講義スライドに対する質問キーワードの変化に基づく質問サジェスト方式の提案

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あらまし　近年, 日本でもオンライン学習が普及し, 学生が授業スライドを利用してリモートで学習する機会が増加している. また, 教育の代表的な課題の 1 つに日本人学生は授業中に質問をしない傾向にあるということがある. そこで, 我々は, 結論を導く過程において「なぜ？」と問いを立てる思考法と定義される「批判的思考」研究を参考に, 学生が質問を発想し, 思考する過程を支援するオンライン学習支援システムを提案した. 本研究では, 学生が生成した質問と授業スライドの関係を, 出現するキーワードの階層関係により明らかにし, 質問に対する適切な授業スライドの推薦手法を提案する.

キーワード　e-Learning, 学習支援, オンデマンド講義, スライド構造, 質問支援. 学習コンテンツ推薦, 質疑応答

1 Introduction

King claimed that good thinkers ask good questions [8]. However, Japanese students tend to be too shy to ask questions about the content of lectures. For example, Ikuta et al. found that 47.7% of children did not generate or ask questions [4]. However, it is common for Japanese students to be too hesitant to query the lecture content. For instance, Ikuta et al. [4] observed that 47.7% of youngsters did not ask or generate inquiries. Therefore, we researched to encourage students to create questions and support the process of careful consideration. Figure 1 illustrates the UI of the implemented learning support system[1] [6]. Depending on the behavior of the learner, our proposed UI switches from "question generation support" to "presentation of relevant slides." In recommending related slides, we determined different methods for each of the six question formats based on the author's thoughts and analysis. In recommending related slides, we determined different methods for each of the six question formats based on the author's thoughts and analysis. In this paper, we extend the recommendation of related slides by analyzing the types of slide explanations and defining recommendation methods for related slides for low-level and high-level questions.

1：Demo:https://www.youtube.com/watch?v=tYl_2KHBYfY

2 Related work

2.1 Question generation support for lecture

In order to encourage critical thinking, King [7] and Ikuta et al. [5] advocated teaching people how to create questions by employing a list of question stems. Ikuta et al. [5], incidentally, translated this list into Japanese. The outcomes of this approach indicate that encouraging learners to create their own study questions enhances their learning. Therefore, we provided an approach for suggesting question maiking that are appropriate for the lecture. In this research, we suggest the method to present lecture slides related for the question.

The questions submitted by learners were divided into low- and high-level versions by Shinogaya et al. [10]. These low- and high-level question definitions were updated to be utilized in this study's keyword-based question categorization framework. We reinterpret low-level questions as verifying facts about the keywords themselves, and high-level questions as aiding the linkage of keywords with existing information.

Gul et al. [2] and Boso et al. [1] stated that developing students' critical thinking abilities is challenging for educators unless they have studied educational systems and methodology that specifically involve critical thinking. In addition, a large study found that lessons by educators using a system that incorporated critical thinking significantly increased the number of high-level questions. We aim to develop learners' critical thinking abilities through a new type of pedagogy us-

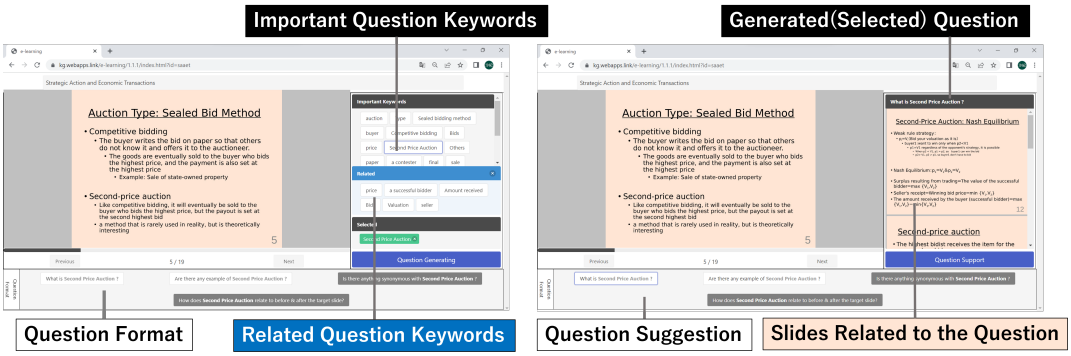

図 1　Support for generating questions (left) and presenting questions-related slides (right) for critical thinking.

ing the proposed methods on behalf of teachers who practice an educational system that considers critical thinking as a learning goal.

2.2 Explore and suggest slides.

Hayama et al. [3] proposed a method of organization and structure to extract structure information from the information presented in a slide. In addition, Mouri et al. [9] proposed a method to classify lecture scenes into five categories. In contrast, in the present work, we use the structure of the slides to provide suggested questions and present related slides.

In a previous study, we proposed question generation support and presentation of related slides to promote critical thinking [6]. In this study, we extend the related slides presentation and suggest the type of slide for questions.

2.3 Presentation of lecture slides

In a previous study, we proposed a method to searching for viewing intervals between presentation content and presenting related scenes by determining the semantic relationships between scenes based on the hierarchical structure of the slide images and the amount of speech in video clips [11]. The present work differs from these investigations in that it analyzes the relationship between the slides and questions.

3 Determination of slide types

We define two types of slides for characterizing recommended candidate slides: specialized and generalized. Specialized slides have detailed explanations for the question keywords. Generalized slides have broad explanations for the question keywords. Therefore, we use the description trends of slides and the hierarchical relationship of keyword as indices for defining slide types.

3.1 Description trends of slides

We determine the description trends of slides by slide

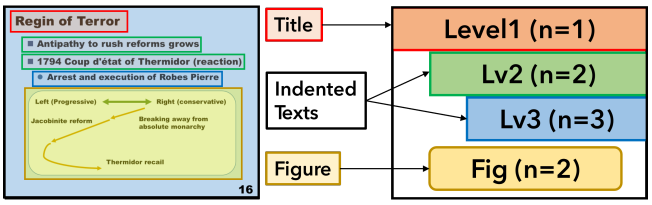

図 2　Examples of indentation and hierarchy levels.

structures of keywords. There are two types of description trends: top-down and bottom-up. The top-down slides explain the question keyword first and tend to explain it mainly. The bottom-up slides explain the question keyword later and tend to explain it supplementary. We judge the description trends by the slides' hierarchical structure. The hierarchical levels defined assign the indentation, thus reprocessing the hierarchical structure of the slide. The title has the highest hierarchy level (n = 1), as shown in Figure 2, and after that, the hierarchy level rises one level in descending order. The following equation is used to judge the description trends of the target slide about the question keywords.

a) Average hierarchy level for slides

$$J\left(x,\ \mathrm{Kw}_{all}\right) = \sum_{m=1}^{M} l_m\left(x,\ Kw\right) \times \frac{1}{M\left(x,\ Kw\right)} \tag{1}$$

b) Question keyword hierarchy level for slides

$$J\left(x,\ \mathrm{Kw}_{que}\right) = \sum_{m=1}^{M} l_m\left(x,\ Kw_{que}\right) \times \frac{1}{M\left(x,\ Kw_{que}\right)} \tag{2}$$

In Eqs. (1) and (2), $l_m(x, Kw_all)$ is The sum of all hierarchical levels of keywords that are nouns on the slide. $M(x, Kw_all)$ is the number of the noun on the slide, and $M(x, Kw_que)$ is the number of the question keywords on the slide.

c) Top-down and bottom-up slides

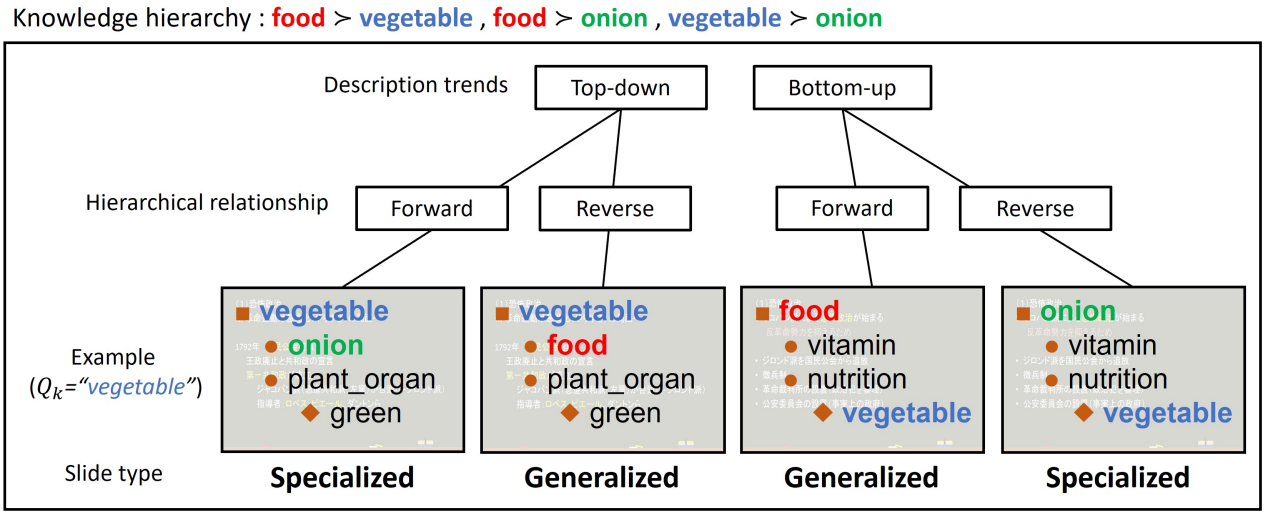

図 3　Determining slide types

$$J\,(x,\ \mathrm{Kw}_{all}) > J\,(x,\ \mathrm{Kw}_{que}) \tag{3}$$

$$J\,(x,\ \mathrm{Kw}_{all}) \leqq J\,(x,\ \mathrm{Kw}_{que}) \tag{4}$$

Subsequently, a comparison is conducted between $J\,(x,\ \mathrm{Kw}_{all})$ and $J\,(x,\ \mathrm{Kw}_{que})$. Upon comparison, if the value of $J\,(x,\ \mathrm{Kw}_{all})$ surpasses that of $J\,(x,\ \mathrm{Kw}_{que})$, it is considered to be of a top-down type, whereas if the value of $J\,(x,\ \mathrm{Kw}_{all})$ is less than or equal to that of $J\,(x,\ \mathrm{Kw}_{que})$, it is considered to be of a bottom-up type.

3.2 hierarchical relationship between keywords

We determine the hierarchical relationship of keywords and question keywords against the knowledge of keywords and slide structure. We get the knowledge structure using tools of conceptual dictionary: Wordnet and Hyponymy extraction tool Version 1.0. We get the slide structure by the indentation style of the slide text. We compute the partial order relation between the question keyword Q and all keywords appearing in the slide. A partial order relationship is a binary relation that is not necessarily symmetric. In other words, it is a type of order relation that satisfies some, but not all, of the properties of the total order. Therefore, the transitive law does not hold in the partial order relationship, and there is a possibility that a contradiction may occur in the hierarchical relationship. We focus on the contradiction to discover the point of slide descriptions. In this study, we compare two hierarchical relationships, namely the knowledge hierarchy of keywords and the slide structure, and define a binary relation that does not result in contradiction in the hierarchical relationships as a forward-order relation, while a binary relation that results in contradiction as a reverse-order relation. For example, suppose the keyword hierarchy shows that "vegetable" is a subordinate of "food," and "tomato" is a subordinate of "vegetable." If, in the slide structure, the keyword "tomato" is positioned below "vegetable," the binary relation between them is "forward-order" because there is no contradiction. However, if the keyword "food" is positioned below "vegetable," the binary relation between them is "reverse-order" due to a contradiction in the slide structure. We calculate the connection of hierarchical relationship between keywords in a slide using a binary system that identifies whether the relationship between the question keyword and other keywords is in forward-order or reverse-order relation. If there are more keywords with a forward-order relationship, we classify the slide as having a forward-order relationship, and if there are more keywords with a reverse-order relationship, we classify the slide as having a reverse-order relationship.

3.3 Judgment of slide types

We categorize slide types based on two factors: the explanatory trend of the slides and the hierarchical connection among the keywords. As shown in Figure 3, for slides with a top-down explanation tendency and a hierarchical relationship of keywords in a positive order, we define them as specialized slides; and for those with a hierarchical relationship in reverse order, we define them as generalized slides. Similarly, for slides with a bottom-up explanation tendency and a hierarchical relationship of keywords in a positive order, we define them as generalized slides, and for those in reverse order, we define them as specialized slides.

4 Presentation of slides for questions

We classify question types into two levels, low-level and high-level, to detect the appropriate slide types for each question and present the users with the appropriate slides when

表 1　Lecture slide themes and IDs

Lecture ID	Tytle of slides
1	“Vegetable”
10	“Fruits and Veggies”
12	“Importance, Nutritional Status Classification of Vegetables and Planning for Kitchen Gardening”
18	“Successful Storage of Garden Produce”
19	“Vegetables Foods I: Fundamentals”

表 2　Lecture slides used for experiments

Lecture ID	Total pages	“Vegetable”	“Tomato”	“Potato”	“Spinach”	“food”
1	54	20	5	4	4	3
10	32	16	2	3	1	1
12	37	0	22	7	7	8
18	23	5	5	8	0	2
19	20	11	4	8	2	4

表 3　Question format

Low	Q_{L_1}: What is k_1?
	Q_{L_2}: Are there any examples of k_1?
	Q_{L_3}: What are k_1 and k_2?
High	Q_{H_1}: Is anything synonymous with k_1?
	Q_{H_2}: How does k_1 relevant to before and after the target slide?
	Q_{H_3}: What is the difference between k_1 and k_2?

表 4　Wordnet

Keyword	Number of hypernyms	number of hyponyms
“Vegetable”	6	186
“Tomato”	10	0
“Potato”	8	3
“Spinach”	23	6
“food”	4	1576

they think about the question.

4.1 Classification of questions

We provide a format for questions that are created by simply combining keywords. The question stem list produced by Ikuta et al. [5] and the question categorization approach given by Shinogaya [10] were used as the basis for the question format presented in Table 3. For example, when he question keyword is “vegetable”, combined with the question format:

- What is “vegetable?”
- Is there anything synonymous with “vegetable?”
- Are there any examples of “vegetable?”
- How does “vegetable” relevant to before and after the target slide?
- What are “vegetable” and “tomato?”
- What is the difference between “vegetable” and “tomato?”

In this work, we define high-level questions as those that promote linkages between keywords and prior knowledge, whereas low-level questions are those that confirm the facts of the keywords themselves. Additionally, we take into account the situation when learners choose one term for a single keyword question and various keywords for a multiple-keyword question. Both Q_{L_3} and Q_{H_3} allow various keywords in the question format.

We use this question format to associate questions with slide types, allowing users to efficiently learn slides that are highly relevant to their questions.

4.2 Presentation slides for question format

We propose a recommendation system that varies the suggested slides based on the low and high levels of a question. Specifically, for low-level questions, we recommend specialized slides that provide detailed explanations about the question keywords and are suitable for confirming keyword facts. Furthermore, for advanced questions, we recommend generalized slides that offer broad descriptions of the keywords and are appropriate for facilitating the connection between keywords and prior knowledge.

5 Evaluation experiment plan

We plan to conduct two experiments using actual lecture slides to validate the effectiveness of our proposed approach. The first experiment aims to verify the accuracy of slide type classification, while the second experiment evaluates the relevance between questions and recommended slide types. For this experiment, we used five lecture slides on the topic of “vegetables,” as detailed in Table 12. We extracted five hierarchical slides from 23 lecture slides shared online. The keywords chosen for the questions were “vegetable,” “potato,” “spinach,” “tomato,” and “food.” The hierarchy of these keywords was extracted using WordNet. However, there are limitations to obtaining upper-lower relationships using WordNet, so Table 4 shows the number of upper and lower words. It is revealed that only keywords in a part-of relationship are obtained.

5.1 Judgment accuracy of slide type

We will evaluate the accuracy of slide-type classification by comparing the proposed method's slide-type classification and participant questionnaire-based slide-type classification, using the participant questionnaire as the ground truth data. We will calculate precision, recall, and F-measure as evaluation metrics.

5.2 Relevance between question and slide type

We will evaluate the relationship between the questions and slide types by conducting a participant survey to determine the relevance of the question format and the degree of specialization or generalization of the slides. We will present a group of slides that are defined as specialized for each question, as well as a group of slides that are defined as generalized, and ask participants to choose which group they believe contains slides that are useful for considering the question.

6 Concluding Remarks

We proposed an online learning support system to encourage learners' critical thinking. In this paper, we extended the method for presenting related slides to learners' questions and proposed a recommended method for related slides based on the analysis of slide types and question formats. In future research, as planned in Chapter 5, we will conduct an evaluation experiment to analyze the accuracy of slide type identification and the correlation between slide types and question formats. However, WordNet, which we use for extracting semantic relations, has a limitation that it can only retrieve keywords in a "part-of" relationship. Therefore, we will explore new methods for extracting semantic hierarchies in future work.

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