Development of a Learning Support System for Class Structure Mapping Based on Viewpoint

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Abstract. To be able to use knowledge, learners must arrange the relationships between information as a knowledge structure. A class structure is a typical knowledge structure. The skills required to build class structures are (1) identifying the attributes of the target instance, (2) selecting attributes of the target instance on the basis of several viewpoints, and (3) describing relationships between instances hierarchically. As a first step, learners need to understand "discrimination and inheritance" in a class structure; therefore, we have previously proposed a method for learning class structure construction. To facilitate the acquisition of skills for learners to build class structures, however, they should be supported in setting a viewpoint and selecting attributes of instances on the basis on that viewpoint. In this study, we propose a learning support system for selecting several attributes of each instance in the construction of a class structure based on several viewpoints.

Keywords: Systematization of knowledge · Learning class structure construction · Article structure

1 Introduction

To understand some fields, learners must arrange the relationships between information in the field as a knowledge structure. Let us start by looking at an example. Suppose a learner reads articles A and B in order to understand educational pedagogy. Article A describes the "analysis of learning effects" and "teaching methods," and article B describes "learning support systems" and "teaching methods." In this example, the learner needs to understand that the feature that the articles have in common is "teaching methods," whereas they have the different features of "analysis of learning effects" and "learning support systems." It is important for learners to understand aspects common to and different between several pieces of knowledge, and to organize as the knowledge structures by themselves.

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A class structure is a typical knowledge structure. A class structure is composed of abstract concepts (classes) and instances (individuals). Instances are located at the bottom of the hierarchical structure. Attributes are used to characterize instances and classes. A class is generated by grouping instances that have an attribute in common. In this paper, we focus on the construction of a class structure based on viewpoint as a learning method for learners. We have developed a learning support system for the selection of attributes with instances.

2 Process of Class Structure Construction

In this section, we start by explaining the learning method for the conventional construction of class structure. Then, we describe the polysemy of class structures by viewpoint and proposed a support method for class structure construction.

2.1 Previous Research

Tomoto et al. [1, 2] and Arai et al. [3] developed a learning system for class structure construction by learners. In those studies a learning support system was developed that promotes the understanding of discrimination and inheritance relationships in a class structure. Tomoto et al. [1, 2] developed a learning support environment for concept map building with the aim of promoting an understanding of inheritance relationships, attributes of discrimination, and relationships between higher and lower classes. In addition, Arai et al. [3] developed a support system for class structure construction to help with errors in the inheritance relationships of a class structure. Results of the evaluation experiments in those studies showed that the systems promote construction of class structures by learners in consideration of the discrimination of attributes and inheritance.

These learning method for class structure construction require learners to build class structures when all attributes of the class structure are given. However, when people build a class structure, they select their own viewpoints. Therefore, the learner must be able to select attributes of an instance based a proper viewpoint.

2.2 Polysemy of Class Structures by Viewpoint

When learners build a class structure, it is changed by their viewpoint. Viewpoint provides the guidelines by which learners construct a class structure [4, 5]. They can get a better understanding of a target by re-organizing knowledge of the target based on their viewpoints [6].

Figure 1 shows a class structure of articles that is changed according to viewpoint. In the left panel, the attributes of article 1 “algorithm learning” and “programming education” are selected based on the viewpoint of “Target area of support.” In the right panel, however, different attributes are selected such as “for beginners” and “for the learner.” The structure is based on the viewpoint of “target users of support.”

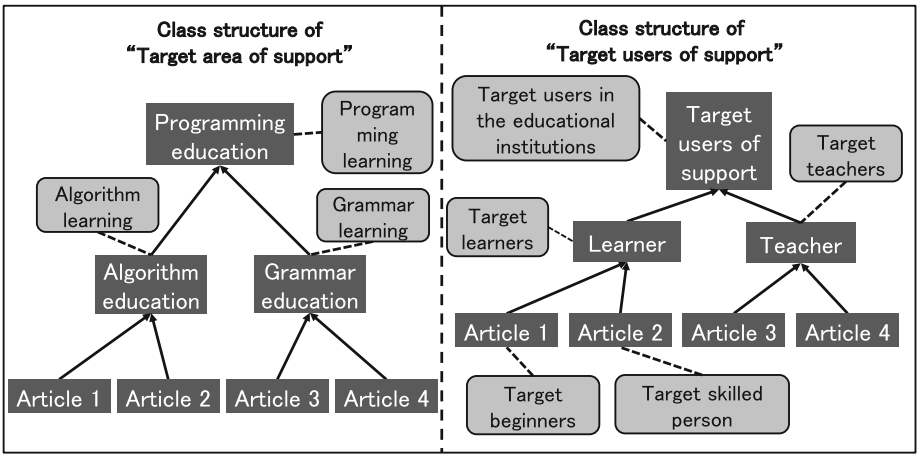

Fig. 1. Class structure based on different viewpoints for four articles

2.3 Class Structure Construction Tasks

In this section, we describe tasks required in building a class structure based on viewpoint and the errors that can occur when building the structure. Class structure construction can be divided in the following three steps:

(1) Identify the attributes of the target instance.
(2) Select attributes of the target instance on the basis of several viewpoints.
(3) Describe relationships between instances hierarchically.

Step (1) entails identifying multiple attributes of the target instances. In Fig. 2, the attributes of an article (article 1) are given as an example. This is the model displayed in step (1). The structure is displayed such that the learner does not consider the attributes required in the class structure construction but rather considers only whether article 1 has certain attributes.

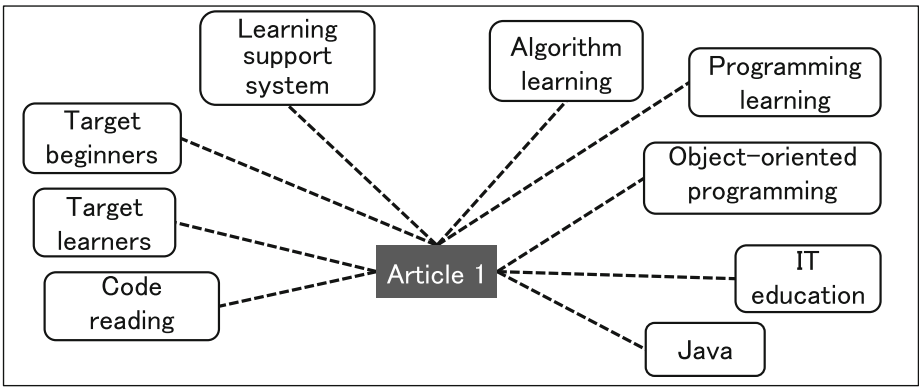

Fig. 2. Identifying the attributes of article 1

In step (2), attributes of an instance are selected based on the set viewpoint from among those identified in step (1), such as the attribute selection shown in Fig. 1. Figure 3 shows an example of the attribute selection based on the viewpoint for articles 1 and 3. As shown here, for article 1 "Algorithm education" and "Programming education" are selected and "Beginner" and "Learner" are deleted. This is a class structure in which the attributes are selected based on the viewpoint of "Target area of support."

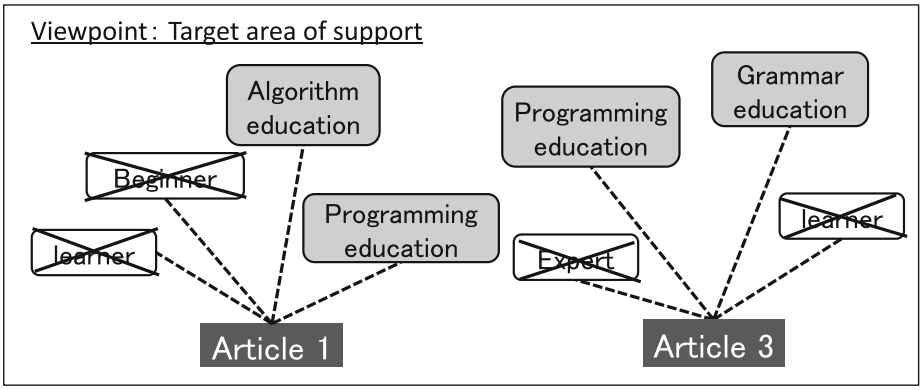

Fig. 3. Selection of attributes of two articles based on the viewpoint of "Target area of support"

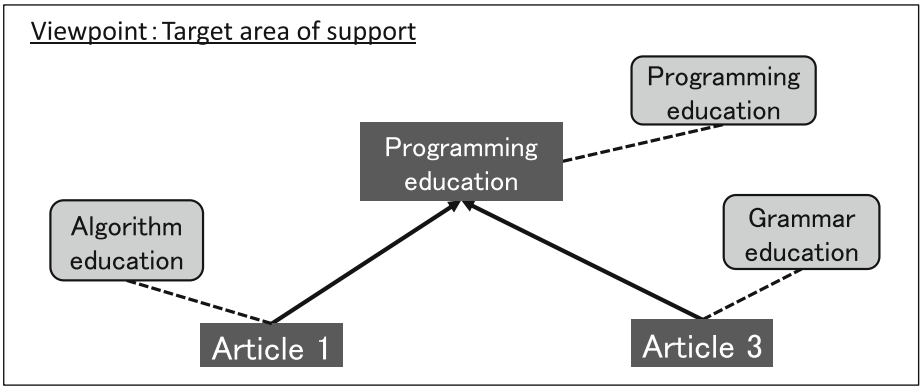

Fig. 4. Structure describing relationships between instances hierarchically

In step (3), common attributes of multiple instances are grouped together, which means a layered structure is constructed. Figure 4 shows the example of such a class structure. By performing these tasks, the learner can construct a class structure based on viewpoint.

2.4 Error by Learners

In this section, we describe the errors that occur when learners perform step (2) in Sect. 2.3. Our ultimate aim is to support all three steps, (1) to (3), but in this basic study toward this aim, we focus on the step (2). In this step, selection of too few attributes and selection of too many attributes are assumed as errors by learners. Figure 5 shows an example of the error of selecting too many attributes. Here we see the selection of attributes of article 1 based on the viewpoint of "Target area of support." The left panel shows the correct selection of attributes; the right panel shows the section of too many. In particular, the learner has incorrectly selected an attribute unrelated to the "Target area of support." If the attribute "Algorithm education" were left out, then the error would be selection of too few attributes. We believe that these errors in particular should be noted in the learning of class structure construction based on viewpoint. Accordingly, our support system helps students become aware of these errors.

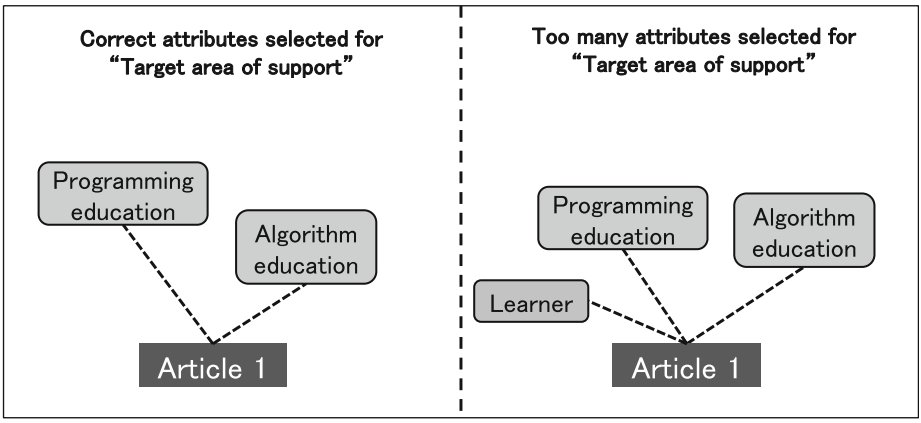

Fig. 5. Example of expected learner of error

3 Proposed Learning Method and Support System

Here, we propose support for the selection of attributes based on the viewpoint adopted in the construction of a class structure. As noted in Sect. 2.3, it is necessary to set a viewpoint when the learner builds a class structure. Setting an incorrect viewpoint will subsequently prevent correct selection of attributes. So, the system (teaching side) should control how the viewpoint is set. Therefore, in this study, we have developed a learning support system for selecting attributes based on a viewpoint that is formulated.

3.1 Formulate the Viewpoint

As a method for organizing articles, we apply the article organization method using the 5W1H (Who, What, When, Where, Why, How) format by Aoki et al. [7]. A research

question by arranging characteristics of several articles based on viewpoint of the 5W1H. In this study, we used the three viewpoints "What," "Why," and "How." (Table 1).

Table 1. Viewpoint of 5W1H in science and technology articles

	Meaning
Who	Person to be assited
What	Target area of support
When	Support limiting
Where	Place where support is given
Why	Why support is needed
How	Means of providing support

3.2 Learning Using the System

In the learning support system developed in this study attributes articles are selected based on viewpoint with the aim of class structure construction. This system uses an article in educational technology as an instance. The learning task is to select an attribute from the six articles based on the 5W1H viewpoint. Figure 6 shows the interface of the system. This system is composed of an article screen (left panel), attribute selection screen (right panel), article tab (top left), and viewpoint tab (top right). The learner selects the required attributes from each article based on the viewpoint selected. Specifically, in Fig. 6, having set the "What" (target area of support) viewpoint, the learner selects attributes based on this viewpoint in six articles. When the learner selects the article, they look for the appropriate attributes from the attributes (underlined) included in the article. When the learner clicks an attribute, it is added to the attribute selection screen shown in the right portion of Fig. 6.

3.3 Feedback

Next, we describe the feedback method of the system. In Feedback is given in response to incorrect selection or omission of attributes. The reason for this is to remind learners of the errors of selecting too many or too few attributes. An example of the feedback is shown in Fig. 7, which presents the learner's answer and the correct answer for articles 1 and 2 under the "What" viewpoint. The learner's answer is lacking the attribute "mechanics." When the learner clicks the answer button, the system displays the following message as the first round of feedback: "The viewpoint of the missing attribute is *What*" Having received this feedback, the learner focuses on the "What" viewpoint and compares the selected attributes with the remaining attributes in the article. Thus, the learner is made aware of his or her error and will try to select another attribute. When the learner has submitted an incorrect modification, the system displays the following message as the second round of feedback: "The missing attribute from the *What* viewpoint is in article 2." From this feedback, the learner's focused is directed to

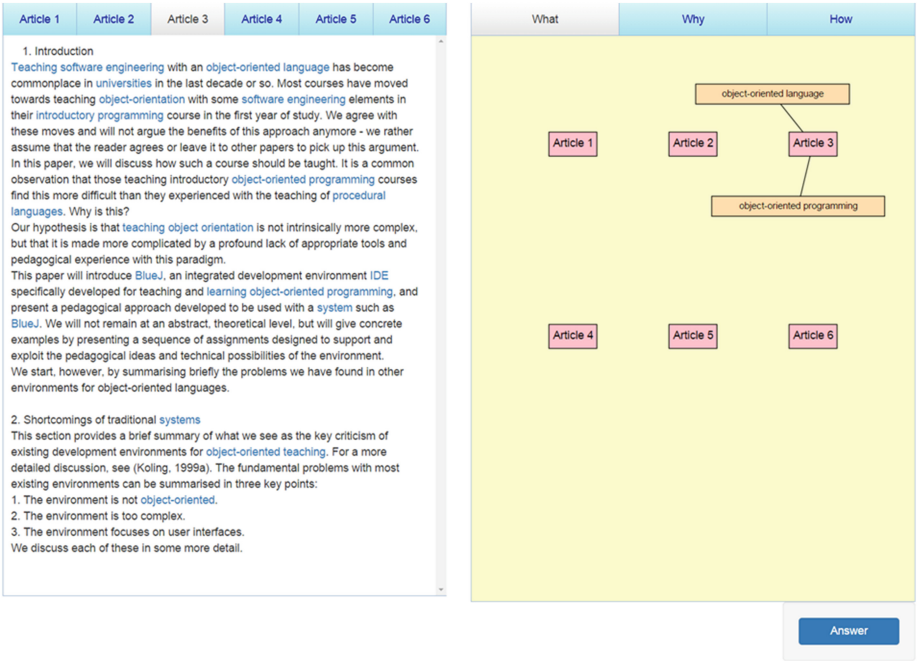

Fig. 6. Interface of the system

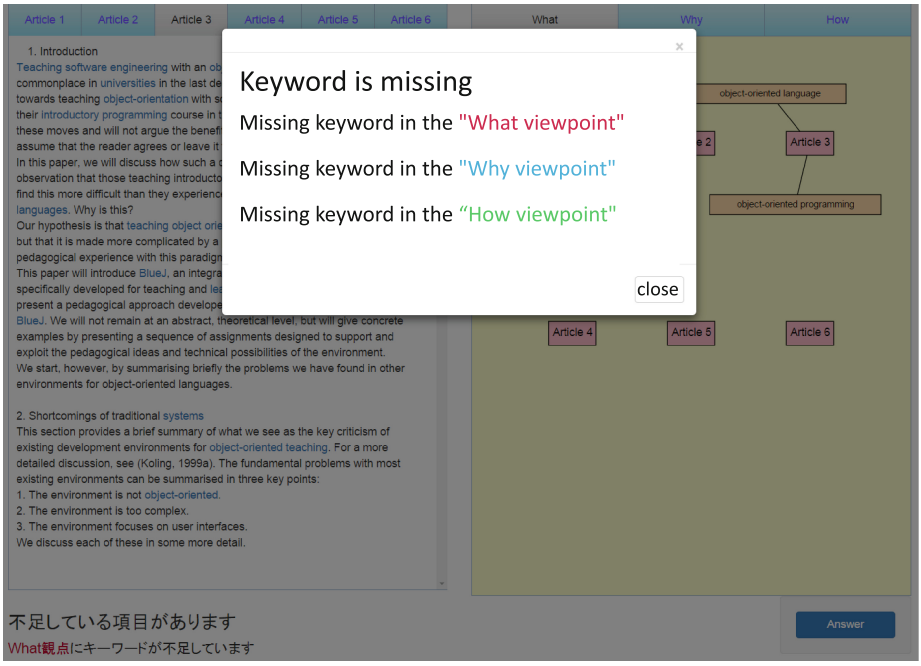

Fig. 7. Feedback screen

article 2 from the "What" viewpoint. The learner then attempts to select another attribute. After a third mistake, the number of incorrect attributes is added into the feedback: "There is 1 missing attribute from the *What* viewpoint in article 2." When the learner has selected too many attributes, the system provides feedback in a similar way, prompting the user to modify the selected attributes.

4 Assessment Experiment

To evaluate the usefulness of the learning support system, we conducted an assessment experiment. First, the participants were asked to solve 4 keyword selection problems (test 1) in 30 min. Next, after explaining the meaning of viewpoint to participants for 5 min, they were asked to solve 4 keyword selection problems each having a particular viewpoint (test 2) in 30 min. Participants were asked to learn the selection of keywords based on the viewpoint by using the system and paper in 3 h. Finally, the participants were asked to answer a questionnaire in 10 min. In the experiment, participants in the A-a and B-a groups were given articles that were included in the test of learning procedures. Participants in the A-b and B-b groups were not given articles included in the test of learning procedures. Participants in the A-a and A-b groups were asked to learn by using the present system. Participants in the B-a group and B-b group were asked to learn by using paper-based teaching materials.

Table 2 shows the questionnaire results for learning method and system. Questionnaire items were scored on a seven-point scale (1 = "I don't think so at all", 7 = "I think so very much"). The questionnaire items Q2-7 (Do you think it's effective to read an article based on a viewpoint in order to understand the article?) and Q2-8 (Is it useful to classify a keyword based on viewpoint to understand the article?)" received a high score of 6.00 or higher from all groups. These results suggest that reading an article based on viewpoint is helpful in understanding it more deeply. Item Q3-3 (When you read the article, were you aware of the viewpoint?) received a very high score from the A-a and A-b groups, but the B-a and B-b groups gave a lower score. The A-a and A-b groups also gave high scores for items Q3-8 (Do you think the teaching materials that you used (system or paper) were effective when selecting keywords from an article based on a viewpoint?), Q3-9 (Did learning with the teaching material that you used (system or paper) improve your ability to organize the article, based on the viewpoint?),

Table 2. Questionnaire results

Group		Q2-7	Q2-8	Q3-3	Q3-8	Q3-9	Q3-10	Q3-11
A-a	average	6.33	6.33	6.17	6.33	6.50	6.17	5.83
	S.D	0.47	0.47	1.46	0.47	0.50	0.69	0.90
A-b	average	6.25	6.50	6.00	7.00	6.00	6.25	6.00
	S.D	0.83	0.50	0.71	0.00	1.22	0.83	1.00
B-a	average	6.00	6.40	4.60	4.80	5.00	5.20	4.40
	S.D	0.63	0.80	1.36	1.47	1.67	1.00	1.36
B-b	average	6.00	6.50	5.50	5.25	5.00	5.25	4.25
	S.D	0.71	0.50	1.12	1.30	1.22	1.48	1.30

Q3-10 (Do you think the teaching materials that you used (system or paper) were effective for understanding the article?), and Q3-11 (Do you think that you got a better understanding of the target area by learning with the teaching material that you used (system or paper)?). These results suggest that the system can support learners in reading articles based on viewpoint and that it possibly helps learners understand articles more deeply.

5 Conclusions and Future Work

In this study, we have proposed a learning method and system for selecting the attributes based on viewpoint so that learners can construct a class structure. In the developed system the learner selects attributes of articles based on three viewpoints. In the future, the learning support system should be evaluated in more detail. Also, we plan to develop a learning support system for building class structures that integrates the attribute selection learning and hierarchical learning.

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References

1. Tomoto, Takahito, Imai, Isao, Horiguchi, Tomoya, Hirashima, Tsukasa: A support environment for learning of class structure by concept mapping using error-visualization. J. Inf. Sys. Educ. **30**(1), 42–53 (2013)
2. Tomoto, T., Imai, I., Horiguchi, T., Hirashima, T.: error-based simulation for learning of meaning of class structure by concept mapping. In: Proceedings of ICCE2012 (11 poster acceptance in 23 submissions; acceptance rate 48%), Singapore (2012)
3. Arai, T., Tomoto, T., Akakura, T.: Development of error-visualization system for learning of inheritance in class structure. IEICE Trans. Inf. Syst. (Japanese Edition) **98**(1), 42–53 (2013)
4. Kiyotaka Miyazaki, Naoki Ueno.: Collection 3 Metaphor and Understanding. University of Tokyo Press, Tokyo(2007)
5. Yamanashi, M.: Collection 5 Metaphor and Understanding. University of Tokyo Press, Tokyo (2007)
6. Suzuki, H.: Similar and thinking. Kyouritsushuppan, Tokyo (1998)
7. Aoki, M., Hayashi, Y., Kojiri, T., Watanabe, Ts: Paper Classification for Supporting Creative Research. IEICE Technical report, **111**(85), 15-20 (2011)