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Sectional Review Recommendations based on Learner's Comprehension in Video-based Learning

Yusuke HAYASHI*, Keisuke MAEDA, Toshio HONDA and Tsukasa HIRASHIMA
Graduate School of Engineering, Hiroshima University, Japan
*hayashi@lel.hiroshima-u.ac.jp

Abstract: This paper proposes a video-based learning environment that can evaluate learners' understanding and provide them with recommendations for reviewing sections that they did not understand sufficiently. For such recommendations, the system needs to recognize the video content and identify the parts the learners did not understand. This study develops the function with Kit-build concept map that allows for the automatic evaluation of the learners' concept maps and for review recommendations of the video sections the learners did not understand. To verify the function, we used the system as homework to prepare for a lecture. From the learners' log information; although only a few learners used this mechanism, they had a higher improvement rate in their concept maps when they use the function than they did not. This result shows the possibility of the use of KBmaps in self-learning with video lectures used in MOOCs, flipped learning and so on.

Keywords: Video lecture, Review recommendation, video annotation, automatic assessment of concept map

1. Introduction

Videos are becoming some of the most popular learning-resource media, primarily from the spread of massive open online courses (MOOCs) and flipped classrooms (Admiral, 2015). Video-based learning (VBL) is a rich and powerful model used in technology-enhanced learning to improve learning outcomes as well as learner satisfaction (Yousef, 2014).

However, learners have difficulty gaining the comprehension expected of teachers through watching a video-lecture (Anderson, 2014). Because watching videos is an inherently passive form of learning, to learn effectively, students need to engage actively with the video content by themselves (Mitrovic, 2017). Engagement with the videos can be facilitated by embedding interactive activities, e.g., quizzes and assessment problems (Chauhan, 2014), or by providing environments for collaborative annotation of the videos (Chatti, 2013) (Mitrovic, 2017).

In VBL, for the conceptual development used in xMOOCs and flipped classrooms, the goal of a video lecture is for the learner to understand the core concepts it presents (Drake, 2015) (Seery, 2012). Quizzes are typical methods of helping learners engage in learning and checking their understanding (Admiral, 2015) (Wachtler, 2016). However, many learners fall into the trap of learning just enough to pass the quizzes and course assessments (Deb, 2017). Writing essays can encourage learners to understand the content at a more in-depth level and measure their understanding more accurately than multiple-choice tests. However, it is costly, and the automatic assessment is still emergent technology (Reilly, 2014).

This study proposes a video-based learning environment which helps learners to organize the content of a video-lecture in the form of a concept map with the review recommendation. Concept maps are a kind of schematic summary of what learners learn (Novak, 1984). In this study, learners watch a video-lecture and then create concept maps about what they have learned. If a learner can make concept maps reflecting the lecture content, the teacher can assess they have understood the lecture. If not, s/he has a misunderstanding about what the video lectures. Generally, in such case, learners try to find the part of the video related to the question by them or review all the

part. The proposed function recommends the section the learners should review and encourage to reflect their understanding.

This study developed a video-based learning environment with Kit-build concept map (KBmap) (Hirashima, 2015). This system recommends learners to review parts of video-lectures according to the learners' misunderstandings based on the video annotation on the teacher's concept maps. The annotation enables the system to detect the learners' misunderstandings as the difference between teacher's and learner's concept map and to provide learners with the recommendation to review the sections of the video that the learners cannot understand. This approach uses video annotation for retrieval at the scene level, rather than the complete level (Zhu, 2012) and lecture comprehension rather than collaboration.

This paper is structured as follows. Section 2 presents the mechanism of automatic evaluation in KB map. The method for recommendations for reviewing with annotated video sections is presented in Section 3. To evaluate the function for correcting the learners' maps is presented in Section 4. Section 5 concludes this paper.

2. Sectional Review Recommendation in the Kit-Build Concept Map System

2.1 Kit-Build Concept Map

KBmap is a particular type of concept map. Novak's definition of the concept map is well-known (Novak, 1984). "Concept map" is a generic name for a graphical representation of a learner's knowledge or understanding. A concept map is a structure of "propositions," which are composed of two concepts connected by a link. When a learner creates a concept map, he/she can use any nodes and links. On the other hand, in the KBmap approach, learners compose concept maps (learner-maps) not freely, but by assembling the provided parts.

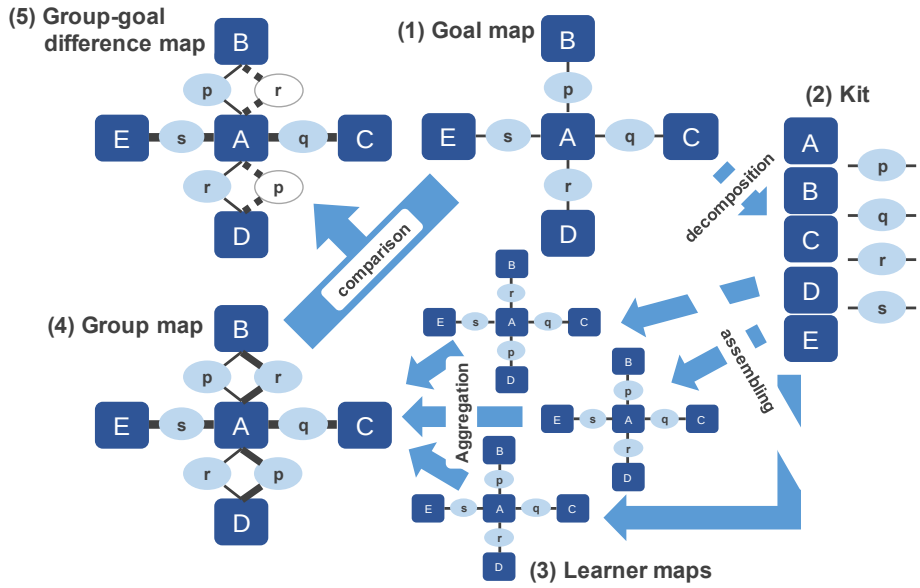

Figure 1 Kit-build concept map and diagnostic system

A characteristic of the KBmap approach is the automatic evaluation of the concept maps assembled with the provided parts. Figure 1 shows an overview of the concept-map evaluation. Firstly, the teacher creates a concept map representing the information that he/she wants the learners to obtain from the lecture (Fig. 1 (1)). This map is called the "goal map." The teacher hopes that the learners can reconstruct the goal map from the parts when they understand the lecture. In KBmap, with the parts of the goal map (Fig. 1 (2)); learners create concept maps (learner maps) as the representation of their understanding (Fig. 1 (3)).

If a learner map includes propositions that differ from the goal map, the learner has formed a different understanding than the teacher. KBmap can evaluate learner maps, not only for an individual but also for a group of learners. Because all the learner maps are created from the same parts, it is possible to overlap them (Fig. 1 (4)). The overlapped map is called a "group map." The group map can also be compared with the goal map (Fig. 1 (5)).

The KBmap system supports kit-build concept maps (Sugihara, 2012). The system can be used in classrooms from elementary school to graduate school for a variety of subjects: science in elementary schools (Hirashima, 2011) (Hirashima, 2015), geography in junior high schools (Nomura, 2014), learning English as a second language (Alkhateeb, 2015), and university-level social science and computer science (Hayashi, 2015). Even if the learners only assemble the concepts instead of segmenting them, investigation shows the same learning effect regarding the contents included in the goal map (Funaoi, 2011). The KBmap assessment method is automated, and its validity for evaluating learners' understanding has been confirmed (Wunnasri, 2018). With the evaluation results, teachers can utilize the diagnostic results from KBmap as a formative assessment tool for designing feedback for their class (Yoshida, 2013) (Pailai, 2017).

2.2 Annotating a Video with a Goal Map

This study uses goal maps to annotate video-lectures. As mentioned above, the goal map represents the information a teacher wants to tell the students in the lecture. That means that each section in the video-lecture explains one or more propositions in the goal map. The relationship between the video sections and the propositions in the goal map makes it possible to use the propositions as section annotations in the video. The left of Figure 2 shows an example of annotating a video-lecture with a goal map. Each proposition is explained to the learners in a section of the video; for example, video section B illustrates [Sun]-<rise>-[Eastern sky]. It is also possible to annotate a section with more than one proposition. For example, section D is annotated with two propositions: [Sun]-<through>-[Southern sky] and [Sun]-<not through>-[Northern sky].

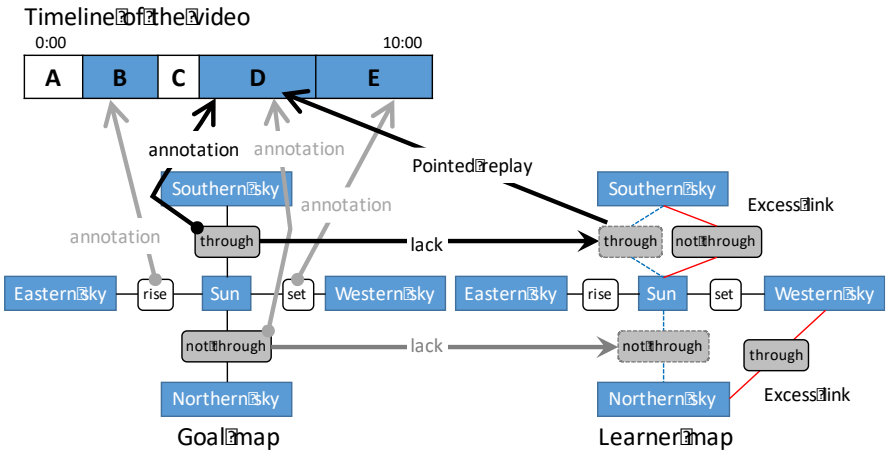

Figure 2 Selecting the part to re-watch

Combining the automatic evaluation and the video annotation with a goal map allow for specific review recommendations. The automatic evaluation identifies the differences in understanding between the learners and the teacher by comparing the goal map and the learner maps. The evaluation results and the annotations indicate the sections of the video to be recommended. The recommended sections are the ones annotated with the propositions in the goal map that the learner did not make in the learner map.

Figure 2 also shows an example of a sectional recommendation. The goal map and the video sections are shown in Fig. 2, and a learner map is shown in Fig. 3. In the learner map, the learner makes different propositions than the goal map using the links "through" and "not through." Although the goal map includes [Sun]-<through>-[Southern sky] and [Sun]-<not through>-[Southern sky], the learner map includes [Sun]-<not through>-[Southern sky] and

[Western sky]-<not through>-[Northern sky]. Both of the propositions composed of the links "through" and "not through" are annotated in section D of the video. Based on the evaluations and the annotations, section D is recommended for the learner to review.

2.3 A video-based learning environment with Kit-build concept map

We developed a video-based learning environment with Kit-build concept map. The recommendation function suggests learners review the section of the video related to learners' misunderstandings. In the system, like the usual kit-build system, learners firstly create their concept map from a kit. Then, the recommendation function works when the users ask the system to diagnose their map after uploading it. The system firstly provides feedback about the difference between the learners' and the teacher's proposition. Fig. 3 shows the feedback image. The color of each link differs depending on whether a proposition is the same as or different from the goal map. If the propositions in a learner's map are different from the goal map, the link color is red, and it is called an excess link. If the propositions in a learner's map are the same as the goal map, the color is black. If a link appears in the goal map but not in the learner's map, it is colored blue and called a "lacking link." In the feedback, lacking links are shown without the link name. When the learner clicks a lacking link, the system shows the section of the video annotated with the link. The learner can watch the section and reconsider which excess link can replace the lacking link, instead of reviewing the entire video.

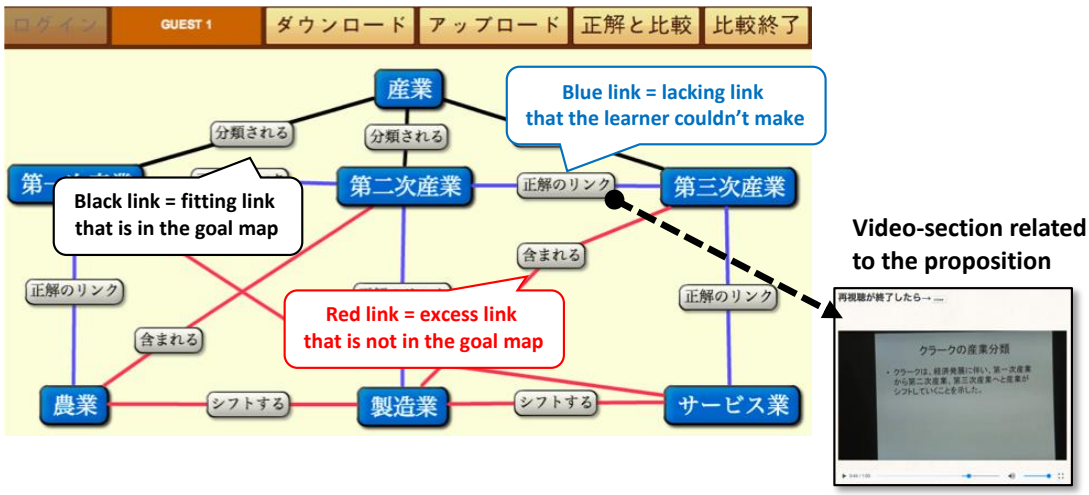

Figure 3 Screenshot of feedback in the KBmap system

3. Practical Use of Sectional Review Recommendations in Video-lectures with KBmaps

To validate the sectional review recommendation function, the authors used the KBmap system with the function as a pre-lecture resource. The lecture is in an omnibus lecture course for first-year undergraduate students. The lecture was presented in 2015 and 2016. The author used the system as the lecture-preparation task as an assignment before the lecture. The students watched a short video (about 10 min.) and then created a concept map from the kit. After they uploaded their maps onto the server, they can check how their learner map differed from the goal map. If there is the difference, learners could use the recommendation function. However, the use was not mandatory for the students. The students were asked to repeat the process until their map matched the goal map.

This paper focuses only on the learners who used the recommendation, to investigate the effectiveness of the function because the purpose of this study at this stage is whether this recommendation function works well or not. We picked up the data of learners who used the

recommendation (2015: 17.0 % (18/106), 2016: 18.4 % (18/98)) and analyzed the correct-modification rates with the chi-square test when the learners used the recommendation.

The results of the analysis are shown in Tables 1. There were significant differences between the correct-modification rates both in 2015 and 2016. From the result, using the recommendation was more efficient for correct rebuilding the concept map than not using it. This show the higher probability of successful modification of concept map with the recommendation than the learners seeks the sections by themselves.

Table 1 Correct-modification rate

		rate		p-value	Effect size	Power
2015	w/ recommendation	77.8%	(21/27)	0.0000	0.2556	0.9946
	w/o recommendation	33.8%	(96/284)			
2016	w/ recommendation	53.8%	(21/39)	0.0012	0.1755	0.9275
	w/o recommendation	27.4%	(93/340)			

Effect size: large = 0.5, medium = 0.3, small = 0.1

4. Conclusion

This paper proposed the sectional review recommendation in video-based learning. In general, it is difficult to assess learners' misunderstanding and to recommend the review parts. By annotating sections of a video with a teacher's concept map, the function proposed in this paper can identify learners' misunderstandings, and recommend learners to watch specific video sections again to modify their misunderstandings. Although this mechanism costs teachers to make a concept map and video annotations with the map, the assessment can be facilitated and advanced because KBmaps can cover the lecture content more than the usual comprehension test such as quizzes and questions and can provide recommendations based on the automatic assessment of the learners' answers.

This result showed the possibility of the use of KBmaps in self-learning with video lectures used in MOOCs and flipped learning. As stated in Introduction, KBmap can cover the lecture content more thoroughly than quizzes and questions (Kitamura, 2016) and the automatic assessment can attain almost the same level of validity as well-known manual assessment methods (Wunnasri, 2017). However, the number of learners who used the recommendation was smaller than the learners who modified their concept map by themselves without using the recommendation.

The following two issues are considered for future study. First, we need more data to justify the above consideration. We will use the system for the same lecture, but with a different year and different students, to validate the generality of the effect. Second, we should improve the recommendation function. Notably, many learners did not use the function. It is necessary to make them aware of it.

References

Admiral, W., Huisman, B., and Pilli, O., “Assessment in Massive Open Online Courses,” *Electronic Journal of e-Learning*, 207–216, 2015.

Alkhateeb, M., Hayashi, Y., and Hirashima, T., "Comparison between Kit-Build and Scratch-Build concept mapping methods in supporting EFL reading comprehension," *Journal of Information and Systems in Education*, 14(1), 13–27, 2015.

Anderson, A., Huttenlocher, D., Kleinberg, J., and Leskovec. J., "Engaging with massive online courses," *Proceedings of the 23rd International Conference on World Wide Web*, 687–698, 2014.

Chatti, M.A., Marinov, M., Sabov, O., Laksono, R., Sofyan, Z., Yousef, A.M.F., and Schroeder, U., "Video annotation and analytics in Course-Mapper," *Smart Learning Environments*, 3(1), 10, 2016.

Chauhan, A., "Massive Open Online Courses (MOOCS): Emerging Trends in Assessment and Accreditation,” *Digital Education Review*, 25, 7–17, 2014.

Deb, S., Pal, A., Bhattacharya, P., "Design Considerations for Self Paced Interactive Notes on Video Lectures - A Learner’s Perspective and Enhancements of Learning Outcome," in *Proc. of IHCI 2017*, 109–121, 2017.

Drake, J.R., O'Hara, M., and Seeman, E., "Five principles for MOOC design: With a case study," *Journal of Information Technology Education: Innovations in Practice*, 14, 125–143, 2015.

Funaoi, H., Ishida, K., and Hirashima, T., "Comparison of Kit-Build and Scratch-Build Concept Mapping Methods on Memory Retention," in *Proc. of ICCE 2011*, 539–546, 2011.

Hayashi, Y. and Hirashima, T., "Analysis of the Relationship Between Metacognitive Ability and Learning Activity with Kit-Build Concept Map," *Proc. Int. Conf. on Human Interface and the Management of Information*, United States, 304–312, 2015.

Hirashima, T., Yamasaki, K., Fukuda, H., and Funaoi, H., "Kit-Build concept map for automatic diagnosis," *Proc. of 15th Conf. on Artificial Intelligence in Education*, Auckland, New Zealand, 466–468, 2011.

———. "Framework of Kit-Build concept map for automatic diagnosis and its preliminary use," *Research and Practice in Technology Enhanced Learning*, 10(1), 1–21, 2015.

Mitrovic, A., Dimitrova, V., Lau, L., Weerasinghe, A., and Mathews, M., "Supporting Constructive Video-Based Learning: Requirements Elicitation from Exploratory Studies," *Proc. of AIED 2017*, 224–237, 2017.

Kitamura, T., Yamanaka, A., Maeda, K., Hayashi, Y., and Hirashima, T., "Comparison between Kit-Building Task of Concept Map and Multiple Choice Task of Fill-in-the-blank Question Generated from the Same Series of Propositions," *Workshop Proc of ICCE2016*, 419–427, 2016.

Nomura, T., Hayashi, Y., Suzuki, T., and Hirashima, T., "Knowledge propagation in practical use of Kit-Build concept map system in classroom group work for knowledge sharing." *Proc. Int. Conf. on Computers in Education Workshop 2014*, Nara, Japan, 463–472, 2014.

Novak, J. D., and Gowin, D., Learning How to Learn, New York: Cambridge University Press, 1984.

Pailai, J., Wunnasri, W., Yoshida, K., Hayashi, Y., and Hirashima, T., "The practical use of Kit-Build concept map on formative assessment," *Research and Practice in Technology Enhanced Learning*, 20(12), 1–23, 2017.

Reilly, E.D., Stafford, R.E., Williams, K.M., and Corliss, S.B., "Evaluating the validity and applicability of automated essay scoring in two massive open online courses," *The International Review of Research in Open and Distributed Learning*, 15(5), 2014.

Seery, M. K. and Donnelly, R., "The implementation of pre-lecture resources to reduce in-class cognitive load: A case study for higher education chemistry," *British Journal of Educational Technology*, 43, 667–677, 2012.

Sugihara, K., Osada, T., Nakata, S., Funaoi, H., and Hirashima, T., "Experimental evaluation of Kit-Build concept map for science classes in an elementary school," *Proc. Int. Conf. on Computers in Education 2012*, Singapore, 17–24, 2012.

Yoshida, K., Sugihara, K., Nino, Y., Shida, M., and Hirashima, T., "Practical use of Kit-Build concept map system for formative assessment of learners' comprehension in a lecture," *Proc. Int. Conf. on Computers in Education 2013*, Bali, Indonesia, 906–915, 2013.

Yousef, A.M.F., Chatti, M.A., and Schroeder, U., "Video-Based Learning: A Critical Analysis of The Research Published in 2003-2013 and Future Visions," in eLmL 2014, *The Sixth International Conference on Mobile, Hybrid, and On-line Learning*, 112–119, 2014.

Wachtler, J., Hubmann, M., Zöhrer, H., and Ebner, M., "An analysis of the use and effect of questions in interactive learning-videos," *Smart Learning Environments*, 3(1), 13, 2016.

Wunnasri, W., Pailai, J., Hayashi, Y., and Hirashima, T.: Validity of Kit-Build Method for Assessment of Learner-Build Map by Comparing with Manual Methods, *IEICE Transactions on Information and Systems*, Vol.E101-D(4), 1141-1150, 2018.

Zhu, X., Fan, J., Xue, X., Wu, L., and Elmagarmid, A.K., "Semi-automatic video content annotation," *Proc. of Third IEEE Pacific Rim Conference on Multimedia*, 37–52, 2002.