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Doctorate Thesis

A Personalized Japanese Grammar Learning Support System using Ontology-driven Engine And Its Evaluation

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Abstract

This thesis presents a course-centered ontology for assisting learning support systems to embody the relations among knowledge points and also among the learning materials for those points. This ontology design was applied to the construction of a course-centered ontology for an existing Japanese grammar course. Furthermore, a customizable language learning support system was built to manipulate the course-centered ontology and to provide an interface for the learning objects arrangement which displays the visual representation of knowledge points and their relations. The intention underlying the development of the system is to encourage instructors to orient their teaching materials to specific knowledge points and even directly to relations between knowledge points. With these orientations, the learning support system is able to provide an environment in which learners can readily distinguish between related knowledge points in response to their knowledge structure. Finally, in order to explore the impact of learning styles and learning habits on learning performance, a series of experiments, including a preliminary evaluation and two studies, has been conducted to evaluate our ontology-based learning support system.

Keywords

course-centered ontology; language learning support; knowledge structure; knowledge comparison; learning habit; learning style; learning preference; personalized learning objects

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Chapter 1
General Introduction

1.1 Research Background

A Learning Management System (LMS) is "a software application that automates the administration, tracking, and reporting of training events" (Ellis, Ryann, 2009). Instead of creating course content, the focus of an LMS is to deliver online courses or training to learners, while managing students and keeping track of their progress and performance across all types of training activities.

The first Learning Management System- FirstClass was launched by SoftArc in 1990. Unlike previous teaching systems which run on a mainframe computer, FirstClass ran on a personal computer (the Apple Macintosh). This system was used in the United Kingdom's Open University to deliver online learning information across Europe. In 1997, Interactive Learning Network, the LMS that first used a relational MySQL database, was developed by CourseInfo. Depending on database technique, numerous commercial LMSs have been developed. However, at the beginning, those LMSs only focused on providing service to instructors who created and published the training/course information. This situation continued until the present of the social constructionist pedagogy (Dougiamas & Taylor, 2003), which emphasizing that not only teachers but also learners can contribute to the educational experience. This social constructionist view is supported by Moodle system which was first released in 2002.

Moodle system provides platforms for communication and collaboration among instructors and students. Instructors use the platforms to efficiently manage the learning materials; learners are able to conveniently download the materials they need. Furthermore, all the users can discuss related issues by using the communication tools of these platforms. Each participant in a course can be an instructor as well as a learner. The job as a 'teacher' change from being 'the source of knowledge' to being an influencer and role model of class culture, connecting with learners in a personal way that addresses their own learning needs, and moderating discussions and activities in a way that collectively leads learners towards the learning goals of the class.

Since then, learner-centered infrastructure has attracted widespread research interest. How to personalize learning scenarios for enhancing learning, rather than just publishing and assessing the information the instructor want they need to know, nowadays become the focus of e-learning systems. Many personalized or adaptive systems intended to support customizable learning in response to the characteristics of learners and showed their effectiveness. Their designs incorporate elements involving knowledge level, learning styles, and so on, for the personalization of learning objects.

1.2 Research Issues and Objectives

In recent years, LMS has grown rapidly in all sectors of education, particularly in higher education. Commercial products developed based on different LMSs are popularly used to support Language teaching. This thesis mainly addresses the following two problems about the previous LMSs.

The learning materials in those LMSs 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 student comprehension, especially when the KPs are located in different teaching content clusters which are far apart in the tree structure. Even worse, in those older systems it is difficult for students 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. Even for a group of learners who have the same learning objective, different learner may have individual knowledge structure, learning styles and learning preferences. These individual characteristics will lead to learning abilities differences and complicated requirements. 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, older systems simply provide the same learning materials to every student; this limits the effectiveness of those learning support systems.

To address the above two problems, this thesis 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. A customizable language learning support system (CLLSS) based on this framework provides LOs according to the learner's knowledge structure and learning styles by means of the alignment of a course-centered ontology (i.e. an ontology based on a specific course) and a teaching method ontology. This prototype system also makes use of the course-centered ontology to provide learners (a) a visual representation of every KP (including displaying its essential properties and related KPs); and (b) a pedagogical approach which enable the learner to compare an unlearned KP with all its related KPs (especially with those acquired KPs) and assimilate it into his/her prior knowledge framework.

In order to evaluate CLLSS, the construction of a course-centered ontology for an existing Japanese grammar course (N3) is discussed in this thesis as an instance of "course-centered ontology". Also, the partial of the teaching method ontology referring to Japanese grammar teaching, was designed from the perspective of learning style. Afterwards, these two ontologies were incorporated in CLLSS to provide personalized learning support for learners. Furthermore, three experiments were conducted to evaluate the effectiveness of this ontology-based system.

1.3 Dissertation Overview

The structure of this dissertation is shown in Fig. 1.1. As a first step, an introduction (Chapter 1) is presented to describe the research background and the objective of the research in this dissertation. After the introduction, the problem of older LMSs' tree structure is discussed in detail and a "course-centered ontology" with map structure is presented to fix the problem (Chapter 2). The construction of a course-centered ontology for an existing Japanese grammar course (COJG) is discussed in Section 2.3 as an instance of the modeling of "course-centered ontology". In Chapter 3, a detailed review of previous ontology-based e-learning systems is described and then 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, is presented. Based on this framework, a prototype system (CLLSS 1.0) has been developed and a preliminary experiment was conducted to evaluate CLLSS 1.0.

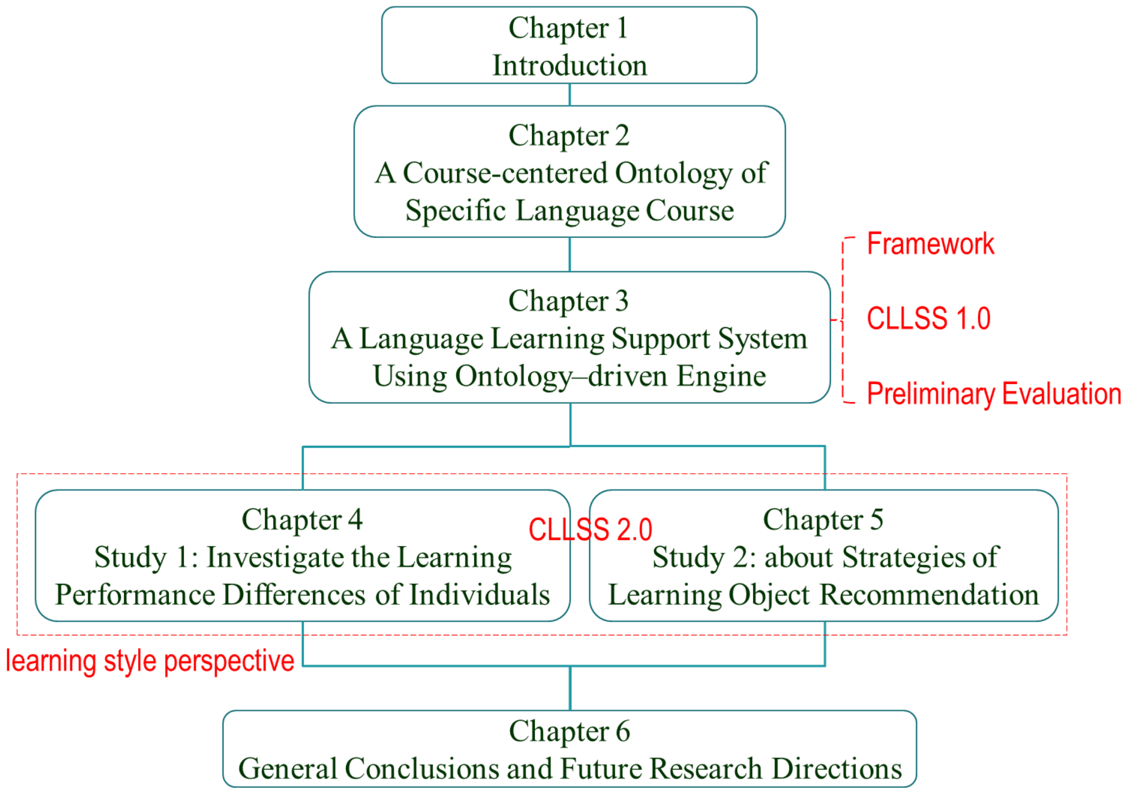


Fig. 1.1. The dissertation structure.

After getting the feedback from the users of CLLSS 1.0, some modifications were made to the system and two studies from learning style perspective are performed (Chapter 4 and 5) based on the new version 2.0. The Study in Chapter 4 is aiming at investigate the correlations between learning styles and learning performance, and between learning habit and learning performance while the learners study with CLLSS. The other study in Chapter 5 is intended to search a better strategy of learning object recommendation to balance the learner's motivation and learning effectiveness. Two modes of CLLSS are provided to study the user's performance differences. Finally, a summary will be given in Chapter 6 and the future research directions will be described.

Overall, the purpose of this thesis is to design a personalized learning support system based on the characteristics of learners, instructors and courses to maximize the learners' performance.

Chapter 2
Course-centered Ontology of Specific Language Course

2.1 Research issue discussion

Nowadays, LMSs, such as Blackboard, Moodle and Desire2Learn, are widely used in language teaching. In such systems, the instructor can organize a course by topic or by schedule. In one topic or one lesson, the course content description is followed by the related learning materials. In other words, the course content is normally organized in a tree structure (as shown in Fig. 2.1, in which the yellow circles represent the learning contents while the blue rectangles represent learning objects), the branches of which represent either topics or class schedule elements.

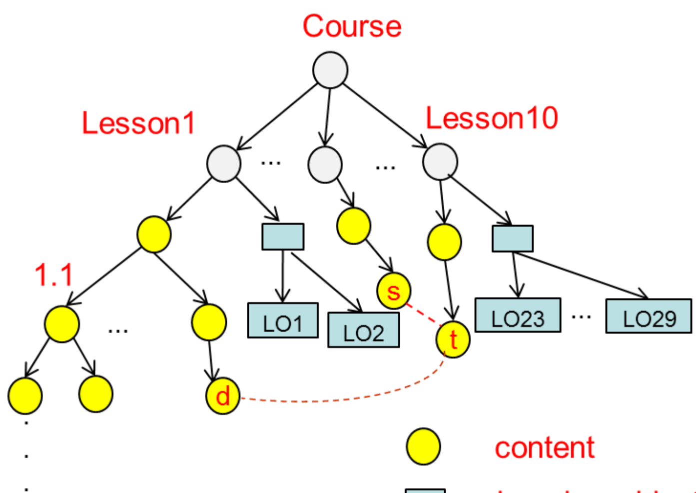


Fig. 2.1. An example of the tree structure in Moodle system.

For effective second language learning, it is essential that the learners are able to make connections between related knowledge points (KPs) and distinguish between similar ones. However, those older systems with tree structure usually do not support the development of those skills because they cannot characterize essential relations between KPs.

For example, in Fig.2.1 there are two KPs, “d” and “t”, which are located in Lesson 1 and Lesson 10 respectively. To enable learners compare the KP “t” with the prior KP “d” while studying Lesson 10, the instructor has to indicate the location “d” (this can be done by hyperlink) and explain the relation between “d” and “t”. Even so, it is still difficult for the learners to locate the learning materials, which directly address the relation between these two KPs, unless they look through all the learning material in lessons 1 and 10. The searching will be even more time-consuming if the learner is comparing three or more KPs in the course at one time.

In order to support the development of learner ability to distinguish between related KPs, this research presents the "course-centered ontology" with map structure that could assist e-learning systems to encourage the instructor to produce and arrange teaching materials that directly address specific KPs and even directly address relations between KPs. The construction of a course-centered ontology for an existing Japanese grammar course is discussed in this chapter as an instance of "course-centered ontology".

2.2 Maps and Ontologies basis

2.2.1 Maps

To encourage meaningful learning patterns, using maps, which have nodes as key concepts and links as relationships between key concepts (Lee, & Segev, 2012), can solve the problem caused by tree structure. According to Ausubel's learning psychology theories (Ausubel, 1963; 1968; Ausubel et al., 1978), meaningful learning is achieved when new knowledge is assimilated into existing frameworks of the learner. However, individuals vary not only in the quantity and quality of the relevant knowledge they possess, but also in the strength of their motivation to seek ways to incorporate new knowledge into relevant knowledge they already possess.

Human memory is a complex set of interrelated memory systems which interact with affective and psychomotor inputs. After reaching short-term memory, all incoming information will be organized and processed in the working memory which could incorporate knowledge into long-term memory. However, the working memory's processing capacity limits the transformation of unrelated concepts into long-term memory (Miller, 1956).

Although the retention of information learned by rote still takes place in long term memory, that knowledge tends to be quickly forgotten unless repeat rehearsed and cannot contribute to enhance learner's knowledge framework. In further problem solving, there is little or no potential that the persisting knowledge learned by rote will be used (Novak, 2002). (A full discussion of memory mechanisms is beyond the scope of this research.) Evident from diverse sources of research suggests that knowledge finally gets incorporated into human brain when organized in hierarchical frameworks and that learning approaches that facilitate this kind of organization significantly enhance the learning capability of all learners (Bransford, Brown, & Cocking, 1999; Tsien, 2007). From this point of view, maps can serves as a kind of scaffold to help learners to organize knowledge and structure their own knowledge framework (Novak, & Cañas, 2008); this facilitate the meaningful learning.

Organizing knowledge concepts in map structure, e-learning systems can present/provide progressively more explicit knowledge to help learners to slowly develop conceptual frameworks; learners also can clearly understand large general concepts before learning more specific concepts and incorporate new knowledge into their prior knowledge frameworks to foster meaningful learning. In addition, when learners have different levels of prior domain knowledge, using maps they can jump directly to a specific chapter interested. Although a search engine in the LMS can also be used to look for the information on a certain concept, the inquiry results without relation information between KPs limit its usage.

In knowledge presentation field, "Concept Map", "Knowledge map" and "Topic Map" are three main types currently used (Lee, & Segev, 2012). Concept maps are constructed with reference to a focus question. The word "Concept" is defined as "*a perceived regularity in events or objects, or records of events or objects, designated by a label*" (Novak, & Cañas, 2008). One characteristic of concept maps is that the concepts are represented in a hierarchical fashion with the most inclusive, most general concepts at the top of the map and the more specific, less general concepts arranged hierarchically below. The designer of a concept map normally attempts to organize the knowledge, which pertains to some situation or event, in a map form to ease the understanding of the knowledge. “Knowledge map” differs from “Concept maps” or other graphic organizers in the deliberate use of a common set of labeled links that connect ideas (O’Donnell, Dansereau, & Hall, 2002). In a word, “Concept Map” and “Knowledge map” are often used as learning materials instead of the metadata of learning material.

Unlike these two types of maps, topic maps (TM) are used to associating the knowledge structures it represents with corresponding resources. In other words, one of the main functions of topic map is to work as metadata of learning materials or objects. This is exactly what our research is interested in. The differences between our work and topic maps such as TM4L (Dicheva and Dichev, 2006) will be described in Section 3.5.

In literature, ontology is a common technique for construct maps in e-learning systems. For examples, the concept map learning system of Chu et al. (Chu, Lee and Tsai, 2011), which is intended to help reduce the user’s cognitive load, or TM4L (Dicheva and Dichev, 2006), which is a specialized environment for creating, maintaining and using “TM-based” learning repositories, those are all ontology-based. Therefore, we will introduce the ontology technique in the following section.

2.2.2 Ontologies

Ontology is one of the main techniques which are adopted in maps for knowledge representation. “*An ontology is a formal explicit specification of a shared conceptualization*” (Gruber, 1993). Such formal definitions facilitate information sharing and interaction, which are indispensable in e-learning systems.

From the knowledge-based systems point of view, an ontology consists of a set of hierarchically organized concepts and the relations between them, and thus explain objects appearing in the target world as their instances (Mizoguchi, 2003). Common vocabularies are defined by ontology for the users (such as instructors, learners and researchers) who need to share information in a domain (Noy & McGuinness, 2001). Using ontology to describe domain knowledge promotes the reuse of the ontology in other ontologies and applications.

A number of reusable ontologies have been constructed to support the modeling of efficient learning or teaching solutions. A knowledge management ontology characterized in terms of formal definitions and axioms was presented by Holsapple et al. (2004); this ontology enables the development of intelligent tools for knowledge sharing and reuse. An ontology of programming concepts (Gomez-Albarran & Jimenez-Diaz, 2009), developed based on existing educational ontology (Sosnovsky & Gavrilova, 2006) for procedural and object-oriented programming, is used to provide unique vocabulary for query retrieval in a case-based recommendation strategy for personalized access to learning objects in educational repositories. The recommendation strategy considers the student ranking scores of learning objects and the taxonomical information provided by the ontology to calculate similarity between concepts and decide the ranking of learning objects. OMNIBUS (Hayashi, Bourdeau, & Mizoguchi, 2009), a task ontology which covers different learning/instructional theories and paradigms, was built to support an authoring system called SMARTIES. This system is a theory-aware authoring system using a top-down approach to the support of learning/instructional scenario design by teachers.

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. However, most of the domain ontologies (Gomez-Albarran & Jimenez-Diaz, 2009; Oltramari, Gangemi, Guarino, & Masolo, 2002; Sosnovsky & Gavrilova, 2006) just focus on "is-a" or "part-of" relation, which describe only the inclusion relation between concepts and just can provide taxonomical information in a domain.

Actually, as an extension of taxonomies, ontologies which provide a hierarchy network rather than hierarchy tree structure by taxonomies, further allow any relation exist between any two concepts.

Since the discussion about similarity or contrast relations between knowledge points are indispensable in language teaching, only inclusion relation in an ontology is insufficient for supporting this pedagogic procedure. Although other ontologies presented some relations for their specific requirements, such as task ontology OMNIBUS (Hayashi, Bourdeau, & Mizoguchi, 2009), which uses the relations "OR","AND" and "is-achieved by" to describe functional achievement way (called "WAY"), or process ontology PSL (Grüninger, 2004), which uses three relations "participates-in", "before" and "occurrence-of" to describe rigorous logic relations between concepts (activity, activity occurrence, time point and object), those relations are inappropriate for ontologies of language courses.

Therefore, "course-centered ontology", which involves the construction of domain knowledge network especially the relations (such as similarities, contrasts, and so on) between knowledge points inside specific language course, is presented for language learning support systems in this research. Language learning systems can build their "course-centered ontology" of target language courses to create the metadata of learning objects and identify learners' knowledge structures. Obviously, the key concepts and relations in hierarchical structure depends on the particular domain that knowledge is being applied or considered. In the following section, we will describe an effective way to build "course-centered ontology" by showing the construction process of an instance.

2.3 The design of Course-centered Ontology

The literal meaning of "course-centered ontology" is an ontology based on a specific course.

The flexible hierarchical network represented by ontology, allows not only the containment relation as tree structure but also any kind of relations between any two nodes. This facilitates the embodiment of relevance among KPs and also among their learning materials in the learning support systems. Therefore, a course-centered ontology not only formalize all the KPs of a course, but also describe all kinds of relations (include the concept dependences, contrasts, and so on) between those KPs.

The construction and maintenance of ontology is quite time consuming. Therefore, the following two steps suggest an effective way to design and develop a course-centered ontology:

(1) General Design: for a specific course, use the classes of ontology to reflect the knowledge classification in the course and the individuals (also called "instance") of those classes to represent corresponding KPs in the course.

(2) Individual attributes Design: for each individual, (a) use its data attribute to describe the properties of the KP that it represents; (b) use the object attribute to describe the relations between this KP and its related KPs which is represented by another individuals.

Both this two steps need the participation of both instructors and ontology builder.

2.3.1 General Design

The construction of a course-centered ontology for an existing Japanese grammar course is discussed in this research as an instance of "course-centered ontology". COJG (a course-centered ontology of Japanese grammar) has been developed as the domain model for the learning support system in this research. For COJG, knowledge point (KP) refers to grammar point (GP).

"Protégé", which is an open source ontology editor and knowledge-base framework, was used to develop COJG and formalized it in OWL 2.0 (W3C OWL Working Group, 2012). OWL allows the meaning of Object properties to be enriched through the use of property characteristics and restrictions (Horridge, 2011); this enables the described ontology can be processed by a "reasoner" to compute class hierarchy and perform consistency checking, which ensures that the ontology remains in a maintainable and logically correct state.

A group of expert Japanese teachers, who work in the foreign language department of a Chinese university, participated in the construction of COJG for an existing Japanese grammar course. The learning objective of this grammar course is the grammar contents of Japanese language Proficiency Test Level 3(shorten by N3).

The reference of this course-centered ontology is a Japanese grammar book (Shigeno, Seki, & Nishikimi, 2009) which has been extensively used by Chinese learners of Japanese for years. This book is functional or situational based, in which every chapter includes a dialogue introducing target structures and vocabulary, a formal explanation of the grammar points covered, practice exercises ranging from controlled to free production, and perhaps a meaning-focused task or reading that elicits the use of target structures during the performance.

Assume the course-centered ontology as O, all the classes or individuals (directly named by the knowledge concepts in target second language) which represent the knowledge concepts of the target course as G, all the attributes (which actually refer to "data attributes" in ontology) of the classes or individuals as A, and all the relations (which actually are described by "object attributes" in ontology) among G as R, then

$$O=\langle G, A, R\rangle.$$

According to the course design, the knowledge points of this grammar course are the grammar points of N3, which can be generalized into 23 top-level concepts. In other words, G={Nominal Predicate Sentences, Existential Sentences, Adjectival Predicate Sentences, Verbal Predicate Sentences, Particle, the Expressions of Desire, the Expressions of Will, the Expressions of Change, Conjectural Expressions, Imperative Expressions, the Expressions of Prohibition , the Expressions of Permission, Causal Expressions, Paradoxical Expressions, the Expressions of Purpose, Conditional Expressions, the Expressions of advice, Potential Expressions, Passive Expressions, Causative Expression, Giving and Receiving Expressions, the Expressions of Request, Honorific}.

These 23 top-level concepts, which reflect the topics of N3 grammar course, are designed as top-level classes in COJG. Every topic represented by class has only sub-topics represented by subclass or has only GPs represented by individuals. These classes and individuals are linked by the "is-a" or "instance-of" relation to show the inclusion relation between them. Fig.2.2 describes a partial relation schema of COJG while the DA is implied in the figure, in which three top-level concepts (Causative Expression, Giving and Receiving Expressions, and the Expressions of Request) are included. Obviously, "is-a" relation is shown between each concept and its sub-concepts and "instance-of" is shown between each GP and its belonging topic.

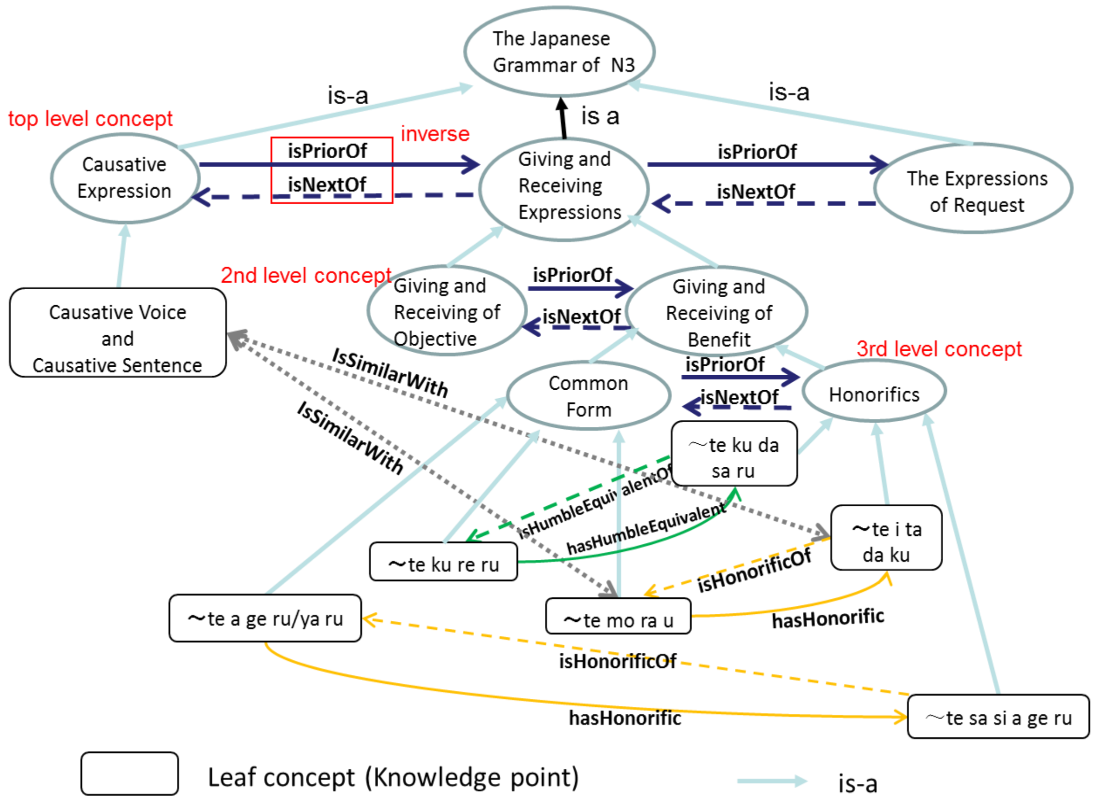


Fig. 2.2. A partial relation schema of COJG

The depth of the ontology and the number of individuals in one class both should not to be too large. Too many level of classes or too many individual in one class will caused the difficulty of the maintenance of the ontology.

In COJG, the depth of the ontology, which includes 23 top level classes, 23 second level classes and 25 third level classes (54 of these classes have only individuals), is 4. Of all the 205 individuals in COJG, the average number of individuals in one class is 3.7 and the largest number of individuals in one class is 9.

After this step, the construction of domain knowledge taxonomy is finished.

2.3.2 The design of individual attributes

Each individual of COJG, which represents 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.

2.3.2.1 Data Attribute Design

For all the 205 GPs represented by individuals which is designed in the previous steps, their properties can be easily extracted from the reference book (Shigeno, Seki, & Nishikimi, 2009) and the lesson plan of expert teachers. 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.

Fig. 2.3 below shows an example of all the properties of the individual that represent GP “~te mo i i”. This individual has four data properties (“pattern”, “example”, “respectForm” and “negativeForm”) and three related knowledge points described by three object properties.

Fig. 2.3. All the properties of the individual that represent the GP “~te mo i i”.

2.3.2.2 Object Attribute Design

Different from the tree structure in those older LMSs, 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. This advantage is one of the main reasons ontology technique is chose for learning support system in our research.

In addition to using ontology for the construction of domain knowledge taxonomy as the former researches, the contribution of our research is integrating the advantage of ontology relations with traditional education methodologies to support e-learning systems to provide pedagogical intervention to help learners to find their personalized learning process.

From the educator's perspective, knowledge comparisons could significantly support learner comprehension of the new KP (Amadieu, Tricot, & Mariné, 2010; Fisher, 2004; Rittle-Johnson, Star-Jon, & Durkin, 2009). Assume a learner's present knowledge framework of a course as Set A (as shown in Fig. 2.4), then the KPs of Set B still need to be learned to achieve the objective of this course. 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.

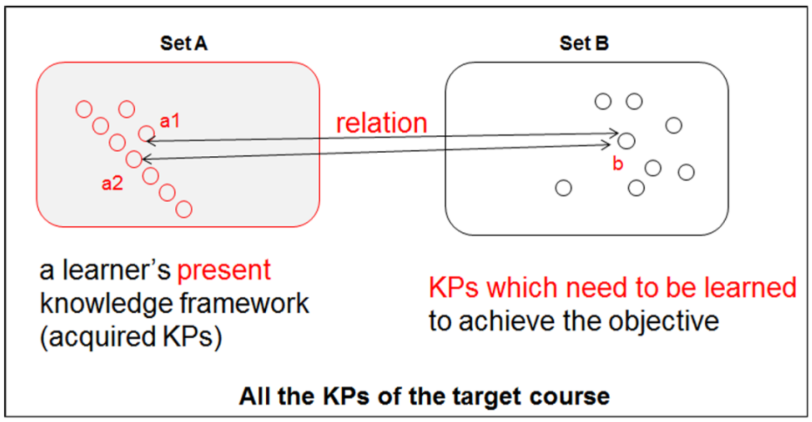


Fig. 2.4. The pedagogic procedure for learners.

To provide such pedagogic procedures based on knowledge structures of learners, the ontology-based system requires the ontology of the target course not only to formalize all the KPs of the course, but also describe all kinds of relations between those KPs. Therefore, the expert teachers who participated in the construction of COJG were ask to provide a document which listed in natural language all the grammatical related GPs among all the 205 GPs in this N3 grammar course. Afterwards, for each GP, one of its grammatical related GP determines one OA of its represented individual. Therefore, according to the document, totally 630 OAs of all the 205 GPs are designed in COJG.

Take the partial relation schema of COJG shown in Fig. 2.2 as an instance, a pair of inverse relations "isPriorOf / isNextOf" is designed to show the teaching steps of Japanese grammar of N3. For example, "Causative Expression" in Fig. 2.2 is the prior learning concept of "Giving and Receiving Expressions", and then the inverse relations "isPriorOf" and "isNextOf" exist between these two concepts. Moreover, there still have 2 pairs of inverse relations "hasHumbleEquivalent / isHumbleEquivalentOf" and "hasHonorific / isHonorificOf". These two pairs of inverse relations are designed to emphasize Honorific and Humble Equivalent, which are very common phenomena in Japanese grammar. For example, "~ te i ta da ku" in Fig. 2.2 is the Honorific of "~ te mo ra u" ,then the inverse relations "hasHonorific" and "isHonorificOf" exist between these two GPs. Beside these 2 pairs of relations designed to indicate equivalence of the grammatical phenomena, COJG also contains other type of relations which are used to indicate the contrasts between similar grammar expressions. "isSimilarWith" is this type of relation which exists between two concepts that can be used in the same language context. For example, "~te mo ra u" and "Causative Voice and Causative Sentence" in Fig. 2.2 both can used to express the "request sentence", then the symmetric relation "isSimilarWith" exists between them.

Fig. 2.5 describes another example of relation schema of COJG while just the object properties of two leaf concepts ("~mi ta i da" and "~na sa i") are shown. In Fig. 2.5, the relation "isColloquialEquivalentOf" (and its inverse relation "hasColloquialEquiva-lent" which is implied in Fig. 2.5) is used to emphasize the Colloquial language which is a common grammatical phenomenon. Moreover, three pairs of inverse relations are designed to facilitate the comparison of degree of expression for grammar points: "isMoreImpoliteThan" and "isLessImpoliteThan" are used to compare two concepts for the degree of impoliteness; "hasMoreCertaintyThan" and "hasLessCertaintyThan" are used to compare two concepts for the degree of certainty; "isMoreSubjectiveThan" and "isLessSubjectiveThan" are used to compare two concepts for the degree of subjectivity.

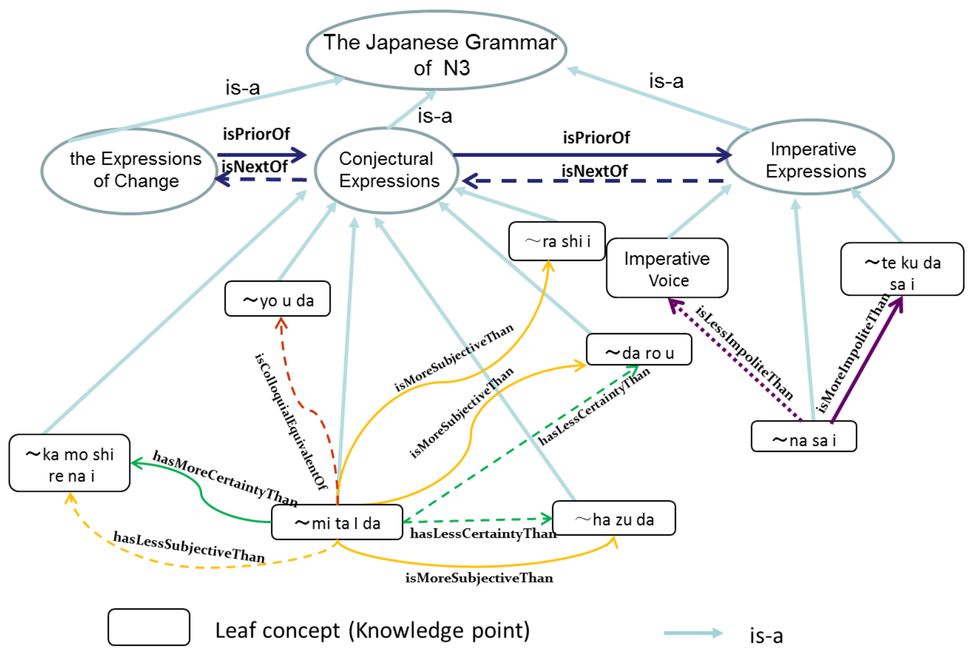


Fig. 2.5. Another example of relation schema of COJG

To sum up, besides inclusion relation already decided by the previous step, another twenty-four types of relations were concluded in COJG. As shown in Table 1, these relations include the concept dependences, similarities and contrasts, and even grammatical equivalence phenomena. Except for "*isPriorOf*" and "*isNextOf*" relations, which can also exist between two classes, all these relations are only exist between two individuals.

Except for the unidirectional relation "*hasNecessaryPrior*", other 23 bidirectional relation in COJG are either inverse relation or symmetric relation. It is essential to prepare inverse relations (such as "*hasHonorific*" and "*isHonorificOf*") and symmetric relations (such as "*isSimilarWith*") when there is a bidirectional semantic relation between two GPs. For example, assumed that GP X1 has honorific X2 and COJG just indicates the relation "*hasHonorific*" from X1 to X2, it is time-consuming to discover this relation from X2 direction when a learner is studying X2. However, preparing inverse relation or symmetric relation just needs one-time setting on the "description" of a relation. This setting enables the bidirectional relation location.

Table 2.1

Frequency and usage of all the relations of COJG.

Function of Relation	Relation name	Frequency	Type	Usage
indicate concept dependences	*hasNecessaryPrior*	242		When the pattern of concept A involves another prior concept B, this relation exists from A to B.
	isRelatedTo	17(17)	symmetric	When two concepts are normally used together in a Japanese sentence, this symmetric relation exists between them.
	isPriorOf / isNextOf	54/54	inverse	This pair of inverse relations is used to give a suggestion of the teaching steps. (This pair of relation can exist between two classes or between two individuals.)
indicate equivalence of grammatical phenomena	*hasHonorific/ isHonorificOf*	13/13	inverse	This pair of inverse relations is used to show the honorific of a common form and the common form of an honorific.
	hasHumbleEquivalent/ isHumbleEquivalentOf	7/7	inverse	This pair of inverse relations is used to show the humble equivalent of a common form and the common equivalent of a humble form.
	hasColloquialEquivalent /isColloquialEquivalent Of	1/1	inverse	This pair of inverse relations is used to show the oral equivalent of a written expression and the written equivalent of an oral expression.
indicate concept similarities or contrasts	*isSimilarWith*	41(41)	symmetric	When two concepts have similar meaning and both can be used in the same context, this symmetric relation exists between them.
	isOppositeOf	3(3)	symmetric	When two concepts with the same usage pattern have the opposite meaning, this symmetric relation exists between them.
	isMoreColloquialThan/ isLessColloquialThan	7/7	inverse	This pair of inverse relations is used to compare two concepts for the colloquialism degree.
	isMoreFormalThan/ isLessFormalThan	1/1	inverse	This pair of inverse relations is used to compare two concepts for the formality degree.
	isMoreRespectfulThan/ isLessRespectfulThan	6/6	inverse	This pair of inverse relations is used to compare two concepts for the respect level.
	isMoreImpoliteThan/ isLessImpoliteThan	3/3	inverse	This pair of inverse relations is used to compare two concepts for the degree of impoliteness.
	hasMoreCertainyThan/ hasLessCertainyThan	30/30	inverse	This pair of inverse relations is used to compare two concepts for the degree of certainty.
	isMoreSubjectiveThan/ isLessSubjectiveThan	11/11	inverse	This pair of inverse relations is used to compare two concepts for the degree of subjectivity.

The frequency of each relation's occurrence in COJG is also described in Table 2.1. (These data are automatically recorded by "Protégé").For example, among the OAs shown in Fig.2, "*isSimilarWith*" relation are used to indicate the similar GP of "~te mo i i". In COJG, this symmetric relation "*isSimilarWith*" were placed 41 times to indicate similarity between two GPs which can be used in the same language context. However, in the old LMS/CMSs such as Moodle, to build the same content of the same course, an instructor needs to describe this similarity relation 82 times and create 82 hyperlinks for the bidirectional search. Even worse, the consistency maintenance of the old LMS/CMSs is much more difficult than that of ontology which can be processed by a "reasoner" to perform consistency checking.

2.4 Conclusion

In this chapter we describe the "course-centered ontology" which is presented to support the learning support systems in providing customizable learning objects in response to different learning structures of learners. A "course-centered ontology" is required to not only formalize all the KPs of the target course, but also describe all kinds of relations between those KPs.

As an instance of course-centered ontology, COJG (a course-centered ontology referring to an existing Japanese grammar course) shown in Fig.2.6 has been designed.

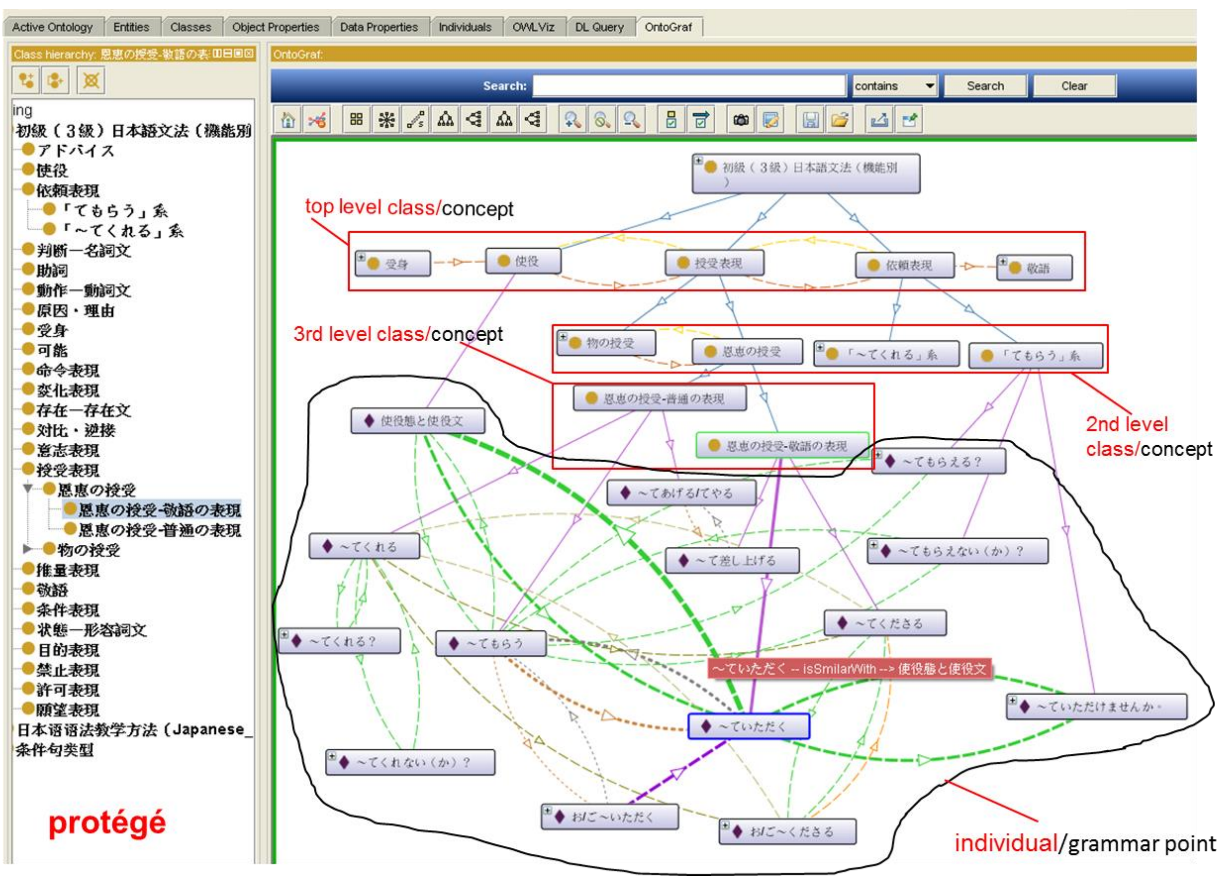


Fig. 2.6. A part of COJG shown in "OntoGraf" panel of Protégé

According to the way described in Section 2.3, open source ontology editor Protégé, are used to build COJG for Japanese Grammar (Level 3) course. The whole ontology has 23 top-level concepts, 23 second level classes, 25 third level classes, and totally 205 GPs. In COJG, the leaf concepts represent corresponding GPs and the relations between them include concept dependences, similarities and contrasts, and even grammatical equivalence phenomena.

Chapter 3
A Customizable Language Learning Support System Using Ontology-driven engine

3.1 Previous ontology-based e-learning systems

The personalization of learning scenarios has always been a complicated task for e-learning systems. Many personalized or adaptive systems intended to support customizable learning in response to the characteristics of learners and showed their effectiveness. Their designs incorporate elements involving knowledge level, learning styles, and so on, for the personalization of learning objects.

Intended to provide LOs in response to the learner's knowledge structure, learning styles, preferences and habits, a customizable language learning support system (CLLSS) using ontology-engine has been developed in this research. The course-centered ontology mentioned in the previous chapter for the construction of domain knowledge network, and a teaching method ontology considering the learning styles and preferences towards specific course, are coordinated in CLLSS as the foundation for LO's metadata creation.

A number of existing intelligent e-learning systems have used various ontological engines to provide support for teachers in designing efficient instructions or directly provide students with personalized learning solutions. SMARTIES (Hayashi, Bourdeau, & Mizoguchi, 2009), a theory-aware authoring system using a top-down approach to the support of learning/instructional scenario design by teachers, employs OMNIBUS (Hayashi, Bourdeau, & Mizoguchi, 2006), an task ontology (Mizoguchi, 2003) that covers different learning/instructional theories and paradigms. FIMA-Light (Kasai, Nagano, Mizoguch, 2011), an instructional design support system, uses a bottom-up approach to automatically interpreting the flow of lesson plans based on OMNIBUS (Hayashi, Bourdeau, & Mizoguchi, 2006) to support novice teachers in designing instructions. Gomez-Albarran et al. (Gomez-Albarran, & Jimenez-Diaz, 2009) presents a case-based recommendation strategy for personalized access to LOS in educational repositories. An ontology of programming concepts, developed based on existing educational ontology (Sosnovsky, & Gavrilova, 2006) for procedural and object-oriented programming, is firstly used to provide unique vocabulary for query retrieval. Then the recommendation strategy considers the student ranking scores of LOs and the taxonomical information provided by the ontology to calculate similarity between concepts and decide the ranking of LOs.

An ontology defines common vocabulary for users (such as instructors, learners and researchers) who need to share information in a domain (Noy, & McGuinness, 2001). Using ontology to describe domain knowledge promotes the reuse of the ontology in other ontologies and applications.

Therefore, an ontology-driven framework for CLLSS is proposed in this research. A course-centered ontology and a teaching method ontology are required in this framework as the foundation for LO's metadata creation and meanwhile for the modeling of student profiles which include learner's knowledge structure, learning style and preferences.

3.2 System framework

A framework is presented for web-based language learning support systems, intended to personalize the LOs based on learner's characteristics and behaviors. This framework, as shown in Fig. 3.1, 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.

For the web-based CLLSS, there are two groups of users: instructors and learners. After uploading ontologies of specific course knowledge and teaching method to the system, both of which are stored in OWL 2.0 file (W3C OWL Working Group, 2012), an instructor can manage the learning materials based on these two ontologies in order to enable learners to conveniently study the LOs according to their knowledge structure and learning styles.

On the one hand, the domain model provided by COJG contains all the knowledge of an existing Japanese grammar course that the students need to learn; this enables the mechanism to diagnose the knowledge structures of a learner and identify the personalized learning content. On the other hand, the teaching method ontology enumerates all the teaching forms in different teaching/learning styles towards the course; this enables the mechanism to infer suitable types of LOs for a learner based on her/his learning history. Therefore, after determine the personalized learning contents for a learner, the reasoning mechanism can identify LOs that conform to the learner styles and preferences among all the LOs of those contents. In other words, this framework employs COJG and the teaching method ontology as the foundation for modeling the student profiles, which includes learner's knowledge structure and learning styles and preferences.

Meanwhile, these two ontologies are also used for creating metadata for LOs. In older LMSs/CMSs, it is very difficult for the user to find suitable vocabulary to be metadata for LO while uploading new LO. For deciding the metadata of learning objects, users tend to create the metadata for they own end use and purpose; this makes the sharing and retrieval of LOs very difficult. Although Learning Object Metadata (LOM) (IEEE Standards Association, 2002) is a well-designed specification for learning object metadata, it requires more than 80 elements which is a very big burden for users (IMS Global Learning Consortium Inc., 2004).Therefore, COJG and the teaching method ontology, which developed by expert teachers and define common vocabularies both instructors and learners familiar with, are provided for the metadata description of the LOs in CLLSS; this means the organization of the learning materials are conducted based on these two ontologies.

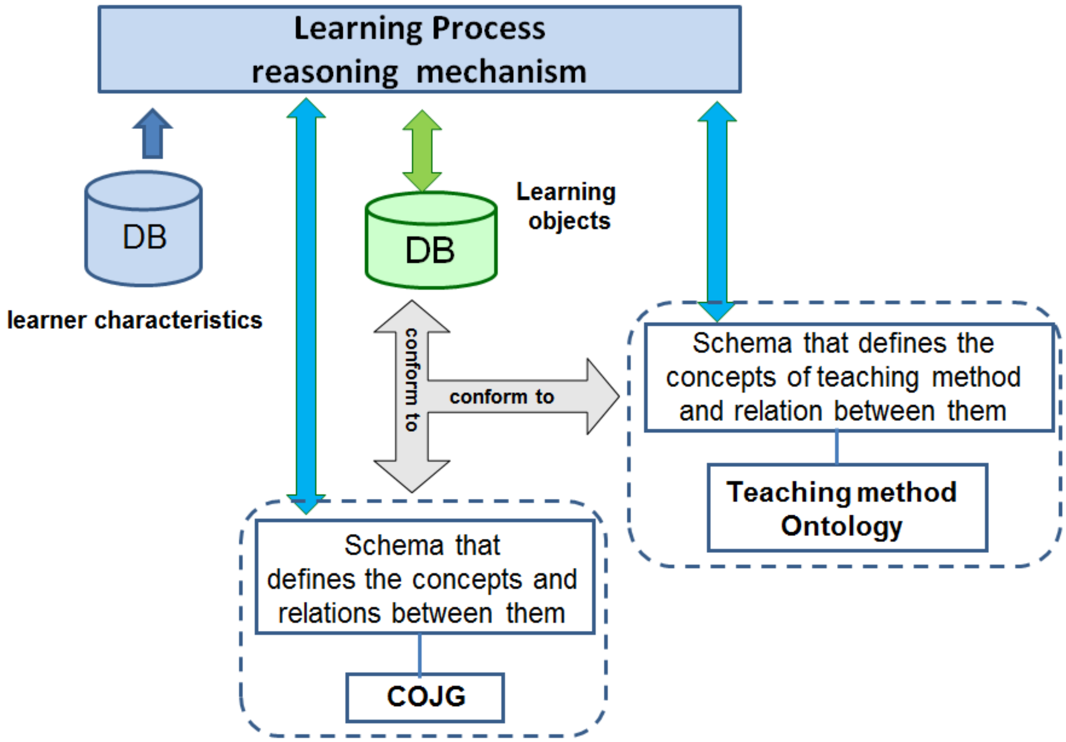


Fig. 3.1. The system framework of CLLSS.

3.2.1 The Course-centered Ontology

In addition to using ontology for the construction of domain knowledge taxonomy as the former researches, the contribution of our research is the CLLSS should integrate the advantage of ontology relations with traditional education methodologies to provide pedagogical intervention to help learners find their personalized learning path to move to the next stage of understanding of the language.

As discussed in Chapter 2, to provide such pedagogic procedures based on knowledge structures of learners, the course-centered ontology of the target course only formalize all the KPs of the course, but also describe all kinds of relations between those KPs. As mentioned before, although CLLSS is suitable for any language course, this research focuses on an existing Japanese Grammar course and built COJG addressing this course. Besides the common inclusion relation "is-a" and “instance-of", other twenty-four types of relations are concluded and then designed in COJG. 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. Furthermore, the accompanying benefit of this relation network is that, not only individuals, which represent the GPs, but also the relations between individuals can be used to annotate LOs.

3.2.2 The Teaching method ontology

To combine the pedagogical methods with characteristics of both learners and courses, the ontology of teaching method is another key element for the CLLSS.

Although the ontology of teaching method might have numerous concepts, for the evaluation of CLLSS this research only focuses on the partial which related to the grammar teaching method. There may be no single best approach to grammar teaching that would apply in all situations to the diverse types of learners. However, different approaches to grammar instruction share common features and appreciation (Hinkel, & Fotos, 2002). In consideration of the function of CLLSS that is to provide learning support in addition to classroom teaching or textbook learning, the functional approach PPP (presentation, practice and production) by Skehan (1998) labeled from the model of Second-language textbooks and widely used by classroom teaching, are adopted in this research .

Based on PPP model, two stages as shown in Fig.3.2 are discussed in this research. The first stage is “exposure with explanation” which presents new target language data to learners to facilitate the noticing of grammatical phenomena and then explains the grammar rules (may involving more examples) for their better understanding of the target grammar. The next stage is “practice” which expects learners to apply grammar rules to all forms of exercises until they reach competence expansion. As for the production stage in PPP, which focuses on learner production by less controlled communication, it is difficult to be satisfied by only LOs provided by the e-learning systems. This stage nowadays is normally achieved by taking extra oral course after grammar course. Therefore, in this research production stage is no considered. The concrete contents of these two stages should be also decided by the characteristics of the course.

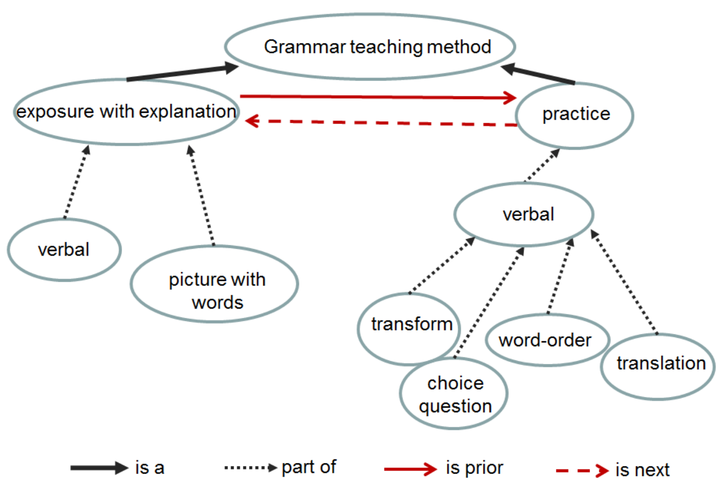


Fig. 3.2. A partial structure of grammar teaching method ontology.

The same as the course-centered ontology mentioned before, the teaching method ontology has also been developed using the open source ontology editor "Protégé". However, in the experiments of Chapter 3 and 4, the main evaluation purpose did not include system ability for identifying learner’s learning preferences. Therefore, only the two kinds of exposure with explanation (verbal and pictures with verbal) and all the four kinds of verbal practice are prepared for all the GPs. More forms of these two stages will be discussed for further studies in chapter 5. To extract learner’s learning preferences for teaching method from learning history, this teaching method ontology is an indispensable component of CLLSS.

3.3 User views

3.3.1 Common view

A Java-based prototype system using a MySQL database has been developed based on the framework discussed above. Fig. 3.3 shows the common view of the prototype system (English version 1.0) for both instructors and learners.

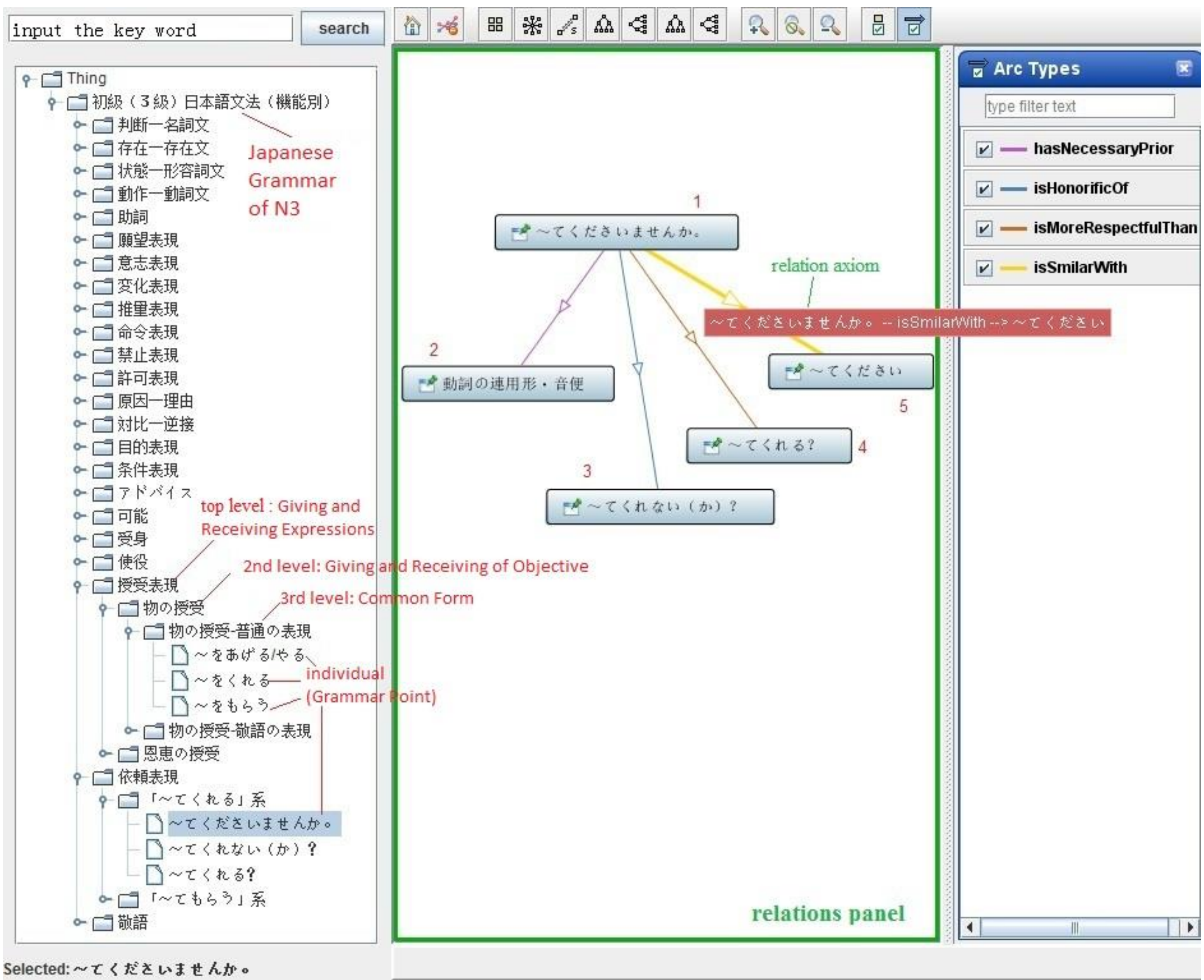


Fig. 3.3. Common view of CLLSS (1.0) for both instructors and learners.

On the left part of this view, all the concepts of COJG including the classes (directly named by grammar concepts in natural Japanese) and the individuals (directly named by grammar points in natural Japanese) are shown by a tree structure. The prototype system automatically extracts all the “isPriorOf” and “isNextOf” relations, from the OWL file of COJG to interpret the recommended teaching steps. Therefore, all the grammar concepts (represented by classes) shown in the tree structure are arranged in the teaching steps defined by COJG.

In CLLSS, if an instructor wants to change the teaching steps, she/he only needs to modify the objects of "isPriorOf" and "isNextOf" relations on the "restriction filler" of any class (or on the "value" of any individual) in COJG and then update the new OWL file. However, in the old LMS/CMSs such as Moodle, if an instructor wants to change the order of topics or chapters in a course, her/he needs to modify the destination URLs of all those hyperlinks which are used to indicate the related KPs among topics or chapters. Obviously, compare to older LMS/CMSs, the advantage of CLLSS that the teaching steps of a course can be flexibly modified, attributes to the use of the course-centered ontology.

Search function is provided right above the tree structure. After putting key searching words, items which contain the key words in tree structure will be highlighted to enable further check for users. Besides, users can also open all the concepts level by level (for example in Fig.3.3, user can open top level concept "Giving and Receiving Expressions", and then open 2nd level and 3rd level concepts) until reach the GP they are seeking.

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. 3.3 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 relevant information as shown in the relations panel.

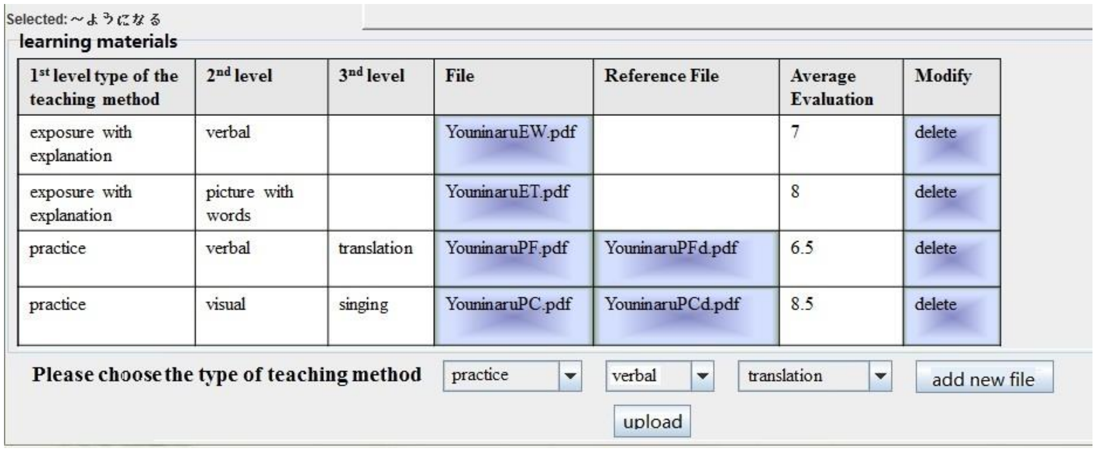
Also, when the user move the mouse on every node shown in relations panel, the essential properties of that grammar point (represented by data properties of the individual in COJG) will be listed; while for every arc shown in relations panel, the relation axiom will be displayed (for example, the displayed relation axiom between Node 1 and Node 5 in Fig. 3.3). Therefore, users can get essential properties of every grammar point (GP) and all its related GPs from the relations panel conveniently. All these information are also extracted from OWL file of COJG. Furthermore, if there are too many relations are shown in relation panel, the user can select the interested relations by Arc-Types panel.

3.3.2 The teaching material management panel for instructors

The relations panel, which displays the complex relevancies between GPs, provides a relation network, which can encourage instructors (especially novice instructors) to follow teaching procedures and teaching strategy of expert teachers. Instructors can produce and organize teaching materials to directly address specific GPs and even directly address relations between them to help learners distinguish related GPs.

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.3.4 displays an example of the teaching material management panel for a selected GP. This teaching material management panel in CLLSS 1.0 includes the information list of all the LOs stored in the database for the selected GP. Teaching method types and the average evaluation mark of every LO are both displayed on the list.



Selected: ～ようになる

learning materials

1st level type of the teaching method	2nd level	3rd level	File	Reference File	Average Evaluation	Modify
exposure with explanation	verbal		YouninaruEW.pdf		7	delete
exposure with explanation	picture with words		YouninaruET.pdf		8	delete
practice	verbal	translation	YouninaruPF.pdf	YouninaruPFd.pdf	6.5	delete
practice	visual	singing	YouninaruPC.pdf	YouninaruPCd.pdf	8.5	delete

Fig. 3.4. The teaching material management panel in CLLSS 1.0 for instructors.

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 file of teaching method ontology discussed above.

Besides the information from this setting before uploading, the information defined by COJG will be also automatically recorded by the system as metadata for new LO since the management panel is open based on relation panel which shows the information extracted from COJG. In other words, the setting before uploading new LO guarantees the metadata description of every learning object in the database conforms not only to COJG but also the teaching method ontology.

3.3.3 A Pedagogical Approach for learners

The prototype system based on COJG which includes special relations provides learners a pedagogical approach of "Learning from Comparing". While studying a new grammar point, the learner can compare it with all its related grammar points through various kinds of different relations, especially with those acquired GPs. This kind of knowledge comparison is intended to support the learner comprehension of new grammar points.

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. 3.3. 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.

In the experiment of following section, the CLLSS simply provide all the LOs in the order decided by teaching method ontology; user can choose LOs according to their learning preferences. The recommendation function of the reasoning mechanism, which suggests LOs conform to the learner's learning preferences, will be discussed in Chapter 5.

3.4 Preliminary evaluation

To evaluate the prototype CLLSS 1.0, analysis of learner data was also conducted after an experiment in the International Language department of a Chinese university. In this experiment participants used the Chinese version of the prototype system discussed in the Section 3.3. The main purpose of the experiment is to preliminarily evaluated the knowledge comparison function provide by CLLSS.

3.4.1 Participants

The subjects included one class of twenty-nine first grade students who major in Japanese. All of the students were taught by the same instructor who had taught Japanese grammar for more than seven years. 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.

3.4.2 Measurement techniques and Experimental Procedures

The Measurement techniques in this experiment included the learning achievement tests, and the questionnaires for measuring the students' learning habits, preferences and technology acceptance.

The test sheets were developed by two experienced teachers. The pre-test aimed to evaluate the students' prior knowledge of Japanese. It contained ten reading items, twenty-five singe-choice items, ten transform items and ten translation items with a perfect score of 100. The post-test contained twenty-three single-choice items, ten transform items and five translation items for assessing the students' knowledge of Japanese. The perfect score of the post-test was 48. The questionnaires written in Chinese are designed based on references (Sweller, Merriënboer, & Fred, 1998; Chu, Hwang, Tsai, & Tseng, Judy , 2010) with some modifications.

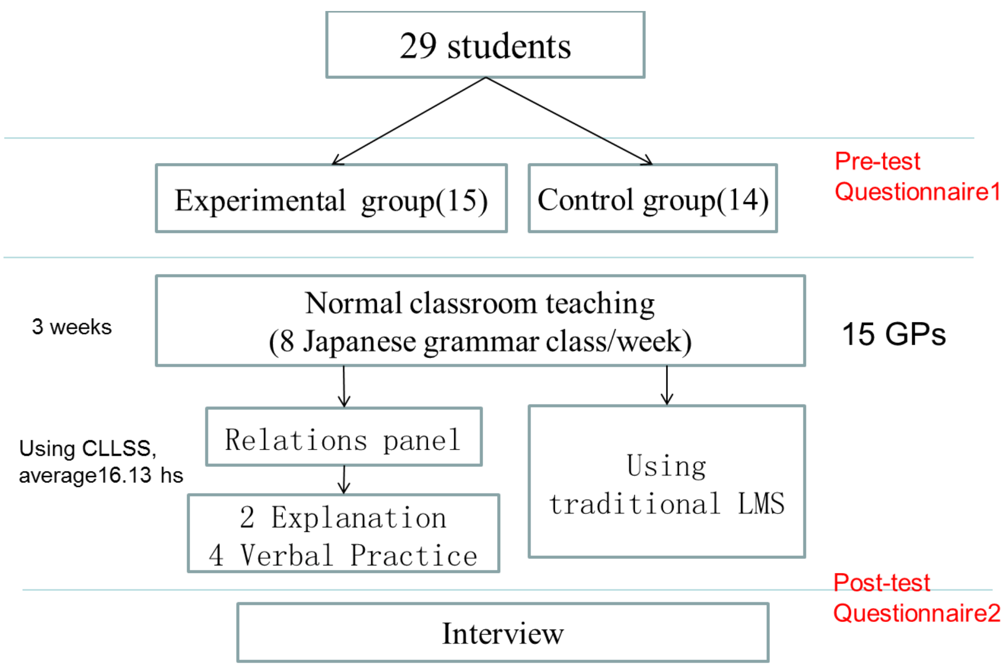


Fig. 3.5. The experimental procedures of the preliminary evaluation.

Fig. 3.5 shows the procedures of the preliminary evaluation. Before the experiment, all the students already studied Japanese for five months. At the beginning of the experiment, they took the pre-test and learning habit questionnaire. In the following 3 weeks, fifteen grammar contents are taught in classroom which mainly involved in Expressions of Will, Conjectural Expressions and Conditional Expressions. In addition to taking the same classroom teaching, after classes the experimental group with fifteen students used the CLLSS while the control group with fourteen students studied with the older LMS the university already had. For not affecting the students' learning motivation, they were informed that the CLLSS would free to be used by all them including control group after post-test.

The CLLSS were installed in the university server before the experiment. At the beginning of the experiment, students of the experimental group were given one-hour training about how to install the java plug-in and use the system. Then they used the web-based CLLSS by themselves on their own computers. The students of experimental group not only can check the relation panel for any grammar point, but also can further open all LOs of any GP or any relation between GP by right clicking the node or the arc in the relation panel. For all the GPs, two kinds of exposure with explanation (verbal and pictures with verbal) and all the four kinds of verbal practice shown in Fig.3.2, are uploaded and organized on the system by two expert teachers in advance.

After the three week learning activity (each student of experimental group at least used the system for 10 hours, the average using time is 16.13 hours), all the students took the post-test and another questionnaire which involved learner learning preference, perception and technology acceptance(just experimental group).

3.4.3 The Analysis of learning perception

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 variable. The purpose of using pre-test scores as concomitant variable in ANCOVA is to use the information about pre-test to reduce the variation in post-test scores and thus increase the chance of detecting differences between the different treatments.

Before performing the ANCOVA, a series of tests are conducted for checking if the sample data satisfy the ANCOVA assumption. Table 3.1 shows the results of tests for checking potential ANCOVA assumption violations. The result ($p > .05$) of the tests of Between-Subjects Effects suggests that the concomitant variable (pre-test scores) is not affected by the treatments.

Table 3.1

Results of Tests for Checking Potential ANCOVA Assumption Violations

Group	p value		
	Pre-test*Groups	***Standardized Residuals***	
	Between-Subjects Effects	***Shapiro-Wilk***	***Liner Regression***
Experimental	0.23	0.99	0.007
Control		0.73	0.002

For the experimental group and the control group, the results (for both groups, $p > .05$) of the Shapiro-Wilk Test and the P-P plots (shown in Fig. 3.6) of Standardized Residuals suggest that both residuals are normally distributed; the results (for both groups, $p < .01$) of Liner Regression suggest that the concomitant variable (pre-test scores) has linear relation to dependent variable (the post-test scores). Based on these results, sample data appear to conform to the assumption of the ANCOVA.

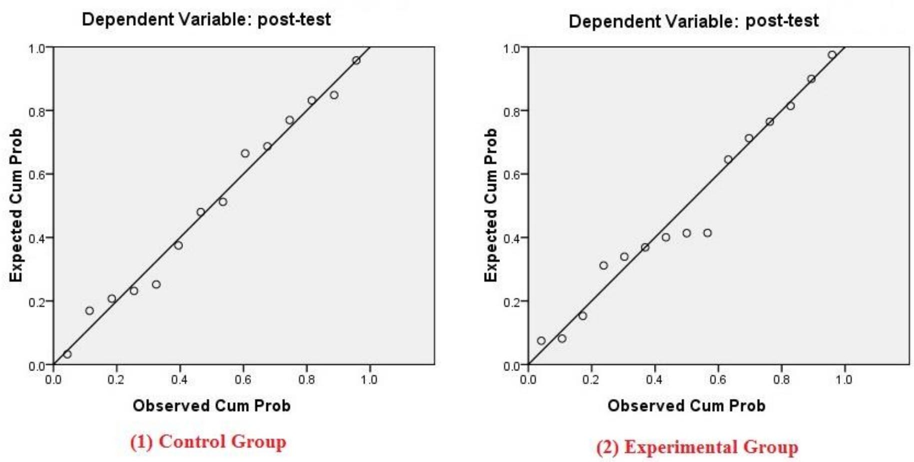


Fig. 3.6. Normal P-P Plots of Regression Standardized Residuals

Table 3.2 shows the descriptive data and ANCOVA results of the post-test scores. The result ($p > .05$) of Levene's test of Equality of Error Variances suggests the homogeneity of variances. The adjusted mean value and standard error of the post-test scores were 28.92 and 1.09 for the control group, 32.28 and 1.06 for the experimental group. According to results ($F=4.85$, $p<.05$) shown in Table 3.2, there was a significant difference between the two groups; this suggests that the students who learned with the learning support system achieved significantly better learning achievement than those who just did self-study while taking the same Japanese course.

Table 3.2

Descriptive Data And ANCOVA Result of The Post-test Scores

Group	N	Mean	S.D	Adjusted Mean	Std. Error	F	Levene's Test
Experimental	15	32.6	4.46	32.28	1.06	4.85*	0.25
Control	14	28.57	6.70	28.92	1.09		

*p<.05

3.4.4 The Analysis of learning achievement

Students' feedback about the learning contents and system evaluation from the experimental group are shown in Table 3.3 (the maximum is 10 for the rating of every item).

For the experimental group and the control group, the average ratings of "content difficulty of the fifteen grammar points" are 5.67 and 6.07 respectively; the T-test result ($p>.05$) suggests the difficulty for these two groups are no significantly different. Moreover, the average ratings of "the effort for understanding the learning content" are 4 and 5.71 respectively; the T-test result ($p<.05$) suggests the experimental group who learned with the CLLSS needed less effort than the control group who learned with the older LMS after classes.

Table 3.3

Questionnaire Results About Learning Content Difficulty And System Evaluation

Dimension	Questionnaire Item	Group	Mean	S.D.	T-test
The Difficulty of Learning Contents	The learning contents is easy to understand.	Experimental	5.67	1.18	0.43
		Control	6.07	1.54	
	The effort you need to put for understanging the learning contents.	Experimental	4.00	1.25	0.0002
		Control	5.71	0.83	
Perceived System Evaluation	CLLSS is helpful to me in learning new knowledge.	Experimental	7.43	1.88	
	Using CLLSS make me cannot focus on my study.	Experimental	2.00	1.25	
	I feel pressure while using CLLSS.	Experimental	2.53	1.46	
	It is easy to use CLLSS.	Experimental	7.13	1.60	

In terms of system evaluation of the experimental group, the average rating of "The CLLSS is helpful in learning new knowledge" is 7.43, implying that most students in the experimental group identified the usefulness of the CLLSS in improving their learning performances. The average rating of the degree of distraction and pressure while using the CLLSS are both lower than 2.6, implying that using the CLLSS the students can concentrate on learning with low pressure. Besides, the item "It is easy to use the CLLSS" received the average rating 7.13; this means most students in the experimental group felt that the CLLSS was easy to get familiar with and operate.

Table 3.4

Questionnaire Results About Learning Habits And Preference

Questionnaire Item	Group	Yes
Do you have the habit of "learning from comparing KPs"?	Experimental	33.33%
	Control	35.71%
Is your preference change with grammar point?	Experimental	33.33%
	Control	45.45%
Is your preference change during learning process?	Experimental	72.22%
	Control	63.64%

The questionnaires also involved questions about students learning habits and preference data. As shown in Table 4, 33.33% of students in the experimental group and 35.71% of students in the control group have the habit of "learning from comparing KPs". It is also found that the percentages of the students whose preference change with grammar points are 33.33% in the experimental group (20% checked more teaching method if the grammar points is more difficult while 13.33% checked fix teaching method based on the type of grammar point) and 45.45% (21.43% checked more teaching method if the grammar points is more difficult while 14.12%

checked fix teaching method based on the type of grammar point) in the control group respectively. Moreover, the percentages of the students whose preference change with learning process are 72.22 %(33.33% change their preference to the new teaching method while 38.89% use multiple teaching method) in the experimental group and 63.64%%(9.09% change their preference to the new teaching method while 54.55% use multiple teaching method) in the control group respectively.

3.5 Related work

CLLSS enables the organization of ontology-aware LOs through the use of a "course-centered ontology" for sematic annotation of learning resources in a specific course. Using the practical ontology as a standard structure for the exploration of LOs, facilitate not only the explanation of what a KP is but also how to use the KP.

The previous research similar to our work is "the only general education topic maps editor and viewer" TM4L system (Dicheva and Dichev, 2006), which makes use of a developed subject ontology with courses on the same subject to increase the reusability of available educational resources. TM4L supports an efficient context-based retrieval of learning content tailored to the needs of a learner working on a specific task.

The common points of TM4L and our system CLLSS are:

(1) they are both based on a general framework for ontology-ware digital course libraries although some differences exist between frameworks they were built on;

(2) they both focus on specifying concepts and relations on a particular domain to providing ground for knowledge sharing and provide the function to using ontology to link concepts to learning resources;

(3) they both propose concept-driven access to learning repositories and use browsable maps to make the understanding more easily.

The differences between these two systems are listed as follow:

(1) Although TM4L enables the learner to understand the relationships between the resources, it does not provide organization of LOs directly addressing relations between concepts or KPs. Therefore, the biggest difference between TM4L and CLLSS is that, CLLSS not only displays the concept relations like Protégé or CmapTool (Novak, & Cañas, 2008), but also encourages the instructors to create and orient their teaching materials to those relations. Owe to this kind of organization, the users of CLLSS can get LOs not only under a specific KP but also under a specific relation in the browsable maps provided in relation panel of CLLSS.

(2) The LOs organization of these two systems is towards opposite direction. The LOs organization of TM4L is bottom-to-top. In TM4L, LOs are classified based on topics/concepts; and then those topics/concepts are clustered in contexts/themes; finally those contexts/themes can be got by multiple viewpoints. However, the LOs organization in CLLSS is top-to-bottom. After deciding a specific course, the characteristics of the course will be studied first; and then the concepts of the course will be classified from top to bottom; finally, the KPs or relations between KPs located in the bottom, will be linked to corresponding LOs.

(3) The TM4L Editor is an ontology editor allowing the user to build ontology-driven learning repositories using Topic Maps. The learning content created by the Editor is fully compliant with the XML Topic Maps (XTM) standard and thus interchangeable and interoperable with any standard XTM tools. However, until the latest version of CLLSS (version 2.0), the system itself do not support the edit of ontology. Our system only provides a plug-in for users to upload their course-centered ontologies which are stored in OWL files to create a map structure for their courses.

(4) Last but not the least, until now, no evaluation of TM4L under a practical course has been presented while a series of experiments has been conducted in our research to examine the learning performance of the learners while using CLLSS.

3.6 Conclusion

In essence, the personalization of the CLLSS is intended to provide a pedagogical learning process according to learner's characteristics to maximize learner performance improvement. The pedagogical criteria are reflected in the domain model determined by COJG and the teaching method ontology which enumerates all kinds of the teaching forms for a specific course. Less obviously, they are also reflected in those twenty-four types of relations in COJG which are designed according to the teaching procedures and strategy to indicate the concept dependences, similarities and contrasts, and even grammatical equivalence phenomena

A prototype system with GUI (Graphical User Interface) has been developed for instructors to upload the course-centered ontology and teaching method ontology and then organize the LOs based on these two ontologies. On the other hand, after setting initial knowledge status, learners are able to follow the personalized learning process which includes knowledge comparison to support the learner comprehension of new grammar points.

The results of the preliminary experiment suggest that the students who learned with the CLLSS achieved significantly better learning achievement than those who learned with the older LMS after classes while taking the same Japanese course.

In Chapter 4 and 5, experiments will be conducted to examine if there are other factors which affect the learning performance of the learner while using CLLSS. In Chapter 5, the teaching method ontology will be enriched by adding more grammar teaching forms of in further evaluation. Moreover, how reasoning mechanism (shown in Fig. 3.1) analyzes and extracts the learner's characteristics from the learning history and how to match the types of LOs with the learner's learning preferences and learning styles, will be discussed in Chapter 5.

Chapter 4
Study 1: to Investigate the Learning Performance Differences of Individuals

4.1 System Overview of CLLSS 2.0

As described in the previous chapter, CLLSS is intended to provide learning objects according to the learner's knowledge structure, learning style and habits. In CLLSS, the course-centered ontology (discussed in Chapter 2), is used for the construction of domain knowledge network and also used as the foundation for the metadata creation of learning objects. Those 24 specific relations of COJG, which is designed according to pedagogical criteria, enable CLLSS to provide the learner a visual comparison of related knowledge points.

After uploading the course-centered ontology of an existing language course (in this research refer to COJG), which is stored in OWL 2.0 file, an instructor of CLLSS can arrange the learning materials based on the domain model provided by the ontology. This kind of arrangement enables the learners to distinguish between related knowledge points and conveniently study relevant learning objects according to their knowledge structure.

Based on the user's comments and suggestions in the preliminary experiment, we modified some functions of CLLSS 1.0. Then, an improved version CLLSS 2.0 is developed and presented in this chapter. The study in this chapter used this new version of our system to investigate the learning effect differences on different individuals.

Fig. 4.1 displays a screenshot of CLLSS 2.0, when a user (instructor or learner) select GP "~te mo i i" and put the mouse on the node shown in the relation panel which represent the GP"~te mo i i". As shown in Fig. 4.1, the essential properties" ("respectForm", "pattern", "negativeForm" and "example") of GP"~te mo i i", represented by data properties of an individual in COJG are listed. (All the properties of the individual of COJG which represent the GP "~te mo i i" is shown in Fig. 4.1.) On the other hand, the same as version 1.0, putting the mouse on any arc in the relation panel will caused the display of the name and the direction of a relation which are represented by a relation axiom in COJG(an example are shown in Fig. 3.3).

The same as the previous version, all the information in the common view of CLLSS, which includes the tree structure on the left and relation panel on the right, is automatically extracted from the OWL file of COJG. Consequently, after selecting one GP from the tree structure, in the relation panel the user can get essential properties of this GP and all its related GPs conveniently. Moreover, Arc-Types panel can help user to can select her/his interested relations when there are too many relations shown in the relation panel.

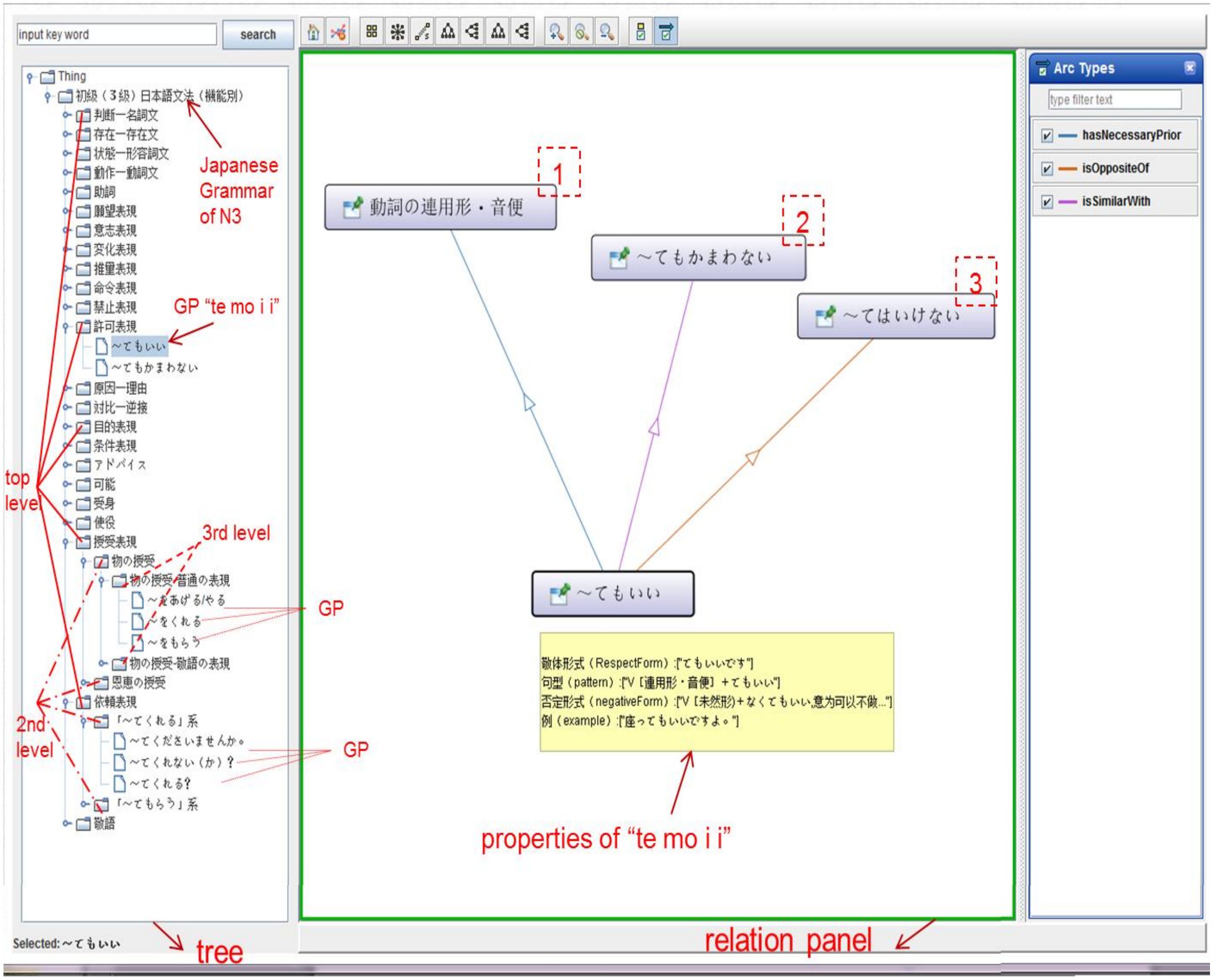


Fig. 4.1. The common view of CLLSS 2.0 for both instructors and learners.

According to the learning materials' organization method described in Section 3.3.2, CLLSS assisted by COJG which includes special relations (as shown in Table 2.1) is able to support the learner to compare an unlearned GP with all its related GPs, especially with those acquired GPs. This pedagogical approach is enabled by the consideration of the learners' dynamic knowledge structure.

For example, when the GP "~te mo i i" is identified as the present learning content according to a learner's present knowledge structure, the learner can get a visual representation of relevant information as shown in the relation panel of Fig. 4.1: the pattern of "~te mo i i" involves the prior concept represented by Node 1; the expression "~te mo i i" and the GP represented by Node 2 have similar meaning and both can be used in the same context; the expression "~te mo i i" and the GP represented by Node 3 have the same usage pattern but the opposite meaning. COJG enable the learner of CLLSS to compare "~te mo i i" with all its three related knowledge points through three kinds of different relations. This learning process including knowledge comparison is intended to support the learner comprehension of the new grammar point.

In addition to learning objects directly addressing certain GP, learning objects directly addressing those relations between GPs also are provided by CLLSS. Learners can open learning objects panel not only at every node but also every arc on the relation panel. Fig. 4.2 displays the learning object panel opened on the arc which represents the "isOppositeOf" relation between "~te mo i i" and the GP represented by Node 3 of Fig.4.2.

The Learning Objects that address the relation [isOppositeOf] between [～てもいい] and [～てはいけない]			
Exposure With Explanation			
Style	File Name	Average Rate	
Verbal explanation	temoiiTewaikenaiEW.pdf	0.0	open

Practice					
Style	Type	File Name	Reference File	Average Rate	
Visual	Fill-in-blanks with pictures	temoiiTewaikenaiPT.pdf	temoiiTewaikenaiPTd.pdf	0.0	open
Verbal	Transformation	temoiiTewaikenaiPZ.pdf	temoiiTewaikenaiPZd.pdf	0.0	open
Verbal	Translation	temoiiTewaikenaiPF.pdf	temoiiTewaikenaiPFd.pdf	0.0	open

Fig. 4.2. The learning objects panel addressing the similarity between "~te mo i i" and the GP represented by Node 3

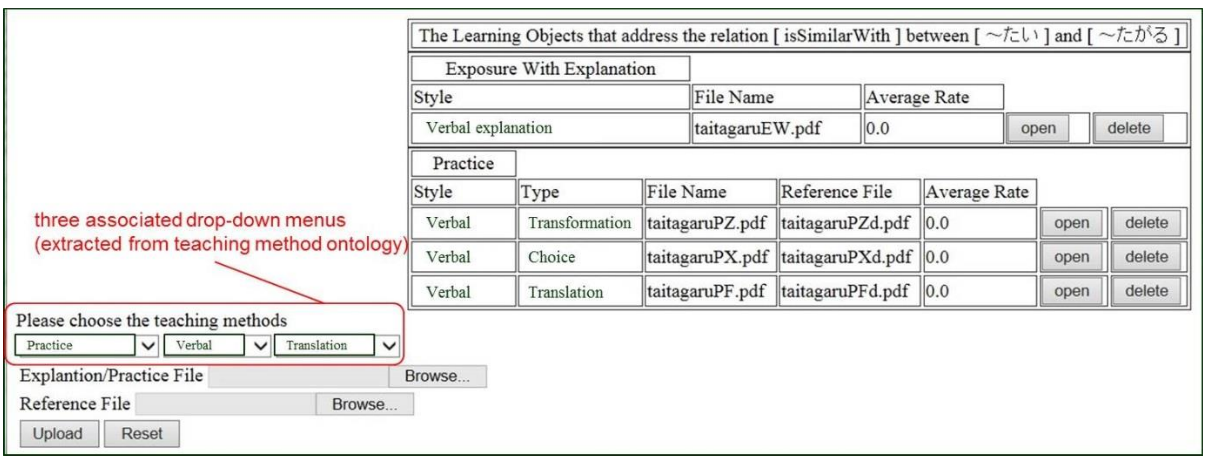


Fig. 4.3. The teaching material management panel in CLLSS 2.0 for instructors.

As mentioned in Section 3.2.2, two stages of grammar teaching, which are "exposure with explanation" and "practice", are considered for learning object organization. Apparently, the concrete contents of these two stages is designed based on the characteristics of the course and described by the teaching method ontology. In the version 2.0 of CLLSS, not only on the "learning objects panel" (example as shown in Fig.4.2) for learners but also on the "teaching material management panel" (example as shown in Fig.4.3) for instructors, the learning objects addressing these two stages are separately displayed to highlight the order of these two stages. Consequently, while uploading a new learning object on the teaching material management panel, the instructor need to choose which stage it belongs to (at the first drop-down menu shown in Fig. 4.3). In additional, in the new version of CLLSS, when learners open a file from "practice stage", they will be required to submit their exercises to the system before checking the reference file; on the other hand, the instructor also can review those answers through the system.

Besides, as shown in Fig 4.3, compared to version 1.0 shown in Fig. 3.4, CLLSS 2.0 enables the instructors to upload the Practice File and its Reference File at the same time. Furthermore, the new version also adds a "Reset" button for instructors to change the chosen files before uploading.

4.2 Experiment Design

4.2.1 The purpose of this study

To evaluate the prototype system of CLLSS 1.0, a preliminary experiment was conducted in the International Language department of a Chinese university. (The detail of the preliminary experiment is described in Section 3.4.) The experimental results suggest that the average learning achievement of the students in the experimental group, who studied with CLLSS 1.0, was significantly better than that of the control group, who studied with the traditional learning management system while taking the same Japanese course as the experimental group.

However, in the interview section of the preliminary experiment, 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, the experiment of this chapter was conducted to further evaluate the knowledge comparison function provide by the system. The following research questions are intended to investigate:

(1) What is ***the optimum number*** of related GPs to be shown in the relation panel at one time?

(2) Is there correlation between ***learning styles*** and learning performance (including learning achievements, perception, cognitive load, and so on) while the learners study with CLLSS?

(3) Is there correlation between ***learning habit*** (in this study refer to the habit of learning from the comparison of related KPs) and learning performance while the learners study with CLLSS?

From the experimental results, we aim to evaluate the effectiveness of the learning support function of CLLSS and also search for a better solution to the design of the relation panel of CLLSS.

4.2.2 The experiment design from learning style perspective

"The ways in which an individual characteristically acquires, retains, and retrieves information are collectively termed the individual's learning style" (Felder and Henriques, 1995, p.21). Among the learner's characteristics, learning style has been considered as one of the key elements that affect the learning effectiveness in many studies (Hwang, Sung, Hung, & Huang, 2012; Filippidis & Tsoukalas, 2009).

In this research, the widely adopted leaning style model, which was presented by Felder and Silverman in 1988 and revised by Felder in 2002, is used to model the learner' learning styles. This model defined four dimensions of learning style: Active/Reflective, Sensing/Intuiting, Visual/Verbal, and Sequential/Global dimensions. Learners of active scale tend to understand the knowledge through active trial, discussion or by explaining it to others while learners of reflective scale tend to observe reflectively; learners of sensing scale prefer to perceive data by the senses while learners of intuiting scale prefer by accessing memories or insights; visual learners prefer that information is presented by diagrams, flow charts, pictures or films rather than in written words, which is preferred by verbal learners; sequential learners gain understanding in logically linear steps while global learners need the big picture of a subject before mastering details.

As shown in Fig. 4.1, the relation panel of CLLSS provides a visual representation of every knowledge point and makes use of diagram to highlight the relations between knowledge points. Therefore, from the learning style perspective, the global learners, who like to relate the new knowledge to their prior knowledge and experience, may fell less pressure than sequential learners while using the comparison function provided by this relation panel; on the other hand, the visual learners, who prefer the knowledge presented by diagrams than in written words, may feel more comfortable than verbal learner while using CLLSS. Based on this hypothesis, the experiment in this chapter was conducted to further analyze learner performance while using CLLSS.

4.2.3 The ILS Questionnaire results of the preparatory phase

In the preparatory phase, a questionnaire was conducted in 3 Chinese universities with 183 undergraduate students in the Japanese major for collecting learning style distribution data.

The measuring tool adopted in this phase was a questionnaire written in Chinese, translated from the Index of Learning Styles (ILS) questionnaire of 44 questions (Soloman and Felder, 2001). The ILS questionnaire was designed based on the Felder-Silverman learning style model (1988, 2002) mentioned above and its current version was suggested to be reliable, valid and suitable for capturing learners' behavioral tendencies (Felder and Spurlin, 2005). All the participants including 78 male and 105 female students were voluntarily to fill in this questionnaire. The results of the learning style questionnaire are shown in Table 2.

According to Felder and spurlin (2005), each learning style dimension has associated with 11 force-choice items, with each option (a or b) corresponding to one or the other category of the dimension (such as active or reflective). Given visual/verbal dimension as an example, based on the answer of its related 11 items, participant would be identified as having strong, moderate or mild preference for visual or verbal. Learner with strong or moderate preference for one category normally is stably exhibiting consistent learning behavior. Conversely, learner with mild preferences would be expected to shift their preference in learning activities readily.

As shown in Table 4.1 (Dimension 3: Visual/ Verbal), 20.2% of student are strong visual learners, who strongly prefer that information be presented visually, and 30.1% are moderate visual learners, while only 1.6% of student are strong verbal learner who strongly prefer spoken or written explanations to visual presentations, and 6% are moderate verbal learner .Meanwhile, 42.1% of students with mild preference for visual or verbal are fairly well balanced in the dimension of Visual /Verbal.

Table 4.1

The results of the learning style questionnaire.

Learning style	The number (and percentage)of Students in every scale					
Dimension 1: Active/ Reflective	**Strong Active**	**Moderate Active**	**Mild Active**	**Mild Reflective**	**Moderate Reflective**	**Strong Reflective**
	5 (2.7%)	28 (15.3%)	55 (30.1%)	56 (30.6%)	31 (16.9%)	8 (4.4%)

Dimension 2: Sensing/ Intuitive	Strong Sensing	Moderate Sensing	Mild Sensing	Mild Intuitive	Moderate Intuitive	Strong Intuitive
	19 (10.4%)	44 (24%)	64 (35%)	37 (20.2%)	13 (7.1%)	6 (3.3%)
Dimension 3: Visual/ Verbal	**Strong Visual**	**Moderate Visual**	**Mild Visual**	**Mild Verbal**	**Moderate Verbal**	**Strong Verbal**
	37 (20.2%)	55 (30.1%)	47 (25.7%)	30 (16.4%)	11 (6%)	3 (1.6%)
Dimension 4: Sequential/ Global	**Strong Sequential**	**Moderate Sequential**	**Mild Sequential**	**Mild Global**	**Moderate Global**	**Strong Global**
	6 (3.3%)	17 (9.3%)	52 (28.4%)	59 (32.2%)	41 (22.4%)	8 (4.4%)

4.3 Experiment and Results

4.3.1 Participants

Among the 183 students who participated in the ILS questionnaire, 90 of them participated in the experiment in the study this chapter. These 90 first-grade undergraduates of the Japanese language major from 3 different classes of a Chinese university were taught by the 3 different instructors who had taught Japanese grammar course for more than seven years. Before the experiment, all the students already studied Japanese for 8 months and used the same reference books for the Japanese grammar course.

All the participants including 38 male and 52 female students were required to fill in the ILS questionnaire. The learning style profiles suggested by the results of the learning style questionnaire are shown in Table 4.2.

Table 4.2

The learning style profiles suggested by the results of the ILS questionnaire.

Dimension 1: Active/ Reflective	Strong Active	Moderate Active	Mild Active	Mild Reflective	Moderate Reflective	Strong Reflective
	2 (2.2%)	11 (12.2%)	30 (33.3%)	23 (25.6%)	18 (20.0%)	6 (6.7%)
Dimension 2: Sensing/ Intuitive	**Strong Sensing**	**Moderate Sensing**	**Mild Sensing**	**Mild Intuitive**	**Moderate Intuitive**	**Strong Intuitive**
	6 (6.7%)	21 (23.3%)	31 (34.4%)	19 (21.1%)	12 (13.3%)	1 (1.1%)
Dimension 3: Visual/ Verbal90	**Strong Visual**	**Moderate Visual**	**Mild Visual**	**Mild Verbal**	**Moderate Verbal**	**Strong Verbal**
	22 (24.4%)	26 (28.9%)	25 (27.8%)	13 (14.4%)	2 (2.2%)	2 (2.2%)
Dimension 4: Sequential/ Global	**Strong Sequential**	**Moderate Sequential**	**Mild Sequential**	**Mild Global**	**Moderate Global**	**Strong Global**
	3 (3.3%)	11 (12.2%)	21 (23.3%)	27 (30.0%)	23 (25.6%)	5 (5.6%)

As shown in Table 4.2 (Dimension 3: Visual/Verbal), 24.4% of participants are strong visual learners, who strongly prefer that information is presented visually, and 28.9% are moderate visual learners, while only 2.2% are strong verbal learner who strongly prefer spoken or written explanations to visual presentations, and 2.2% are moderate verbal learner. Meanwhile, 42.2% of participants with mild preference for visual or verbal are fairly well balanced in the dimension of Visual/Verbal. Since there are too few verbal learners (19.9%) comparing to verbal learners (81.1%) among the 90 participants, it is very difficult to analyze the learning performance differences between visual learners and verbal learners.

Therefore, the analysis of the learner data in the study of this chapter only focuses on the Sequential/Global dimension of learning style model. As shown in Table 4.2, among all the 90 participants the percentages of strong, moderate and mild sequential learners are 3.3%, 12.2% and 23.3% respectively, while the percentages of strong, moderate and mild global learners are 5.6%, 25.6% and 30% respectively.

4.3.2 Measurement techniques and Experimental Procedures

Fig.4.4 shows the procedures of the experiment. The Measurement techniques in this experiment included the learning achievement tests, and the questionnaires for measuring the students' learning perception, habits, preferences, and so on.

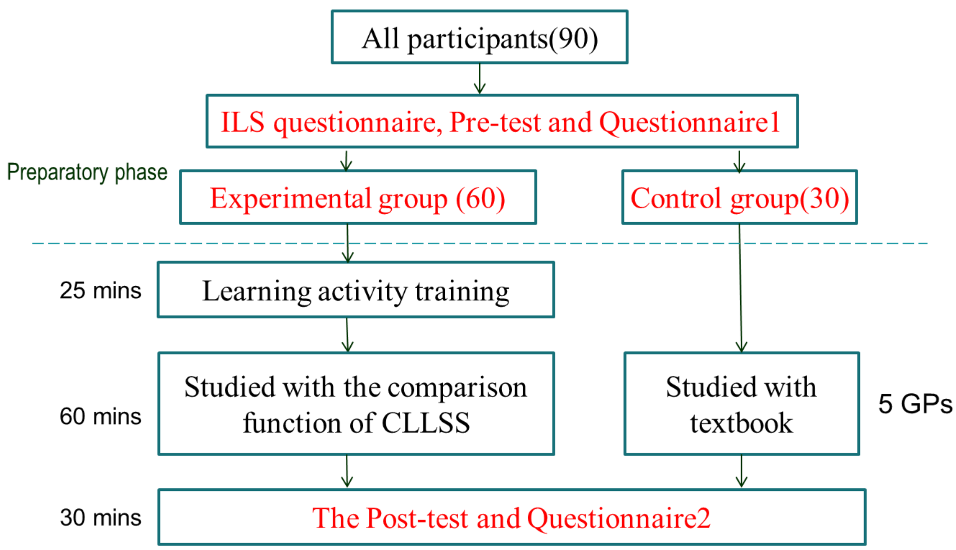


Fig. 4.4. The experimental procedures.

In the preparatory phase of the experiment, all the participants took the ILS questionnaire, the pre-test and Questionnaire-1 which involved learning attitude (Hwang and Chang, 2011) and motivation (Pintrich and DeGroot, 1990), the habit of "learning from the comparison of related KPs".

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.

Based on the answers to the question about learning habit in Questionnaire-1, participants are divided into "learners who don't have habit of learning from comparison (N-learners)" and "learners who have the habit of learning from comparison (H-learners)". As shown in Fig. 4.5, "N-learners" of experimental group included 2 students who completely did not have the comparison habit and 32 students who sometime would compare the related KPs while reminded by the instructor or other learners ;“H-learners” of experimental group included 21 students, who most of the time would realize the relations between acquired GPs and new GP and would like to compare them to increase the understanding of the knowledge, and 5 students, who already have the comparison habit and always record the contrast between related GPs in notebooks, even organize their related practices. Meanwhile, the control groups included 16 “N-learners” learners and 14 “H-learners”.

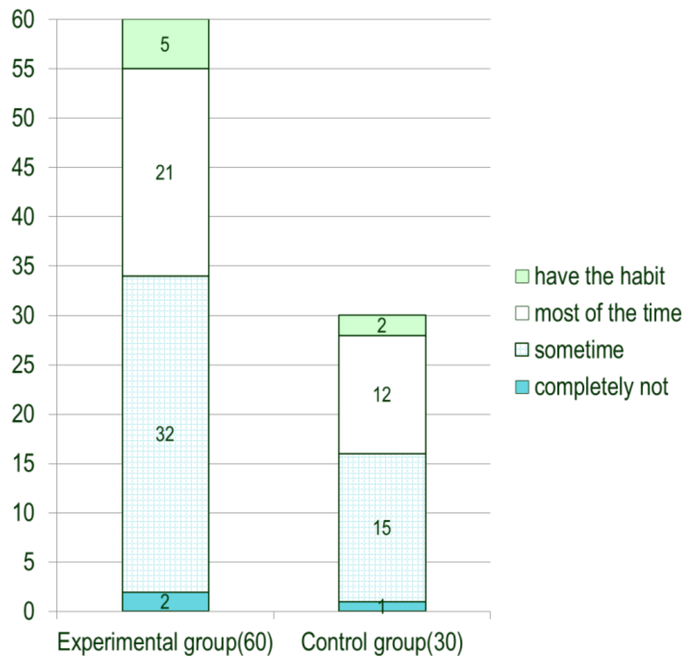


Fig. 4.5. The participant profiles from the learning habit perceptive.

The learning style profiles of participants suggested by results of the ILS questionnaire (shown in Table 4.2) are already discussed in section 4.3.1. The learning styles (Sequential/ Global Dimension) of participants in both experimental and control groups are displayed in Fig. 4.6. The experimental group included 25 Sequential learners and 35 Global learners while the control groups included 10 Sequential learners and 20 Global learners.

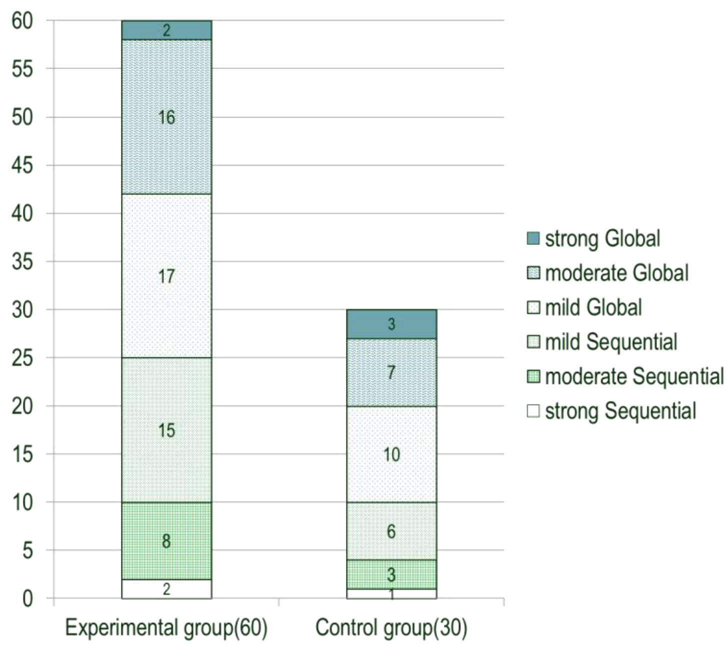


Fig. 4.6. The participant profiles from the learning style (Sequential/ Global Dimension) perceptive.

After the assignment of experimental and control groups, five GPs "~hoshigaru", "~tagaru", "~tekuru", "Causative Sentence", and"~hazuda", which have one, two, three, five and seven related GPs respectively in this grammar course, were chosen as target learning contents.

Fig. 4.7. The learning environment of the experiment groups.

The learning activity of experimental group was performed in the computer-assisted language learning lab. Fig. 4.7 shows the learning environment of the experiment groups of this experiment.

During the whole experiment, students in experiment group used the Chinese version of CLLSS 2.0 presented in Section 4.1. After a 25-minutes training, the experimental group with 60 students used the comparison function provided by the relation panel of CLLSS to study the target contents. They were required to compare the target contents with their prior knowledge points shown in relation panel during the learning activity. Meanwhile, the control group in another classroom with 30 students studied with the textbook (Shigeno, Seki, & Nishikimi, 2009). For both experimental and control groups, the time of the learning activity towards the target contents was 60 minutes. Students in both groups were encouraged to mainly compare "~hoshigaru" with“~hoshii”, “~tagaru” with “~tai”, “~tekuru” with “~teiku”, “~hazuda” with “~darou”, “Causative Sentence” with “~temorau” respectively.

After the learning activity, all the students took the post-test and another questionnaire (Questionnaire-2) which involved their learning attitude and motivation. Unlike the control group, the experimental group was required to answer some additional questions on the Questionnaire-2, which involved the satisfaction for learning mode (Chu, Hwang, &Tsai, 2010), technology acceptance measures (Chu, Hwang, Tsai, & Tseng, 2010; Davis, 1989), and cognitive load (Sweller, Merriënboer, & Fred, 1998).

The test sheets were created by two experienced teachers. The pre-test aimed to evaluate the students' prior knowledge of Japanese. It contained ten fill-in-blank items, twenty-five singe-choice items and ten translation items with a perfect score of 100. The post-test contained fifteen fill-in-blank items with a perfect score 90. Those fifteen items were designed for assessing the students' knowledge of target contents after the learning activity.

Both Questionnaire-1 and Questionnaire-2 written in Chinese were designed based on the measure tools of other researches (Chu, Hwang, &Tsai, 2010; Chu, Hwang, Tsai, & Tseng, 2010; Hwang and Chang, 2011; Pintrich and DeGroot, 1990; Sweller, Merriënboer, & Fred, 1998) with some modifications.

4.3.3 The Analysis of Learning perception

The feedback about the learning activity and the system evaluation from the experimental group, are shown in Table 4.3. According to this table, for the answers to “What is the maximum number of the relations shown in the relation panel of the system at one time that do not make you feel pressure and disturbed?”, the average number given by the 60 students in experimental group is 4.67; this means that 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. This result suggests that the system should encourage the instructors describe the priority of the relations and just show the top 4 of them in the relation panel while making the rest selectable.

The average ratings of “Effort for understanding the target GPs” (the maximum is 7) is 4.05; this suggest the learning activity was moderate (neither too easy nor too difficult) for the students in experiment groups. The average ratings of “Effort for understanding the purpose and the explanation of learning activity” (the maximum is 7) is 3.02; this means most students in the experimental group could easily understand the learning purpose of this activity.

In terms of mental load, the average rating of the degree of distraction and pressure of experimental group are both lower than 2.2, implying that using the CLLSS the learners could concentrate on learning with low pressure.

In terms of technology acceptance measures of the experimental group, the average rating of the item “It is easy to use this Comparison function of CLLSS.” (1-3: strongly to slightly disagree, 4-6: slightly to strongly agree) is 4.75; this means that most students in the experimental group felt that it was easy to operate and get familiar with the system. The item “This Comparison function of CLLSS is useful for study.” (1-3: strongly to slightly disagree, 4-6: slightly to strongly agree) received the average rating 4.83, implying that most of the students in the experimental group identified the usefulness of CLLSS in improving their learning performances.

Table 4.3

The Descriptive Data of experimental group' learning perception.

Item	optimum number of relations	Mental Effort		Mental Load		Technology Acceptance	
		learn the GPs (1-7)	understand the purpose (1-7)	Distraction (1-7)	Pressure (1-7)	Easiness (1-3:no 4-6:yes)	Usefulness (1-3:no 4-6:yes)
Mean	4.67	4.05	3.02	1.80	2.17	4.75	4.83
S.D.	1.39	1.43	1.41	1.02	1.12	0.91	0.81

For items shown in Table 4.3, the analysis results from learning style perspective are described in Table 4.4, in which the analysis of the learner data focuses on the learning style differences in Sequential/ Global dimension (shown in Fig.5). In Table 4.4, the MANOVA result of "Technology Acceptance" (Wilks' Lambda, $p<0.05$) indicates that there was significant difference between "Sequential learners" and "Global learners" of experimental group in how they accepted the technology of CLLSS. The results of individual univariate analyses further indicate that this significant difference is caused by the difference of the rating of "Perceived usefulness" between "Sequential learners" and "Global learners"; this suggests that compared to "Sequential learners", most "Global learners" had stronger feeling that the comparison function provided by CLLSS is useful in improving their learning performances. For the other rating items in Table 4.4, the results suggest that there was no significant difference between "Sequential learners" and "Global learners".

Table 4.4

The analysis results of experimental group' learning perception from learning style (Sequential/ Global) perspective.

Item / **Learning style**		optimum number of relations	Mental Effort		Mental Load		Technology Acceptance	
			learn the GPs (1-7)	understand the purpose (1-7)	Distraction (1-7)	Pressure (1-7)	Easiness (1-3:no 4-6:yes)	Usefulness (1-3:no 4-6:yes)
Sequential (25)	Mean	4.88	3.84	2.76	1.72	2.16	4.48	4.56
	S.D.	1.30	1.49	1.16	0.98	0.94	1.00	1.04
Global (35)	Mean	4.51	4.20	3.20	1.86	2.17	4.94	5.02
	S.D.	1.44	1.39	1.55	1.06	1.25	0.80	0.51
MANOVA (Wilks' Lambda)	Sig.		0.463		0.828		0.046* ($p<0.05$)	
Levene's Test		0.322	0.475	0.073	0.892	0.259	0.085	0.064
One way ANOVA		0.381	0.341	0.236	0.612	0.969	0.038	0.024* ($p<0.025$)

Table 4.5

The analysis results of experimental group' learning perception from learning habit perspective.

Item / Comparison habit		optimum number of relations	Mental Effort		Mental Load		Technology Acceptance	
			learn the GPs (1-7)	understand the purpose (1-7)	Distraction (1-7)	Pressure (1-7)	Easiness (1-3:no 4-6:yes)	Usefulness (1-3:no 4-6:yes)
N-learners (34)	Mean	4.73	4.12	3.12	2.06	2.47	4.73	4.73
	S.D.	1.64	1.51	1.47	1.10	1.24	0.99	0.96
H-learners (26)	Mean	4.58	3.96	2.88	1.46	1.77	4.77	4.96
	S.D.	0.99	1.34	1.34	0.81	0.82	0.82	0.53
MANOVA (Wilks' Lambda)	Sig.		0.819		0.033* (p<0.05)		0.463	
Levene's Test		0.204	0.662	0.523	0.380	0.068	0.693	0.064
One way ANOVA		0.665	0.679	0.530	0.024* (p<0.025)	0.015* (p<0.025)	0.888	0.285

On the other hand, Table 4.5 describes the analysis results of the learning perception of experimental group from learning habit perspective, in which the analysis of the learner data focuses on the learning habit differences. According to Table 4.5, the MANOVA result "Mental Load" (Wilks' Lambda, p<0.05) indicates that there was significant difference between "N-learners" and "H-learners" of the experiment group. The results of individual univariate analyses further indicate that there were significant differences in the rating of "Distraction" and "Pressure" items between "N-learners" and "H-learners"; this suggests that 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. For the other rating items in Table 4.5, the results suggest that there was no significant difference between "N-learners "and "H-learners".

Besides those 8 items shown in Table 4.3, experimental group had 7 additional questions about the satisfaction for learning mode. The results of the answers of experimental group are shown in Table 4.6. The maximum is 6 for the rating of every item (1-3: strongly to slightly disagree, 4-6: slightly to strongly agree). According to Table 4.6, for experimental group, most of them slightly agreed that the learning content were provided in a vivid way, but most of them showed general agreement with the fact that using the "comparison function" provided by the relation panel did help them find some new information and did help them understand the knowledge points in new ways. Also, most of the student in experimental group generally agreed that they (a) liked to use the "comparison function" during the activity of this experiment, (b) hoped this function could be used while studying other subjects or in future study, and (c) would recommend this method to other learners.

To investigate user satisfaction for learning mode, MANOVAs were also conducted by focusing on the learning style differences in Sequential/ Global dimension and the learning habit differences respectively. However, significant differences are found neither between "N-learners "and "H-learners" nor between "Sequential learners" and "Global learners".

Table 4.6

The results of the satisfaction for learning mode of experimental group.

Question	Mean	S.D.
Q1: The system provides the learning contents in a vivid way.	4.33	0.86
Q2: Using the “comparison function” provided by the relation panel of the system can help me find some new information.	4.98	0.70
Q3: Using the “comparison function” in the system can help me to understand the knowledge points in new ways.	4.77	0.81
Q4: I like to use the comparison function in the system.	4.83	0.76
Q5: I hope other subjects can also be learned with this method.	4.70	0.91
Q6: I hope I can learn with this method in future study.	5.05	0.70
Q7: I will recommend this methods to other learners	4.93	0.76

4.3.4 The Analysis of Learning achievement

The analysis of covariance (ANCOVA) was used to test the learning achievement difference between the experiment group and control group by using the pre-test scores as the concomitant variable and the post-test scores as dependent variable. The purpose of using pre-test scores as concomitant variable in ANCOVA is to use the information about pre-test to reduce the variation in post-test scores and thus increase the chance of detecting differences between the different treatments.

Before performing the ANCOVA, a series of tests, which includes the tests of Between-Subjects Effects, Shapiro-Wilk test, the checking on P-P plots of Standardized Residuals and the Liner Regression test, were conducted to confirm the sample data satisfy the ANCOVA assumption. (Those tests were conducted before every ANCOVA in this section.)Based on the results of these tests, sample data appear to conform to the assumption of the ANCOVA.

Table 4.7 shows the descriptive data and ANCOVA results of the experimental group and control group. The result ($p > .05$) of Levene’s test of Equality of Error Variances suggests the homogeneity of variances. The adjusted mean value and standard error of the post-test scores are 52.67 and 2.74 for the experimental group, 41.71 and 4.61 for the control group. According to results ($F=4.139$, $p<.05$) shown in Table 4.7, there was a significant difference between these two groups; this suggests that the students who learned with the learning support system achieved significantly better learning achievements than those who just did self-study with textbook after studying the same target contents for the same time.

Table 4.7

Descriptive data and ANCOVA result of the post-test scores between experimental and control group.

Group	N	Mean	S.D	Adjusted Mean	Std. Error	F	Sig.	Levene's Test
Experimental	60	53.50	19.12	52.67	2.74	4.139	0.047	0.674
Control	30	39.43	17.68	41.71	4.61			

ANCOVA was also used to test the learning achievement difference between sequential and global learners of experimental group. As shown in Table 4.8, the result ($p > .05$) of Levene's test of Equality of Error Variances suggests the homogeneity of variances. The adjusted mean value and standard error of the post-test scores are 51.97 and 4.30 for sequential learners of experimental group, 54.66 and 3.78 for global learners of the experimental group. According to results ($F=0.218$, $p>.05$) shown in Table 4.8, there was no significant difference between sequential and global learners of experimental group; this suggests that no matter the sequential or global learners of experimental group, who studied with the learning support system, their learning achievements did not have significant difference.

Table 4.8

Descriptive data and ANCOVA result of the post-test scores between sequential and global learners of experimental group.

Group	N	Mean	S.D	Adjusted Mean	Std. Error	F	Sig.	Levene's Test
Sequential	25	53.36	18.37	51.97	4.30	0.218	0.643	0.781
Global	35	53.60	20.11	54.66	3.78			

For the learning achievement difference between "N-learners" and "H-learners" of experimental group, the ANCOVA result ($F=2.801$, $p>.05$) shown in Table 4.9 suggests that there was no significant difference between these two groups; this suggests that no matter the learners have or don't have the habit of learning from comparison, using CLLSS their learning achievements did not have significant difference.

Table 4.9

Descriptive data and ANCOVA result of the post-test scores between "N-learners" and "H-learners" of experimental group.

Group	N	Mean	S.D	Adjusted Mean	Std. Error	F	Sig.	Levene's Test
N-learners	34	56.29	18.69	57.36	3.58	2.801	0.103	0.277
H-learners	26	49.85	19.76	47.92	4.30			

4.4 Conclusion

From the perspectives of learning style and learning habit, the study described in this chapter conducted an experiment to further evaluate the effectiveness of CLLSS' relation panel. In the experiment of this study, the 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 learners 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)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 that habit while both using CLLSS.

For future work, we will conduct some analyses to investigate the changes on the learning attitude and motivation of this experiment and discuss the results. Furthermore, in the experiments of the study in this chapter, students were required to use CLLSS to learn some chosen grammar points in the grammar course. Only short-term learning performances of learners are discussed. Since there were learning perception differences between learners of different learning styles(Sequential/ Global dimension) and also between learners with different learning habits, those differences may lead to long-term leaning performance differences. Therefore, in the next stage, long-term effects of CLLSS will be studied by conducting more experiments. The system will track the situation of students during the learning processes of the whole course. The learner data will be collected and analyzed in future. Besides, the number and the type of the acquired GPs which have relation with a new GP will be considered for ranking new GPs when more than one GP are suitable to learner’s next learning process.

Chapter 5
Study2: about strategies of learning object recommendation

5.1 Introduction

One of the biggest problems in older LMS, such as Moodle, is that they cannot satisfy the complicated requirements of learners, especially with regard to differences in learning abilities. Even for a group of learners who have the same learning objective, different learner may have individual knowledge structure, learning styles and learning habits. These individual characteristics will lead to learning abilities differences and complicated learning requirements. Therefore, simply providing the same learning materials to every student, limits the effectiveness of the system.

To address this problem, in recent years personalized or adaptive learning support has been considered in many e-learning systems (Hwang et al., 2012; Klašnja-Milićević et al., 2011; Romero et al., 2009) and have shown their effectiveness. Essalmi et al. (2010) described 16 personalization parameters that are most commonly used in e-learning systems and presented a general framework that supports the specification and the application of personalization strategies by combining several personalization parameters. Among the learner's characteristics that affect the learning effectiveness, learning style has been recognized as one of the important factors (El Bachari E., Abdelwahed E. H., & El Adnani M., 2012; Filippidis & Tsoukalas, 2009; Hwang et al., 2012).

Numerous adaptive systems were deliberately designed to attempt the integration of learning styles as a parameter for the personalization of learning scenarios. The programming tutoring system "Protus" (Klašnja-Milićević et al., 2011) forms clusters of learners based on learning style and then mining the behavioral patterns for each cluster by AprioriAll algorithm (Tong &Pi-Lian, 2005) to create a recommendation list for individual of each cluster according to the ratings of these frequent sequences. Hwang et al. (2012) proposed a personalized game-based learning approach considering the sequential/global dimension of the learning style model of Felder and Silverman (1988). This approach was applied to the construction of role-playing game addressing an elementary school natural science course to promote the learning motivation and improve the learning achievement of the students.

Despite the agreement that diagnosing individual's learning styles is essential to support personalized learning, there are two main types of different theories about how to exploit the leaning style or preference information.

One type of theories is "matching hypothesis", which is hold by many researches (Essalmi et al., 2010: Hwang et al., 2012; Klašnja-Milićević et al., 2011; Stash et al., 2006) and contends that information should be presented in the way which fits learners' learning style. This hypothesis claims that optimal instruction requires tailoring teaching style to match learner's leaning styles so that the learners will have better learning attitudes and get a better achievement.

Another group of researchers support "balance hypothesis" which suggests that a balance of instructional methods is the best way to make learners achieve effective learning. Some (Friedman and Alley 1984; Cox 1988) argued that learners will inevitably need to deal with problems and challenges that require the use of their less preferred mode. Therefore, the learners should regularly be given practice in the use of less preferred modes, even that they might have stress and frustration. Moreover, several experiments ultimately supported the multimedia effect theory(Mayer and Sims, 1994) which claims that learners who had access to more than one learning mode learned more effectively than those who had access to only one mode, especially in second-language learning (Plass, Chun, Mayer,& Detlev Leutner, 1998).

So, which is the better strategy of learning object recommendation from the learning style perspective? That is exactly the study in this chapter is intended to investigate. Assume a learning support system organizes the learning objects based on one learning style theory, among the following three ways which is a better strategy for learning object suggestion?

(1) Suggest the LOs whose types match the learner's learning style.

(2) Present all types of LOs and let the learner make their decision.

(3) Suggest types of LOs that were most frequently opened based on the learning history.

Or maybe the best strategy is considering the combination of the learning style and learning history? If so, how to combine them will be another question.

5.2 The design of teaching method ontology

As mentioned in the Chapter 3 and 4, CLLSS is intended to provide LOs according to the learner's knowledge structure, learning style, preference and habits. However, how reasoning mechanism in CLLSS analyzes the learner's characteristics and suggests the types of LOs in response to the individual profile are still unsolved yet. Therefore, a series of experiments in this research are conducted to examine what factors affect the learning performance of the learner while using CLLSS. The study in Chapter 4 focuses on the individual learning style differences and learning habit differences; the study in this chapter focus. Based on the results of these experiments, we intend to determine the mode and the strategy which could improve the learner's learning performance more effectively.

5.2.1The learning style models

There are many learning style models in literature, for example, the learning style model by Felder et al. (1988, 1995 & 2002), Myers(1993), Honey and Mumford (1982), Kolb (1984) and Pask (1976).

In this research, the widely adopted leaning style mode, which was firstly presented by Felder and Silverman in 1988 and revised by Felder in 2002, is used to modeling the learner' learning styles. As mentioned in Section 4.2.2, Felder and Silverman learning style model (FSLSM) defined four dimensions (shown in Fig 5.1) of learning style: Active/Reflective, Sensing/Intuiting, Visual/Verbal, and Sequential/Global dimensions. The first dimension is about information processing: learners of active scale tend to understand the knowledge through active trial, discussion or by explaining it to others while learners of reflective scale tend to observe reflectively. The second dimension involves information perception: learners of sensing scale prefer to perceive data by the senses while learners of intuiting scale prefer by accessing memories or insights. The third dimension refers to information reception: visual learners prefer that information are presented by diagrams, flow charts, pictures or films rather than in written words, which is preferred by verbal learners. The last dimension involves information understanding: sequential learners gain understanding in logically linear steps while global learners need the big picture of a subject before mastering details. “These four dimensions have not been shown to be fully independent, and validated instruments to assess individual preferences on all of them do not exist.”(Felder and Henriques, 1995, p.27)

Processing		Perception	
Active	**Reflective**	**Sensing**	**Intuitive**
discussing/applying /explaining to others	think about it quietly first	be patient with details and good at memorizing facts	prefer discovering possibilities and relationships, grasping new concepts /abstractions
group work	working alone	solving problems by well-established methods, Practice	like innovation /dislike repetition

Reception		Understanding	
Visual	**Verbal**	**Sequential**	**Global**
pictures, diagrams, flow charts, time lines, films, and demonstrations	written and spoken explanations	absorb information in small connected pieces	need the big picture of a subject before mastering details
		gain understanding in logically linear steps	how the material being presented relates to their prior knowledge and experience

Fig. 5.1. The four dimensions defined by FSLSM.

Obviously, it is very difficult to accommodate the full variety of learning styles in LOs of any chosen course. The experiment in this Chapter only focuses on the Visual/Verbal dimension of learning style since the LOs in language teaching have obvious contrast in this dimension.

Actually, the theory on Visual/Verbal dimension is in accord with the behavior distinction between visualizers and verbalizers in multimedia learning. The generative theory (Mayer and Sims, 1994; Mayer, 1997) of multimedia learning claims that an effective learning is supported when learners can construct and coordinate visual and verbal representations of the same material. In Mayer et al.’s experiments, the learning targets are the workings of a bicycle tire pump and of the human respiratory system. The experiments result suggested that learners can build two types of retrieval cues in their memory when they studied both types of LOs presented in verbal and visual forms, whereas they can only build one or no type of retrieval cue when they studied only one or no forms. But these studies also admit the learning performance differences caused by individual differences.

5.2.2 The contents of teaching method ontology

The multimedia learning theory was extended to second-language learning by the study of Plass et al. (Plass, Chun, Mayer, ,& Detlev Leutner, 1998). Furthermore, it is also supported by their experiments' results that the effects of different learning modes are content-depended in second-language learning. For example, in their experiments on German language learning, the learning effect on the acquisition of individual vocabulary was illustrated different from the one on the overall comprehension of a reading text.

Different from of the experiments of Plass et al, in the experiment of this chapter, the target learning content is the grammar of Japanese language. As described in Section 3.2.2, in the teaching method ontology of CLLSS, the two stages of grammar teaching are considered in our research. In this study, the concrete contents of these two stages both include visual and verbal forms as sub-concepts are shown in Table 5.1. In our experiment of this chapter, the LOs, which respectively involve two kinds of exposure with explanation (verbal and pictures with verbal), four kinds of verbal practices and three kinds of visual practices, are prepared by two expert teachers for all the target grammar points. Examples of the "Fill-in-blanks with pictures" type LO and "Singing Practice" type LO of the grammar points "~tekudasai", are shown in Fig. 5.2 and Fig. 5.3, respectively. In other words, the teaching methods shown in Table 5.1 were adopted as one of the foundations for LO's metadata creation (another one is the contents of COJG.)

Table 5.1

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

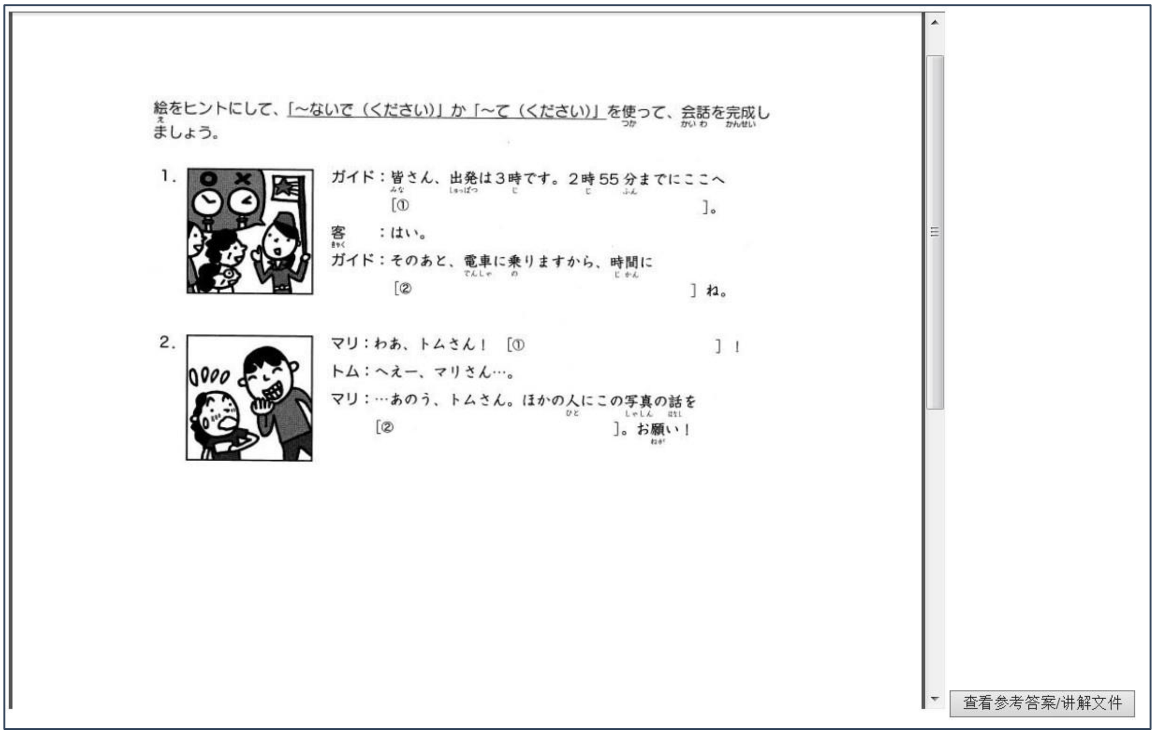


Fig. 5.2. The “Fill-in-blanks with pictures” LO of the grammar points “~te ku da sa i”.

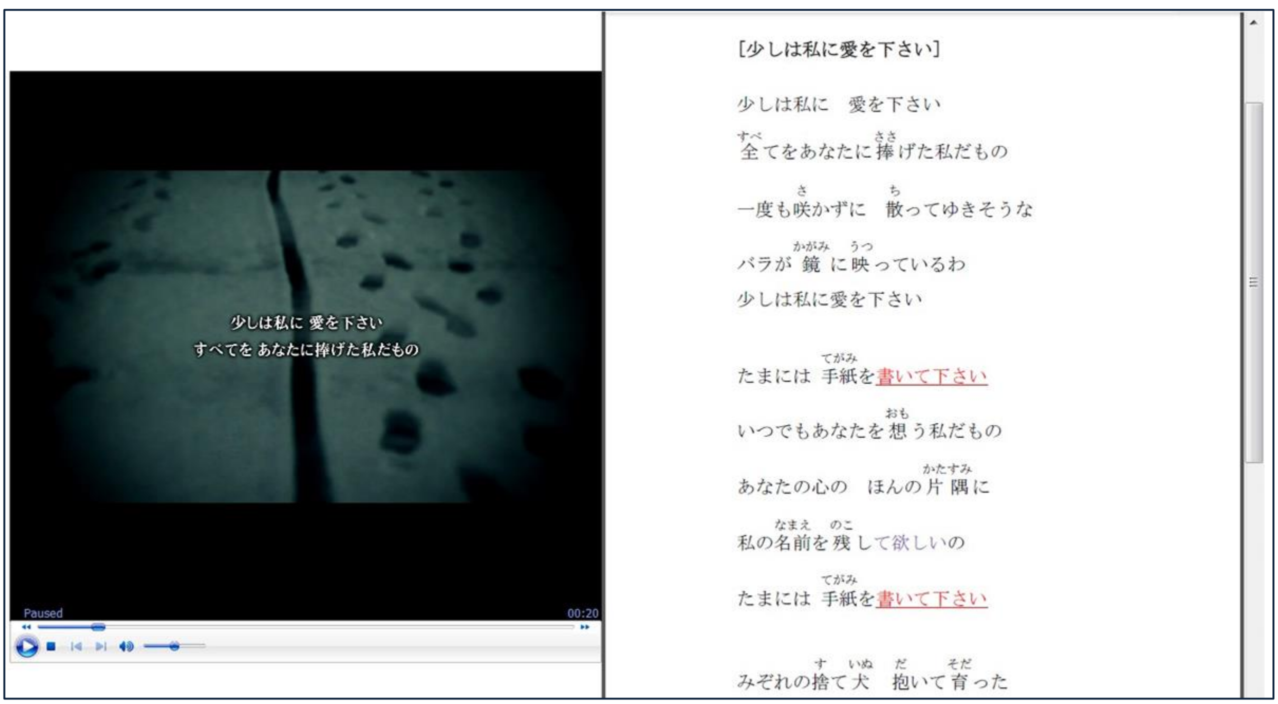


Fig. 5.3. The “Singing Practice” LO of the grammar points “~te ku da sa i”.

5.3 The purpose of this study and two modes of CLLSS

5.3.1 The purpose of this study and related work

For designing a better strategy of learning object recommendation to balance the learner's motivation and learning effectiveness, we conducted an experiment which only focuses on the Visual/Verbal dimension of learning style to investigate the learning performance differences of different modes of CLLSS. The following research questions are investigated:

(1) **While using CLLSS, are there any learning performance (including learning achievements, perception, cognitive load, and so on) differences between the students, who are provided with all types of the LOs and can choose LOs according to their preferences, the students who are only provided with the LOs matching their learning style, and the students who studied with a given textbook?**

In the posttest of the experiments of Plass et al., they only assessed the students' knowledge of target contents in verbal aspect (by scoring the students' word translation form German to English as "learning achievement of vocabulary" and their summary of the story as "reading comprehension achievement"). Therefore, their experiment results only represented the students' learning achievement in verbal aspect without visually aspect. Thus, in the experiment in the study of this chapter, all the students' knowledge of target contents in both verbal and visual aspects was accessed after the learning activity.

(2) **Besides learning styles, what are the factors that affect the choice of learners while given LOs presented in a variety of types by CLLSS?**

As claimed by many researches(Essalmi et al., 2010: Hwang et al., 2012; Klašnja-Milićević et al., 2011; Stash et al., 2006) that when learners are provided with the types of LOs which match their learning style preference, they normally will feel more comfortable in the learning process. This kind of comfortable learning environment would active their learning motivation. However, a learner's learning style may not correspond to the style that enables her/him to learn most effectively (Felder and Henriques, 1995). If a LOs is well designed by expert instructor, learners could learn effectively even the type of this LO does not match their learning style. Also the learning effectiveness can be affected by other factors. Therefore, our study attempts to investigate what factors affect the learner's choice from the perspective of learning style.

Another thing worthy of attention is that the items "learning style" and "learning preference" are not used consistently in literature. Some papers even evasively equated these two words. However, there is a growing body of researches (Stash et al, 2006) show that the stated preferences of the students are no completely in line with the ILS questionnaire (Soloman and Felder, 2001) results. Hwang et al. (2013) also pointed out that the learning preferences detected from learning behavior and the cognitive learning styles inferred by the ILS questionnaire (Soloman and Felder, 2001) are inconsistent. The results of these experiments suggested that the choices made by the learners were not related to their learning styles inferred by the ILS questionnaire (Soloman and Felder, 2001); instead, most learners made their choices by intuition based on personal preferences.

The identification methods of learning styles and learning preference are also different. The identification of learning styles are relied on self-reported questionnaire (Essalmi et al., 2010;

Klašnja-Milićević et al., 2011; Hwang et al., 2013), whereas the leaning preferences detection is directly based on the analysis of behavioral data (Leutner & Plass, 1997; Plass, Chun, Mayer, & Detlev Leutner, 1998). Therefore, in our study, “learning preference” is considered as different factor from “learning style”.

(3) **Can students actively choose all the LOs or the LOs that mostly match their learning style while given LOs presented in a variety of types by CLLSS?**

As mentioned above, the multimedia learning theory was extended to second-language learning by the study of Plass et al. (1998). They stated that when learners actively select both visual and verbal modes their performances are better than those who only select one mode. (The degree of the learning effectiveness from high to low are: actively access both modes, preference-fit mode, preference-unfit mode and none.) The experiment results suggested that providing both verbal and visual presentation medium for learner is the most effective way in addressing learning preferences differences. However, few studies have been conducted to investigate if the learners are able to actively select LOs of both styles, or even actively choose the style-fit ones.

In the previous experiments (described in Section 3.4 and Section 4.3), in which the experimental group students were presented with all types of LOs by CLLSS on each chosen grammar content, most of them reported after the learning activity that they got confused about how to make choices while confronted different types of LOs. This situation suggested that it is difficult to make the learners actively select all types of LOs, or style-fit. Therefore, the experiment in the study of this chapter is conducted to further investigate this issue.

5.3.2 Open mode and Learning Style Matching mode of CLLSS

To find out the answers of the questions mentioned above, two CLLSS modes with two different strategies for LO suggestion are discussed in this chapter: Open Mode and Learning Style Matching Mode. Fig. 5.4 shows the LOs list of the grammar point “~te ku da sa i” in Open mode which provides both the visual and verbal LOs to the learner. Different from Open Mode, Learning Style Matching Mode only provides the visual LOs to visual learners and the verbal LOs to verbal learners.

The Learning Objects of [～てください]

Exposure With Explanation

Style	File Name	Average Rate	
Verbal explanation	tekudasaiEW.pdf	0.0	open

Practice

Style	Type	File Name	Reference File	Average Rate	
Visual	Singing	tekudasaiPC.mp4	tekudasaiPCd.pdf	0.0	open
Visual	Pictures	tekudasaiPT.pdf	tekudasaiPTd.pdf	0.0	open
Verbal	Transformation	tekudasaiPZ.pdf	tekudasaiPZd.pdf	0.0	open
Verbal	Choice question	tekudasaiPX.pdf	tekudasaiPXd.pdf	0.0	open
Verbal	Words-order	tekudasaiPP.pdf	tekudasaiPPd.pdf	0.0	open

Fig. 5.4. The list of LOs of the grammar points “~te ku da sa i” in Open mode.

The learning performances of students in two experimental groups, who learned respectively with these two modes of CLLSS, will be compared with a control group, who study a given textbook at the same time. From the experimental results, we aim to show the effectiveness of the learning support function of CLLSS and also search a better solution to the strategy for LO suggestion of CLLSS.

5.4 Experiment and Results

5.4.1 Participants

Among the 183 students who participated in the ILS questionnaire of the preparatory phase (the detail are described in Section 4.2.3), 90 of them participated in the experiment in this chapter. These 90 first-grade undergraduates from 3 different classes were taught by the 3 different instructors who had taught Japanese grammar course for more than seven years. Before the experiment, all the students already studied Japanese for six month. Although these 3 classes are using slightly different reference books for the Japanese grammar course, the sequence of concepts in the past six month are mostly the same as the beginning of the course.

In addition, the teaching styles of these 3 instructors were all verbal style. The students hardly received any visual explanation or practice in previous classroom teaching. The results of the learning style questionnaire of these 90 participants (14 male and 76 female students) are described in Table 5.2.

Table 5.2

The learning style profiles suggested by the results of the ILS questionnaire.

Learning style	The number (and percentage)of Students in every scale					
Dimension 1: Active/ Reflective	**Strong Active**	**Moderate Active**	**Mild Active**	**Mild Reflective**	**Moderate Reflective**	**Strong Reflective**
	3 (3.3%)	13 (14.4%)	24 (26.7%)	28 (31.1%)	17 (18.9%)	5 (5.56%)
Dimension 2: Sensing/ Intuitive	**Strong Sensing**	**Moderate Sensing**	**Mild Sensing**	**Mild Intuitive**	**Moderate Intuitive**	**Strong Intuitive**
	10 (11.1%)	18 (20%)	36 (40%)	19 (21.1%)	6 (6.7%)	1 (1.1%)
Dimension 3: Visual/ Verbal	**Strong Visual**	**Moderate Visual**	**Mild Visual**	**Mild Verbal**	**Moderate Verbal**	**Strong Verbal**
	17 (18.9%)	27 (30%)	22 (24.4%)	17 (18.9%)	5 (5.5%)	2 (2.2%)
Dimension 4: Sequential/ Global	**Strong Sequential**	**Moderate Sequential**	**Mild Sequential**	**Mild Global**	**Moderate Global**	**Strong Global**
	3 (3.3%)	9 (10%)	28 (31.1%)	27 (30%)	19 (21.1%)	4 (4.4%)

As shown in Table 5.2 (Dimension 3: Visual/ Verbal), 18.9% of students are strong visual learners, who strongly prefer that information be presented visually, and 30% are moderate visual learners, while only 2.2% of students are strong verbal learner who strongly prefer spoken or written explanations to visual presentations, and 5.5% are moderate verbal learner .Meanwhile, 43.3% of students with mild preference for visual or verbal are fairly well balanced in the dimension of Visual /Verbal.

Fig.5.5 illustrates the learning styles of participants in each class. Students from each class were assigned to be the experimental groups A, B and the control group based not only on their learning style type in visual/verbal dimension but also on their learning achievement in last semester's final exam, so as to minimize the group composition differences.

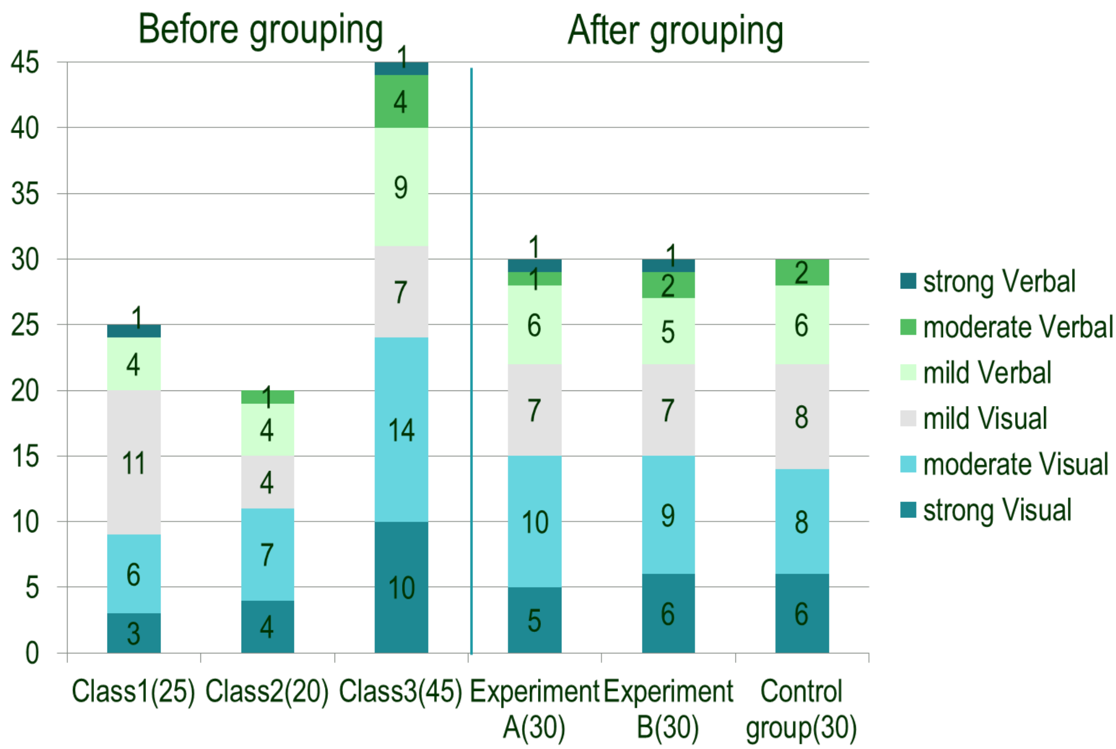


Fig. 5.5. The participant profiles from the learning style (Visual/Verbal dimension) perceptive.

5.4.2 Measurement Techniques and Experimental Procedures

The Measurement techniques in this experiment included the learning achievement tests, and the questionnaires for measuring the students' learning perception and preferences and so on.

The test sheets were developed by two experienced teachers. The pre-test aimed to evaluate the students' prior knowledge of Japanese. It contained ten fill-in-blank items, twenty-five singe-choice items and ten translation items with a perfect score of 100. The post-test contained 5 fill-in-blank items and 5 transformation items presented in verbal form, and 5 fill-in-blank items and 5 transformation items presented in visual form. Those 20 items are designed for assessing the students' knowledge of target contents in both verbal and visual aspects after the learning activity. The perfect score of the post-test was 100(50 for verbal aspect and 50 for visual aspect). (Since the participants hardly received any visual explanation or practice before the experiment, the visual form items are no considered in the pre-test.)

Fig. 5.6 shows the procedures of the experiment. At the beginning of the experiment, all of them took the pre-test and learning attitude and motivation questionnaire (Questionnaire-1).

Then, five GPs("~tekudasai", "~naru", "~to", "~nara" and "~temorau"), which mainly involved in Imperative Expressions, the Expressions of Change, Conditional Expressions, and Giving and Receiving Expressions, are chosen as target learning contents. The learning activity of experimental groups was performed in the computer-assisted language learning lab. In this experiment, participants in experimental groups used the Chinese version of the CLLSS 2.0 presented in Section 4.1. After a 25 minutes training, the experimental group A with thirty students used the Open Mode of web-based CLLSS while the experimental group B with thirty students used the Learning Style Matching Mode of CLLSS for studying the target contents. Meanwhile, the control group in another classroom with thirty students studied with the given textbook. For all these three groups, the time of the learning activity towards the target contents was 60 minutes.

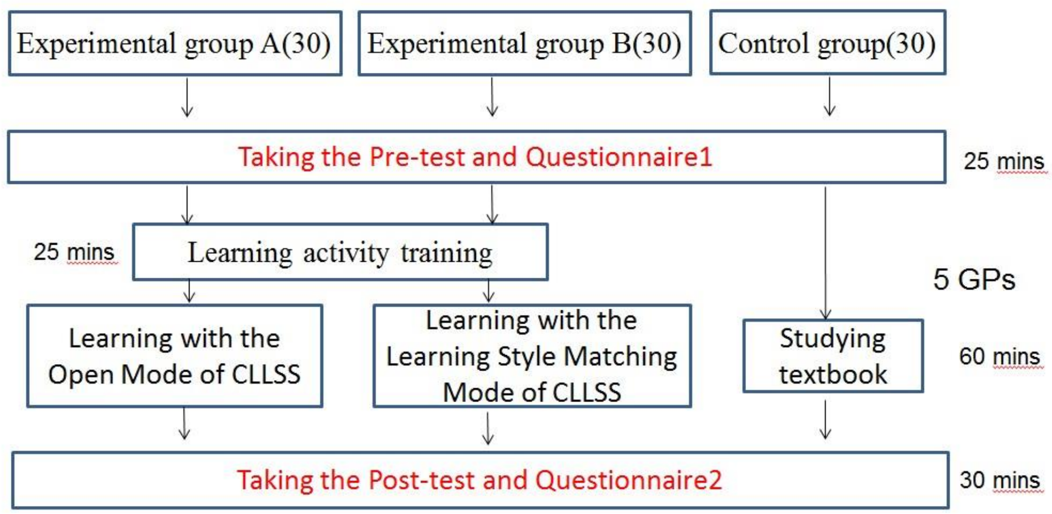


Fig. 5.6. The experimental procedures.

After the learning activity, all the students took the post-test and another questionnaire (Questionnaire-2) which involved learning attitude, motivation and preference, technology acceptance measures, and cognitive load (the last two aspects just for experimental groups). Both two questionnaires written in Chinese are designed based on the measure tools respectively designed by Hwang and Chang (2011), Pintrich and DeGroot (1990), Chu et al. (2010) and Sweller et al. (1998) with some modifications.

5.4.3 The Analysis of Learning perception

The feedback about the learning activity and the system evaluation from the experimental groups, are shown in Table 5.3.

For the experimental group A, B, the average ratings of "Effort for understanding the target 5 GPs" (the maximum is 7) are 3.45 and 3.5 respectively. The average ratings of "Effort for understanding the purpose and the explanation of learning activity" (the maximum is 7) are 3.06 and 2.86 for the experimental group A and B respectively; this means most students in the experimental groups can easily understand the learning purpose of this activity.

In terms of technology acceptance measures of the experimental groups, the average rating of "It is easy to use this Mode of CLLSS" (1-3: strongly to slightly disagree, 4-6: slightly to strongly agree) received the average rating is 5.13 for group A and 4.94 for group B respectively; this means most students in the experimental groups felt that the CLLSS was easy to operate and get familiar with. The average rating of the item "This Mode of CLLSS is useful in learning knowledge" (1-3: strongly to slightly disagree, 4-6: slightly to strongly agree) is 4.94 for group A and 4.72 for group B respectively, implying that most students in the experimental group identified the usefulness of the CLLSS in improving their learning performances.

In terms of cognitive load, the average rating of the degree of distraction and pressure while using the CLLSS are both lower than 2.5 for both experimental group A and B, implying that using the CLLSS the students can concentrate on learning with low pressure.

Table 5.3

The MANOVA results of items about learning perception in Questionnaire-2.

				Technology Acceptance		Cognitive Load	
		Effort for the 5 GPs (1-7)	Effort for understanding the purpose (1-7)	Easiness of Mode (1-3:no 4-6:yes)	Usefulness of Mode (1-3:no 4-6:yes)	Distraction (1-7)	Pressure (1-7)
Group A	Mean	3.45	3.06	5.13	4.94	2.45	1.87
	S.D.	1.23	1.34	0.62	0.73	1.5	1.29
Group B	Mean	3.5	2.86	4.94	4.72	1.77	1.90
	S.D.	1.02	1.10	0.46	0.99	1.28	0.92
MANOVA (Wilks' Lambda)	Sig.	0.038* ($p<0.05$)					
Box's M Test		0.323					
One way ANOVA		0.918	0.675	0.150	0.340	0.041* ($p<0.05$)	0.857

The multivariate test result (Wilks' Lambda, $p<0.05$) indicates that there was a significant difference between the experiment group A and B in the ratings of the 6 items (shown in Table 5.3) about the learning perception. Furthermore, the results of individual univariate analyses indicate that there was a significant difference in the rating of "Distraction" item between groups A and B; this suggests that the students who learned with "Open Mode" were easier to lose their attention than the students who learned with "Learning Style Matching Mode" while both using CLLSS. For the other five rating items in Table 5.3, the results show that there was no significantly different between the experimental groups A and B.

Besides, the Questionnaire-2 papers for experimental group A (who learned with the Open mode of CLLSS) had the following four more questions compare to those for experimental group B:

Q1: Which type (visual or verbal) of LOs you feel more comfortable with and prefer more to continually studied with?

Q2: Which type (visual or verbal) of LOs is more effective for you?

Q3: Did you Struggle to make choice and sometimes get confused?

Q4: Did you preference change during the learning activity?

The students in experimental group A were required to answer these questions after studying with Open Mode of CLLSS. Their answers of these additional items are shown in Fig.5.5.

According to Fig. 5.5, in experimental group A, 50% of students (including strong and moderate visual learner, totally 15 students) are stable visual learners and only 6.7% of them (1 moderate verbal learner and 1 strong verbal learner, totally 2 students) are stable verbal learners. The rest 43.7% of student in this group with mild preferences would be expected to change their preference readily. And the answers of Q1 in Fig. 5.7 shows that 83.3% (falling into the range between 50% and 93.7%) of student in experiment group A were more comfortable with visual LOs; this coincides with the data in Table 3.

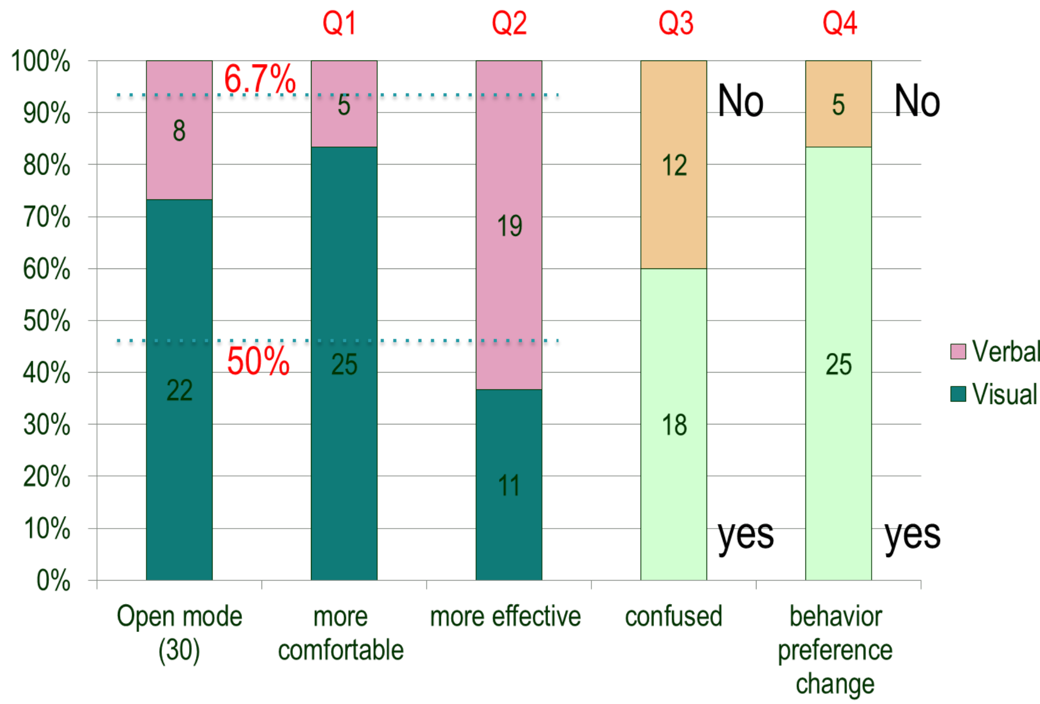


Fig. 5.7. The results of the additional questions in Questionnaire-2 of experimental group A.

However, according to answers of Q2 in Fig. 5.7, only 36.7% (11 students) of students in experiment group A thought that the visual LOs were more effective for their study; 46.7%(14 students) thought that their preferred type of LOs, was not the type of LOs stated more effective for their learning by the FSLSM. Moreover, these 14 students all reported that although they felt more comfortable with visual presentation medium, they still believed that verbal LOs is more effective for study, In other words, none of the students, who felt more comfortable with verbal LOs, reported that visual LOs is more effective for them.

After further interview with these 14 students, it is found that their inconsistent situation between Q1 and Q2 may be caused by the students' learning habits formed in their learning environments. Since nowadays in China a majority of LOs of most curriculums especially Japanese Language course are presented in verbal form, the students already use to verbal LOs no matter what learning style they belong to. (Among more than 200 students participated in experiments of our research, all of them are hardly received any learning materials of visual form from the regular classroom teaching.) Moreover the final exams of those curriculums are mostly in verbal form; this also encourage the students emphasize the skill at verbal tasks more than visual tasks. Consequently, students believe that verbal LOs are more effective under the circumstance that the evaluation of their learning achievement actually simply involves verbal task.

Therefore, it is worthwhile to note that not only the instruction strategies but also the assessment /evaluation measures will affect the learning habits of learners. The typical objective tests seldom require more than the ability to fill verbal questions(reading and writing), merely because clinical interviews, which require visual (listening and speaking) ability for identifying the relevant knowledge a learner possesses after instructions, are more time-consuming. This situation impedes the language learners to develop their visual ability especially the capacity of oral expression. (Though nowadays tests of language courses normally include listening questions, they hardly involve questions where oral expression is needed.) In a second-language speaking environment, when a learner need to tries to express something about a scene, he needs to transform the image of a situation into sentences for speaking. The ability of this kind of transformation is exactly visual ability.

Furthermore, Fig. 5.7 indicates 60% of students in experiment group A struggled to choose LOs between visual and verbal type and even got confused sometimes. It is also found that there were 25 students (83.3% of students in experimental group A) whose behavior preference change during the learning activity: 13 of them reported that they checked more teaching method if the grammar points is more difficult, 5 of them reported that they checked fix teaching method based on the type of grammar point, while 8 of them reported both situations happened to them. The Chi-Square test ($p=0.027$) revealed that there was strong effect of the confusion of choice on the behavior preference changes of learners.

As a trend ($p=0.100$ in the Chi-Square test), compare to the students who hold the same answer in Q1 and Q2 (11 out of 16 changed their behavior preference), the students who hold different answers in Q1 and Q2 (13 out of 14 changed their behavior preference), were found more easily to change their behavior preference during the learning activity.

5.4.4 The Analysis of Learning achievement

The analysis of covariance (MANCOVA) was used to test the learning achievement difference (in both visual and verbal aspects) among the experimental groups A, B and control group by using the pre-test scores as the concomitant variable and the post-test scores as dependent variable. The purpose of using pre-test scores as concomitant variable in MANCOVA is to use the information about pre-test to reduce the variation in post-test scores and thus increase the chance of detecting differences between the different treatments.

Before performing the MANCOVA, a series of tests, which includes the tests of Between-Subjects Effects, Shapiro-Wilk test, the checking on P-P plots of Standardized Residuals and the Liner Regression test, were conducted to confirm the sample data satisfy the MANCOVA assumption. (Those tests were conducted before every MANCOVA in this dissertation.) According to the results of these tests, sample data appear to conform to the assumption of MANCOVA.

Table 5.4 shows the descriptive data and MANCOVA results among two experimental groups and control group. The results of Box's M test ($p > .05$) suggests the homogeneity of variances. In terms of the scores of visual part in post-test, the adjusted mean value and standard error were 40.06 and 10.17 for the experimental group A, 40.76 and 8.23 for the experimental group B, and 29.24 and 9.04 for the control group; in terms of the scores of verbal part in post-test, the adjusted mean value and standard error are 40.26 and 8.97 for the experimental group A, 40.76 and 8.23 for the experimental group B, and 29.24 and 9.04 for the control group.

The MANCOVA result (Wilks' Lambda test, $p<0.05$) indicates that there were significant differences among these three groups in the learning achievement. The results of individual ANCOVA analyses further indicate that this significant difference was caused by the difference of the scores of visual part in post-test; this suggests that the learners who studied with Open Mode, Style-matched Mode or textbooks, did have significantly different level skills at visual tasks.

Table 5.4

The MANCOVA results of the post-test scores among experimental groups A, B and control group.

		Visual aspect		Verbal aspect	
		Mean	**S.D.**	**Mean**	**S.D.**
Experimental A (Open Mode)		40.07	10.17	40.27	8.97
Experimental B (Style-matched Mode)		40.77	8.23	42.10	7.24
Control		29.23	9.04	37.87	9.13
Levene's Test	Sig.	0.630		0.462	
Box's M Test	Sig.	0.250			
MANOVA (Wilks' Lambda)	Sig.	0.0001*(P<0.05)			
ANCOVA	Sig.	0.00002*(p<0.05)		0.231	

Table 5.5 further describes the difference of learning effectiveness among the experimental groups A, B and control group. The results of ANCOVA between control group and each experimental group revealed that, no matter the learner studied with Open Mode, Style-matched Mode or the given textbook, there were no significant differences in their skills at verbal tasks. However, their skills at verbal tasks towards target contents were different: those who studied with Style-matched Mode are best, those who studied with Open Mode are moderate, and those who studied with the given textbook are worse.

Table 5.5

Pairwise Comparisons between groups (ANCOVA)

	Visual aspect		Verbal aspect	
	Experimental A	**Experimental B**	**Experimental A**	**Experimental B**
Control	0.00007*	0.00002*	0.386	0.088

As shown in Table 5.2 (Dimension 3: Visual/ Verbal), only 6.7% of the participants in this experiment are stable verbal learners, which means majority of the participants are visual learners. The high percentage of visual learners may affect the result in Table 5.4. Therefore, MANCOVA was also used to test the learning achievement difference (in both visual and verbal aspects) among visual learners of experimental group A, B and control group.

Table 5.6 shows the descriptive data and MANCOVA results among visual learners of two experimental groups and control group. The results of Box's M test (p >.05) suggests the homogeneity of variances. In terms of the scores of visual part in post-test, the adjusted mean value and standard error were 40.17 and 10.34 for visual learners of the experimental group A, 40.95 and 8.39 for visual learners of the experimental group B, and 31.00 and 9.11 for visual learners of the control group; in terms of the scores of verbal part in post-test, the adjusted mean value and standard error are 40.08 and 9.17 for visual learners of the experimental group A, 42.62

and 7.28 for visual learners of the experimental group B, and 37.91 and 9.78 for visual learners of the control group.

The MANCOVA result (Wilks' Lambda test, p<0.05) indicates that there was significant difference among the visual learners of these three groups in the learning achievement. The results of individual ANCOVA analyses further indicate that this significant difference was caused by the difference of the scores of visual part in post-test; this suggests that the learners who studied with Open Mode, Style-matched Mode or textbooks, did have significantly different level skills at visual tasks.

Table 5.6

The MANCOVA results of the post-test scores among the visual learners of experimental groups A, B and control group.

		Visual aspect		Verbal aspect	
Visual learners in		**Mean**	**S.D.**	**Mean**	**S.D.**
Experimental A (Open Mode)		40.17	10.34	40.08	9.17
Experimental B (Style-matched Mode)		40.95	8.39	42.62	7.28
Control (Style-unmatched)		31.00	9.11	37.91	9.78
Levene's Test	Sig.	0.668		0.470	
Box's M Test	Sig.	0.347			
MANOVA (Wilks' Lambda)	Sig.	0.02*(p<0.05)			
One way ANOVA	Sig.	0.04*(p<0.05)		0.448	

Table 5.7 further describes the difference of learning effectiveness among the visual learners of the experimental groups A, B and control group. Actually, for visual learners in control group they received style-unmatched LOs since they only studied with textbook without only visual LOs. Therefore, according to Table 5.7, for visual learners, no matter they were provided both visual and verbal LOs and were encouraged to choose their preferred LOs, or they studied with only visual or only verbal LOs, there were no significant difference in the verbal aspects of their learning achievement. However, for visual learners, the visual aspects of the learning achievement were best when they only studied with visual LOs, moderate when they were provided both visual and verbal LOs and were encouraged to choose their preferred LOs freely, and worse when they studied with only verbal LOs.

Table 5.7

Pairwise Comparisons between the visual learners of groups (ANCOVA)

	Visual aspect		Verbal aspect	
	Experimental A	**Experimental B**	**Experimental A**	**Experimental B**
Control	0.013*	0.001*	0.688	0.217

It is stated that when learners actively select both visual and verbal modes their performances are better than those who only select one mode (Plass et al., 1998). From this point of view, if most of the learners in in experiment group A, who studied with Open Mode, actively selected all the types of LOs or at least style-fit LOs, their learning achievement should be better or at least the same as those in experiment group B who studied with Style-matched Mode. However, the results of the visual aspect in post-test shown in Table 5.5 and 5.7 both suggests that it is difficult to make the learners actively select all types of LOs, or at least style-fit. This situation is consistent with the result shown in Fig. 5.7, that 60% of students in experiment group A, got confused when they needed to select LOs from the LOs list panel.

5.5 Discussion and Conclusion

From perspective of learning style, the study of this chapter conducted an experiment for evaluating the different modes of CLLSS 2.0 (also designed by authors). Since this experiment focus on the Visual/Verbal dimension of learning style, visual and verbal teaching methods, considered the two classifications in teaching methodology, enrich this teaching method ontology, which is one of the main ontology engines for CLLSS.

Furthermore, two modes were provided by CLLSS in this experiment: Open mode, which provides the learners with both the visual and verbal types of LOs, and Learning Style Matching Mode, which only provides visual learners with the visual LOs to and verbal learners with the verbal LOs.

90 students attended in the experiment in this paper and were assigned to be the experimental group A, who studied with Open mode of CLLSS, the experimental group B, who studied with Learning Style Matching Mode of CLLSS, and the control group who studied with a given textbook.

About the answer of the three questions in Section 5.3.1, we would like to discuss in there:

(1) **About the learning performance (including learning achievements, perception, cognitive load, and so on) differences between the experimental groups A and B, and the control group, the summary is as follow:**

From the analysis of learning perception of experiment groups, the points listed below, suggested by the results, are worthy of consideration: (a) the students who learned with Open Mode are easier to lose their attention than the students who learned with Learning Style Matching Mode while both using CLLSS. (b) For the student using Open Mode, 83.3% of them are more comfortable with visual LOs, but only 36.7% of them thought that the visual LOs are more effective for their study; (c) 46.7% of students using Open Mode thought the type of LOs, which they preferred more and felt more comfortable with, was not the type of LOs which is more effective for learning, and all of them reported that although they felt more comfortable with visual presentation medium, they still believed that verbal LOs is more effective for study; this may be caused by their learning habits formed in their learning environments. (d) For the students using Open Mode, 60% of them suffered from how to make decision between visual and verbal LOs while 83.3% of them change behavior preference during the learning activity. (e) It is revealed that there was strong effect of the confusion of choice on the behavior preference changes of learners.

The learning achievement differences in both visual and verbal aspects among the experimental groups A, B and control group are also analyzed. It is revealed that, no matter the learner studied with Open Mode, Style-matched Mode or the given textbook, there were no significant differences in their skills at verbal tasks. However, those who studied with Style-matched Mode their skills at verbal tasks towards target contents were best, those who studied with Open Mode were moderate, and those who studied with the given textbook were worse. Furthermore, for visual learners, no matter they were provided both visual and verbal LOs and encouraged to choose their preferred LOs, or they studied with only visual or only verbal LOs, there were no significant difference in the verbal aspects of their learning achievement. However, for visual learners, the visual aspects of the learning achievement were best when they only studied with visual LOs, moderate when they were provided both visual and verbal LOs and were encouraged to choose their preferred LOs freely, and worse when they studied with only verbal LOs. These two results both suggest that it is difficult for learners to actively choose all the types of LOs or style-fit LOs.

In our further work, the learning attitude, motivation, technology acceptance measures aspects will also be discussed.

(2) The analysis of learning perception of experiment group A, who studied with Open Mode, suggest that, **besides learning styles, learning habits of learners also affect their behavior learning preference, which lead to their different choice of LOs.**

(3) **It is difficult for students to actively choose all the LOs or the LOs that mostly match their learning style while given LOs presented in a variety of types.**

The analysis of learning perception of experiment group A also suggests that in those students are more difficult to focus on studying and most of them are felt confused of the LOs choice. The learning achievement differences between students who studied with Open Mode, Style-fit Mode and given text book, also confirmed the fact that it is difficult for learners to actively choose all the types of LOs or style-fit LOs.

Chapter 6 General Conclusions and Future Research Directions

6.1 Summary of Contributions

In this research, “course-centered ontology” is designed as the domain model for learning support systems. This ontology design was applied to the construction of a course-centered ontology (COJG) for an existing Japanese grammar course. For the domain of this course, the classes of ontology are used to reflect the knowledge classification and the individuals of those classes are used to represent corresponding grammar points (in total about 205 grammar points). To support e-leaning systems to provide the comparison of KPs in response to knowledge structures of learners, COJG not only formalize all the grammar points of the course, but also describe all kinds of grammatical relations between those grammar points. Twenty-four types of relations, which include the concept dependences, similarities and contrasts, and even grammatical equivalence phenomena, are designed in COJG to describe 436 grammatical relations in the course. These 24 types of relations and all the individuals which represent corresponding grammar points in COJG constitute a relation network of all the grammars in this Japanese grammar course.

Based on COJG, a customizable language learning support system (CLLSS) has also been built to help instructors to organize the teaching materials and provide personalized learning objects in response to the knowledge structure of the learner. The relations of COJG, which is designed according to pedagogical criteria, enable the system to provide the learner a visual comparison of related knowledge points.

A series of experiments , including a preliminary evaluation and two studies, has been conducted to: (1) evaluate the knowledge comparison function provide by the system;(2) examine if the learning performance (including learning achievements, effectiveness, perception, cognitive load and so on) differences of experiment groups are caused by learning styles or learning habit differences; (3) from learning style perspective, examine the learning performance differences between difference kind of strategies for suggesting learning objects.

More than 200 undergraduate students, who major in the Japanese language, participated in these experiments. The learning performance (including learning achievements, perception, cognitive load, and so on) of participants in those experiments were analyzed and discussed to evaluate CLLSS in a variety of perspectives.

6.2 Future Research Directions

There are some directions can be performed in future on the topic of this research:

1. Long-term effects of the learning support system will be studied by conducting more experiments. In all the experiments of our current research, students were required to use my system to learn some chosen grammar points in the grammar course. We only collected and analyzed short-term learning performance of learners. The next stage, we will use the system to track the situation of students in the learning processes of the whole course.

2. The learning support effect of CLLSS in group studying or discussion can be studied in future also. Although in our experiments we allow the learner to discuss with each other when they needed during the learning activity, most of the time learners studied with CLLSS independently. Investigation about the group studying or discussion with the support of CLLSS should be conducted to further evaluate CLLSS.

3. Future adaptation of CLLSS should also extend its supporting work from displaying expert-generated maps to encourage learners' self-generated or group-generated maps. The efficacy of the latter two should be studied and compared with the former.

4. How to automatically build a course-centered ontology is still an open issue. In this research, COJG was built manually based on a document made by expert teachers of Japanese Grammar. Although Section 2.3 presents an effective way to design and develop a course-centered ontology, the cost of the creation process is still high. A method for automatic generation of course-centered ontology should be studied.

5. The effectiveness of the ontology-based learning support system in other language's learning, such as English or Chinese, can be studied. All the experiments in our research are based on the course-centered ontology of a specific Japanese grammar course for Chinese learner. But actually the prototype system that we developed can be used to any language courses after uploading the ontology of the chosen course. By cooperating with other language teachers to create course-centered ontologies of other language courses and conducting more studies on CLLSS, the comparison of course-centered ontologies of different language courses can be made and the system can also be studied from different perspectives.

6. Except ontologies of language education, course-centered ontologies for engineering education, which normally involve task-based learning and problem-solving process and much more complicated to be presented in machine-understandable format, can be studied in future. By studying and analyzing the characteristic of engineering education, a suitable framework for its learning support systems would be presented.

7. Finally, other applications of the course-centered ontology will be presented and discussed. The course-centered ontology can be used not only in leaning support systems, but also in other areas. For example, for the writers of textbooks, an application can be developed based on the logic of course-centered ontology to help the writers to organize the topics and chapters of the textbooks in a more logical order for learner's understanding.

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Appendix & Publications

A.1 Articles in Refereed Journals

[1] Wang J.Y., & Mendori T. and Xiong J., "A Customizable Language Learning Support System using ontology-driven engine", International Journal of Distance Education Technologies, vol.11, no.4, 2013, in press.

[2] Wang J.Y., & Mendori T. and Xiong J., "A Language Learning Support System using Course-centered Ontology and its evaluation", Computer & Education, conditional accepted.

A.2 Articles in Full Paper Refereed International Conference Proceedings

[1]Wang J.Y., & Mendori T. (2012, Sep.). "A Course-centered Ontology of Japanese Grammar for a Language Learning Support System", Frontiers in artificial intelligence and applications (KES 2012), pp.654-663.

[2] Wang J.Y., & Mendori T. (2012, Sep.). "A Customizable Language Learning Support System Using Course-centered Ontology and Teaching Method Ontology", Advanced Applied Informatics (IIAI AAI) 2012, Published by IEEE CPS, pp. 149 – 152.

[3] Wang J.Y., & Mendori T. (2013, Dec). "An Evaluation of a Customizable Ontology-driven Language Learning Support System", Proceedings of the 21st International Conference on Computers in Education.

A.3 Articles in Refereed International Conference Proceedings

[1] Wang J.Y., & Mendori T. (2011, Nov). "A Japanese grammar learning support system using teaching method ontology and course-centered ontology", Proceedings of the 19th International Conference on Computers in Education.

[2] Wang J.Y., & Mendori T. (2013, May). "An Ontology-based second language learning support system", Computer Assisted Language Instruction Consortium, USA.