of the PPDAC cycle consist of Problem - Plan - Data - Analysis - Conclusion. The Problem phase involves understanding the problem and setting it. The Plan phase assumes the data and plans the collection. The Data phase collects the data and organizes them into tables. The Analysis phase creates graphs and understands the characteristics and trends. Finally, the Conclusion phase involves drawing conclusions and reflecting on the results. This renders it difficult to understand what should be taught in each phase. Therefore, by extracting knowledge of the problem-solving process and structurally describing procedural knowledge using systematized knowledge, a method for teaching inquiry based learning utilizing the PPDAC cycle becomes evident.

2.3. Knowledge Acquisition

Japanese high schools have a Super Science High School (SSH) , which aims to nurture the ability to think through scientific inquiry and to develop internationally competent human resources. Inquiry based learning curriculum development and rubrics for evaluation have been developed in SSH. SSH have developed rubrics for evaluation in Inquiry based learning. The rubric developed by SSH is an effective resource for acquiring knowledge regarding the problem-solving process of inquiry based learning. Therefore, we used a rubric developed by eight SSH schools (standardized rubrics)[6].

3. Ontology Construction Steps

In this study, the following approach was employed

Step1 Knowledge related to the problem-solving process extracted.

Step2 Systematization of the extracted state of knowledge performed.

Step3 Structured procedural knowledge based on the PPDAC cycle.

In Step 1, terms related to the state of the problem-solving process were listed with reference to the descriptive terms in the standard rubric. A comprehensive list of terms created without considering the overlap between concepts, relationships between terms, or whether the term represented a class or a property.

In Step 2, we systematized the knowledge obtained in Step 1. The lower classes were created by specializing the upper classes using properties.

In Step 3, the knowledge systematized in Step 2 was structured based on the PPDAC cycle. The status of each phase was assigned, that is, we set up the state as initial, intermediate, evolving, and end states. We undertook structuring to consider the correspondence between the state of inquiry based learning and the phases of the PPDAC cycle.

4. Construction of PPDAC cycle Ontology

The PPDAC cycle ontology implemented on the "Hozo" ontology editor[7].

4.1. Knowledge Extraction

The standardized rubric has four perspectives: setting the problem, planning and conducting the research, gathering and evaluating information, and reflecting on the results. For each perspective, the standardized rubric presents standards that represents steps to be achieved, signs of the learner corresponding to the steps, and instructional strategies. Using these as a reference, knowledge about the state of inquiry based learning extracted and developed 93 concepts including 49 state concepts.

4.2. Knowledge Systematization

Based on the extracted knowledge and the standardization rubric, we defined the class-is-a relationship in the states by setting properties for the upper and lower concepts.

By the standardized rubric, we systematized knowledge as "hypothesis setting state", "execution state", "data collection state", "analysis state" and "conclusion state". The "hypothesis setting state" and the "execution state" could only represent transitions of the states, whereas the remaining states could represent the transitions and granularity of the states.

4.3. Structuring Procedural Knowledge

Based on the PPDAC cycle, we structured the extracted knowledge.

First, "process," which was the upper class of each phase of the problem-solving process, was assigned initial, intermediate, advanced, and end states. As the initial state and the end state are states that must be reached, we set "p/o 1". Next, we set intermediate states for the relevant phases because intermediate states may exist to facilitate transition from the initial to the end state. Finally, the granularity of the states does not always result in a transition.

Therefore, for each phase, if there was a corresponding state, we set it as an advanced state.

5. Conclusion

In this study, we constructed a PPDAC cycle ontology for the inexperienced teachers of inquiry based learning using the problem-solving process. Based on a standardized rubric, we extracted and systematized the knowledge about the problem-solving process. Referring to the process model, we developed the PPDAC cycle ontology related to the problem-solving process.

- We extracted and rendered the knowledge about the detail of the problem-solving process explicit.
- Systematized knowledge, that is, PPDAC ontology rendered tacit teaching methods explicit.
- The PPDAC ontology revealed that the Problem phase comprised many states and processes, which requires sufficient guidance and time.

The proposed ontology constructed in this study should help both the computer and the inexperienced teachers to understand the overall view in the teaching of inquiry based learning and helps the computer system to reason about the teaching methods and/or class planning for the teachers.

In the future, the PPDAC cycle ontology will be restructured by evaluating the ontology through consultations with experts in the field of education in high schools and universities.

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