Chapter XXII
Development of a Web-Based System for Diagnosing Student Learning Problems on English Tenses

Gwo-Jen Hwang
National University of Tainan, Taiwan

Hsiang Cheng
National Chi Nan University, Taiwan

Carol H.C. Chu
National Chi Nan University, Taiwan

Judy C.R. Tseng
Chung-Hua University, Taiwan

Gwo-Haur Hwang
Ling Tung University, Taiwan

ABSTRACT

In the past decades, English learning has received lots of attention all over the world, especially for those who are not native English speakers. Various English learning and testing systems have been developed on the Internet. Nevertheless, most existing English testing systems represent the learning status of a student by assigning that student with a score or grade. This approach makes the student aware of his/her learning status through the score or grade, but the student might be unable to improve his/her learning status without further guidance. In this paper, an intelligent English tense learning and diagnostic system is proposed, which is able to identify student learning problems on English verb tenses and to provide personalized learning suggestions in accordance with each student’s learning portfolio. Experimental results on hundreds of college students have depicted the superiority of the novel approach.
Development of a Web-Based System for Diagnosing Student Learning Problems on English Tenses

INTRODUCTION

The advance of computer and Internet technologies has significantly affected the style of tutoring and learning (Kuo & Chen, 2004). Many educational institutions all over the world have started to develop and deliver Web-based courses on the Internet (McCormick, 2000).

English has been the most popular language for the past decades, probably due to its systematical grammatical structure. Even though English has such positive characteristics, learning it has always been substantially difficult for ESL/EFL (English as Second/Foreign Language) students. Additionally, English tenses play an important part in explaining the temporal background of English sentences. Nevertheless, EFL learners in general often omit or misuse them. These errors can significantly alter the intended meanings, especially in higher-level communications. Moreover, EFL learners’ confusion about English tenses seemed to be the most significant reason for their learning obstacles.

Experts of language education have recommended that the best way to learn English is to establish a good study environment and practice it through various approaches, thus making it a satisfying learning experience (Wang & Lin, 2004). From this viewpoint, an e-learning environment seems to be a good solution to improve a student’s English learning performance.

Most existing e-learning systems for English courses evaluate and represent the learning status of a student with a score or grade, which merely makes the student aware of his/her learning status through the score or grade, but the student might be unable to improve his/her learning status without further guidance. In this article, an intelligent English tense learning and diagnostic system is proposed by employing artificial intelligence (AI) technologies, which is able to identify student learning problems on English verb tenses and to provide personalized learning suggestions in accordance with each student’s learning portfolio. Furthermore, some experimental results are given to demonstrate the benefits of the novel approach.

RELEVANT RESEARCH

In recent years, many researchers have attempted to make use of computers to help ESL students in learning English (Chan et al., 2001). Through implementing computer-mediated education, many advocates emphasize its positive aspects and the English learning tutoring systems, which are computer-based, that have been developed by numerous academic research groups (Wang & Lin, 2004). For example, Tsou et al. (2002) applied the ideas from computer-assisted learning (CAL) and language learning to the development of a multimedia Web-based English abstract word learning system. An experiment on thirteen commonly encountered abstract words at the elementary school level has demonstrated the benefit of applying the system. Recently, Yang et al. (2005) proposed a Web-based interactive writing environment designed for elementary school students. The environment includes several writing themes to encourage reading comprehension, creativity and problem-solving skills of students.

In addition to the examples mentioned above, there exist innumerable splendid and elaborate works devised by researchers around the world (e.g., Park & Shirai, 1998; Brett & Nash, 1999; Li, 2000; Wintergerst et al., 2003; Itakura, 2004; Ruthven et al., 2004; Coniam & Wong, 2004; McDonald, 2004). Moreover, the issue of applying information technologies to the improvement of English learning efficacy for those who are not native English speakers has attracted researchers from various fields regardless of educational circles, such as linguistics and computer science.

Meanwhile, the computer has evolved into a tool that can improve the accuracy, efficiency,
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interface, and feedback mechanism of online tests (Ho & Yen, 2005). Many researchers have attempted to inject information technology into computer-assisted learning (CAL) for further diagnosis on how well students learn, or where they are having difficulties during the learning process. For instance, Virou et al. (2000) created an intelligent multimedia tutoring system for the passive voice of the English grammar. The main focus of the tutoring system is on the student’s error diagnosis process, which is performed by the student modeling component.

In 2001, Virvou & Tsiriga (2001) created the Web PVT (Web Passive Voice Tutor), an adaptive Web-based intelligent computer assisted language learning (ICALL) system that aims at teaching non-native speakers the passive voice of the English language. The system incorporates techniques from intelligent tutoring systems (ITS) and adaptive hypermedia to tailor instruction and feedback to each individual student. Furthermore, it is capable of detecting misuse and performing ambiguity resolution of passive voice based on the long-term student model. One year later, Fox & Bowden (2002) presented GRADES (GRAmmar Diagnostic Expert System), a diagnostic program that detects and explains grammatical mistakes made by non-native English speakers. GRADES performs its diagnostic task, not through parsing, but through the application of classification and pattern matching rules. This makes the diagnostic process more efficient than other grammar checkers. GRADES is envisioned as a tool to help non-native English speakers learn to correct their English mistakes, and it is also a demonstration that grammar checking need not rely on parsing techniques.

The study of new methods for diagnosing learning problems has also attracted the attention of researchers from computer and education fields. Hwang (2003) developed a network-based testing and diagnostic system that provides learning suggestions for each student by analyzing answer sheets and the relationships between subject concepts and test items. Furthermore, to assist the teachers in providing the relationships between subject concepts, some methodologies and tools have been proposed (Tseng et al., 2004; Hwang, 2005).

RESEARCH ARCHITECTURE AND DESIGN

In this section, we shall demonstrate our novel approach to diagnosing student learning problems in learning English tenses.

Classification of Tenses in English Grammar

In diagnosing student learning problems on English tenses, it is an important issue to classify the associated grammatical concepts (e.g., articles, quantity words, countable nouns, uncountable nouns, verbs, and even sentence patterns) of English by defining its grammatical category. By means of referring to various English grammar bibles, consulting English experts on grammar teaching, and grouping relevant English concepts into grammatical categories, we bring out a systematic categorization of English grammar by proposing fourteen tense-related concepts of English grammar in this study. Table 1 shows the name and the instance of these concepts.

In the tense category, four patterns (i.e., simple pattern, progressive pattern, perfect pattern, and perfect progressive pattern) and two adverbs (i.e., time adverb and frequency adverb) that might affect the variation of verbs in a clause are taken into consideration.

Identification of Online Learning Performance with Fuzzy Approach

We attempt to identify each learner’s online performance and provide corresponding learning suggestions based on the fuzzy approach. Fuzzy
Set theory was proposed in the mid-sixties by Zedah (1965), and was extended later to include fuzzy logic (Zedah, 1973), a superset of conventional (Boolean) logic that has been developed to handle the concept of partial truth. Fuzzy sets (or vague sets) generalize the notion of crisp sets (Gau & Buehrer, 1993); that is, an element could be in a set with a membership degree between 0 and 1.

The source of fuzziness in “if-then” rules stems from the use of linguistic variables (Zadeh, 1971). Concept understanding degree, for example, may be viewed as a numerical value ranging over the interval [0, 100%], and a linguistic variable that can take on values like “high,” “not very high,” and so on. Each of these linguistic values may be interpreted as a label of a fuzzy subset of the universe of discourse $X = [0, 100\%]$, whose base variable, $x$, is the generic numerical value concept understanding degree.

Each linguistic value is defined by a membership function, which helps to take the crisp input values and transform them into degrees of membership (Ngai & Wat, 2003). A membership function (MF) is a curve that defines how each point in the input space is mapped to a membership value, or degree of membership, between 0 and 1. The function itself can be an arbitrary curve whose shape can be defined as a function that suits the particular problem from the point of view of simplicity, convenience, speed, and efficiency (Kalogirou, 2003). In practical application, four standardized MFs are constantly used: Z-type, Λ-type (lambda), Π-type (pi), and S-type, as shown in Figure 1.

Fuzzy rules serve to describe the quantitative relationship between variables in linguistic values. These IF-THEN rule statements are used to formulate the conditional statements that comprise fuzzy logic (Kalogirou, 2003). In the following, we shall present the fuzzy approach for identifying online learning performance in detail.

- Definition of the Linguistic Variables

<table>
<thead>
<tr>
<th>Category</th>
<th>Concept</th>
<th>Instance</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C_1$ Past Simple</td>
<td>Present Simple</td>
<td>The earth is round.</td>
</tr>
<tr>
<td>$C_2$ Past Simple</td>
<td>Past Simple</td>
<td>I graduated from Harvard last year.</td>
</tr>
<tr>
<td>$C_3$ Future Simple</td>
<td>Future Simple</td>
<td>I will be the winner.</td>
</tr>
<tr>
<td>$C_4$ Present Progressive</td>
<td>Present Progressive</td>
<td>Kent is reading that best-selling biography.</td>
</tr>
<tr>
<td>$C_5$ Past Progressive</td>
<td>Past Progressive</td>
<td>They were dancing when the teacher came in.</td>
</tr>
<tr>
<td>$C_6$ Future Progressive</td>
<td>Future Progressive</td>
<td>Two days later, I will be driving a new car.</td>
</tr>
<tr>
<td>$C_7$ Present Perfect</td>
<td>Present Perfect</td>
<td>I have seen that movie twenty times.</td>
</tr>
<tr>
<td>$C_8$ Past Perfect</td>
<td>Past Perfect</td>
<td>Jerry had studied a little English when he came to the US</td>
</tr>
<tr>
<td>$C_9$ Future Perfect</td>
<td>Future Perfect</td>
<td>I will have perfected my English by the time I come back from the US</td>
</tr>
<tr>
<td>$C_{10}$ Present Perfect Progressive</td>
<td>Present Perfect Progressive</td>
<td>I have been studying English since 1987.</td>
</tr>
<tr>
<td>$C_{11}$ Past Perfect Progressive</td>
<td>Past Perfect Progressive</td>
<td>He had been driving all day before he went to class.</td>
</tr>
<tr>
<td>$C_{12}$ Future Perfect Progressive</td>
<td>Future Perfect Progressive</td>
<td>By the time you leave, you will have been living in Rome for six months.</td>
</tr>
<tr>
<td>$C_{13}$ Time Adverbs</td>
<td>Time Adverbs</td>
<td>The plane landed five minutes early.</td>
</tr>
<tr>
<td>$C_{14}$ Frequency Adverbs</td>
<td>Frequency Adverbs</td>
<td>I always brush my teeth before I go to bed.</td>
</tr>
</tbody>
</table>
Related linguistic variables and the membership functions to measure the status of learners shall be defined in this section, including individual’s relative learning achievement, concentration, and patience. As the system will eventually provide a five-scale remedial learning suggestion, these linguistic variables are designed to have five linguistic values, as shown in Table 2.

The linguistic values of the output linguistic variable $RLAsc(S_i, C_j)$, for example, are between Grade 1 to Grade 5, where Grade 1 represents the lowest achievement degree and Grade 5 represents the highest achievement degree.

Moreover, in order to know whether the learner was concentrating on the online learning materials, as well as to forbid them from daydreaming, gossiping, browsing irrelevant Web pages, or even playing games, we designed a concentration windows (CWs) mechanism. Learners were asked to make responses to these pop-up windows (click to close) during the learning progress (Hwang, 1998). The system kept track of the time when CWs popped open ($CW_{jumpingTime}$) and were closed ($CW_{closeTime}$), as well as whether the CW was valid ($CW_{valid}$). Whether a CW is valid is defined as:

$$CW_{valid} = \text{true if } (CW_{closeTime} - CW_{jumpingTime}) \leq CW_{autoCloseTime},$$

where the setting of the parameter $CW_{autoCloseTime}$ is considered to be one of the functionalities that the role teacher can use. For example, suppose the auto-close time of CWs ($CW_{autoCloseTime}$) is set to 8 seconds, the CWs will close themselves automatically after the eighth second if the learner did not respond to it. In contrast, the system will

![Figure 1. Four standardized membership functions](image)

Table 2. Linguistic variables and values used in the study

<table>
<thead>
<tr>
<th>Linguistic Variables</th>
<th>Definitions</th>
<th>Linguistic Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>$LaSc(S, C_j)$</td>
<td>Learner $S$’s individual learning achievement toward a certain concept $C_j$.</td>
<td>Low, Medium, High</td>
</tr>
<tr>
<td>$ALaC(C_j)$</td>
<td>The learning group’s average learning achievement toward a certain concept $C_j$.</td>
<td>Low, Medium, High</td>
</tr>
<tr>
<td>concentration($S_i$)</td>
<td>Learner $S_i$’s response rating toward the concentration windows during the learning progress.</td>
<td>Grade 1–5</td>
</tr>
<tr>
<td>pageBT($S_i$)</td>
<td>Learner $S_i$’s average browsing time to the learning materials.</td>
<td>Short, Moderate, Long</td>
</tr>
<tr>
<td>$RLAsc(S_i, C_j)$</td>
<td>The $S_i$’s relative learning achievement toward a certain concept $C_j$ compared with the learning group.</td>
<td>Grade 1–5</td>
</tr>
<tr>
<td>Patience($S_i$)</td>
<td>Learner $S_i$’s patience rating performed during the learning progress.</td>
<td>Low, Medium, High</td>
</tr>
</tbody>
</table>
also record valid responses when the learner clicks the close button on the window within the time span.

Hence, we are able to know a learner’s concentration degree $\text{concentration}(S)$ through the following mathematic formula:

$$\text{concentration}(S_i) = \frac{\sum_{i=1}^{nCW} cw_i}{nCW},$$

where $cw_i$ is the $i$-th concentration window ($cw_i = 1$ if $cw_i \in$; $cw_i = 0$, otherwise), $nCW$ is the total number of concentration windows that popped up during the learner’s learning progress, and represents the set of concentration windows to which the learners responded validly.

In spite of concentration, patience was also adopted to measure the learner’s ability to continuously engage in the learning progress, which could be calculated by comparing the learner’s individual and learning group’s average browsing time on learning materials. We have

$$\text{pageBT}(S_i) = \frac{\text{Total time the learner } S_i \text{ spent on browsing the materials}}{\text{Total number of learning materials that learner } S_i \text{ browsed}},$$

and

$$\text{pageABT} = \frac{\sum_{i=1}^{nStu} \text{pageBT}(S_i)}{nStu},$$

where $nStu$ is the total number of learners who participated in the study.

Consequently, by mapping the rules, the grade of patience can be met and the appropriate learning suggestion will be provided to the learner.

- Definition of the Membership Functions

In this study, we assume that the input and output fuzzy numbers are in triangular forms and these forms approximate human thought processes. That is, three membership functions: Z-type, Lambda-type (triangular), and S-type are used. Related membership functions of input and output linguistic variables are defined as follows:

**Learning Achievement:** $LAsc(S, C)$ and $ALAc(C)$

(1)

Generally, most examinations are assessed using a cut-off point of 60 percent to judge whether a learner passed or failed. This rule of thumb is also adopted in our study. We use 60 points as the minimum criterion for determining whether a learner/learning group understands enough of the concept. Hence, the membership function of learner $S_i$’s learning achievement degree toward the concept $C_j$ is defined as follow:

- $Z(x;0.4,0.6)$; Linguistic Term is Low
- $\text{Tri}(x;0.4,0.6,0.8)$; Linguistic Term is Medium
- $S(x;0.6,0.8)$; Linguistic Term is High

The graphical representation of membership functions is shown in Figure 2.

**Online learning behavior:** $RLAsc(S, C)$, $\text{concentration}(S)$ and $\text{patience}(S)$

(2)

For the learner’s relative learning achievement degree, valid response ratio toward CWs (concentration) and the patience manifested during the process of material learning, we split them into five grades: *Grade 1~5* (Grade 1 represents the worst performance; Grade 5 represents the best performance). Based on these grades, the system renders the learner with the individualized learning suggestions. The Membership Functions are as follows:
Definition of the Fuzzy Rules

Fuzzy reasoning model plays an important role in our system for diagnosing learning performance. For learners, it provides indispensable assisted information. Thus, the establishment of fuzzy rules is critical to analysis and concerns the correctness of inference results. There are twenty-four rules defined in our study, as shown in the following:

\[ R_1: \text{IF } LAs(\text{C}) = \text{Low AND ALAc(}C) = \text{Low THEN RLAs}(\text{C}) = \text{Grade 3} \]

\[ R_2: \text{IF } LAs(\text{C}) = \text{Low AND ALAc(}C) = \text{Medium THEN RLAs}(\text{C}) = \text{Grade 2} \]

\[ R_3: \text{IF } LAs(\text{C}) = \text{Low AND ALAc(}C) = \text{High THEN RLAs}(\text{C}) = \text{Grade 1} \]

\[ R_4: \text{IF } LAs(\text{C}) = \text{Medium AND ALAc(}C) = \text{Low THEN RLAs}(\text{C}) = \text{Grade 4} \]

\[ R_5: \text{IF } LAs(\text{C}) = \text{Medium AND ALAc(}C) = \text{Medium THEN RLAs}(\text{C}) = \text{Grade 3} \]

\[ R_6: \text{IF } LAs(\text{C}) = \text{Medium AND ALAc(}C) = \text{High THEN RLAs}(\text{C}) = \text{Grade 2} \]

\[ R_7: \text{IF } LAs(\text{C}) = \text{High AND ALAc(}C) = \text{Low THEN RLAs}(\text{C}) = \text{Grade 5} \]

\[ R_8: \text{IF } LAs(\text{C}) = \text{High AND ALAc(}C) = \text{Medium THEN RLAs}(\text{C}) = \text{Grade 4} \]

\[ R_9: \text{IF } LAs(\text{C}) = \text{High AND ALAc(}C) = \text{High THEN RLAs}(\text{C}) = \text{Grade 3} \]

\[ R_{10}: \text{IF } \text{concentration}(\text{C}) = \text{Grade 1 AND pageBT}(\text{C}) = \text{Short THEN patience}(\text{C}) = \text{Grade 1} \]
For example, 2 is concerned and mainly expresses that the learner’s individual concept achievement degree is low and the learning group is medium. Consequently, we would consider the relative concept achievement degree of this learner to be Grade 2, and provide the equivalent learning suggestion to him. Moreover, from 10 to 24, there are fifteen fuzzy rules defined for enumerating distinct patience grades based on linguistic variables \( \text{concentration}(S) \) and \( \text{pageBT}(S) \).

**IMPLEMENTATION OF A FUZZY EXPERT SYSTEM FOR ENGLISH TENSE DIAGNOSIS**

ET-DES (English Tense Diagnosis Expert System), a Web-based diagnosis expert system focusing on the verb tenses of English, was built to evaluate EFL students’ learning performance and to render personalized learning suggestions. An expert system is a computer program in which the knowledge of an expert on a specific subject can be incorporated in order to solve problems or give advice (Jackson, 1990). It usually consists of a knowledge base (KB), an inference mechanism, an explanation component, and a user interface (Nebendahi, 1987). Figure 3 shows the basic architecture of a fuzzy expert system. Individual components are illustrated as follows.

Expert system shell packages give users the opportunity to develop an expert system-based decision aid that is geared toward their specific needs while assisting users who do not possess technical expertise in computers. In our study, we adopt DRAMA to serve the core of fuzzy reasoning. DRAMA is an expert system shell developed by CoreTec Corp.

**System Architecture and Functionality**

ET-DES accommodates three roles: learners, teachers, and system administrator. The users

\[
\tilde{R}_{11}: \text{IF concentration}(S) = \text{Grade 1 AND pageBT}(S) = \text{Moderate} \quad \text{THEN patience}(S) = \text{Grade 2}
\]

\[
\tilde{R}_{12}: \text{IF concentration}(S) = \text{Grade 1 AND pageBT}(S) = \text{Long} \quad \text{THEN patience}(S) = \text{Grade 3}
\]

\[
\tilde{R}_{13}: \text{IF concentration}(S) = \text{Grade 2 AND pageBT}(S) = \text{Short} \quad \text{THEN patience}(S) = \text{Grade 1}
\]

\[
\tilde{R}_{14}: \text{IF concentration}(S) = \text{Grade 2 AND pageBT}(S) = \text{Moderate} \quad \text{THEN patience}(S) = \text{Grade 2}
\]

\[
\tilde{R}_{15}: \text{IF concentration}(S) = \text{Grade 2 AND pageBT}(S) = \text{Long} \quad \text{THEN patience}(S) = \text{Grade 4}
\]

\[
\tilde{R}_{16}: \text{IF concentration}(S) = \text{Grade 3 AND pageBT}(S) = \text{Short} \quad \text{THEN patience}(S) = \text{Grade 1}
\]

\[
\tilde{R}_{17}: \text{IF concentration}(S) = \text{Grade 3 AND pageBT}(S) = \text{Moderate} \quad \text{THEN patience}(S) = \text{Grade 3}
\]

\[
\tilde{R}_{18}: \text{IF concentration}(S) = \text{Grade 3 AND pageBT}(S) = \text{Long} \quad \text{THEN patience}(S) = \text{Grade 4}
\]

\[
\tilde{R}_{19}: \text{IF concentration}(S) = \text{Grade 4 AND pageBT}(S) = \text{Short} \quad \text{THEN patience}(S) = \text{Grade 2}
\]

\[
\tilde{R}_{20}: \text{IF concentration}(S) = \text{Grade 4 AND pageBT}(S) = \text{Moderate} \quad \text{THEN patience}(S) = \text{Grade 3}
\]

\[
\tilde{R}_{21}: \text{IF concentration}(S) = \text{Grade 4 AND pageBT}(S) = \text{Long} \quad \text{THEN patience}(S) = \text{Grade 5}
\]

\[
\tilde{R}_{22}: \text{IF concentration}(S) = \text{Grade 5 AND pageBT}(S) = \text{Short} \quad \text{THEN patience}(S) = \text{Grade 2}
\]

\[
\tilde{R}_{23}: \text{IF concentration}(S) = \text{Grade 5 AND pageBT}(S) = \text{Moderate} \quad \text{THEN patience}(S) = \text{Grade 3}
\]

\[
\tilde{R}_{24}: \text{IF concentration}(S) = \text{Grade 5 AND pageBT}(S) = \text{Long} \quad \text{THEN patience}(S) = \text{Grade 5}
\]
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Figure 3. Architecture of an expert system

<table>
<thead>
<tr>
<th>Working Memory (Task-specific data)</th>
<th>Inference Engine</th>
<th>Knowledge Bases</th>
</tr>
</thead>
<tbody>
<tr>
<td>User Interface</td>
<td></td>
<td>Knowledge Acquisition</td>
</tr>
</tbody>
</table>

of different roles logs into the system via the same user interface. ET-DES will identify the user privilege and guide the user to different main pages based on their IDs. Figure 4 depicts the architecture of ET-DES, where KB of LSA represents Knowledge Base of Learning Statue Assessment, while KB of LOD stands for Knowledge Base of Learning Obstacle Diagnosis.

From the perspective of technique, ET-DES is developed on a 3-tier architecture: in the client-tier, the users access the system through Internet browsers (e.g., Microsoft Internet Explorer); in middle-tier, Tomcat 4.0.4 is used as the Web server, in coordination with J2SDK1.4., and JSP (Java Server Pages) is used to write programs of various functions, such as parameter transmissions among Web pages, data computations, database accessing, learning portfolio recording, and DRAMA expert system invoking. On the user-tier, the client language JavaScript is employed to check user’s input, preventing any possible error from happening. Moreover, SQL Server 2000 is

Figure 4. Architecture of ET-DES

<table>
<thead>
<tr>
<th>Setting system parameters</th>
<th>Setting quiz parameters</th>
<th>Tense Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setting personal learning portfolio</td>
<td>Inspecting personal learning portfolio</td>
<td>Inspecting fuzzy analysis results and Individualized learning suggestions</td>
</tr>
<tr>
<td>Browsing tense materials</td>
<td>Receiving on-line testing</td>
<td>Browsing the testing results</td>
</tr>
<tr>
<td>Setting the relations between concepts and test items</td>
<td>Inspecting the relations between concepts and test items</td>
<td>Setting the learning suggestions</td>
</tr>
<tr>
<td>Inspecting learners learning performances</td>
<td>DRAMA Expert System</td>
<td></td>
</tr>
</tbody>
</table>
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employed to maintain the databases, including the item bank, user's individual information, the relationships between concepts and test items, and so on.

User Interface Design

A registered learner logging into the system is first shown a system operation instruction describing the characteristics of the system and its functions (see Figure 5). The following sub-sections demonstrate the functions of the interfaces for learners in accordance with the operational sequences.

Browsing Tense Materials

As shown in Figure 6, the screen is divided into two: concept material selection buttons are on the left; the content of the materials is shown on the right. By clicking on these buttons, learners can select any specific tense material to browse.

To detect if the learner paid attention to the subject materials, the system pops up some con-

Figure 5. Learner interface for system operation instruction

Figure 6. Learner interface for learning the tense materials
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Figure 7. Concentration window

A concentration window (as shown in Figure 7) and asks the learner for a response. If the learner does not respond to the concentration window within the predefined period of time, the windows will automatically close.

Receiving Online Testing

This part of the system provides learners the opportunity of self-evaluation. The test is designed in the form of multiple-choice questions with four answer choices and all concepts included in the test alternatives are limited to the tenses of English grammar. Figure 8 shows the user interface for conducting a test.

Browsing the Testing Results

Via the user interface depicted in Figure 9, learners can browse the list of relevant concepts, the correct answer, and his/her own answer for each test item. Moreover, there are two “supplements” given to the learner, providing the learner the opportunity of improving his/her learning performance. One is the magnifying glass icon, which can display the original question accompanied with the four possible answers, another is the question mark icon, which provides detailed explanation to every test item.

Browsing Personal Learning Portfolio

Figure 10 shows the user interface for presenting a learner’s learning portfolio. The presented information includes the Web pages that have been visited, the time the learner entered and exited those Web pages, the concepts learned, and so forth.

Figure 8. Learner interface for taking the tense testing
Browsing Analysis Results and Individualized Learning Suggestions

After comparing a learner’s individual learning performance with that of the learning group by invoking the DRAMA expert system, ET-DES presents the diagnosis results, which are displayed in a horizontal bar chart, together with the percentage value (see Figures 11-15).

The information contained in the learning diagnosis results are depicted as follows:

- The average learning achievements of all participants: such as average score, browsing time, concentration window response time, concept understanding degree, and so forth, are shown in Figure 11.
The online behaviors of learners: such as a student’s score for the testing, total staying time, response time, learning achievement of each tense concept, and so on, all are provided on the Web page as shown in Figure 12.

The summarized information on learning achievements: (as shown in Figure 13) is used to compare and highlight the learning achievement of the individual and the group for every concept to be learned.

Personal information on learning achievements: (as shown in Figure 14) reveals the learning levels of fourteen English tense concepts and the corresponding learning suggestions.

Evaluation of the learner’s online behavior: includes patience and the comprehensive learning suggestions (as shown in Figure 15). The summarized learning suggestion consists of two parts: first, it provides a clear
learning guidance for the learner (a list of the concepts the learner needs to improve and a brief conclusion of the learner’s understanding degree), informing the learner of his/her strengths and deficiencies; second, it draws an integrated comment of the learner’s level of concentration and patience. These suggestions are followed by concrete suggestions for advancement.

**EXPERIMENT AND ANALYSIS**

To evaluate the performance of ET-DES, an experiment was conducted at National Chi Nan University in March 2005. Two hundred and fifty-seven undergraduate students participated in the experiment. Initially, the system developer gave the participants a brief orientation about the purpose of the experiment and the operations of
Figure 15. Learning suggestions based on the student’s individual learning perfor-

![Learning Status Diagnosis](image)

Table 3. Statistics of questions of four facets

<table>
<thead>
<tr>
<th>Issues</th>
<th>Options</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Mean</th>
<th>S.D.</th>
<th>(4+5)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Facet 1 - SYSTEM</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. System Function Grading</td>
<td>(1=VP, 2=P, 3=N, 4=G, 5=VG)</td>
<td>5</td>
<td>4</td>
<td>69</td>
<td>124</td>
<td>21*</td>
<td>3.6816</td>
<td>.7605</td>
<td>145(65%)</td>
</tr>
<tr>
<td>2. System Interface Grading</td>
<td>(1=VP, 2=P, 3=N, 4=G, 5=VG)</td>
<td>4</td>
<td>8</td>
<td>49</td>
<td>130</td>
<td>32</td>
<td>3.7982</td>
<td>.794</td>
<td>162(72.7%)</td>
</tr>
<tr>
<td>3. System Operation Difficulty Grading</td>
<td>(1=VD, 2=D, 3=N, 4=E, 5=VE)</td>
<td>6</td>
<td>5</td>
<td>39</td>
<td>132</td>
<td>41</td>
<td>3.8834</td>
<td>.824</td>
<td>173(77.6%)</td>
</tr>
<tr>
<td>4. System Operation Flow Smoothness Grading</td>
<td>(1=VP, 2=P, 3=N, 4=G, 5=VG)</td>
<td>14</td>
<td>34</td>
<td>41</td>
<td>105</td>
<td>29</td>
<td>3.4529</td>
<td>1.0931</td>
<td>134(60.1%)</td>
</tr>
<tr>
<td><strong>Facet 2 - MATERIAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Material is easy to understand?</td>
<td>(1=SD, 2=D, 3=N, 4=A, 5=SA)</td>
<td>5</td>
<td>40</td>
<td>75</td>
<td>86</td>
<td>17</td>
<td>3.3139</td>
<td>.931</td>
<td>103(46.2%)</td>
</tr>
<tr>
<td>2. Material typesetting is good?</td>
<td>(1=SD, 2=D, 3=N, 4=A, 5=SA)</td>
<td>3</td>
<td>8</td>
<td>80</td>
<td>111</td>
<td>21</td>
<td>3.6233</td>
<td>.7617</td>
<td>132(59.22%)</td>
</tr>
<tr>
<td><strong>Facet 3 - QUIZ</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Test items of the testing are easy?</td>
<td>(1=SD, 2=D, 3=N, 4=A, 5=SA)</td>
<td>26</td>
<td>86</td>
<td>77</td>
<td>24</td>
<td>10</td>
<td>2.5785</td>
<td>.9827</td>
<td>34(15.3%)</td>
</tr>
<tr>
<td>2. The test items can gauge your understanding degree for tenses?</td>
<td>(1=SD, 2=D, 3=N, 4=A, 5=SA)</td>
<td>6</td>
<td>18</td>
<td>58</td>
<td>121</td>
<td>20</td>
<td>3.5874</td>
<td>.8648</td>
<td>141(63.3%)</td>
</tr>
<tr>
<td><strong>Facet 4 – DIAGNOSIS RESULT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Learning Achievement of Concepts</td>
<td>(1=SD, 2=D, 3=N, 4=A, 5=SA)</td>
<td>4</td>
<td>13</td>
<td>57</td>
<td>122</td>
<td>27</td>
<td>3.6951</td>
<td>.8255</td>
<td>149(66.8%)</td>
</tr>
</tbody>
</table>

*continued on following page*
Development of a Web-Based System for Diagnosing Student Learning Problems on English Tenses

the system. The participants were asked to fill in a questionnaire after using the system. This questionnaire was composed of four facets: the system, the learning material, the test items of the quiz, and the diagnosis result. The choice of each question is based on a scale of 1 to 5. Table 3 shows the statistical results.

Table 4 shows that the participants have a positive attitude toward the facet of SYSTEM (Mean = 3.704), indicating that the functionality, interface, difficulty of operation, and operation flow smoothness have been well accepted by the participants (S.D.=0.1867).

When considering the facet of MATERIAL (Mean = 3.4662), based on the statistical results of “Material is easy to understand” (Mean = 3.3139) as well as “Material typesetting is good” (Mean = 3.6233), we conclude that there is room to improve the quality and content of learning materials in our system.

For the question “The test items can gauge your understanding degree for tenses?,” the mean value is 3.5874, reflecting a positive agreement. That is, the students tend to believe that the system is helpful in improving their learning performance.

For the facet of DIAGNOSIS RESULT, approximately seventy percent of the students agree or strongly agree that the provided diagnostic information (grades and corresponding learning suggestions) of “Learning Achievement of Concepts” is helpful for their learning, as shown in Figure 16.

Additionally, other provided information about the diagnosis results such as concentration, patience, and comprehensive learning suggestions are also well accepted by the participants with a high rate of acceptance, as shown in Figure 17.

Consequently, the question “If possible, are you willing to take other relevant system assis-

Table 3. continued

<table>
<thead>
<tr>
<th>Facets</th>
<th>Options</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Mean</th>
<th>S.D.</th>
<th>Min</th>
<th>Max</th>
<th>Satisfaction(4+5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSTEM</td>
<td></td>
<td>29</td>
<td>51</td>
<td>198</td>
<td>491</td>
<td>123*</td>
<td>3.704</td>
<td>0.1867</td>
<td>0.7605</td>
<td>1.0931</td>
<td>614 (68.83%)</td>
</tr>
<tr>
<td>MATERIALS</td>
<td></td>
<td>8</td>
<td>48</td>
<td>155</td>
<td>197</td>
<td>38</td>
<td>3.4662</td>
<td>0.2198</td>
<td>0.7617</td>
<td>0.931</td>
<td>235 (52.69%)</td>
</tr>
<tr>
<td>QUIZ</td>
<td></td>
<td>32</td>
<td>104</td>
<td>135</td>
<td>145</td>
<td>30</td>
<td>3.083</td>
<td>0.7134</td>
<td>0.8648</td>
<td>0.9827</td>
<td>175 (39.24%)</td>
</tr>
<tr>
<td>DIAGNOSIS RESULT</td>
<td></td>
<td>22</td>
<td>65</td>
<td>229</td>
<td>430</td>
<td>146</td>
<td>3.6872</td>
<td>0.1539</td>
<td>0.7647</td>
<td>1.0547</td>
<td>576 (64.57%)</td>
</tr>
</tbody>
</table>
tances in the future?” has a high mean of 3.6061 and a standard deviation of 0.7344; therefore, we conclude the system has been well approved by the experiment participants.

CONCLUSION AND FUTURE WORKS

In this article, we designed and implemented a Web-based English Tense Diagnosis Expert System named ET-DES, which is capable of finding out the tense-related concepts that the learners failed to learn and rendering personalized learning suggestions by invoking a fuzzy approach. To sum up, with the assistance of the system we proposed, EFL students have better opportunities to enhance their learning efficiency of English tenses by aiming at those concepts that were diagnosed to be deficient. Currently, we are planning to conduct a long-term experiment on college English courses by applying ET-DES. The learning portfolios of the students will be analyzed at the end of each semester to find out the efficacy of our novel approach; moreover, the performance of the system can also be improved based on the experimental results and the suggestions from the learners.

REFERENCES


**ENDNOTE**

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