DEVELOPMENT OF AN ONLINE ENGLISH LEARNING ENVIRONMENT USING A USER-BASED COLLABORATIVE FILTERING SYSTEM

Masanori Yamada*
*Kanazawa University **
*Kakuma-machi, Kanazawa, Ishikawa, 920-1192, Japan **

Satoshi Kitamura **
*Tokyo Keizai University ***
*1-7-34, Mnami-cho, Kokubunji, Tokyo, 185-0021, Japan***

Tadashi Misono***
*Shimane University ****
*1060, Nishi-kawadu-machi, Matsue, Shimane, 690-8504, Japan****

Noriko Kitani****
*Benesse Corporation *****
*12F, Shinjuku-Mitsui building, 1-1, Nishi-Shinjuku, Shinjuku-ku, Tokyo, 163-0411, Japan*****

Yuhei Yamauchi *****
*The University of Tokyo ******
*7-3-1, Hongo, Bunkyo-ku, Tokyo, 113-0033, Japan***

ABSTRACT

In this study, an online English learning environment with a user-based collaborative filtering system is developed, which enables learners to learn English while expanding their interests. In particular, the online learning environment recommends English news articles based on information of "other users who have interests similar to a learner," and the learner learns English from these recommended articles. This system provides an environment in which students can read a wide range of topics in English and also yields good study results.

KEYWORDS

Recommendation system, Interests, Learning support, Language study.

1. INTRODUCTION

Concomitantly with the advancement of information communication technology, interest in using online learning environments for language learning has grown. Online learning environment can support learning out of class. In foreign language learning, it can increase the opportunities to use foreign language resources, however, Sakai (2008) pointed out that online learning environment does not work for the increase the time to use foreign language resources. It should be required to build online learning environment for foreign language learning with learner's high motivation. Input, which is information in foreign language, plays an important role in foreign language learning (Oxford, 1990) and should be increased. Foreign language skills consist of four skills (reading, listening, writing and speaking). Building a strong vocabulary is crucial for fostering foreign language skills

Yamada, et al. (2009) developed an online English learning environment with a collaborative filtering system that recommends learning material based on a learner's interests for learning English outside of

school and university time allotted to studying English. This learning environment allows learners to read news articles that match their own interests in English. This, in turn, motivates them to learn English. Motivation is a central factor in successive learning. Especially, potential problems related to motivation arise in online learning environments. One is connected with the learning materials themselves. In language learning, input information such as learning material has a strong effect on learning performance (Krashen, 1985) and motivation (Dörnei, 2001). Input means written or spoken information in the target language that the learner can comprehend (e.g. Krashen, 1985, Gass, et al, 1998). It is useful to refer to aptitude treatment interaction (ATI) for learning contents and system development. Actually, ATI signifies the interaction effect of learner's features and learning contents on learning performance, i.e., the effect of learning materials depends on the learner's independent features such as the learner's level, learner's interest, and hobbies (Cronbach, 1957, 1967). Learning support considering ATI is apparently effective on learning performance and on the enhancement of learners' motivation. It is difficult for an online learning environment to provide appropriate learning materials to each learner because teachers must prepare learning materials conforming to each learner's prior knowledge and preferences. Collaborative filtering seems to be one of considerable solution for the problems mentioned above.

The basic idea behind recommender systems with collaborative filtering is to provide results based on the prediction of a user's interests (Kamijima 2007). High prediction accuracy is desirable in this system. However, such a system of learning may cause bias in the learning content because learners will read news articles in English based only on their interests.

A learning environment that continuously recommends material that match a user's interests is essential in maintaining the user's motivation to learn. However, to use English in everyday situations, it is important to study the language without excessively concentrating on a specific field. In other words, building a learning environment that goes beyond the range of the learner's interests is desirable.

2. SYSTEM

The online learning environment system developed in this study includes four functions: news article recommendation, vocabulary definition, marker function, and comments function. Although this system uses the same vocabulary definition, marker function, and comments function as that used in online learning environments developed by Yamada, et al. (2009), a significant change was made to the algorithm for the news article recommendation function.

The system's structure is shown in Figure 1, its main screen in Figure 2, and the article details screen in Figure 3.

2.1. News article recommendation function

The news article recommendation function displays a list of articles on the main screen based on the learner's interests. A user-based collaborative filtering system is used for the recommendation algorithm. Yamada, et al. (2009) used the algorithm proposed Resnick, et al. (1994), which is a basic user-based collaborative filtering algorithm used for motivating learners by providing appropriate learning materials, considering ATI. Collaborative filtering is an algorithm for the recommendation of information. The system with added collaborative filtering predicts a user's preference based on analyses of a similar user's preference. A collaborative filtering algorithm first finds similar users. Collaborative filtering has various ways to find similar users. An important way to find similar users is to use the correlation rate between users in a preference pattern. Users who have a high correlation rate are regarded as similar users to active users. However, this study applied an alteration to this algorithm.

First, a group of users (user group X) excluding the learner who receives recommendations, is divided into two groups depending on correlation of interests: user group A, which has high absolute value of correlation coefficient with the learner, and user group B, which has low absolute value of correlation coefficient with the learner. From user group B, user group C is extracted, which has high absolute value of correlation coefficient with a certain group of users in group A. The data of user group C is used for the recommendation method proposed Resnick, et at. (1994).

It is known that making recommendations based on only the data of user group A, which has high absolute value of correlation coefficient with the learner, does not result in less accurate prediction compared to that of recommendations based on the entire data (Herlocker, et al. 1999). On the other hand, using only the data of user group B will decrease accuracy.

To expand the range of interests, we focused on the sociological concept of transitivity. Transitivity states that "if A and B have a strong close link, and A and C have a strong close link, then B and C tend to have a strong close link with similar thoughts, actions, and values" (Granovetter 1973). Based on this concept, we hypothesized that "there is a high possibility that although preferences of all users are not similar, when a three users are considered, the preferences of the first and second user will be similar and the preferences of the first and third user will be similar. Hence, the preferences of the second and third user will also be similar," and thus decided to apply the above-mentioned algorithm.

In this way, we considered that the system would make recommendations that match a learner's preferences to a certain extent while also going beyond the learner's interests.

2.2. Vocabulary definition and marker functions

When a user places the cursor on an underlined word in a news article, its definition (first definition) is displayed. The user can also view further detailed definitions of the word, clicking the "detail" button..

The underlined words are determined on the basis of results of an English vocabulary test taken by the user in advance. The words follow JACET8000, a vocabulary glossary created by the Japan Association of College English Teachers (JACET), which separates words into levels based on frequency of use. JACET 8000 is a standardized vocabulary level measurement for English learners over college level. Clicking "detail" button enables learners to make lists of unknown words too. When a learner finds an unknown word, the learner can make such a list by clicking the button on vocabulary definition display. This system records the word and news headers that learners have read.

In the article details screen, learners can mark any sentence and word. These marks can be saved and displayed whenever the same article is reopened. These functions were developed, based on cognitive learning strategies such as underlining and motivating with learning materials in which learners have an interest are reportedly effective for fruitful learning experiences (Garcia and Pintrich, 1994). This study first designed and developed marking, vocabulary definition functions for support to use cognitive learning strategies (elaborating by highlighting and using dictionary).

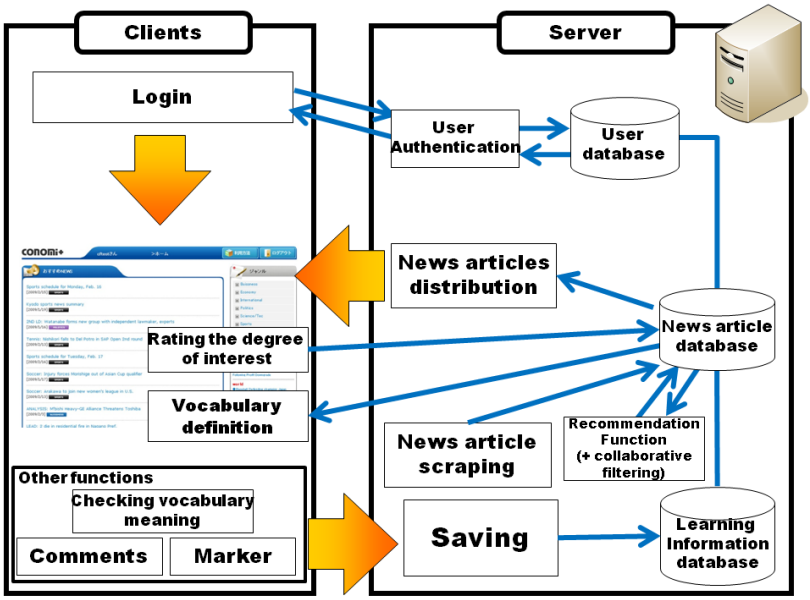

Figure. 1 System structure

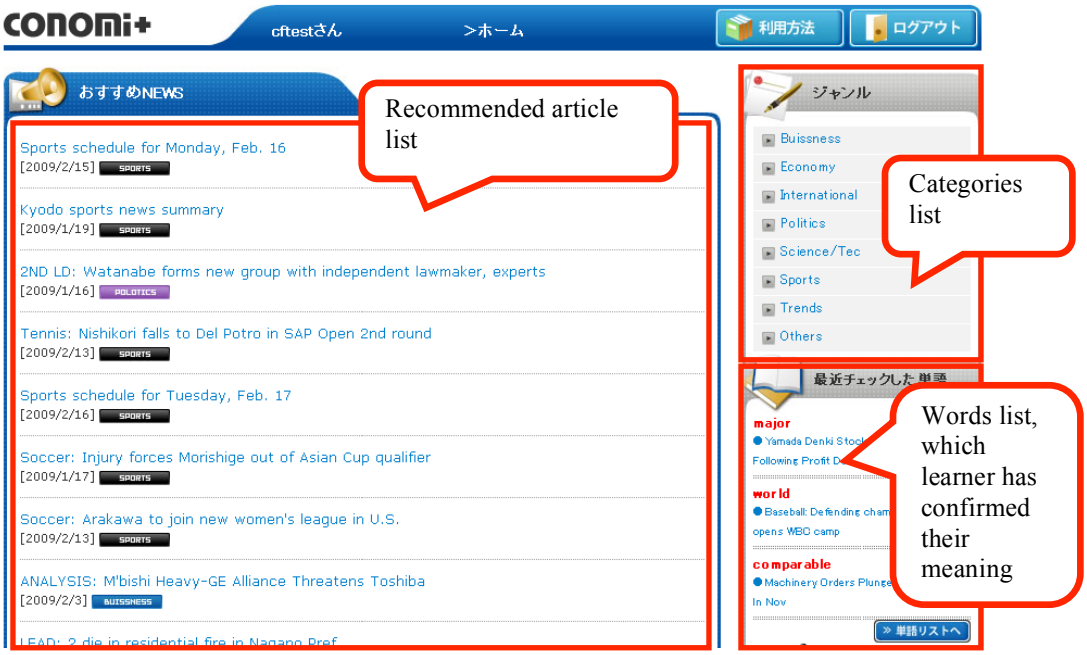

Figure. 2 Main screen

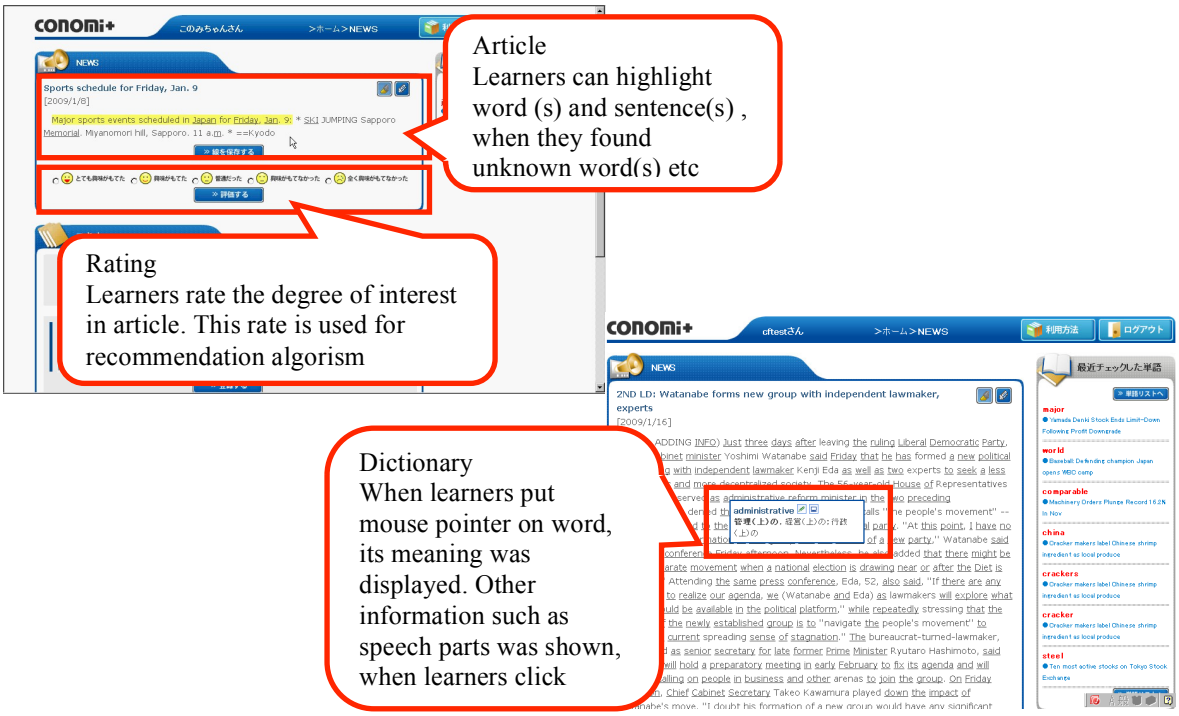

Figure. 3 Article details screen

2.3. Comments function

This function allows learners to insert Japanese comments on the articles they read. With this function, a learner can share thoughts and opinions on articles with other learners.

At the bottom of each article details screen, learners can find a list of all users who rated that article. When a user's name is clicked, other articles that he/she rated will be displayed. This function related to interaction among learners aims to motivate learners to understand the content and active feedback. White (2003) suggests that social learning support such as feedback among learners affects the promotion of self-regulated learning. After the active learner clicks article reader icon, this system shows news readers each article and an article list of news that readers have already read. Furthermore, learners can comment on each article. This function seems to reduce isolation and encourage readers to read articles, being aware of similar learners.

3. EXPERIMENT

3.1. Content of experiment

The purpose of this experiment was to observe how the alteration in the algorithm influences learning. To conduct a controlled experiment, the algorithm of Resnick, et al. (1994), known as basic user-based collaborative filtering algorithm, was used.

The two recommendation algorithms were randomly applied to learners to minimize the probability of bias caused by individual differences. Hereafter, the group that studied English news articles recommended by the user-based collaborative filtering algorithm developed for this study will be called the experimental group and the group that studied English news articles recommended by the basic user-based collaborative filtering algorithm will be called the control group.

3.2. English news articles used in the experiment

The English news articles used in this study were acquired from Kyodo News. The articles in Kyodo News have tags that separate them into different categories. After considering the number and content of news articles in a month, we identified seven categories: politics, economics, accidents and incidents, science and technology, sports, Asia, and society.

3.3. Experiment flow

The period of registration was from 13 to 19 October 2009. Learners were randomly assigned to the control group or the experimental group, and the learners started studying sometime during this period. During registration, learners filled a pre-questionnaire and took an online English vocabulary test based on JACET8000 consisting of 80 questions. From 20 October to 1 November, both groups studied from recommendations made by the algorithm of Resnick, et al (1994). From 2 to 29 November, the experimental group studied from recommendations made with the user-based collaborative filtering algorithm developed in this study, while the control group studied from recommendations made by the algorithm of Resnick, et al. (1994). The period between 30 November and 6 December was designated for collecting data, and learners filled a post-questionnaire and took an English vocabulary test based on JACET8000 consisting of 80 questions. This was the same test as the learners took before the experiment. They also took an online English vocabulary test of 42 questions based on each news category, which included six characteristic words from the news articles of each category.

3.4. Target group

First to fourth year undergraduate or graduate students in their Master's program from multiple universities and graduate schools participated in this experiment. The final stage consisted of 116 learners who had complete data (including pre-test, post-test, and questionnaire data).

As this study focused on vocabulary learning, learners who had a high vocabulary score at the starting point were excluded from the final analysis. Learners who got less than 50 correct answers in the English

vocabulary pre-test based on JACET8000 were included in the analysis. This is less than one standard deviation from the overall average score. The number of learners included in the final analysis was 53 from the experimental group (15 males, 38 females) and 45 from the control group (15 males, 30 females).

3.5. Data used in analysis

The post-questionnaire, results of the English vocabulary pre- and post-test based on JACET8000 (80 questions), results of the category-based English vocabulary post-test (42 questions), answers to the pre- and post-questionnaire, and system log data were used in the analysis.

4. ANALYSIS RESULTS

4.1. Analysis of response to news recommendations

To examine the influence of the recommendation algorithms on the relationship between the learners' interests and recommended English news articles, we analyzed the post-questionnaire data. The questionnaire included two fields: interesting news articles were recommended and interesting news articles were not recommended, to which learners selected an answer on a scale of five (ranging from [1. Yes, very much] to [5. No, not at all]).

We applied the Wilcoxon signed-rank test to the results, and found no significant difference between the experimental and control groups in response to the two questions. Hence, it can be inferred that making recommendations using the user-based collaborative filtering algorithm developed in this study does not significantly decrease the level of accuracy of the recommendations.

4.2. Analysis of learning behavior

To examine the influence of the recommendation algorithms on the articles read by the learners, we analyzed the data of articles rated by the learners.

The average number of articles rated by the experimental group was 87.56, and that by the control group was 88.93. There was no significant difference in these results ($t(80.70) = .08$, n.s.). The comparison of the average number of rated articles by category also showed no significant difference between the experimental and control groups.

The comparison of standard deviations of the number of articles rated by category by both groups showed a significant difference in the sports category ($p < .05$) and a non-significant difference in the Asia category ($p < .10$).

From the analyses, it was concluded that although the total number of articles that are read does not change depending on the algorithms, it is possible that recommendations based on the user-based collaborative filtering algorithm developed in this study decrease the bias of articles read.

4.3. Analysis of study results

To examine the influence of the algorithms on study results, we analyzed the scores of the category-based English vocabulary test and the JACET8000 English vocabulary test.

4.3.1. Analysis of category-based English vocabulary test scores

To examine the bias in individual strengths, the category-based English vocabulary test scores were analyzed. The number of correct answers was calculated for each category and was compared to average scores. There was a 5% level significant difference in the science and technology ($t(84.91) = 2.23$, $p < .05$), politics ($t(91.53) = 2.12$, $p < .05$), and accidents and incidents categories ($t(94.96) = 2.37$, $p < .05$) as well as a 10% level non-significant difference in the Asia category ($t(85.63) = 1.88$, $p < .10$).

In contrast, there was no significant difference between the experimental and control groups regarding the standard deviation of correct answers in each category.

These results show that the experimental group had overall higher scores in the category English vocabulary test compared to the control group.

4.3.2. Analysis of JACET8000 English vocabulary test scores

To examine the overall study results, we analyzed the scores of the JACET8000 English vocabulary test. The average score of the experimental group was 43.83 (SD 9.35), and the average score of the control group was 40.07 (SD 8.85), showing a significant different in the average scores ($t(94.84) = 2.04$, $p < .05$). As the members in each group were selected randomly, there was no significant difference in scores in the JACET8000 English vocabulary pre-test. Thus, the difference in the post-test can be considered to be caused by the difference in group treatment. These results show that the experimental group had higher learning performance than the control group.

5. CONCLUSION

This study expanded the online learning environment developed by Yamada, et al. (2009) by using a collaborative filtering system that recommends English learning materials based on a learner's interests, designed a user-based collaborative filtering algorithm better focused on learning, and compared the difference in study results by using a general collaborative filtering algorithm. It was found that receiving recommendations from the collaborative filtering algorithm developed in this study allows learners to study a wide range of learning material, and possibly leads to higher learning results. For the learning environment of this study, only the recommendation algorithms were different for the experimental group and control group; the interface was the same. This study shows that even if the same system interface is used, changing the algorithm that recommends learning materials results in better quality of learning.

This study focused on the possibility that when data processing technologies are considered for educational purposes, "optimization" of data processing does not necessarily lead to "optimization" of learning. When a new technology for educational purposes is used, it is important to consider how the technology was developed and the educational and learning context were developed and adequately examine how it should be applied to the education field.

ACKNOWLEDGEMENT

This research is supported by "Grant-in-Aid for Scientific Research (B) from Japan Society for the Promotion of Science.

REFERENCES

Cronbach, L. J. (1957) The two disciplines of scientific psychology, *American Psychologist*, 12, pp.671-684

Cronbach, L.J. (1967) How can instruction be adapted to individual differences? In: Gagne, R.M. (ed.) *Learning and individual differences*, Charles Merrill, OH. USA

Dörnei, Z. (2001) *Motivational strategies in the language classroom*. Cambridge University Press, Cambridge, UK

Garcia, T., Pintrich, P.R. (1994) Regulating motivation and cognition in the classroom: The role of self-schemas and self-regulatory strategies. In: Schunk, D.H., Zimmerman, B.J. (eds.) *Self-regulation of learning and performance: Issues and educational applications*, Lawrence Erlbaum Associates, Hillsdale, NJ, USA

Gass, S., Mackey, A., Pica, T.(1998) The role of input and interaction in second language acquisition. *The Modern Language Journal*, 82(3), pp.299–305

Granovetter, M. S. (1973) The strength of weak ties. *AJS*, 78, pp.1360-1380.
Herlocker, J. L., et al. (1999) An algorithmic framework for performing collaborative filtering. *Proc. 22nd annual international ACM SIGIR conf. on Research and development in information retrieval*, pp. 230-237.
Kamishima, T (2007) Algorithms for Recommender Systems (1). *The Japanese Society for Artificial Intelligence Journal*, 22(6), pp. 826-837
Krashen, S.(1985) *The input hypothesis: Issues and implications*. Harlow, Essex: London House, UK (1985)
Resnick, P., et al. (1994) GroupLens: An open architecture for collaborative filtering of netnews. *Proc. 1994 ACM conf. on Computer supported cooperative work*, pp. 175-186.
Sakai, S.(2008) A study on the relationship between developing learner autonomy and ICT in ELT, *Journal of Multimedia Aided Education Research*, 6(1), pp.46–56
White, C.(2003) *Language Learning in Distance Education*, Cambridge University Press, Cambridge, UK.
Yamada, M., et al. (2009) Vocabulary learning environment with collaborative filtering for support of self-regulated learning. In J. D. Velasquez, et al. (Eds.) *KES 2009, Part II, LNAI 5712*, pp. 523-530