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An e-Learning Content Delivery System "LECMIS" employing Collective Intelligence

Yuya DOBASHI Wataru TSUKAHARA Tatsuya TERADA Norihide SHINAGAWA Masaki NAKAGAWA
Department of Computer and Information Sciences , Tokyo University of Agriculture and Technology

Abstract: We developed an e-Learning content delivery system "LECMIS". LECMIS employs collective intelligence approach for supporting motivation of learners. In LECMIS, learners can add hints for problems they had solved. Hints are evaluated by those who read them. Contents are refined by the cycle of reading/writing/evaluating hints which is essential for collective intelligence. By this approach, we aim to motivate learners to continue learning by giving them a feeling that other learners are also learning and actively participating in improving the contents. Once they have solved problems, they are proud and willing to add hints for others. We evaluated LECMIS by two kinds of evaluation experiment. First evaluation showed that the hint reading/writing/evaluating cycle actually appeared. Second evaluation experiment showed that LECMIS improved learning time which corresponds to motivation of learners.

Introduction

E-Learning is becoming widely applied to various learning tasks in various situations. For example, commercial companies which intend to improve efficiency of their competency education system use e-Learning in their intranet. Organizations for middle and higher education also conduct e-Learning for the purpose of efficient knowledge transfer and support for motivating learners to learn each specific topic (EC 2000). In general, e-Learning contents for such purposes are carefully elaborated and designed by content designers to interest and motivate learners. One of these elaborations is for example the use of animations in e-Learning contents.

Even though these elaborations are successful, we think there are three problems in e-Learning content design. One problem we think as a drawback is that in these e-Learning contents transition from content to content is usually monotonous. In many cases the transition is simple: a learner might be given a next problem if they had solved a problem, or they could be given commentary or explanation on the problem before moving into the next problem. This monotony may be one of the reasons why learners quit their e-Learning in mid-course.

The second problem we see in e-Learning contents is that learners might feel isolated because knowledge transfer is unidirectional in the course of learning. In traditional learning environment such as in school and in university, learners can teach and learn each other and thus there is less chance of feeling isolated. However in e-Learning, knowledge is implemented in content materials itself and its transfer is unidirectional from teacher (system) to learner. This decreases interactions with other learners and thus makes it difficult to feel relationships with other learners, and this feeling of isolation eventually reduces motivation (Ueno 2008).

The third problem is the cost for preparing good contents and the stationary nature of contents. It is very costly to prepare good contents which interest learners and answer well to doubts that learners feel. Since the cost is high, e-learning contents tends to become static, which makes repeated learning tedious.

We propose to apply collective intelligence to tackle these problems. There are various web sites using collective intelligence and some of them are becoming more popular. Yahoo! Answers is one such example (Fig. 1). In the site, a user's problem is solved by other uses' knowledge. These services provide users with a sense of being connected to each other because problems are often solved by direct interaction among users. We focus on this feature of collective intelligence, by which learners will not feel isolated and therefore be able to maintain their learning motivation.

Based on the above observation, in this paper we analyze effect of making learners feel other learners' activity and contribution to their community. Our focus is on its effect to maintenance of learner's motivation. Also, we propose a learning support environment for this purpose. We choose drill book type e-Learning contents as a baseline content

delivery style because their learning process is simple and tend to be monotonous. Our approach is that we add a new content delivery environment "LECMIS" which uses collective intelligence to this simple content delivery structure, and observe effectiveness. LECMIS constructs collective intelligence by collecting knowledge from successful learners and reflecting other learners' evaluation.

This paper consists of the following sections. In the next section collective intelligence is introduced. In third section the main function of the proposed system LECMIS and the way how it works to construct collective intelligence is explained. In the forth section evaluation experiments and their results are described, followed by discussion section. In the last section summary and future tasks are described.

Collective Intelligence

Collective intelligence becomes popular as Web 2.0 has been becoming widely known. Recently it is used in various real situations. It is defined as "collecting information from individuals, then modifying or adding, and eventually creating new values" or "well examined notion through discussions by people of different opinion" (Heylighen 1999). Following this definition, two modules become necessary for implementing collective intelligence; one for collecting information from individuals and the other for modify them. Using the Web, the former part can be efficiently accomplished, and the latter part also can be easier. Therefore recent popularization of the Web contributes to generate collective intelligence easier and more efficiently (Olivier 2004, Pentland 2006).

The process of constructing collective intelligence consists of following four parts; disclosure, chain, filtering, and evaluation. Collective intelligence is efficiently increasing by following these four steps. They are more specifically described as follows:
i. Disclosure: Basically, make all information public. Avoid personalization of knowledge.
ii. Chain: Increase connection between information or knowledge by citations and links. This can be done by any participants who reach to public information described in **i**.
iii. Filtering: Measure importance of original information and information created by chain process. Filter them.
iv. Evaluation: Estimate priority of each filtered information according to necessity and usage. Group them and present them to participants. Participants evaluate the information.

Function of LECMIS and Method of Creating Collective Intelligence

We developed a learning content delivery system LECMIS which uses collective intelligence. The main aim of LECMIS is to support maintenance of learning motivation while taking an e-Learning course. Our approach is based on the hypothesis that in addition to usual e-learning content elaboration, it is important to make learners feel that other learners are actively learning. Thus we decided to use creation process of collective intelligence by learners. In the design of the LECMIS system, functions corresponding to item i.-iv. in the previous section are carefully introduced. By implementation of these functions, we expect LECMIS provides environment where learners can realize that they are not alone and they actually contribute to the community, and therefore continue to participate in



Figure 1: An example of Web Service Using Collective Intelligence

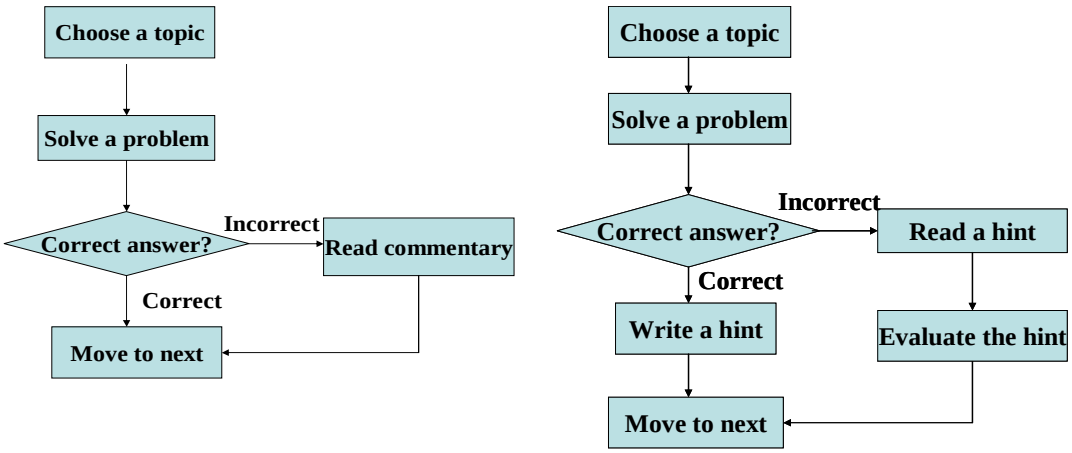


Figure 2: Learning Flow in Usual e-Learning (left) and in LECMIS (right)

learning. This is the basic idea of the maintenance of learning motivation in LECMIS.

Figure 2. shows flow of the usual learning in drill type e-Learning contents, and the flow in LECMIS. In the usual flow shown in the left, learners choose a topic and solve the problem. If the answer is correct, next question is presented. If the answer is incorrect, usually commentary or explanation in textbook is displayed and a next question is presented. While LECMIS follows the same process before solving a problem, there are additional stages in LECMIS: hint creation, hint reading, and hint evaluation. Hints are written by learners who answered correctly. It is known that explication of ideas they believe once understood leads to better understanding of that idea. We expect they can reflect the problem more deeply by writing hints. Such a learning effect is also an aim of LECMIS.

To motivate a learner who answered correctly to add hints, the count that each hint is reviewed is displayed with the evaluation score. Good evaluation gives hint creators higher satisfaction and confidence, which leads to raise motivation for creating better hints. On the other hand, a leaner with incorrect answer can read hints which are created by the people who knows pitfalls and popular misunderstanding among their age. Furthermore, through this mutual assistance we expect that learners feel other learners' existence without isolated.

Actual learning flow is as follows: firstly, a problem is presented (Fig. 3). If the learner's answer is correct, an

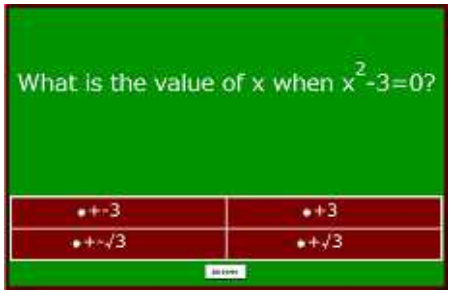


Figure3: A Screenshot of Problem Presentation

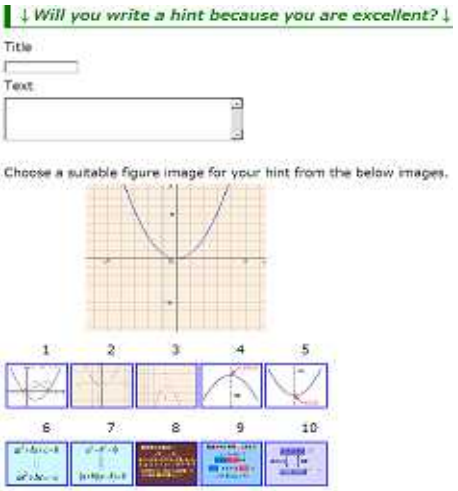


Figure 4: Hint Creation Page

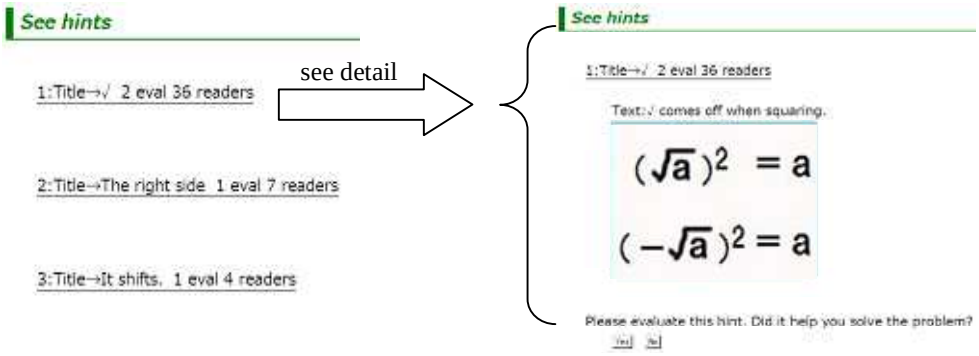


Figure 5: Display of Hint List (left) and Detail of a Hint after Hint Selection (right)

invitation page for hint creation is displayed (Fig. 4). The learner writes a hint title, hint text, and an optional hint description image. Optional hint images are prepared beforehand by teachers so that hint creators can just choose to create hints. On the other hand, if the answer is incorrect, hints are displayed. In this phase only the hint title, evaluation score, and review count can be displayed (Fig 5). Evaluation score and review count tell the value of each hint and help learners choose appropriate hints for them. In addition, this display also support motivation of hint creators as previously described. A hint list is displayed sorted in descending order of the sum of evaluation scores by the past learners. The newest hint is put on the bottom of the hint list. When a learner read a hint, he/she evaluates the hint into a binary score (i.e. useful / not useful. ; Fig. 5). There is an option to pass the evaluation of the hint. In this case only the review count will be incremented.

This cycle of problem presentation, hint creation, evaluation, and change of display order by the evaluation score realizes a cycle of making disclosure, chain, filtering, and evaluation.

The LECMIS system is implemented by PHP, JavaScript, and MySQL. We confirmed it is correctly working in browsing environments such as Internet Explorer, Mozilla Firefox, and Opera.

Evaluation Experiment

We conducted evaluation experiment in two steps. In the first step we checked if the cycle of constructing collective intelligence is realized. In the second step we examined if learning motivation is maitained.

Experiment I. Construction of Collective Intelligence

The purpose of this experiment is to confirm realization of construction cycle of collective intelligence. In this phase we hypothesized the existence of learners who is motivated to write hints. Subjects are five university students. They are told to use LECMIS and study 8 to 24 problems. The topics of the problems are math for junior high school third grade (15 years old). They were explained the usage of hint creation, hint reading, and hint evaluation. Four of subjects have no experience of e-Learning. Subjects are told to behave as learners with motivation to create hints. Average learning time was 34 minutes (Min. 17min. Max. 69min.). As a result, 28 hints are created and hints are read 18 times. Evaluation was done 6 times and change of hint display order occurred 3 times. These figures support the construction cycle of collective intelligence. From this result, we can observe there is a possibility that if there are a certain number of learners who have motivation to write hints, the cycle of collective intelligence construction occur. In addition, subjects evaluated the usefulness of hint display in 4 scales (Table 1). Usefulness evaluation increases according to the increase of hints. This shows satisfaction for e-Learning content can possibly be improved by this method if there are sufficient learners who write hints. In table 1, fourth subject did not evaluate hint display because he never failed in the course of learning, thus there was no chance of reading hints. Total increase of hints in this experiment was 2.8 hints per problem.

Subject	1st	2nd	3rd	4th	5th
Total # of Hints	2	10	16	19	27
Usefullness Evaluation(Max:4)	0	2	3	N/A	4

Table 1. Number of Hint and Subjects' Usefullness Evaluation after the Experiment I

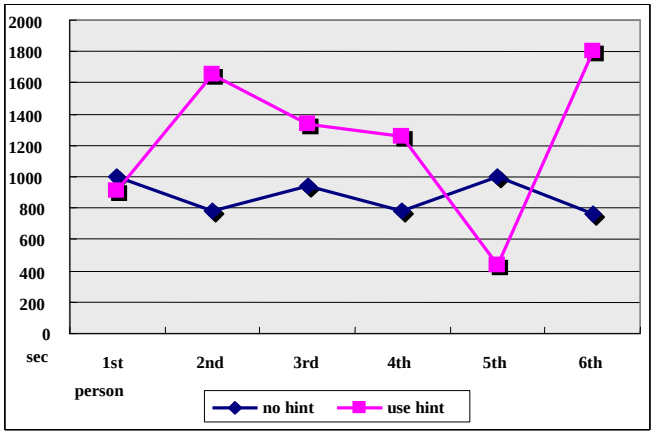


Figure 6: Difference at learning time with and without hint functions

We have to note that in this experiment most of negative comments were given to graphical user interface of hint creation page. For the improvement to this part, we abolished length limitation of hint title, widened text area of hint writing, and simplified choice process of image figures. We conducted the same experiment for the previously participated subjects and obtained satisfaction point increased to 0.8, whose original score was 0.2 (full scale is 1.0).

In this experiment learners can only add hints and are not allowed to create problems and solutions. However it is possible to enhance learners' activity to these parts. The reason why currently we restrict learners to hints creation is that creating problems and solutions require higher level of understanding compared to adding hints to existing problems. This enhancement would be the future task of the LECMIS system.

Experiment II. Learner Motivation

In experiment I, learners are asked to write hints. However it is not clear whether there are always a certain number of learners who wish to write hints. Thus we decided to conduct the second experiment without this condition. In this experiment we observed whether learning motivation can be elongated by the existence of hints created by other learners. Six subjects who did not participate in the previous experiment used LECMIS and learning time was measured. Subjects used both the system with and without the hint writing/reading/evaluating function. Order of system type was shuffled to avoid order effect. Each subject was told the following instruction:
(i) Subjects can finish learning whenever they want to quit. Maximum learning time is 30 minutes.
(ii) Subjects can write hints, but it is optional. This direction is for the system with hint writing function.
Subjects were asked in which experiment learning motivation was better sustained.

13 problems were solved when learner used hint function, which were 15 without hint function. There was no significant difference. However the averaged learning time was 6 min. 40 seconds longer in LECMIS (Fig. 6). This is because they read / wrote/ evaluated hints. On the other hand, all the subjects evaluated that LECMIS was effective for motivation maintenance. This implies that by using the LECMIS learners would spend more time for learning with higher learning motivation compared to usual e-Learning contents.
In this experiment, hint creation was not asked. However, 6 learners voluntarily created 33 hints in total.

Discussion

In this experiment university students solved junior high school math problems. To make situation more realistic, matching the knowledge level between learners and problems are necessary. It might be difficult for junior high school students to create hints. However it is pointed out that students in collaborative learning situation actively teach each other, so we have to examine if this also happens with LECMIS in real use in junior high school.

This time we chose math for the target learning topic. This is because in most cases math problems in junior high school have unique correct answers and therefore possible to judge correctness easily. However, at the same time math problems sometimes have multiple solutions for one correct answer. This is a beneficial point for writing elaborated hints. In addition use of figures and tables also help understand the problem. If system provides these figures and tables as available gadgets for hints, creative hint makers will use them.

LECMIS basically depends upon motivated hint creators. We speculate most learners create hints because they want to tell their ideas for the problem. Then, motivating learners to feel like telling their ideas will be the key issue. To motivate learners so that they try to create better hints, the LECMIS system introduced voting evaluation as a praise or appreciation from hint readers.

We asked the way of increasing hint in free form questionnaire after experiment. Many of the answers were such as “give points to whom write hints.” Currently, we have no reward system but we are planning to introduce it in some form. The reward system must be designed in a form where motivation of a hint creator is strengthen and abuse of points is avoided. Furthermore, if we link points to grading system, it might inspire weakly motivated learners.

Summary and Future Plan

In this paper we proposed an e-Learning content delivery environment LECMIS which uses collective intelligence. First evaluation experiment confirms the cycle of constructing collective intelligence appeared with sufficient hint creators. Second evaluation experiment implies that there are learners who create hints voluntary. Also the result shows possibility that learner motivation measured by the learning time is enhanced, which is the main purpose of the LECMIS system.

Currently we plan to examine more precisely about the method for motivating hint creation. We also plan to check effectiveness of the system in real use and we hope to find suitable generation and suitable topic for the approach employed in LECMIS.

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