論 文 内 容 の 要 旨

I. INTRODUCTION

In recent years, numerous commercial products have been developed based on different learning/content management systems (LMSs/CMSs), such as Moodle. These products provide platforms for communication and collaboration among instructors and learners. However, the learning materials in those systems are normally organized in a tree structure with divisions based on either textbook chapters or class schedules; the leaf nodes are used to represent learning materials.

One problem with the tree structure in older systems is the difficulty of emphasizing the relation between two leaf nodes, especially when there are numerous branches between them. As is the case in other education fields, in language teaching the presentation of the similarities and contrasts between knowledge points (KPs) is indispensable. However, older LMSs/CMSs, which organize the learning materials in a tree structure, cannot characterize grammatical relations between KPs for learner comprehension, especially when the KPs are located in different teaching content clusters which are far apart in the tree structure (for example, one in section 2 of lesson 1, another in section 3 of lesson 10). Even worse, in those older systems it is difficult for learners to locate the learning materials which directly address the relations between KPs they are studying.

Another problem in older LMSs/CMSs is that they cannot satisfy the complicated requirements of learners, especially with regard to differences in learning abilities. A learning support system serves as a mediator between the learner and the learning objects (LOs). Such a system's assistance to a learner would be more effective if it could provide LOs appropriate to the learner's characteristics. However, the older systems simply provide the same learning materials to every learner; this limits the effectiveness of those learning support systems.

To address the above two problems, we present a framework for web-based language learning support systems, intended to provide pedagogical procedures by using ontological engine to analyze the characteristics of both learners and courses.

II. ONTOLOGIES BASIS

Recently, ontologies have been used in many research fields to facilitate information sharing and interaction, especially in knowledge-based systems.

From the knowledge-based system point of view, ontology is considered as a hierarchical network, where nodes represent concepts and arches or arrows represent the relations which exist between related concepts. Using ontology to describe domain knowledge not only promotes the reuse of the ontology in other ontologies and applications, but also ensures that the ontology remains in a maintainable and logically correct state. Therefore, an ontology-driven framework for customizable language learning support systems is proposed in our research.

A. The Ontology of a Specific Japanese Grammar Course

Assume a learner's present knowledge framework of a course as Set A (as shown in Figure 1), then the KPs of Set B still need to be learned to achieve the objective of this course. From the educator's perspective, knowledge comparisons could significantly support learner comprehension of the new KP from set B. The standard pedagogic procedure is to provide KPs of B which related to KPs of A according to the teaching procedures until the learner achieve the learning objective. For example, when a learner need to learn KP b of Set B, which has related KPs a1 and a2 of set A, the pedagogic teaching approach is to encourage the learner review the acquired KPs (a1 and a2) first; then explain the relations between the acquired KPs and

KP b; finally expose and explain the new KP b. To provide such pedagogic approach, the ontology of the target course needs not only to formalize all the KPs of the course, but also describe all kinds of relations between those KPs.

Different from the tree structure in those older LMSs/CMSs, the hierarchical network structure provided by ontology allows any relations exist between any two nodes; this facilitates the embodiments of relevance among KPs and also among their related learning materials, which are indispensable in education fields. Therefore, in addition to using ontology for the construction of domain knowledge taxonomy, we intend to integrate the characteristic of ontology relations with traditional education methodologies to provide pedagogical intervention to support learners.

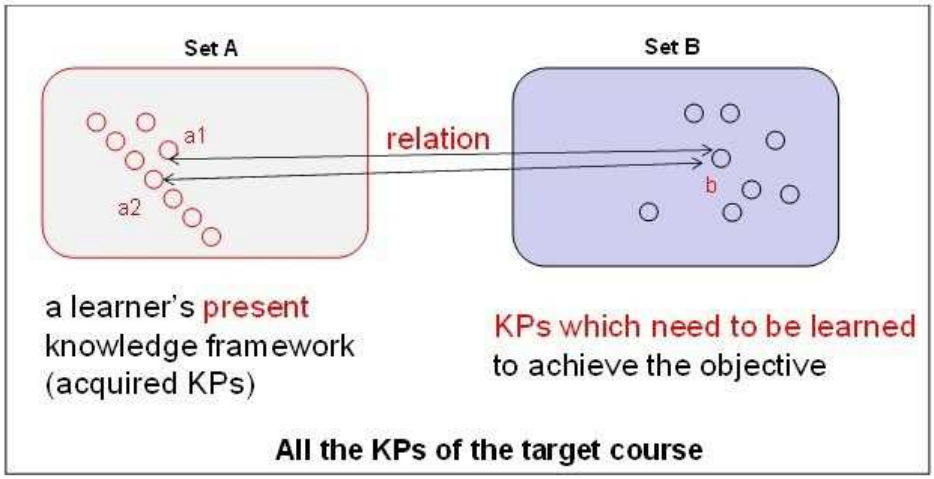

Figure 1. The pedagogic procedure for learners.

This ontology design was applied to the construction of a course-centered ontology for an existing Japanese grammar course (COJG), which has been developed as the domain model for the CLLSS(Although the system is suitable for any language course, this research just focuses on Japanese grammar teaching). The learning objective of this grammar course is the grammar contents of Japanese N3 Test.

In COJG, the classes (including 23 top level classes, 23 second level classes and 25 third level classes; these represent grammar concepts of the grammar course) reflect the knowledge classification and their individuals represent corresponding grammar points (GPs, in total about 205 GPs). These classes and individuals are linked by the "is-a" relation to show the inclusion relation.

Each individual of COJG, which represents each GP of N3, consists of two types of attributes: the data attribute (DA) which describes the datatype properties of the GP and the object attribute (OA) which describes its relations with other GPs

In COJG, there are fifteen kinds of DAs which includes “pattern”, “example”, “subject”, “object”, “content”, “judgmentBasis”, “variationCharacteristic”, “negativeForm”, “respectForm”, “normalForm”, “limitedToMale/Female”, “languageStyle”, “passive/negative”, “objective/ subjective” and “partOfSpeech”. These DAs are designed to describe the essential properties of GPs according to the characteristics of Japanese grammar course. Among them, “pattern” and “example” are the default DAs of every individual.

TABLE I. ALL THE RELATIONS OF COJG

Function	Relation name	Frequency
indicate concept dependences	*hasNecessaryPrior*	251
	isRelatedTo	35
	isPriorOf / isNextOf	54
indicate equivalence of grammatical phenomena	*hasHonorific / isHonorificOf*	13
	hasHumbleEquivalent /isHumbleEquivalentOf	7
	hasColloquialEquivalent /isColloquialEquivalentOf	1
indicate concept similarities and contrasts	*isSimilarWith*	82
	isOppositeOf	4
	isMoreColloquialThan /isLessColloquialThan	7
	isMoreFormalThan /isLessFormalThan	1
	isMoreRespectfulThan /isLessRespectfulThan	6
	isMoreImpoliteThan /isLessImpoliteThan	3
	hasMoreCertainyThan /hasLessCertainyThan	30
	isMoreSubjectiveThan /isLessSubjectiveThan	11

In addition to default inclusion relation(named "is-a") in other ontologies, to provide the pedagogic teaching approach discussed above, COJG includes other twenty-four types of relations(shown in Table 1) between concepts which are designed according to the teaching procedures and strategy. These relations include the concept dependences, similarities and contrasts, and even grammatical equivalence phenomena. These twenty-four types of relations and all the individuals which represent corresponding GPs in COJG consist of a relation network of all the GPs in this Japanese grammar course. This relation network, which includes the teaching steps and complex relevancies between GPs, enables the CLLSS to provide the pedagogic procedures, which includes knowledge comparison to support the learner comprehension of GPs.

B. The Ontology of Teaching Method

To combine the pedagogical methods with characteristics of both learners and courses, the ontology of teaching method is another key element for the CLLSS to identify learner's learning preferences for teaching method.

In this research, two stages of grammar teaching are considered in the teaching ontology. The first stage is "exposure with explanation" which presents new target language data to leaners to facilitate the noticing of grammatical phenomena and then explains the grammar rules (may involving more examples) to the learners to better understand the grammar points. The next stage is "practice" which expects learners to apply grammar rules to all forms of exercises until they reach competence expansion. Apparently, the concrete contents of these two stages should be also decided by the characteristics of the course.

Although these two stages also might have numerous concepts, for the experiments in this paper we only focuses on the teaching methods shown in Table 2 which are designed form the respective of learning styles. LOs respectively involve two kinds of exposure with explanation (verbal and pictures with verbal) and four kinds of verbal practices and three kinds of visual practices are prepared by two expert teachers for all the

grammar points.

TABLE II. THE SUB-CONCEPTS OF GRAMMAR TEACHING METHOD IN TEACHING METHOD ONTOLOGY.

Exposure with explanation	Verbal explanation	
	Pictures or diagrams with verbal explanation	
Practice	Verbal	Transformation question
		Choice question
		Translation
		Order words to make a sentence
	Visual	Fill-in-blanks with pictures
		Anime fragment
		Singing Practice

III. A PERSONALIZED LEARNING SUPPORT SYSTEM

A. System Framework

As shown in Fig. 2, a framework is presented for web-based CLLSSs, intended to personalize the LOs based on learner's characteristics and behaviors. This framework employs a reasoning mechanism which integrates learner knowledge structure identified by the schema of course-centered ontology (in this research COJG is employed) and learning styles and preferences identified by the schema of teaching method ontology.

In other words, a course-centered ontology for the construction of domain knowledge network and a teaching method ontology describing teaching forms of the specific course are built as the foundation for the student model, which includes learner's knowledge structure, learning styles and preferences. Meanwhile, the metadata description of the LOs should conform to COJG and the teaching method ontology, which means the organization of the learning materials should be conducted based on these two ontologies.

B. Main panel of Prototype System

A Java-based prototype system using a MySQL database has been developed based on the framework discussed above. Fig. 3 shows the common view of the prototype system for both instructors and learners.

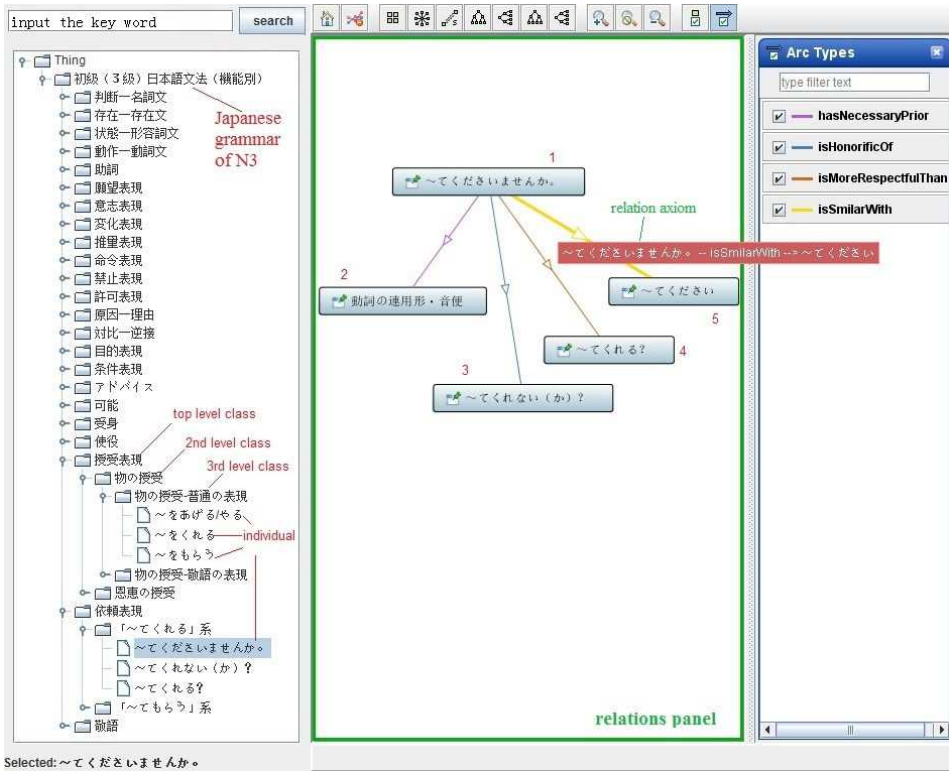

Figure 3. Common view of CLLSS

On the left part of this view, all the concepts of COJG including the classes and the individual are shown by a tree structure. When users double click one individual which represents one GP, the right relations panel will display this individual and all its related individuals lined by relations defined in COJG. For example, in Fig. 3 the individual which represents the grammar point "~te ku da sa i ma sen ka" is chosen. Then users can get a visual representation of related information as shown in the relations panel. Also, when the user move the mouse on every node shown in relations panel, the essential properties of that grammar point (represented by data properties of the individual in COJG) will be listed; while for every arc shown in relations panel, the relation axiom will be displayed(for example, the displayed relation axiom between Node 1 and Node 5 in Fig. 3). Therefore, users can get essential properties of every grammar point (GP) and all its related GPs from the relations panel conveniently.

C. The Teaching Materials Organization for Instructor

At every node or arc on the relation panel, instructors can open another panel to upload and manage teaching materials for the chosen GP or relation between GPs. This means, each LO should cover the information about one individual or one relation of COJG.

Fig. 4 shows an example of the teaching material management panel for a selected GP. Instructors not only can open or delete the existed LOs on the list, but also can upload new teaching material after setting the type of teaching method by three associated drop-down menus. The display information of these three associated drop-down menus are also automatically extracted and interpreted by the system from the OWL[1] file of teaching method ontology discussed above. In other words, the setting before uploading new LO guarantee the metadata description of every learning object in the database conforms not only to COJG but also the teaching method ontology.

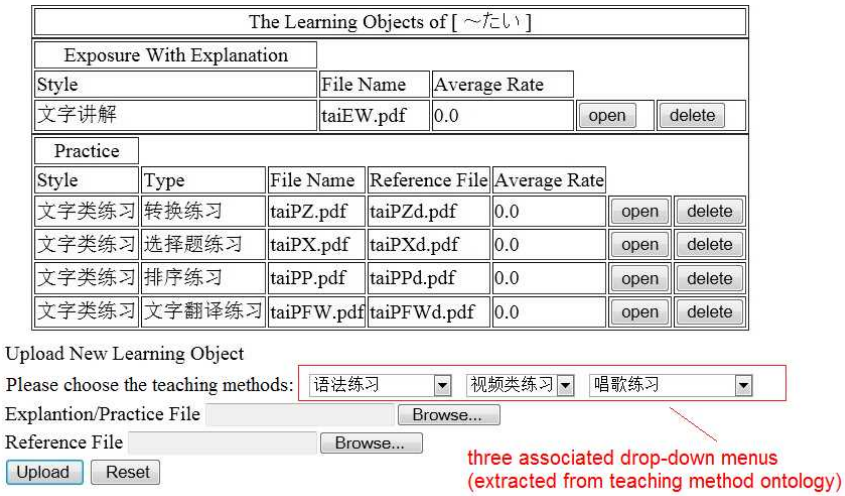

Figure 4. The . The teaching material management panel.

D. A Pedagogical Approach for Learners

When a GP is identified as the present learning content, the learner can get a visual representation of relations network of this GP as shown in the relations panel of Fig. 3. The system will encourage the learner to review the acquired GPs which related to the new GP and then study the relations between GPs according to a learner's knowledge structure. The learner's comprehension of the new GP would increase by means of this pedagogical approach.

In addition to specific LOs directly addressing grammar points, LOs directly addressing these relations also are provided by the system. Learners can open LOs not only at every node but also every arc on the relation panel. Moreover, they can choose LOs according to their learning preferences.

IV. EXPERIMENT1 AND ITS RESULTS

The subjects of experiment 1 included one class of 29 first grade students who major in Japanese from the international language department of a Chinese university. The Measurement techniques in this experiment included the learning achievement tests, and the questionnaires for measuring the students' learning habits, preferences and technology acceptance.

Before the experiment, all the students already studied Japanese for five month. They were assigned to be the experimental group and the control group based on their achievement on the pre-test, so as to minimize the group composition differences. After the three week learning activity (at least 10 hours system using by 15 student of experimental group, the average using time is 16.13 hours)addressing 15 grammar points, all the students took the post-test and another questionnaire.

The analysis of covariance (ANCOVA) was used to test the learning achievement difference between the two groups by using the pre-test scores as the concomitant variable and the post-test scores as dependent variables. The ANCOVA results of learning achievement suggest that the average learning achievement of the students in the experimental group, who studied with the learning support system, was significantly better than that of the control group, learned with the older LMS after class while taking the same Japanese course.

From the analysis of learning perception of both experimental and control group, the results of the ratings of "mental effort" suggest the learning content difficulties for these two groups are no significantly different. Moreover, the results also suggest the experimental group who learned with the CLLSS needed less effort for understanding the learning content than the control group who learned with the older LMS after classes.

V. EXPERIMENT2 AND ITS RESULTS

In the interview section of the experiment 1, some students in experiment group reported that they felt pressure while using the knowledge comparison function especially when confronted with numerous related grammar points in the relation panel at one time. To determine the factors underlying this pressure, from the perspectives of learning styles [2] and learning habit, experiment 2 was conducted to further evaluate the effectiveness of CLLSS.

90 undergraduate of the Japanese language major participated in the experiment 2. Before the experiment, all of them already studied Japanese for 8 months and used the same reference books for the Japanese grammar course.

In the preparatory phase, questionnaires were conducted to collecting learning style [3] and learning habit distribution data. According to the participants' learning style in Sequential/Global dimension and their learning habit of "learning from the comparison of related KPs", students from each class were assigned to be the experimental group and the control group, so as to minimize the group composition differences. Then, the experimental group with 60 students studied five target GPs with CLLSS in a computer-assisted language learning lab while the control group in another classroom with 30 students studied with the textbook. After 60 minutes learning activity, all the students took the post-test and another questionnaire.

The ANCOVA analysis result of learning achievement suggests that the experimental students who learned with the CLLSS achieved significantly better learning achievement than those who just did self-study with textbooks after studying the same target contents for the same time. Furthermore, the sequential and global leaners of experimental group, who studied with CLLSS, did not show significant differences in their learning achievement. Moreover, the learners who don't have habit of learning from comparison and the learners who have the habit of learning from comparison, also did not show significant differences in their learning achievement while both using CLLSS. In other words, in this experiment the learning achievement of experimental group was not related to either their learning style in Sequential/Global dimension or their habit of learning from comparison.

From the analysis of learning perception of experiment groups, the points listed below, suggested by the results, are worthy of consideration: (1) when a GP involves more than 4 relations in the course the optimum number of its related GPs to be shown in the relation panel at one time is 4: (2)compared to "Sequential

learners", most "Global learners" had stronger feeling that the comparison function provided by CLLSS is useful in improving their learning performances; (2) the learners who don't have habit of learning from comparison were easier to lose their attention and felt more pressure than the learners who have the habit of learning from comparison while both using CLLSS.

VI. CONCLUSION

In essence, the personalization of the ontology-based CLLSS is intended to provide pedagogical learning scenarios in response to learner's characteristics(knowledge structure, learning styles and preference) to maximize learner performance improvement.

A series of experiments was conducted to evaluate the effectiveness of CLLSS and the learning performances (including learning achievements, perception, cognitive load and so on) of participants in two experiments were analyzed.

There still have another experiment in which two CLLSS modes with two different strategies for LO suggestion were investigated from learning style perspective. The analysis of the learning performances of participants in this experiment will be discussed in future.