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A Semantic Tag-based enhanced Learning Recommendation approach for enhancing student learning experiences

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Abstract: With the rapid development of semantic web and ubiquitous learning applications, constructing prior knowledge has also become increasingly important for on-line reading learning. Traditional studies on prior knowledge generation during reading activities have focused on extracting sentences from reading materials that are manually generated by website administrators and educators. This is time-consuming and strenuous, and hence personalized prior knowledge recommendation is difficult to perform. To cope with this problem, we combine the concept of prior knowledge with semantic tagging methods to assist the reading comprehension of students studying science subject, which then identifies suitable supplementary materials for quickly constructing a student's prior knowledge reservoir. Moreover, we incorporate tags into a tag based learning approach to automatically monitor running activities and student status. The experimental results clearly show that the proposed approach not only significantly improves the efficiency of knowledge learning but also helps teachers assist students in improving their reading ability.

Keywords: ubiquitous learning, intelligent tutoring systems, interactive learning environments, museum learning

1. Introduction

In the past, learning was considered a process of accumulating information or experience (Hwang & Chang, 2016). Building prior knowledge through reading is becoming increasingly important for students, as it helps students learn quickly and effectively. Thus, obtaining this skill early during the learning process is crucial. Research has shown that a student's prior knowledge often confounds an educator's best efforts to deliver ideas accurately (Sung & Hwang, 2018). Thus, to help students make the most of new experience educators need to understand how prior knowledge affects learning (Falk, J. H., & Dierking, 2018). However, despite the value of prior information, Taiwanese schools have largely focused on skill development rather than expanding a student's knowledge of the world, such that reading comprehension and prior knowledge instruction are still a challenge in English as a foreign language (EFL) classes in Taiwan's education (McNAMARA, Ozuru, & Floyd, 2017).

Additionally, studies have found that students who find it hard to link new knowledge in a social learning environment, resulting in students having problems understanding, recalling, and accessing the new knowledge later (Song, Kalet, & Plass, 2016). This leads to poor levels of reading comprehension among students, such that even above average students are unable to read and fully understand material. In short, there is a gap between the rich information received and the knowledge generated.

To cope with the problem, this paper proposes a Semantic Tag-based Enhanced Learning Recommendation approach (STLR) by employing semantic tag analysis and visualization monitoring mechanism, which provides prior knowledge learning environments that help promote critical thinking through article construction can activate a student's existing schema and help them identify new information from articles more easily (Falk, J. H., & Dierking, 2018; Peng, Zhang, & Ho, 2019). Such background information may even help students find clues for identifying the meanings of new vocabulary or sentence patterns (Cottrell, 2017). The most important value of this social tagging system,

however, is the promise it shows for dramatically improving student reading comprehension. Meanwhile, designing a monitoring interface that enables teachers to navigate to potentially relevant information, and assists teachers in both analyzing interactions from student tag behaviors and evaluating student learning performance.

2. STLR: a Semantic Tag-based enhanced Learning Recommendation approach

Reading involves a complex cognitive process for students who take the initiative in learning. In order to effectively assist the students in enriching prior knowledge and raise their reading comprehension, and is also helpful in assisting teachers in evaluating student reading comprehension by tag-cloud visualization, in this study, a Semantic Tag-based enhanced Learning Recommendation (STLR) system was developed by employing semantic web and its related techniques for conducting visiting learning activities in museum. The proposed system consists of a mobile reading learning module, a prior knowledge recommendation module, learning monitoring module, and a back-end databases module s for computer-aided reading practices, as shown in Figure 1.

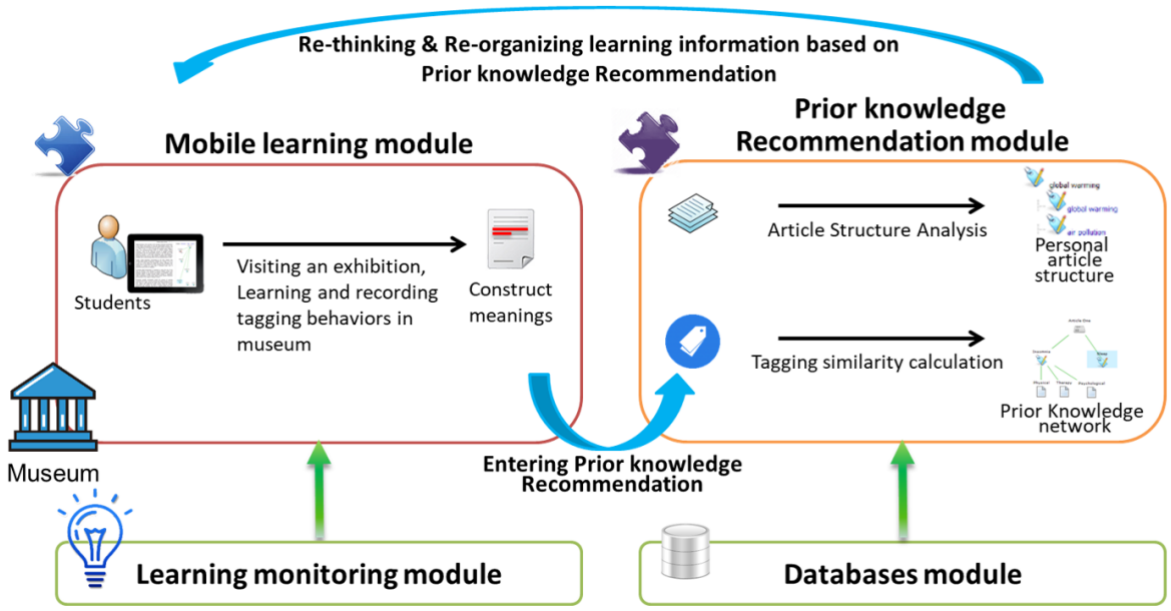

Figure 1. Structure of the proposed STLR system.

(1) **Mobile Learning module:** students can use their tablets to learning via a wireless network, observe exhibitions, read on-line learning materials and record their learning behaviors. Students can annotate various online resources (materials) with freely chosen tags. Tagging certain activities can help students summarize new ideas and quickly grasp the structure and concepts of English articles (Chen et al., 2010; Klašnja-Milićević et al., 2018). Moreover, these tags are also designed to enhance critical thinking skills by directing students to evaluate and then support or oppose different viewpoints on their readings. The functions of this module contain viewing exhibition information and learning materials and tags recording.

(2) **Prior Knowledge Recommendation module:** the functions of this module contain to construct personalize article structure and prior knowledge network, and then recommends appropriate supplementary knowledge to students and helps them gain new information from articles more easily. The major functions are presented as follows:

- **Article structure analysis:** we combine the results of paragraph analysis and tag classification to decide which paragraphs are most relevant and which paragraphs represent subtopics of the article. The presenting information can help students hold each bit of information or connect it to background knowledge, so that enables students in understanding articles and related elements of exhibitions.
- **Prior knowledge network:** in order to find suitable prior knowledge for a student, we use the key sentence of the paragraph as a query to search for similar articles. Meanwhile, to ensure that these prior knowledge articles are suitably useful for students, we search for topic sentences

from each paragraph by article structure analysis that the student is unfamiliar with or does not understand by students' tagging similarity calculation (Chen et al., 2014). We then recommends appropriate supplementary knowledge to students and helps them gain new information from articles more easily.

(3) **Learning monitoring module:** teachers can observe the current status of a student's learning performance and tagging behavior. When students who have a learning disability are diagnosed by analyzing the tag cloud, this interface can assist teachers in providing focused feedback and questions to students as soon as possible. This information is helpful for assisting teachers in evaluating the reading comprehension status of students, and thus provides teachers with valuable input when they attempt to adjust teaching strategies or diagnose a student's learning obstacles.

(4) **Back-End Databases module:** The module contains databases of the learner's personal information, learning materials, annotated tags, learning portfolios and semantic tag weighting sheets.

Figure 2 illustrates the user interface of the STLR system. Students first select articles via a drop-down menu, after which the context of the selected article is displayed. The personal article structure consists of a root node (e.g. global warming), which presents the main topic of the article, and sub-nodes (e.g. global warming, air pollution, extreme weather, and Kyoto protocol), which present the topic of each paragraph. If the paragraph is not important, no sub-nodes are included. In addition, article content is highlighted whenever students click on the sub-node of the "personal article structure." This highlighted content can include entire paragraphs, any key sentence represented by the sub-node, and the key sentence from the key sentence computation. Overall, this highlighted information provides each student with a quick and useful personal snapshot of the reading material.

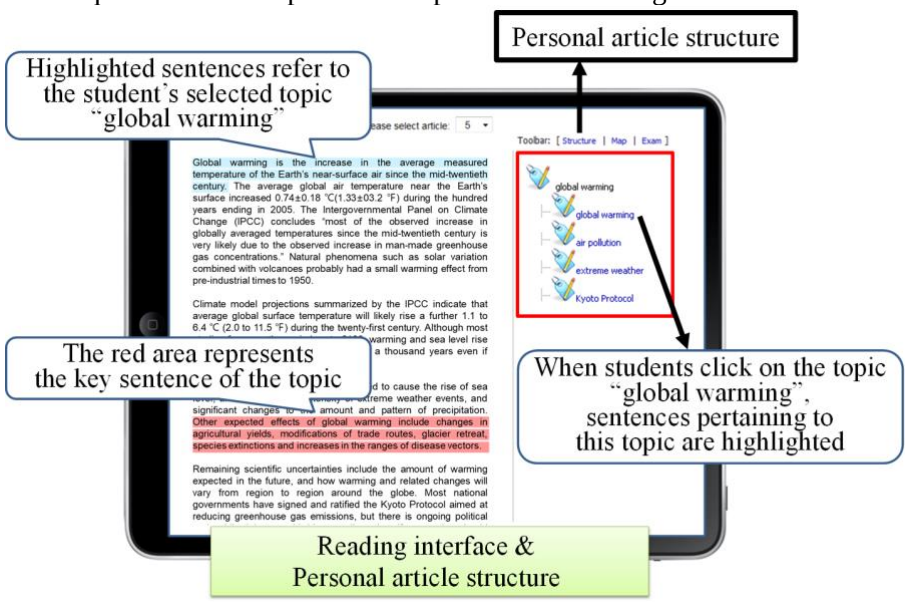

Figure 2. System Interface for Reading learning and Personal article structure.

Figure 3(a) illustrates the structure of the "prior knowledge network" which consists of a root node and sub-nodes, and the locations of nodes that correspond to the order of the paragraphs. This structure varies depending on the student. If a node of the structure represents the recommended topic for a student, such as "global warming," the node is highlighted. The most important function of the network of prior knowledge is its provision of adaptive and necessary prior knowledge. Students click any node in the prior knowledge network and a new window appears, displaying the prior knowledge article to the student. Here, the provided articles are in Chinese, because the goal is to supplement their language knowledge deficiency with prior knowledge, which is more easily consumed in the student's native language. Figure 3(b) shows the teacher interface presenting the current status of a student's learning performance and tagging behavior. When students who have a learning disability are diagnosed by analyzing the tag cloud, this interface can assist teachers in providing focused feedback and questions to students as soon as possible. This information is clearly helpful for assisting teachers in

evaluating the reading comprehension status of students, and thus provides teachers with valuable input when they attempt to adjust teaching strategies or diagnose a student's learning obstacles.

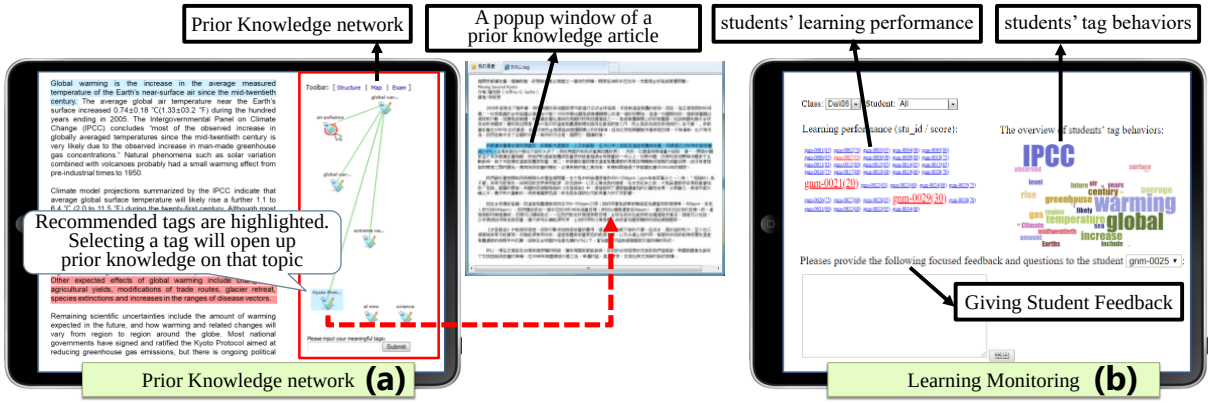

Figure 3. System Interface for Prior Knowledge Recommendation and Learning Monitoring.

3. Experimental design

To evaluate the effectiveness of the proposed approach, an experiment was conducted on visiting learning activity in a Taiwan's museum. The objective of the learning activity was to improve student comprehension, translating into overall better learning performance. The activity encouraged students to observe, read, and tried to help students get a better grasp of what is going on in the articles and associated elements of the exhibition they see. It was expected that the tag visualization and learning recommendation would not only be used by the students to get a quicker grasp of the meanings and the relationships between the learning targets, but also by teachers to assist them in tracing and analyzing the information search behaviors of students.

The participants were 68 students from one senior high school in Taiwan. Before the experiment, one class was assigned to be the control group and the other was assigned to be the experimental group (each with 34 students). The two groups of students did not have any interaction, so that they would not be affected by the other group during the learning activity. Next, each group was given a pre-test evaluation and then entering learning activity. Additionally, in order to evaluate the effectiveness of the proposed learning monitoring mechanism, five participating teachers from a senior high school in Taiwan were invited to experience the use of the teacher interface. The teachers were all experienced with over 5 years in the teaching profession.

4. Experimental Results

4.1 Learning achievement

In order to evaluate the feasibility and potential application of the STLR system, we adopted a pre- and post-test experimental design that made use of before and after surveys to demonstrate the achievement of learning outcomes.

Pre-test: All students took a pre-test at the beginning of the reading activity. Table 1 shows the t-test values for the pre-test and post-test results. The mean score of the pre-test for the control group was 60.58, and 58.01 for the experimental group. The t-test result showed that these two groups did not differ significantly ($t = .437$, $p > .05$). In other words, before performing the experiment, the pre-test revealed that control and experimental group demonstrated a similar understanding of the learning topics at an alpha level of 0.05.

Post-test: After participating in the learning activity, the two groups of students took a post-test. The t-test results of the post-test indicated that the experimental group had a higher mean score than the control group. Furthermore, the results show that the learning achievement of the experimental group was significantly better than that of the control group ($t = -2.318$, $p < .05$). That is, the experimental

results indicate that the proposed STLR approach is an effective approach for enhancing student reading comprehension.

Table 1: Paired t-test of the pre-test and post-test results

Test	Group	N	Mean	Std. Deviation	Std. Error Mean	t-test
Pretest	Control Group	34	60.58	23.8609	4.0921	t = .437
	Experimental Group	34	58.01	24.4024	4.1850	p = .665
Posttest	Control Group	34	60.59	13.8041	2.3638	t= -2.318
	Experimental Group	34	67.65	14.4723	2.4819	**p= .027***

*p < .05

4.2 Analysis of Perceived Ease of Use and Usefulness

To better understand the students' perceptions of the use of the STLR learning system, this study collected the students' feedback on the "perceived usefulness" and "perceived ease of use" of the system. The results indicated that most students gave positive feedback concerning the two dimensions of the STLR learning system. The average ratings for "perceived usefulness" are 3.87 and 2.82 for the experimental group and the control group, respectively; moreover, their average ratings for "perceived ease of use" are 4.14 and 3.89. In comparison with the ratings given by the control group, it should be noted that the students in the experimental group gave higher ratings for "perceived usefulness" and "perceived ease of use", implying that the students who learned with the STLR learning system revealed higher degrees of technology acceptance than those who learned with the mobile learning system.

In terms of perceived usefulness, the t-test result ($t=3.68$, $p<0.001$) shows a significant difference between the experimental group and the control group. From the students' interview feedback, it was also found that most of the students agreed that the proposed A semantic tag-based enhanced learning recommendation learning system is capable of helping them easily comprehend and learn the benefits of learning activity, and can help them improve their learning efficiency.

4.3 A Survey on teacher consensus with STLR recommendation mechanism

To evaluate the validity of the personalized prior knowledge recommendation quality, an experiment has been conducted by arranging five experienced experts. The experts were asked to rate importance and feasibility for STLR recommended prior knowledge based on their knowledge of the literature using 10 point scales. The rating of 10 represents the highest representative.

From the experimental results, it was found that a consistent consensus value with the experts' experience and opinion was 8.6, meaning that the content of the recommendation fits the scoring process of the domain experts. That is, the results demonstrate that the recommendation mechanism of STLR system is valid, and thus the proposed STLR approach serves as a useful tool for assisting teachers with student literacy assessment.

4.4 A Survey on teacher satisfaction with STLR and learning monitoring mechanism

To evaluate the effectiveness of the learning monitoring for a semantic tag-based enhanced learning, teachers' comments from the exit survey were also analyzed. Five participating teachers from a senior high school in Taiwan were invited to experience the use of STLR teaching interface. A questionnaire and interviews were conducted for collecting teacher feedback. From this data, there were two main findings:

(1) Most of the teachers believed that annotated tag can enhance the ability of the students for knowledge acquisition. Moreover, those teachers considered that another reason for the effectiveness of the STLR systems is the ability to aggregate tags added by different students, resulting in a list of weighted tags. This means that each tag is not only present or not for each article, but it may have a weight of relevance, indicating how relevant the tag is for the article. As

such, the proposed learning assistance and teaching mechanisms can provide a different dimension to accumulate more learning experiences which can then make students not only aware that the text has structure but also familiar with the cues that exist within the text.

(2) All teachers agreed that the learning monitoring mechanism is helpful to acquire more knowledge about the learning status of students and effective to decrease the teaching load. This teaching interface can assist teachers in evaluating the reading ability of the students efficiently, enabling constructive suggestions to be given to students, and allowing for the improvement of tutoring strategies. Furthermore, STLR provides a new way to assist teachers in exploiting tag information in the students' tag to capture student attention and keep the attention focused.

5. Conclusions and future work

The study is to propose a Semantic Tag-based enhanced Learning Recommendation approach (STLR) to provide insight on learner comprehension and activity as well as learning monitoring, which is useful for both students and teachers. Moreover, tag extension and application involves using semantic web and its related technologies to generate tag clouds of semantic concepts, which also provides a new way to extract meaningful learning results and to analyze learning behavior.

The experimental results showed that experiences with applying tagging and integrating tag navigation helped students improve their reading comprehension and quickly grasp the structure and concepts of English articles. Moreover, the proposed STLR approach is also helpful in assisting teachers evaluate student learning achievements by tag-cloud visualization. These finding and results can thus provide instructors and administrators with suggestions and references for the design of efficient mobile learning in the future. Further, these indications further warrant future experiments in social tagging applications in collaborative learning environments to improve reading and recommendations incrementally.

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