

# CACHE-CACHE COMPARISON FOR SUPPORTING MEANINGFUL LEARNING

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## ABSTRACT

The paper presents a meaningful discovery learning environment called “cache-cache comparison” for a personalized learning support system. The processing of seeking hidden relations or concepts in “cache-cache comparison” is intended to encourage learners to actively locate new knowledge in their knowledge framework and check the logical consistency of their ideas for clearing up misunderstandings. This active engagement is also expected to prevent a) the emergence of cognitive overload and b) the decreasing of the curiosity and willingness to explore as in the meaning reception learning environment.

## KEYWORDS

Meaningful learning, knowledge structure, reception learning, guided discovery learning, cache-cache comparison,

## 1. INTRODUCTION

Evidence from diverse sources of researches suggests that knowledge gets incorporated into human brain more effectively when it is organized in hierarchical frameworks. Learning approaches that facilitate this kind of organization significantly increase the learning capability of learners (Bransford et al., 1999; Tsien, 2007). Ausubel's learning psychology theories (Ausubel, 1963; 1968; Ausubel et al., 1978) define this effective assimilation of new knowledge into existing knowledge framework as the achievement of “meaningful learning”. Therefore, how to help learners to efficiently develop their conceptual framework becomes the main issue for fostering meaning learning in e-learning systems.

However, most of e-learning systems organize the knowledge of a curriculum in a tree structure, based on the textbook chapters or based on the arrangement of classes. This kind of tree structure obscures the relations between knowledge points (KPs, a KP is defined as “a minimum unit which can independently describe the information of one knowledge and be understood by its own expression or be acquired by practices” in this research). Especially for those KPs which belong to different branches, it is difficult to emphasize their relations (such as similarities and contrasts) in teaching process. Furthermore, it is also difficult to identify the relevant knowledge a learner possesses before and after a learning activity. To resolve these difficulties, an ontology-based customizable learning support system (CLLSS) which uses a hierarchical map structure to manage the KPs of a curriculum has developed to foster meaningful learning (Wang et al., 2014).

Although in the latest version CLLSS 2.0 already provides visualization supports for the emphasis of the relations between KPs and enables learners to easily locate needed learning material addressing relations. However, CLLSS 2.0 simply provides a meaningful reception learning environment which directly displays the relation map created by experts. It could easily lead to passive learning and lower the learner's willing to explore new knowledge. Therefore, to encourage active engagement, we present a timely guided discovering learning environment called “cache-cache comparison”. “Cache-cache comparison” encourages the learner to detect hidden relations between relevant KPs or hidden acquired KPs from given relevant KPs and relations through reflecting the attributes of acquired knowledge. If learners keep making mistakes during the task system will provide hints to help them rethink and get closer to the correct answer. The processing of seeking hidden relations or concepts is intended to encourage learners to locate new knowledge in their knowledge structure and restructure existing knowledge; meanwhile the iterative procedure of confirmation and modification in their own relation map ensure that they check the logical consistency of their ideas and clear up misunderstandings.

## 2. THE PREVIOUS RELATED WORK

To facilitate meaningful learning, learning materials should be well constructed with concepts presented with examples related to learner's prior knowledge. On the other hand, the learner must possess a good attitude and motivation for the construction of knowledge framework by comparing new knowledge with acquired knowledge. The meaningful learning will be impeded by low attitude and motivation even if the knowledge in learning materials is well-organized. Although not only instructional strategies but also evaluation strategies which emphasize and encourage learners to relate relevant knowledge can foster motivation improvement, this paper focuses on the instruction environment in the e-learning system from a system design perspective.

In previous work, from the perspective of learners' knowledge structure, we developed a meaningful reception learning environment (Wang et al., 2013) by organizing KPs in a map structure and clarifying all the relations between KPs. In this meaningful reception learning environment (as shown in Fig.1), whenever learners are studying a new KP, they will be presented with the relations between the new KP and relevant KPs especially the acquired ones to assist them to reach a correct understanding.

It is found that the experimental students who learned with this environment achieved significantly better learning achievement than those who just did self-study with textbooks after studying the same target Japanese grammar contents (Wang et al., 2014). This suggested that the new KP can easily be understood and remembered through this visualization support. However, students reported that they felt pressure and were disturbed when more than 4 related KPs are shown at one time. In other words, from a cognitive load point of view, the e-learning environment needs to avoid directly giving a big number of information at one time.

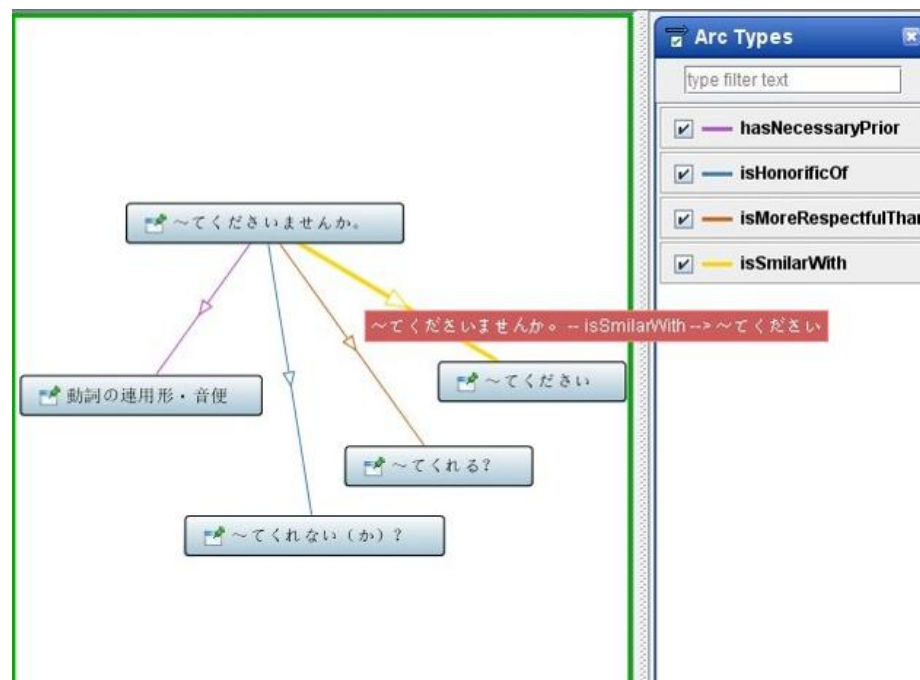


Figure 1. The relation map in CLLSS 2.0

From learning attitude and motivation perspectives, the learner data before and after studying target grammar contents with the support of CLLSS 2.0, were also analyzed (Wang and Mentori, 2015). By considering learning attitude and motivation before the learning activity as individual difference variables, we found that learners with high level of attitude/motivation perceived a greater effect on developing the habit of "learning from the comparison of related knowledge" and felt more satisfied with the learning mode in CLLSS environment. Moreover, compared to learner with low level of attitude towards Japanese grammar before the activity, learners with high level of attitude perceived significantly lower mental effort while studying with CLLSS and achieved better achievement on the grammar test after. These results confirm that the learning attitude and motivation is an essential condition for meaningful learning.

The analysis of learner data also suggest that not only learners' attitude towards Japanese grammar learning, but also their motivation toward Japanese language learning improved after studying with the system. However, in the interview after the experiment, 19 out of 60 participants expressed that, since the system already provides lots of related knowledge they don't have the urge to actively search more by themselves. Furthermore, for the items about the curiosity and willingness to explore more related knowledge on the attitude/motivation questionnaire, 8 students even were found with post\_rankings slightly lower than pre\_rankings. The occurrence of this phenomenon is mainly because the version 2.0 of CLLSS simple directly displays all the information of related concepts and relations. The participants made the comparison between concepts in a passive reception way. This kind of passive learning lowers learners' willingness to explore. This reminder us that CLLSS needed to be modified to encourage learners to actively engage in the construction of relation map.

Therefore, for solving the potential problems in both cognitive load and attitude/motivation, “cache-cache comparison” environment is presented for CLLSS 3.0. This environment, which hides some relations or acquired KPs and guide the learners to actively recall their prior knowledge to design their own relation map before comparison with the relations map of experts, is intended to lower the cognitive load and encourage learners' active engagement.

### 3. CACHE-CACHE COMPARISON

#### 3.1 Why “Cache-cache”?

The word of “cache”, which originally comes from French, means “to hide” or “a hidden place” (Chiaki Itoh and Seiji Fujino, 2014). “Cache memory” as a high speed storage device made the word “cache” well known. In French, some words are formed by combining the same word twice, such as “bonbon” or “cache-cache”. The meaning of the compound word is different from the original simple word. The origin of this kind of words could be that, it seems quite impressive for little children that a short word is pronounced twice and this impression make the word easier to be remembered. The French word “Cache-cache” means “hide and seek” in English. It is one of the popular children games in which one or more player as seekers tries / try to find several hidden players. Although there are slightly different versions of this game, with a simple rule most of children can immediately participate in it and enjoy the game. Ishare Company from Tokyo has conducted an Internet-based survey to investigate the response to “What is the game that make you feel really enjoyed in your childhood?” 458 Japanese (male 54.6%, female 45.4 %,) with the age from 20 to 40 participated in this survey. The top ranking answer was “cache-cache” with 19.7% of supporters.

Therefore, taking advantage of this familiarity, we propose to apply the word of “cache-cache” to represent a process of “hiding and seeking” similar to the kids' game. As an adult, we sometimes consciously or unconsciously do “hiding” and “seeking” not only in daily life but also in research activities. For instance, in parallelism of numerical algorithms, programs were designed to firstly hide some parts that cannot be parallelize and then, after achieving the objective of parallelism, those parts will be found out again to complete the rest of computation. Accordingly, a “cache-cache balance” technique has been presented (Chiaki Itoh et al, 2014; Seiji Fujino et al, 2014).

From learning support perspective, directly presenting too many information related to a new knowledge will create a high level of cognitive load. As mentioned in Section 3, this phenomenon was also revealed in one of our previous work (Wang J.Y. et al, 2014). Therefore, we suggest to hide some parts of the information at the first stage of learning, and then encourage learners to actively detect them in the second stage. This process involving discovering learning is defined as “cache-cache comparison” in this research.

#### 3.2 Discovering Learning

“Discovery learning is an inquiry-based, constructivist learning theory that takes place in problem solving situations where the learner draws on his or her own past experience and existing knowledge to discover facts and relations and new truths to be learned” (Bruner). Bruner (1961) stated that students are more likely to remember knowledge discovered on their own in contrast to those taught directly in reception instruction. A

learner experiences her/his individual discovery process by applying existing knowledge to solving problems. This process which encourages active engagement, can foster the development of creativity and problem solving skills, and promote learning motivation. However, many researchers (Mayer, 2004; Alfieri et al., 2011) also cautioned that unassisted discovering learning lacking of necessary prior knowledge and guidance may easily lead to misconception and cause extra cognitive overload. Timely guidance is needed in discover learning for learners to avoid confusing or frustrating (Kirschner et al., 2006). Learners need to gain confidence that they have the ability to complete the task by providing indispensable knowledge; on the other hand, when confronted with failures they also need to be motivated to learn from mistakes to get closer to the truths.

### 3.3 Meaningful Discovery Learning Supported by “Cache-Cache Comparison”

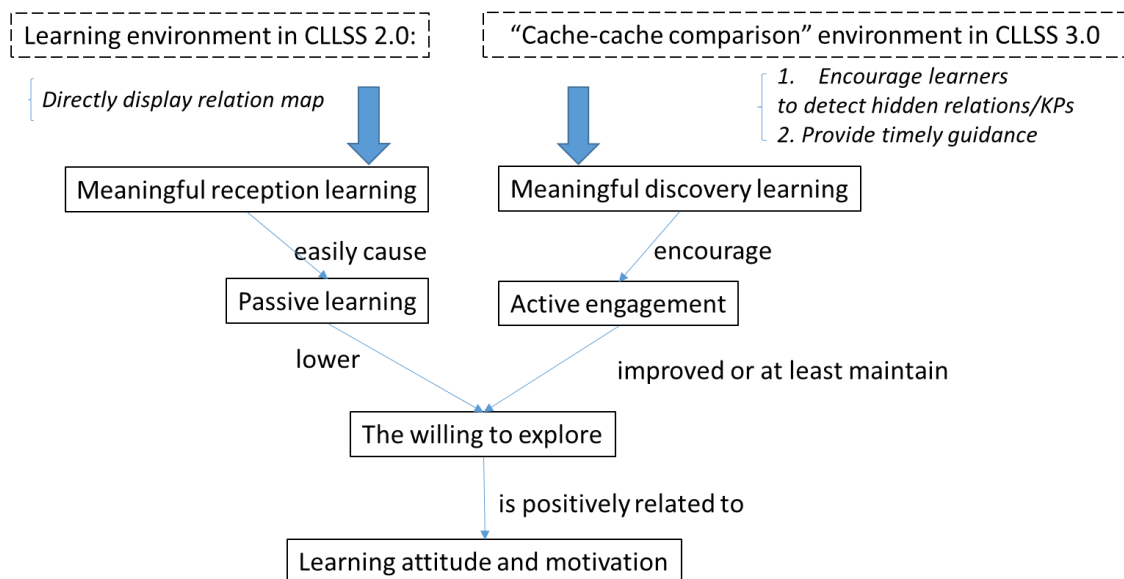


Figure 2. Differences between two versions of meaningful learning environment

To encourage active engagement in meaningful learning, we present “cache-cache comparison” approach by integrating with discovery learning. Considering KPs and relations as the building blocks for relation map of a course, the system hides several blocks in the relation map of experts and guide learners to seek and discover those blocks. Learners are engaged in an active learning process when they struggling to complete the relation map. This active engagement is expected to improve or at least maintain learners’ willing to explore and accordingly improve their learning attitude and motivation. Fig. 2 illustrates the comparison between “cache-cache comparison” environment in CLLSS 3.0 and the meaningful reception learning environment in CLLSS 2.0 from learning attitude and motivation point of view.

To lower the confusion and cognitive pressure, from the uncompleted map learners are enable to easily access the explanations and practices addressing each displayed KP or relation. Learners have to ruminate on their features to determine what the missing KPs or linking relations are. Timely guidance will be provided for learners to elicit positive responses toward finding correct answers. While interacting with “cache-cache comparison” environment, learners need to draw on his existing knowledge and compare with the new knowledge in order to find the missing blocks. This process fosters learners to locate new knowledge in their knowledge framework with relations discovered by themselves and avoids the occurrence of misconceptions. The visualization interface of “cache-cache comparison” which can support the learners to actively build up their knowledge framework are still under development now.

## 4. CONCLUSION AND FURTHER WORK

This paper presents a “cache-cache comparison” environment in a learning support system which encourage learners to detect hidden relations between relevant KPs or hidden acquired KPs from displayed relevant KPs and relations whenever they study a new KP. This learning environment integrates the advantages of meaning learning and discovery learning by providing visualization support and timely guidance to prevent misconceptions and lower cognitive load. “Cache-cache comparison”, intended to support the effective construction of learners’ knowledge framework, is also expected to prevent the decreasing of the curiosity and willingness to explore related knowledge by encouraging active engagement.

After the development of “cache-cache comparison” environment, further evaluation will be conducted to compare the learning performance differences between learners who studied with “cache-cache comparison” and those who studied with the meaning reception learning environment in CLLSS 2.0, especially in the attitude and motivation aspects.

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