Ogata, H. et al. (Eds.) (2015). Proceedings of the 23rd International Conference on Computers in Education. China: Asia-Pacific Society for Computers in Education

Using Topic Maps Standards to Improve Note-Taking/Sharing in Video-on-Demand Based Self-directed Learning through Visualization

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Abstract: Recent development in streaming video and information technology have made it possible for us to access videos of our choice without the restriction of time and space. There are countless videos with educational values being made and uploaded on video-sharing websites by educational organizations and enthusiastic individuals. However, most people have experienced difficulties in note-taking in VOD based learning, which is considered to be an efficient learning process for knowledge building. The purpose of this research is to improve the note-taking of self-directed learners using online educational videos, and in the meantime, promote collaborative note-sharing. In this paper, we introduce a model which visualizes basic note-taking behaviors in VOD based learning by introducing the Topic Maps standards. Then, we design a system which is expected to help the learners construct a knowledge structure while making tags, annotations and comments to the video in accord with the timeline of the video stream, and meanwhile reviewing and sharing notes via collaborative note-taking features.

Keywords: VOD Based Learning, Topic Maps, Note-Taking, Visualization, Knowledge Structure

1. Introduction

With the rapid development in streaming video and information technologies, the advent of multimedia websites and video sharing sites have led to the unprecedented Internet delivery of video contents. Videos are very important learning resources which not only produce authentic learning experiences for students (Kearney and Campbell 2010; Kearney and Schuck, 2006) but also enable students to acquire a range of transferable skills (Allam, 2006). Needless to say, videos are more efficient and intuitive learning resources than that of the text-based. Because of these benefits, countless educational videos are being created and uploaded onto the Internet and the number is still growing exponentially. This opens up another great opportunity for self-directed learners in their pursuit of knowledge for either personal or professional reasons. Millions of users are searching, browsing and sharing online videos as a source of learning information daily. This type of learning activity is referred as VOD based learning, which is now playing an important role in distant learning resources (Deniz, 2004). Note-taking, as an effective way of recording information in traditional lectures, is also equally highly recommended in VOD based learning for various possible purposes of better comprehension, concentration and reflection etc. Although VOD does help us successfully avoid time pressure by allowing us to revise any part of video contents whenever we want, for note-taking there are still difficulties to resolve and rooms left for improvements. For example, the notes taken during VOD based learning should be well organized in a meaningful structure to facilitate later learning activities such as revising, and should also be generally managed over numerous videos. Furthermore, with the new technologies being developed and exploited, we should take several challenges for more possibilities to improve the note-taking situation in VOD based learning. We will discuss these issues in the following section. In this paper, we propose a VOD learning system which intends to help self-directed learners take note more effectively

g and efficiently in a virtual space. Moreover, this system also intends to provide an effective way enabling the learners to share their notes with others, and meanwhile, review others' notes as reference.

2. Issue Addressed

2.1 VOD Based Learning

It has been known that videos are important learning resources that enable learners to gain knowledge more effectively and intuitively than written materials because they are more informative and engaging. For example, a video about an historic event can give the learners more information both verbally and visually, which can never be placed with written words. Furthermore, the videos offer the learners the authentic learning opportunities that are more attractive and motivating. More recently, Willmot et all (2011) found out that there is strong evidence showing that video reporting can inspire and engage students through various aspects of the student-centered learning activities (increasing student motivation, enhancing learning experience, development of learner autonomy, etc.). The fast development in video streaming and information technologies are making all these benefits more universal and accessible. The number of educational video clips is exploding on the Internet. We can literally find videos of any subject on video sharing sites like YouTube uploaded by dedicated individuals, or get access to those high quality lecture videos made by universities and educational organizations around the world, enabling us to learn more effectively and intuitively without the restriction of time and space.

2.2 Related Research on Note-Taking System and The Challenges

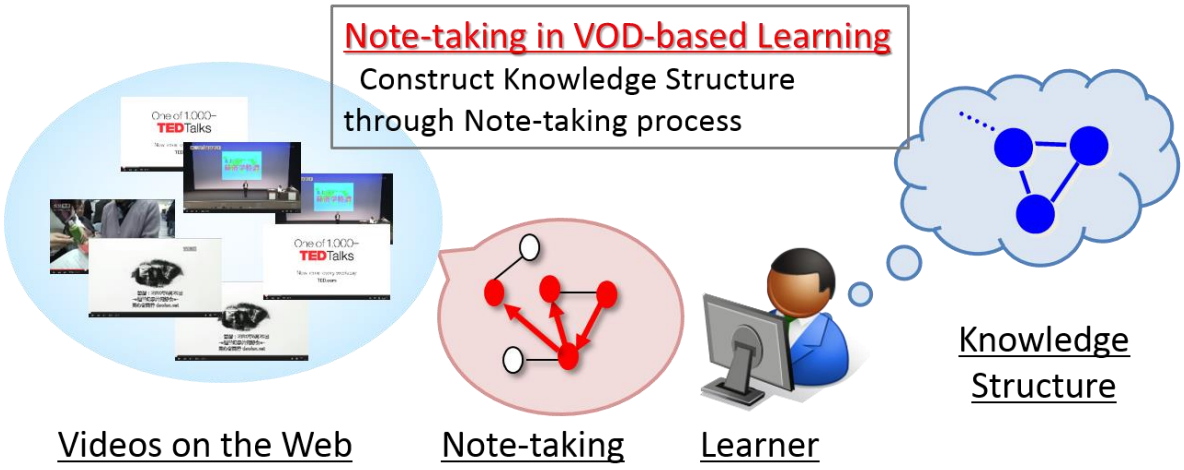

Figure 1. Note-taking in VOD based Learning.

When taking lectures in a classroom, we tend to take notes. The reasons for doing these varies from person to person, but the main advantages for note-taking (Henk, 1985; Barnett et al, 1981) can be summarized as the following:

1. Note-taking forces the learners to listen carefully and measures your understanding of the lecture.
2. The notes taken help the learners remember important points of the lecture.
3. Notes taken are excellent references for future work (reports, essays, projects, presentations, etc.).
4. Notes taken are easier to revise for knowledge attainment and reflection.

This list is even longer under different circumstances. Obviously, most of the benefits equally apply in VOD based learning. In the meantime, as note-taking is a complex activity that requires comprehension and selection of information and written production processes (Piolat, 2005) which is intellectually challenging and time consuming, the difficulties also remains the same in VOD based learning. In order to address these difficulties, there are many research on note-taking (tagging,

annotation indexing) on E-documents. Although there are research mainly focusing on the type of E-documents (for example real-time lectures, text-based webpages etc.) other than videos, most of the issues and proposals discussed in these research can also be applied to the note-taking in VOD. Aware of the fact that it is necessary for the learners to make up for missed lectures as well as to corroborate the accuracy of their notes, Rohit (2013) focused on utilizing speech recognition technology to provide learners all the verbal contents afterwards. Ota (2012) took the same approach but only to filter words possible to provide hints for note-taking instead of the whole verbal contents. Another recent research (Yu et al, 2012) adopted linked data technology (Berners, 2006) to firstly provide the users with machine-understandable keywords for annotation, but also connect current video resources with other knowledge data on the web. As for collaborative note-taking which is very important (Ellis and Phelps, 2000), some emphasized on making connections with the notes of others (Miyake, 2000), some focused on sharing text messages (Singh, Denoue and Das, 2004) or facilitated hand-drawing among lecture participants synchronically with real-time lectures (Kam et al, 2005; Bateman and Brusilovsky, 2007). By considering the fact that, unlike real-time lectures, we can always go back to certain parts of the video contents for revision without the restriction of time, some research (Nakanishi, Shimada, Kojima and Fukuhara, 2010; Hasegawa and Dai, 2015) took this unique advantage in VOD based learning by connecting scene-related comments/questions to the exact timeline to support synchronic communications among the learners.

Undoubtedly, the note-taking situation would be greatly improved if the techniques or ideas proposed in those research can be applied in VOD based learning. However, there are still several limitations. First of all, the notes are not taken in a way to better facilitate later learning activities. They are simply aligned linearly which is too simple to represent the knowledge building. Secondly, the notes should be overall managed other than only in one video. Because it is possible that sometimes notes in different videos should be related for the purposes of better understanding and illustration. Especially when every note connects with the according timelines of different videos, with the properly structured notes the learners can jump through video parts guided by their notes efficiently to reflect scene-related-knowledge. Thirdly, the notes taken are not effectively shared among the learners. Recent situation is more like Q&A in a blog site or sending instant messages to each other. A more sophisticated way to present collaborative notes should be presented for community-based knowledge attainment and reflection.

Concept map (Novak and Gowin, 1984) and knowledge map (O'Donnell, Dansereau and Hall, 2002) are diagrams that represent ideas as node-link assemblies which has been prevalently studied in many research. It has been shown that the concept/knowledge mapping in a digital learning environment was very effective in overall learning gains and knowledge retention (Lin, Wong and Shao, 2012). For this reason, we think it is necessary to introduce the concept of mapping to visualize the note-taking behaviors in VOD based learning. Having considered both the good proposals and limitations existing in current note-taking support systems, and the necessities of introducing mapping techniques into this research, to this end, this paper has identified the following primary challenges.

- *The learners should be able to take notes in a non-linear way*. The current situation for note-taking on online videos are all linear, in the form of strings of words serving as tags or comments. Many research have suggested that all non-linear note-taking strategies benefit learning more than does the liner recording of information (Boyle and Weishaar, 2001). In this way, learners can improve the quality of the selection and the organization of the information that is recorded as knowledge structures. This means that notes taken should be visualized in terms of nodes and links. Goyal and Gilly (2013) has proved in their experiments that visualization of data links significantly improved participants' sense-making ability whereas the notepad did not.
- *Every piece of notes should be synchronized to the playback time of the video.* Recent technology has already made it possible to take synchronized comments that are being overlaid directly over the video (nico nico douga of Japan). This is a privilege in VOD based learning we should take advantage of, to make learners aware of when and why they took the notes when they are revising. Furthermore, by synchronizing the notes of other people, the learners can re-experience the note-taking processes of the others and make that useful for themselves.
- *The notes taken should be able to connect to useful knowledge data from the web.* Piolat (2005) described note-taking as short condensations of a source material that are generated by writing them down while simultaneously listening, studying, or observing. However, sometimes we need to supplement something that is not in the source material to deepen/expand our comprehension.

As a result, the notes taken in VOD based learning should be able to connect with other knowledge data from the web. It might be other parts of the current video, Pdf files from the other website or another videos shared by other people and etc.

- *The notes should be shared and reviewed among the learners.* Most of us have the experience of borrowing lecture notes from classmates to supplement what we missed during the class or for confirmation. It has been found that note-sharing can support collaborative externalization and reflection and should be implemented in VOD based learning (Miura, Kunifuji and Sakamoto, 2007).

This paper adopts the visualization technology in the combination of Topic Maps standards to address these issues. The details will be discussed in the following sections.

3. Approach

3.1 Topic Maps

Topic Maps are ISO standard for describing knowledge structures and associating them with information resources (ISO/IEC 13250, 2002). While it is possible to represent immensely complex structures using topic maps, the basic concepts of the model—Topics, Associations, and Occurrences (TAO) —are easily grasped (Pepper, 2000). Figure 2 illustrates the three basic concepts of Topic Maps and the rough ideas of how are they applied in our research. In this research, topics represent the notes taken by the learners while they are conducting VOD based learning. The notes are pieces of selected information describing the learners' comprehension status at the current situation. Association links represent various relationships among the notes. Occurrence links represent the time point of the video when the notes are being taken. Topic Maps are one of the standardized methods to present concept maps. By following the rules of Topic Maps, the concepts learners generated through the learning process could be properly managed and understood. Especially the merging feature of Topic Maps can enable a more effective way of sharing and collaboration among community learners.

The reason for adapting the concept of Topic Maps is because it properly meets all of our requirements for the challenges we are going to take. Firstly, notes are condensed pieces of information created by the learners to conceptualize the knowledge they have learnt so far. Obviously, topics are quite conveniently fitting this position. Secondly, we have mentioned the necessity of enabling non-linear way of note-taking. The concept of association links enabling learners to make various connections among notes is perfectly serving this purpose. Thirdly, the recorded time points for every note of the video resources are the occurrence links that represents the information resources to better illustrate each note taken. The learners can jump directly to the video clip where and when they made the note for knowledge revision and reflection. To take advantage of the semantic features of Topic Maps, we plans to define several different shapes of nodes (triangle, square, ellipse and etc.) and lines (continuous, dashed with arrow, two arrows and etc.), to represent various types of topics and associations with semantic meanings according to the learners themselves. For example, when watching history-related videos, the learners may define ellipse as people, square as historical site, and triangle as important event and etc. As to associations, we plan to pre-define several types which could meet most scenarios such as "is kind of", "is subject of", "is prior to" and etc. by checking this structure later on, the learners are expected to immediately recall the knowledge they have learnt, and furthermore, deepen their comprehensions. The occurrences will not appear in the whole structure, whose information reveals only when certain notes are selected by the learners for details. Finally, the merging feature in Topic Maps can be used for note-sharing among the learners for community-based learning. All the notes taken in one video will be merged into an understandable formation along the timeline based on a set of rules (notes similarity, connections and etc.) to inform the learners the notes taken by others who have watched the same video. A detailed discussion of how these three concepts are applied and the architecture of our research is held in the following sections.

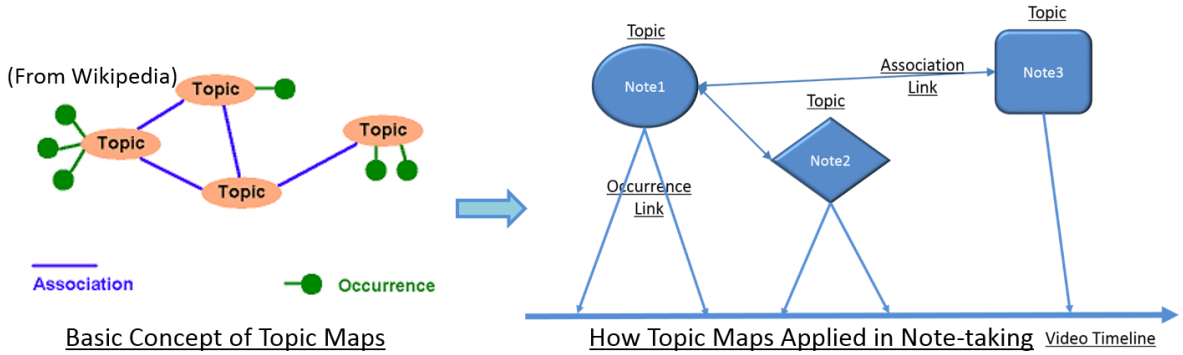

Figure 2. The Basic Concept of Topic Maps.

3.2 The Research Concept

Figure 3 describes the overall concept of our approach. Learners can create notes while they are watching videos. Each notes has three types of occurrences: strings of words, url, and time point. Strings of words are input by the learners for further explaining the notes they have created. Url is the address of other web resources added by them to better illustrate the current note. The time point is automated recorded at the very moment when the note is created and added by them as the other type of occurrence. Then, the learners can make various kinds associations among notes. For better management, the types of associations will be pre-defined. The learners can choose the types they think appropriate to relate the notes they have taken. Moreover, because the number of the notes keeps growing, so as the connections among notes, the appearance of the note structure would be really messy for management. As a result, the learners can once in a while summarize the notes they have taken by combining several notes into one bigger note to make the structure more clear and easy to understand. Not only can they relate the notes taken in one video, but also the notes they took in previous videos. In this way, the knowledge structure can be properly expanded along with the learning processes, and also it makes the revision and reflection more efficient by only using notes to jump through video parts over numerous video clips.

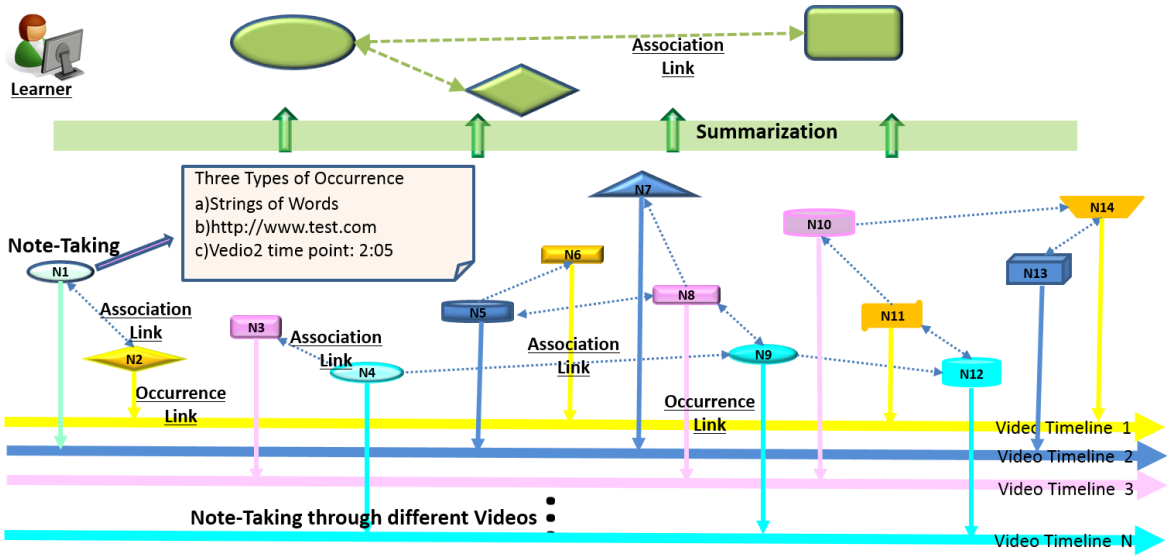

Figure 3. The Concept of Personal Note-taking.

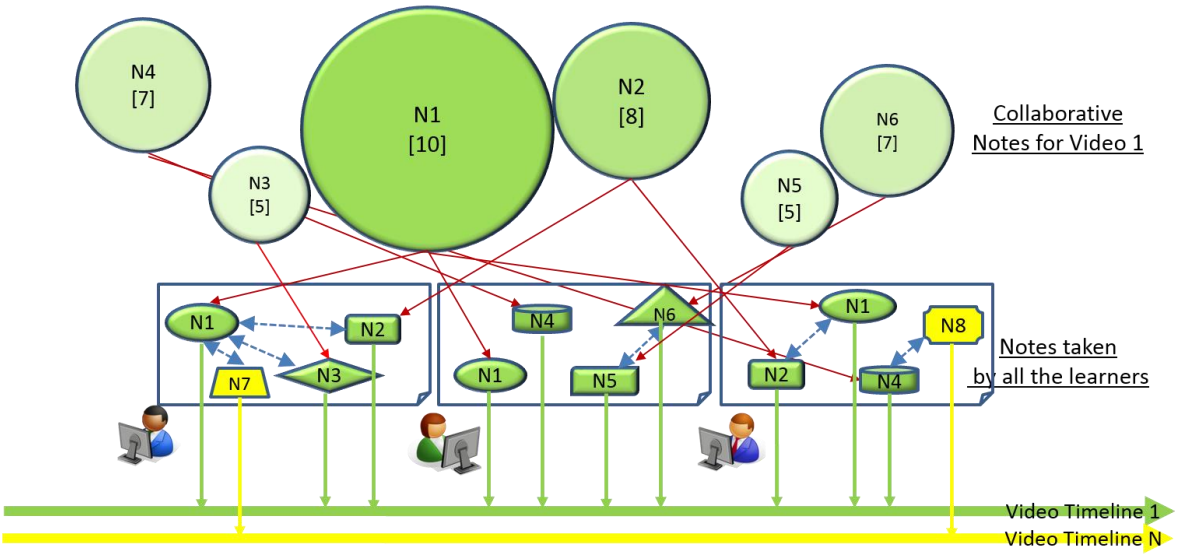

Figure 4. The Concept of Collaborative Note-sharing.

For the purpose of sharing notes taken by the learners who have watched the same video, we intend to merge same/similar notes into bubble form charts as shown in Figure 4. The color density of each bubble represents the number of the learners who have taken the same/similar notes. The system will calculate the similarity from the notes' contents and merge the similar notes created by different learners into one bubble. The denser the bubble is, the more learners have taken the same/similar notes. The relative position between bubbles represents the extent of how two notes relating to each other. Since learners are making all kinds of associations among notes, the number of association links between two notes will be calculated as distance between two bubbles. The size of each bubble represents the number of occurrences included in each note. The strings of words, urls and time points from different videos will all be treated as occurrences. The bigger the bubble is, the more occurrences contained in one note.

3.3 The System Architecture

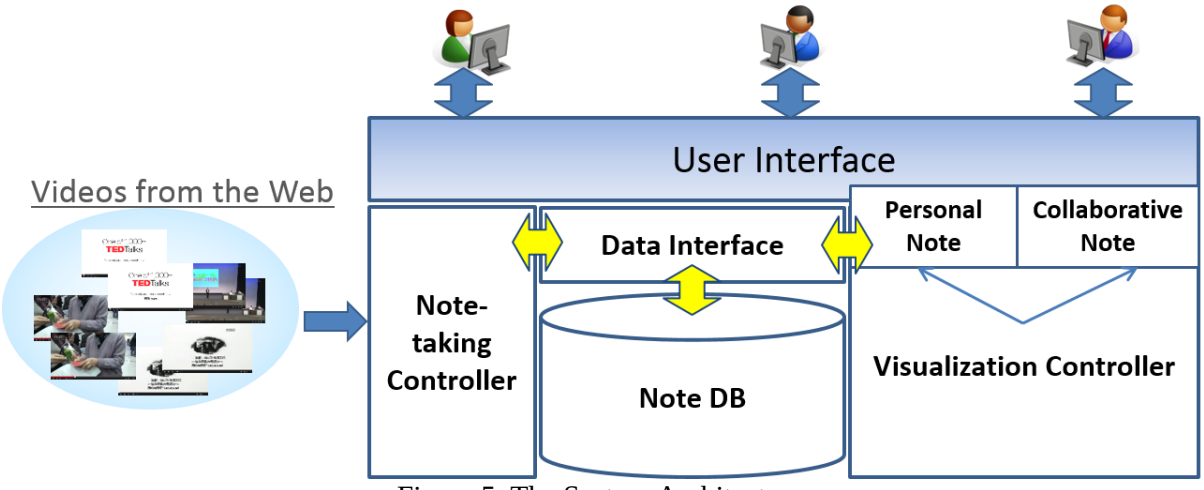

Figure 5. The System Architecture.

From system development point of view, the system bears many resemblances with our previous research (Li, Hasegawa and Kashihara, 2015), we decided to use the system architecture of the previous one only with several minor adjustments. Figure 5 describes the architecture of this system. The learners are interacting with the system through the user interface. The note-taking controller provides the learners with all the necessary functions for note-taking. For example, it provides different shapes of nodes for the learners to choose to represent their notes, various types of association links to draw

among nodes and also the data of the current time point when new notes being created. All data will be stored in Note DB through data interface in term of XML Topic Maps (XTM) which is an xml syntax for expression and interchange of Topic Maps. The visualization controller visualizes the personal notes taken by each individuals for revision and also the collaborative notes taken by all the learners who have watched the current video for note-sharing.

Note-taking Controller visualizes the basic learning behaviors when taking non-linear notes. Firstly, it provides the learners with different shapes of the nodes to represent their notes. And then it enables the learners to draw different types of lines among nodes to make associations among notes. After each node and line are being added, the controller will automatically recorded the time point for learners to add as a type of occurrence. Meanwhile, it also offers the options of adding strings of words or Urls as other types of occurrence. All the information will be recorded to the Note DB in the format of XML according to the Topic Maps standard.

Visualization Controller has two function unit. One is for visualizing personal notes. It visualizes the notes taken for each individual in a non-linear way. The other one is for visualizing collaborative notes. It visualizes the notes taken by all the learners in a universally recognizable way. Learners can share their notes, review the notes of others for knowledge reflection and attainment.

4. The Concept GUI of the Proposed System:

In this section, we will introduce the image of the system GUI and how learners use it to take notes in their self-directed VOD based learning. As the pilot system is still under development, please be noted that the figures used below contain partially Photoshop-edited items to better explain how the support system would work.

As learners are expected to take notes while watching the video, the system offers the learners a block of icons in different shapes right below the video block to help them represent each individual note as shown in Figure 6. When the learners decide to take notes, they can firstly choose one icon from the lower left corner to present a particular concept based on their own reasoning (for example, ellipse represents people.). Meanwhile, the system will record the time point at the moment for the learners to add as one of the occurrence. And then, the learners will define the note by giving it a title, adding occurrences (strings of words, urls and time point) and the type of associations with the existing notes. When all of these are finished, the well-defined icon will appear on the right side of the screen. Also on the lower left corner, there is a block for all the types of association links for the learners to choose. The learners can choose a type of line and use it to directly link icons on the right side directly while the time point will also be recorded. The notes taken will be presented in a non-linear way, consisting only icons (topics) and lines (associations). The text message in the structure are only topic titles and association types, but further details (occurrences) of each topic and association will appear after being clicked. In this way, the learners can define each note and make associations while watching videos, and at the same time connect the related notes over a number of videos. We expect the learners could build up their knowledge structure during this process, which also would help them revise the learnt knowledge points more effectively.

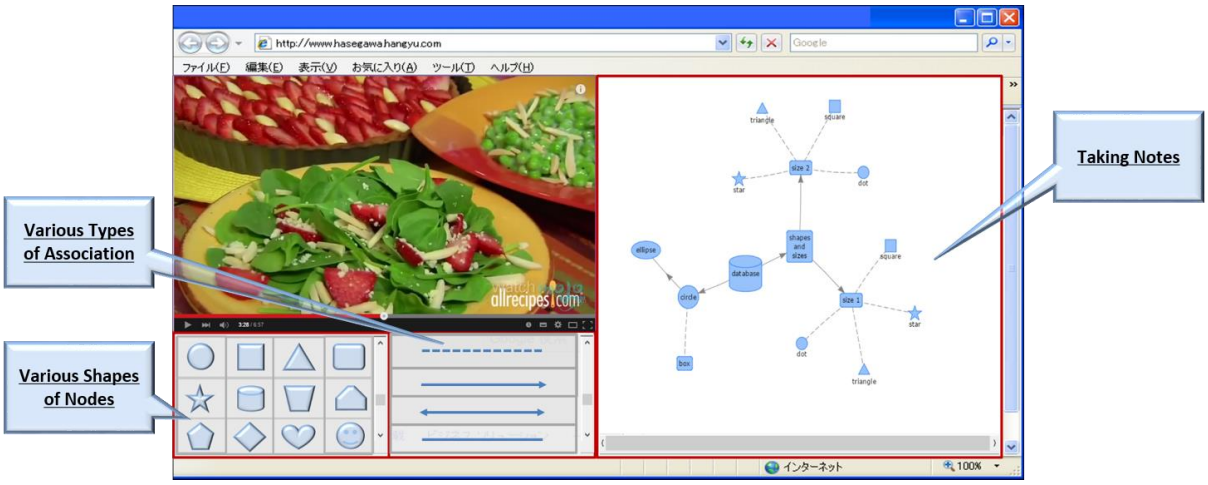

Figure 6. The GUI for learners to take note.

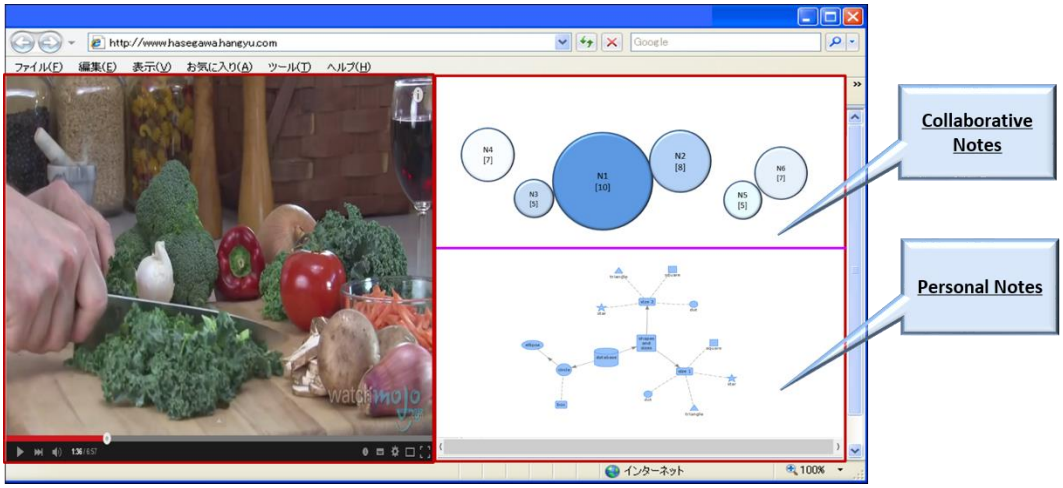

Figure 7. The GUI for learners to view personal and collaborative notes.

When the learners finished watching the video, they can review the notes taken by themselves and also the notes taken by the other people who have watched the same video. On the right side of the window, there are two blocks. One is for personal notes taken by the current learner. And the other one block is for showing the notes taken by other learners in terms of bubble form charts. As we have discussed before, the size of the bubble, the relative distance among bubbles and the color density of each bubble are all informing the learners the note-taking situations of the current videos. All the notes will be synchronized along with the video's time line. In this way, the learners is able to re-experience the moment when they took the notes and the reasons for doing that. Moreover, by checking the collaborative notes, the learners can on one hand catch new knowledge point, and on the other hand have the opportunity to access some other useful learning resources.

5. Conclusions & Future Work:

This paper proposed a Topic Maps based approach to support self-directed learners' note-taking behaviors on VOD based learning. We treated every pieces of notes as topics and the connections among notes as associations. Each note has its occurrences which not only point to the timeline of the current video, but also expand to learning information from other resources. By using the system, we expect the learners not only can note down important things while conducting VOD based learning, but also can construct a complete knowledge structure which indexes important information over numerous learning resources. By introducing the merging feature of Topic Maps standard, we expect the note-sharing among learners will become more smooth and convenient.

In the near future, we firstly will continue our design and development of the pilot system using Microsoft ASP.NET MVC. After the development, an evaluation will be conducted in our institute using the video archive of lectures, which contains all the courses in our department. We will evaluate the effectiveness of knowledge building and reflection by taking notes with the pilot system. And then how the collaborative notes in the system would help the learners accumulate knowledge.

Acknowledgements

The work is supported in part by Grant-in-Aid for Scientific Research (B) (No.26282047), (C) (No. 26330395) from the Ministry of Education, Science, and Culture of Japan.

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