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Development of a Reading Material Recommendation System based on a Multi-Expert Knowledge Acquisition Approach

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***Abstract*—In English courses, it is very important to assign proper articles to individual students for training their reading ability. This study proposes an innovative approach for developing reading material recommendation systems by eliciting domain knowledge from multiple experts. An experiment has been conducted to evaluate the performance of the approach; moreover, a comparison on the existing approaches is given to show the advantages of applying the innovative approach.**

I. Introduction

Reading is one of the most important aspects in English curriculum [2]. To train English reading ability for individual students, teachers need to prepare articles to be read, which has become an important task for teachers in conducting learning activities in English courses. In traditional English classes, a teacher needs to guide tens of students to learn; therefore, it is quite often that identical instructional materials, especially the reading articles, are prepared for every student although the students might have quite different English ability. Consequently, for some students, the articles could be too easy to read, while for others, the articles might be too difficult. Such an article assignment strategy is likely to cause the students to lose interests in learning English.

Researchers have indicated that, it is unreasonable to ask all of the students to read the same article in the English class because their reading achievements, learning preferences or needs are not the same [27, 28]. To improve the reading performance of students, teachers need to provide individual students with different instructions based on their reading abilities and the degrees of text difficulty [26]. Although the students with different ability need to receive different treatments, most of the online learning systems and curriculums provide fixed teaching materials at present [21]. To cope with this problem, researchers have attempted to develop recommendation systems based on the student reading preference information for promoting learning motivations of students [7]. There have been several research devoted into the development of recommendation systems, such as EPERS (Personalized E-Learning Recommendation System) [18] and PIMS (Personalized Intelligent Mobile learning System) [3]. Such systems not only can analyze learning difficulties of students, but also can provide necessary information for instructors to design suitable teaching strategies. Previous research also shows that technology-enhanced learning environment has positive contributions to reading outcomes [5].

Although the existing recommendation systems are capable of reducing teachers' loadings in assigning reading materials to individual students, several problems encountered in using these systems. One major problem is owing to the ignorance of domain expertise, which might make the decisions made by the system be inconsistent with those made by the teachers. Most systems employ data mining or statistics methods to analyze learning portfolios and profiles of the students, and use the analysis results to determine the learning materials to be recommended [2, 7, 8, 19, 21, 24, 25, 28]. It remains a challenging issue to develop an English article-reading recommendation system that simulates the decision-making behaviors of domain experts. To develop such an expert-like system, both the expertise concerning English article reading and the profile of individual students need to be taken into consideration. In this study, an innovative approach is proposed to assist teachers to cooperatively defining English article recommendation rules for individual students. Those rules are stored in a knowledge based that will be used by an expert system to simulate the article recommendation decisions of domain experts (i.e., teachers). To evaluate the effectiveness of the approach, an article recommendation expert system was developed and applied to an online English course.

II. Method

In the study, an expert system is developed for recommending reading materials to individual students. An expert system is an artificial intelligence program designed to simulate expert reasoning based on the knowledge elicited from domain experts [4]. In addition, an expert system can integrate opinions from different experts, and the knowledge in database can be accumulated and preserved for a long time. In the past decades, numerous successful cases of developing

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expert systems have demonstrated the benefits of applying this approach [15, 17, 28]. To develop an English article recommendation expert system, several preparatory works need to be done, including collecting relevant literatures, collecting English articles and interviewing with domain experts. The most difficult stage is the follow-up working item; that is, acquiring knowledge form domain experts. Such a procedure is called the knowledge acquisition. Among various knowledge acquisition approaches, the repertory grid method that originates from the Personal construct theory proposed by Kelly (1955) has been recognized to be very effective. Various studies have reported the effectiveness of using the repertory grid method in assisting the domain experts to better organize their knowledge and experiences [1, 4, 9, 16]. Kelly thought that people can create their own explanation about things from their experience, and these explanations can develop the concept of their knowledge. Furthermore, the explanation can be seen as the base to make judgments for future events.

A. Establishing Repertory Grids

A single repertory grid is represented as a matrix whose columns have element labels and whose rows have construct labels. Elements could be decisions to be made, objects to be classified, or concepts to be learned. Constructs are the features for describing the similarities or differences among the elements. Each construct consists of a trait and the opposite of the trait. A 5-scale rating mechanism is usually used to represent the relationships between the elements and the constructs; i.e., each rating is an integer ranging from 1 to 5, where "5'' represents that the element is very likely to have the trait; ''4'' represents that the element may have the trait; ''3'' represents ''unknown'' or ''no relevance''; ''2'' represents that the element may have the opposite characteristic of the trait; and ''1'' represents that the element is very likely to have the opposite characteristic of the trait in the study. Table 1 shows an illustrative example of a repertory grid for describing the traits of the English articles coded with numbers ranging from 65 to 92. The articles in the same repertory grid are of the same difficulty level, and the constructs to characterize the articles are relevant to the preferences of the students. Note that the content of the repertory grid is usually determined by integrating the opinions from several teachers [4].

TABLE I. EXAMPLE OF DIFFICULTY LEVEL = 3

Article Schema Code	**…**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**…**
Family life		4	1	1	1	1	1	1	1	1	
School life		4	1	1	1	1	1	1	1	1	
Job related		4	1	1	2	1	1	1	1	1	
Food		1	1	1	1	1	1	1	1	1	
Entertainment		1	1	1	1	1	1	1	1	1	
Biology or Environment		1	5	1	1	5	1	5	5	4	
Medical		1	1	1	1	1	1	1	5	1	
Astronomy or Geography		1	1	1	1	5	1	1	1	1	
Art		1	1	1	1	1	1	1	1	1	
Fashion		1	1	1	1	1	1	1	1	1	
Information or Science		1	1	1	1	1	1	5	1	4	
History		4	1	5	5	1	5	1	1	1	
Literature		1	1	1	1	1	1	1	1	1	

In the study, the expert knowledge is obtained by interviewing two experienced English teachers in a senior high school. Furthermore, the features and preferences for characterizing the learners are acquired from both the students and the experts. That is, two kinds of repertory grids are established: one is the repertory grid for categorizing the selected reading articles; the other is the repertory grid for characterizing the learners, as shown in Table II.

TABLE II. ILLUSTRATIVE EXAMPLE OF STUDENT PREFERENCES

Student ID	**S01**	**S02**	**…**	**S09**	**…**	**S25**	**…**	**S31**	**…**	**S34**
Family life	3	3		1		2		4		3
School life	3	3		1		2		4		3
Job related	4	3		3		2		3		2
Food	5	3		3		4		3		2
Entertainment	4	4		3		4		3		2
Biology or Environment	3	4		3		2		1		1
Medical	2	4		3		2		1		1
Astronomy or Geography	2	3		3		2		1		2
Art	2	5		3		3		4		3
Fashion	2	5		3		3		4		4
Information or Science	2	4		4		3		4		1
History	2	3		3		2		3		2
Literature	2	4		3		2		1		1

B. Similarity Analysis

A similarity analysis formula is used to compare the preferences of individual students with the traits of each article, where N is the number of constructs (or traits), *MaxScore* is the maximum rating in the repertory grid, Ai represents the i-th article, Sj represents the j-th student, and $|g_{i,k} - g_{j,k}|$ represents the distance of the article and the student subject for the *k-th* trait in the repertory grid. In the example given in Table 1, $N = 13$ and $MaxScore = 5$.

For instance, the similarity (fitness) degree for the student S25 to read the article 71 is

$$\text{Similarity}\ (A_i, S_j) = 100 - \text{Distance}\ (A_i, S_j) = 100 - \sum_{k=1}^{N} \frac{|g_{i,k} - g_{j,k}|}{MaxScore - 1} \times \frac{100}{N} \quad (1)$$

$$\text{Similarity}\ (A_{71}, S_{25}) = 100 - \text{Distance}\ (A_{71}, S_{25})$$

$$= 100 - \sum_{k=1}^{13} \frac{|\, g_{71,k} - g_{25,k} \,|}{5-1} \times \frac{100}{13}$$

$$= 100 - \frac{|2-4|+|2-4|+|2-4|+|4-1|+|4-1|+|2-1|+|2-1|+|2-1|+|3-1|+|3-1|+|3-1|+|2-4|+|2-1|}{5-1} \times \frac{100}{13}$$

=100-38.46 = 61.54. Figure 1 shows the interface of the expert system for presenting the similarity analysis results

(2) Example of the pretest result of a student

Student ID number	The correct number of the primary reading test	The correct number of the medium reading test	The correct number of the medium high reading test	English reading ability is determined according to a preliminary test of GEPT. The level pass/Next level to study
S31	7	8	6	2

(1) Example of article attribute

Article Schema Code	… 71	72 …
difficulty degree	3	3
Family life	4	1
School life	4	1
Job related	4	1
Food	1	1
Entertainment	1	1
Biology or Environment	1	5
Medical	1	1
Astronomy or Geography	1	1
Art	1	1
Fashion	1	1
Information or Science	1	1
History	4	1
Literature	1	1

(3) Example of the preference investigation

The topic student like \ Student ID	… S25 …
Family life	2
School life	2
Job related	2
Food	4
Entertainment	4
Biology or Environment	2
Medical	2
Astronomy or Geography	2
Art	3
Fashion	3
Information or Science	3
History	2
Literature	2

Figure 1. The similarity analysis

C. *Article Recommendation Strategy*

Based on the similarity analysis results, an English article recommendation algorithm is employed in developing the expert system:

Step 1. Identify the English reading ability of the student.

Step 2. Determine the candidate list of articles based on the English reading ability of the student.

Step 3. Test whether the condition $|g_{ic}-g_{jc}| < 3$ is true.

Step 4. If $|g_{ic}-g_{jc}| < 3$, calculate the similarity between the student preference and the article topical subjects

Step 5. If $|g_{ic}-g_{jc}| \geq 3$, test whether the condition $(g_{ic}-g_{jc}) < 3$ is true.

Step 5.1 If $(g_{ic}-g_{jc}) < 3$, calculate the similarity between the student preference and the article topical subjects

Step 5.2 If $(g_{ic}-g_{jc}) \geq 3$, no recommendation will be given and similarity=0

The recommendation system will provide individual students with the English reading article that that mostly fits their ability and preferences.

D. *Experimental Design*

To evaluate the performance of the recommendation system, an experiment has been conducted in a senior high school, as shown in Figure 2. Two teachers and thirty-four students participated in the experiment. There were ninth-three candidate articles suggested by the teachers The traits to of the articles include “family life”, “school life”, “job related”, “food”, “entertainment”, “biology or environment”, “medical”, “astronomy or geography”, “art”, “fashion”, “information or science”, “history” and “literature”. A pretest and a questionnaire are conducted to evaluate the English reading ability and the preferences of the students. The system then recommended articles to individual students based on their English ability and preferences. In the meantime, the two teachers were asked to recommend articles to the students. The recommendations made by the expert system were then compared with those made by the teachers to show the correctness of the innovative approach. The experimental process is given in Figure 2.

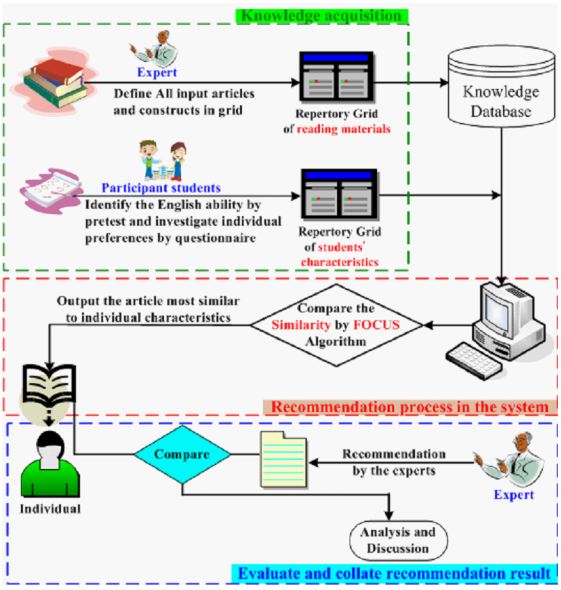

Figure 2. Experiment design

III. Results

A. *Recommendation Results*

Based on the thirteen traits defined by the teachers, a questionnaire was designed for investigating the reading preferences of individual students. The students were asked to rate each item with a five scale rating scheme, that is “very like”, “like”, “more or less like”, “dislike” and “very dislike”, which will be coded as a number ranging from 1 to 5, as having shown in Table

II. The recommendations by the system are given in Table III. From the feedback of the participated students, it was found that the recommendations made by the system were desirable.

TABLE III. RECOMMENDATIONS MADE BY THE SYSTEM

Student ID	Recommendation	Similarity	Difficulty level
S18	Article92	53.8	Medium-high
S19	Article82	69.2	Medium-high
S20	Article71	75	Medium-high
S21	Article71	59.6	Medium-high
S22	Article79	57.7	Medium-high
S23	Article71	51.9	Medium-high
S24	Article84	63.5	Medium-high
S25	Article66	61.5	Medium-high
S26	Article66	59.6	Medium-high
S27	Article71	55.8	Medium-high
S28	Article66	57.7	Medium-high
S29	Article66	50	Medium-high
S30	Article66	48.1	Medium-high
S31	Article71	67.3	Medium-high
S32	Article71	44.2	Medium-high
S33	Article66	57.7	Medium-high
S34	Article84	76.9	Medium-high

To more clearly show the advantages of the innovative approach, a comparison on the existing approaches is given in Table IV, from which it can be seen that the innovative approach make the development of more efficient. Moreover, the system developed with the approach will be easier to maintain and provide more accurate recommendations.

TABLE IV. COMPARISON ON DIFFERENT LEARNING MATERIAL RECOMMENDATION APPROACHES

Comparison	This study	Data mining	Statistics
System training time (development time)	Short	Long	Medium
Behave more like domain experts	Yes	No	No
Need to collect large number of training data	No	Yes	Yes
Flexibility (easy to maintain and modify)	Yes	No	No

B. Experimental Results

More than eighty percent of participants agree that method can improve their motivation. The results is shown in Table V. The learning motivations of most people are increased when they learn English reading by studying the articles recommended from the system. The degree of motivation measured is from one to seven. While one represents strong disagree, seven means strong agree. The paired-samples t test is used to determine whether or not the learning motivations are significantly increased as a whole. It can be concluded that the recommendation results can promote the learning motivations of the students remarkably.

TABLE V. PAIRED-SAMPLES T TEST

Paired-Samples		Mean	N	SD	SE	Sig.
Learning Motivation	After Recommendation	5.46	29	0.81	0.15	.02 (Single-tailed)
	Before Recommendation	5.03	29	0.76	0.14	

α= .05

In order to confirm that the perceptions of the students when the recommendation system is employed in their English reading class, the perceived usefulness questionnaire revised from technology acceptance model is introduced in the study. It is found that there are almost 90% of users in favor of the use of the recommendation results. The proportion is closed to the degree of accuracy in recommendation. From the statistic of user satisfaction, it is found that more than 83.68% of participants agree and satisfy at the recommendation articles. In addition, there are 75.86% of learners pointing out that the article recommended is interesting so that the reading material recommendation is effective to fulfill their interests and improve their learning motivations as well.

IV. Conclusion

In this study, an innovative approach has been proposed for developing reading material recommendation systems by eliciting domain expertise from multiple domain experts. Some pilot tests have shown the efficiency and effectiveness of the innovative approach. In the future, it is suggested that the number of the articles in database should be not only continuously increased for promoting the chances of successfully matching with the users, but also should be increased on targets. The targets are the users who ever used the system but did not get recommendation articles. Trying to find and increase the articles correspond to their preferences in the future. It is hope that optimal or the most suitable article can be easily found. The study has successfully developed the expert system for ESL English reading recommendation by the opinions and domain knowledge from the English teaching experts.

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