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Development and Evaluation of a Thai Learning System on the Web Using Natural Language Processing

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ABSTRACT

The **Thai Learning System** (**TLS**) is designed to help learners acquire the Thai word order system. **TLS** facilitates the lessons on the Web using HyperText Markup Language (HTML) and Perl programming which interfaces with Natural Language Processing (NLP) by means of Prolog. The system introduces an easily understandable presentation of a sentence structure by indicating syntactic trees and case grammar principles. Behind **TLS**, Prolog analyzes affirmative sentences with Thai phrase structure rules and a computational lexicon, and Perl programming transforms the Prolog results back into a user interface display. The system contains interactive features, pictures, sounds, and informative feedback. Questionnaires and factor analysis were used to evaluate the system. The results of the evaluation showed that **TLS** has an effective user interface and handles learners' input efficiently.

KEYWORDS

Natural Language Processing, Thai Learning System, Phrase Structure Rules, Syntactic Trees, Error Processing, System Evaluation, Factor Analysis

INTRODUCTION

A great deal of research on CALL focusing on Natural Language Processing (NLP) asserts that intelligent CALL can perform better than tradi-

tional CALL, for example, **CALLE** for Spanish (Feuerman, Marshall, Newman, & Rypa, 1987), **Grammar-Debugger** for English (Si-Quing & Luomai, 1990), **Linger** for Romance and Germanic languages (Yazdani, 1991), **Miniprof** for French (Labrie & Singh, 1991), **ALICE-chan** for Japanese (Levin, Evans, & Gates, 1991), **GPARS** for English, Russian, Japanese, and Chinese (Loritz, 1992), **BRIDGE** for German (Holland, Maisano, Alderks, & Martin, 1993), and **Nihongo-CALI** for Japanese (Nagata, 1995a). Most research on intelligent CALL has focused on major languages. This article describes an intelligent CALL system for Thai designed for use on the Web. The system, called the **Thai Learning System** (**TLS**) is very effective for situations in which learners have difficulty finding Thai language instructors or Thai learning materials.[1]

The basic design policy of **TLS** is

1) to guide learners to understand the structure of a sentence by indicating the case grammar principles behind the sentence;
2) to offer an interface to support interaction between learners and the computer on the basis of reasonable inference;
3) to assist learners' independent and active learning;
4) to feature the use of sound and pictures on the Web; and
5) to track the improvement of individual learners.

In **TLS**, the NLP results based on analyzed sentence structure by means of Prolog provides the error processing and feedback mechanism.

The system was evaluated to determine the effectiveness of its user interface and performance in handling student input. Questionnaires were completed by 27 learners and analyses such as factor analysis and t-tests were undertaken. The results showed that "Learning Motivation" and "Speech Voice" were highly rated as a whole. Older learners and liberal arts students gave "Learning Motivation" high marks suggesting that learners perhaps not especially inclined toward using computers viewed **TLS** favorably.

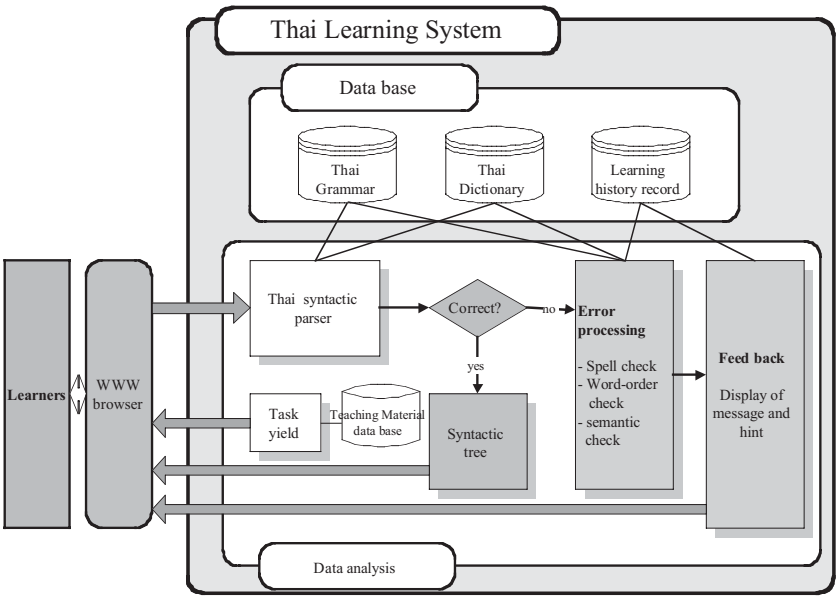
THE TLS MODEL

Diagram of the Model

TLS was developed on the basis of NLP procedures by means of Prolog in order for learners to handle teaching materials on the Web.[2] **TLS**'s display is easier to see, and its interface is more user-oriented than a pure display of Prolog. In addition, a pure display of Prolog comes from a standalone model only, whereas **TLS** can be accessed from anywhere through the Internet. The basic components of **TLS** consist of three dif-

ferent kinds of databases: a grammar (Thai phrase structure rules for affirmative sentences), a dictionary with added semantic features, and learning history record (see Figure 1).

Figure 1
Basic Diagram of **TLS**

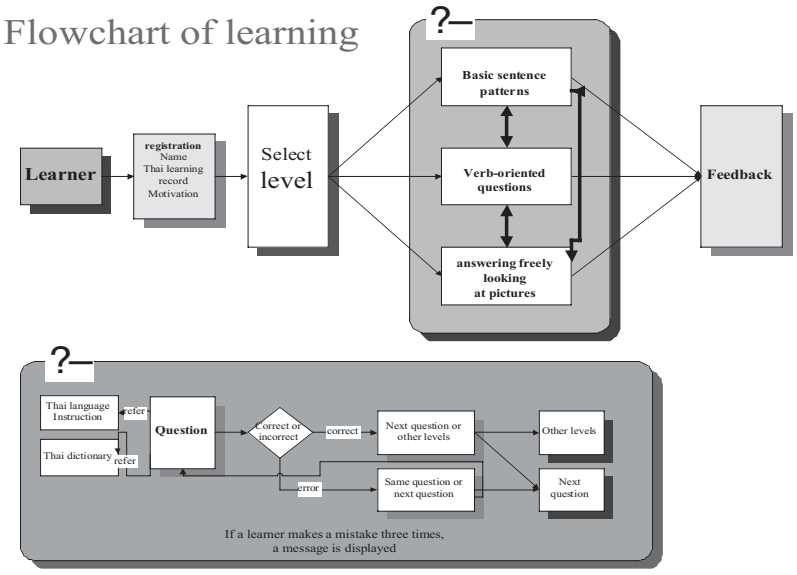


When learners enter a sentence following instructions in the task yield component and click on the submit button, Perl transmits the data to the server where Prolog analyzes the sentence. Because Prolog sits behind **TLS**'s web page, learners do not see the parsing process. After Prolog parses the sentence, Perl transmits the results from the server to the student's browser. The sentences entered during the learning session are stored in the learning history record database.

The TLS Learning Process

When learners start **TLS**, first of all, they fill in a learning history record (see Figure 2).

Figure 2
TLS Learning Process



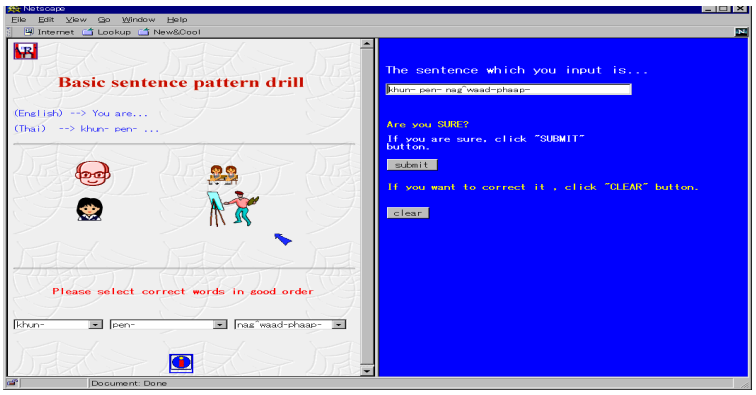
After they finish studying with the system, their complete learning history is also saved to the server.

To use **TLS**, learners select one of three levels: basic sentence patterns, verb-oriented questions and answering freely. Learners enter sentences in the basic sentence patterns and verb-oriented questions by clicking on buttons to select the items for the sentences. Learners create sentences in answering freely by referring to pictures, sounds, and the dictionary.

The TLS Graphical User Interface

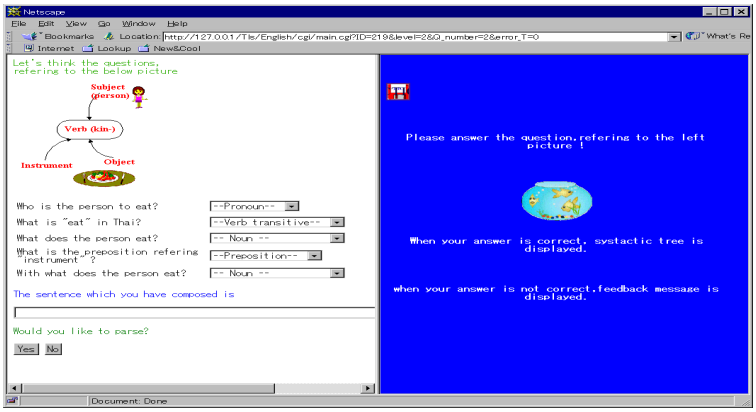
Learners interact with **TLS** by means of a graphical user interface. Figure 3 shows how learners create sentences in the basic sentence patterns exercise.

Figure 3
Basic Sentence Patterns Exercise



The instructions ask learners to select the correct words in their appropriate order for the sentence. Learners select the words in the word frames, retaining *khun- pen-* 'You are.'[3] Sounds are recorded using JavaScript, and learners can check the pronunciation of the word for each picture by clicking on the picture. When learners have selected three words from the words frames, the program displays the complete sentence. Finally, learners click on the submit button to send the sentence to the server. Prolog parses the sentence, and the results are quickly sent back to the browser. Figure 4 shows the learning sequence for the verb-oriented questions exercise.

Figure 4
Verb-Oriented Questions Exercise



Here again, learners complete the sentence in a step-by-step process according to the instructions, the pictures, the dictionary, and the sounds in the exercise. First, the instructions ask learners about the subject of the sentence and guide them to select a word from the pronoun words frame. Second, in the item shown in Figure 4, learners select a word for 'eat' from the verb transitive words frame. Learners select the remaining elements in succession from the other word frames. The final selection causes the program to display the complete sentence. Learners then click on a button to transmit the sentence to the server where Prolog parses the sentence. After processing, the results are sent back to the browser.

In the answering freely exercise, learners input sentences themselves. If they need to check the spelling of a word, they can refer to the dictionary by clicking on the dictionary button (see Figure 5). The process of analyzing a sentence is the same as in the first two exercises.

Figure 5
Learner's Dictionary

FEEDBACK

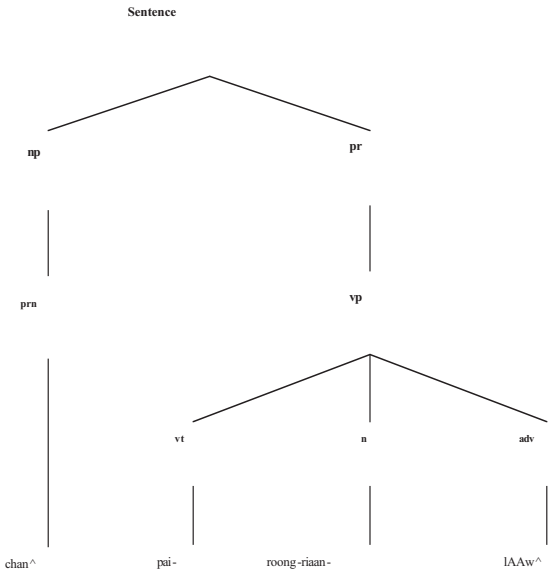
One of merits of using intelligent CALL for language learning is that NLP can provide specific diagnostic feedback to learners instead of the generic wrong-try-again feedback or other simple error messages. NLP procedures analyze errors and display that information to learners. It has been reported that sophisticated and effective feedback system contributes to improved learning (Nagata, 1995b). The feedback in **TLS** is given in the form of a syntax tree display and error processing displays.

Syntax Tree Display

The **TLS** Parser analyzes the sentence submitted by learners and outputs a structural analysis showing whether the sentence conforms to Thai phrase structure rules. The notable graphic feature of TLS is to show a syntax tree in the case of a correct sentence. The Perl module's "GD" is used for making syntax trees from text-based Prolog.

Figure 6 shows the result of the parse of the correct sentence: *chan^ pai- roong-rian lAAw^* 'chan^ [I], pai- [go], roong-rian [school], lAAw^[already].'

Figure 6
Syntax Tree

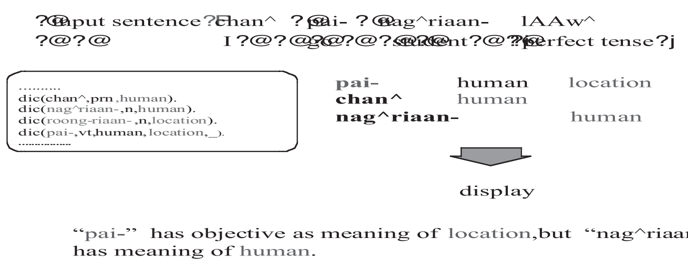


The syntax tree is much easier to understand than the results of just "yes" provided by Prolog. One of the advantages of using a syntax tree is to show the structural relations which underlie comprehension of the sentence to learners. Learning the Thai word order system depends critically on understanding the structural relations in sentences.

Error Processing

The syntax tree in Figure 6 means that the sentence is grammatically correct and semantically consistent. If the sentence is grammatically correct but semantically inconsistent, an error-processing display appears as shown in Figure 7.

Figure 7
Error-Processing Display



TLS implements error processing by referring to the computational lexicon in which the entries have two or three semantic features associated with them. By utilizing the semantic features of noun phrase constituents, **TLS** can match grammatical cases (e.g., agent, object, and location) and semantic features of the verb. In the example shown in Figure 7, the subject of the verb *Åupai-Åv* 'go' is "human," the object of the verb *Åupai-Åv* is "location," but the learner has input *nag^riaan-* 'student' as object, whose semantic feature is "human." Therefore, unification is not successful, and the error message is displayed as shown in lower part of Figure 7.

NLP AND PROLOG

The NLP component contains two databases: Thai phrase structure rules and the computational lexicon. NLP is explained in detail here because, so far as we can determine, NLP for Thai has not been discussed elsewhere.

Generally, Prolog is known as one of the suitable logic programming languages for processing natural languages because it features syntactic

and semantic analyses. These features play an important role in NLP for two major reasons. First, Prolog has a search function, which is a fundamental feature of artificial intelligence. The processing principle of the search function is unification, and unification entails identifying data that match patterns prepared and categorized in advance and also patterns of acceptable combinations. Second, Prolog allows syntactic rules to be described in the form of Definite Clause Grammar (DCG), which is similar to phrase structure grammar. This study introduces the phrase structure rules for Thai affirmative sentences as a key for sentence analysis in the language. Table 1 shows the phrase structure rules, and Table 2 shows how the rules can be applied to sample sentences.

Table 1

Thai phrase structure rules
1) S —> NP, PR
2) NP —> N
3) NP —> PRN
4) NP —> N,ADJ
5) NP —> N,PREP
6) PR —> N
7) PR —> N,ADJ
8) PR —> N,PREP
9) PR —> AD
10) PR —> ADJ, ADV
11) PR —> VP
12) PR —> MOD1,VP
13) PR —> MOD1,MOD2,VP
14) VP —> V_i
15) VP —> V_i,ADJ
16) VP —> V_i,ADV
17) VP —> V_i,PREP
18) VP —> V_i,PREP,ADV
19) VP —> V_t,N
20) VP —> V_t,N,ADV
21) VP —> V_t,N,ADJ
22) VP —> V_t,N,PREP
23) VP —> V_t,N,PREP,ADV
24) VP —> V_t,N,PREP,PREP2
25) VP —> V_t,N,PREP,PREP2,ADV
26) VP —> V_t,N,VP
27) VP —> V_t,N,VP,ADV
28) PREP—> PRE,NP

Table 2

Example sentences applied to the rules
EX. 1
S : chan^ pai- roong-riaan- lAAw^
(I went to the school)
S _ np, pr
NP _ prn
PR _ vp
VP _ vt, n, adv
PRN _ [chanˆ] (I)
V_t _ [pai-] (go)
N _ [roong-riaan-] (school)
ADV _ [lAAw^] (to make perfect tense of verb)
EX. 2
S: chan^ hai" dOOk-maai" kAA' aa-caan- thii' roong-riaan-
(I give the flower to the teacher at the school)
S _ np, pr
NP _ prn
PR _ vt, n, prep, prep2
PREP _ pre, n
PRN _ [chan^] (I)
V_t _ [hai"] (give)
N _ [dOOk-maai"] (flower)
PRE _ [kAA'] (to)
N _ [aa-caan-] (teacher)
PRE _ [thii'] (at)
N _ [roong-riaan-] (school)

Note: S = sentence, PR = predicate, NP = noun phrase, N = noun, VP = verb phrase, V = verb, Vt = transitive verb, Vi = intransitive verb, ADV = adverb, ADJ = adjective, PREP = preposition phrase, PRE = preposition, PRN = pronoun

When phrase structure rules are described as in Table 2, Prolog transfers phrase structure rules easily to DCG. For Prolog to analyze sentences, the phrase structure rules and the computational lexicon are needed.

The following example shows the sentence analysis developed by Prolog.

Som^chai- kin- AAb'peen" duuai" miid"
(Somchai) (eats) (apple) (with) (knife)

When the learner inputs the above sentence, Prolog parses the sentence and displays the result as

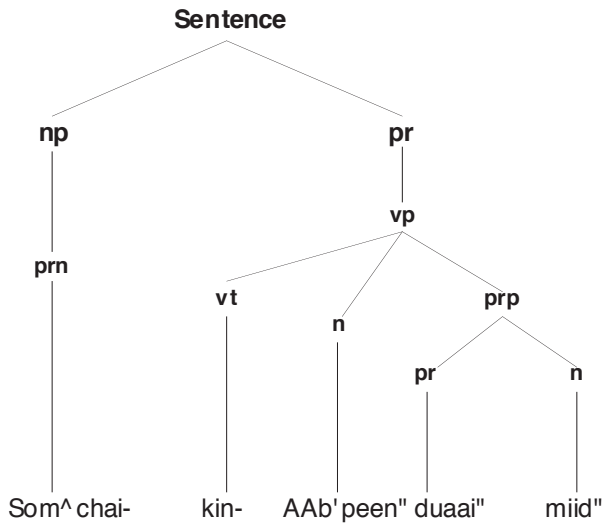
```
|?s(S,SE,[Som^chai-,kin-,AAb'peen",duuai",miid"],[],). ----------------------------------------(1)
S=s(np(prn(Som^chai-)),pr(vp(vt(kin-))),n(AAb'peen"),prp(pr(duuai")),n(miid")).----(2)
SE=[[agt:[animate:[human]]],[obj:[eatable]],[inst:[tool]]] ----------------------------------(3)

Yes
```

The upper third of the line "SE=[[agt:[animate:[human]]],[obj:[eatable]], [inst:[tool]]]" shows the details described in the sentence as "[An animate agent, being a human name Somchai][eats an edible object called an apple][with instrument called a knife]". The result "yes" means the sentence is grammatically and semantically correct. In the following output line, Prolog parsed the statement as

"S=s(np(prn(Som^chai-)),pr(vp(vt(kin-))),n(AAb'peen"),prp(pr(duuai")),n(miid")).”

which has the same structure as the syntactic tree in Figure 8.

Figure 8
Syntactic Tree of the Sample Sentence



The phrase structure rules and the computational lexicon (with added semantic features) produce structures such as those in Figure 9.

Figure 9
Phrase Structure Rules and Computational Lexicon

```
S(S(NP,PR))        ---->  np(NP,SEMF),pr(PR,SEMF).__
np(n(N),SEMF)      ---->  n(N,SEMF).

_____
n(n(Word),SEMF)    ---->  [Word],{dic(Word,n,SEMF)}.
prn(prn(Word),SEMF) ---->  [Word],{dic(Word,prn,SEMF)}.

___

……

%Thai Dictionary%
dic(Som^chai-,prn,human).
dic(Aab'peen",n,eatable).
dic(kin-,vt,animate,eatable,_).
```

If the learner inputs the sentence

Su'da kin- ka'daard duuai" miid"
(Suda) (eats) (paper) (with) (knife).

the result of analysis becomes

|?s(S, SE, [Su'da, kin-, ka'daard, duuai", miid"], [],).

no.

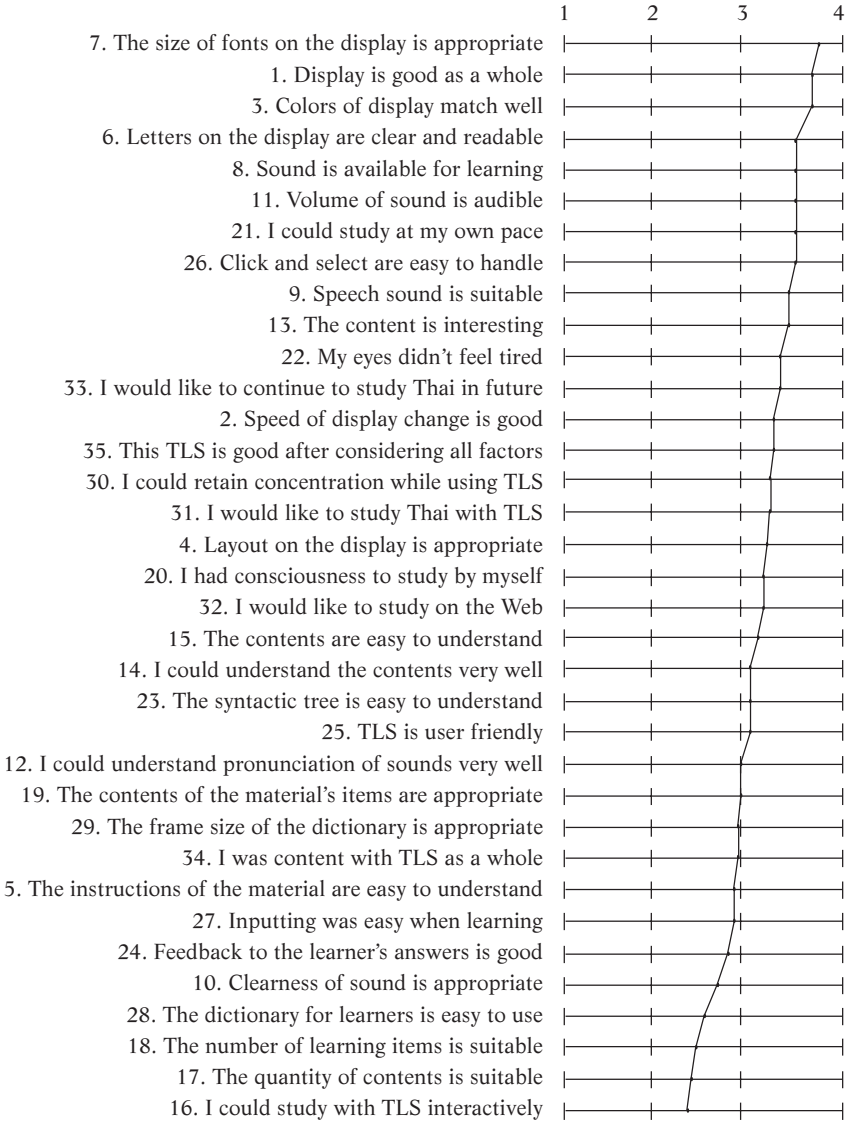
The result with "no" means the sentence is grammatically correct but semantically incorrect because *ka'daard* 'paper' is not an edible object.

EVALUATION OF THE SYSTEM

Procedure

In order to evaluate the extent to which **TLS** is easy for learners to use and helpful to them in learning Thai, a questionnaire focusing on these questions was distributed to 27 learners (see Figure 10).

Figure10
Graph of Mean Learner Responses to Questionnaire Items



These data were submitted to factor analysis which yielded four common factors from the learners' responses, labeled here as (a) learning motivation, (b) learning satisfaction, (c) speech voice, and (d) system. The total contribution of the four factors was 53%. Table 3 shows the common factors with their interpreted items, factor loading greater than .50.

Table 3
Common Factors

	Factor items	Factor loading
Factor 1, learning motivation: contribution rate of 18%		
31	I would like to study Thai with TLS.	0.78
21	I could study it at my own pace.	0.74
35	This TLS is good after considering all the factors.	0.74
20	I had consciousness to study autonomously by myself.	0.72
33	I would like to continue to study Thai with TLS in future.	0.72
32	I would like to study on the Web.	0.71
25	TLS is user friendly.	0.70
30	I could retain concentration while using TLS.	0.58
22	My eyes didn't feel tired.	0.53
13	The content is interesting.	0.53
Factor 2, learning satisfaction: contribution rate of 13%		
	Factor items	Factor loading
14	I could understand the contents very well.	0.72
23	The syntactic tree is easy to understand.	0.70
24	Feedback to the learner's answers is good.	0.68
15	The contents are easy to understand.	0.64
16	I could study with TLS interactively.	0.59
34	I was content with TLS as a whole.	0.50
27	Inputting was easy when learning.	0.50
Factor 3, speech voice: contribution rate of 12%		
	Factor items	Factor loading
10	Clearness of sound is appropriate.	0.82
11	Volume of sound is audible.	0.79
12	I could understand pronunciation of sounds very well.	0.78
9	Speech speed is suitable.	0.78
Factor 4, system: contribution rate of 10%		
	Factor items	Factor loading
18	The numbers of learning items is suitable.	0.84
17	The quantity of contents is suitable.	0.69
1	Display is good as a whole.	0.65
2	Speed of display change is good.	0.56
34	I was content with this TLS as a whole.	0.54

Differences by Major

The difference between liberal arts students and science students was investigated by conducting t-tests between the groups for each common factor. Table 4 shows the results of this analysis.

Table 4
Comparison of **TLS** Evaluation by Liberal Arts Versus Science Students

Major		Learning Motivation	Learning Satisfaction	Speech Voice	System
Liberal Arts students (N = 7)	Mean	3.46*	2.92	2.92	3.14
	SD	0.63	0.79	0.88	0.73
Science students (N = 20)	Mean	3.23	2.89	2.89	2.86
	SD	0.77	1.00	0.89	0.89

*$p < .05$

Both groups rated learning motivation higher than the others, and the liberal arts students rated this factor significantly higher than the science students.

Differences by Age

It has been claimed that people more than 39 years of age tend to have difficulties using computers. However, being older did not lead the learners to view the system unfavorably (see Table 5).

Table 5
Comparison of **TLS** Evaluation by Age Groups

Age		Learning Motivation	Learning Satisfaction	Speech Voice	System
39-55 (N = 13)	Mean	3.43*	2.99	3.13	2.91
	SD	0.73	1.02	0.89	0.96
22-38 (N = 14)	Mean	3.16	2.81	3.14	2.96
	SD	0.74	0.87	0.90	0.75

*$p < .005$

The 39-55 age group and the 22-38 age group rated learning motivation and speech voice higher than the other factors, and the 39-55 age group rated learning motivation significantly higher than the 22-38 group.

Differences by Gender and Place of Study

Differences between groups of male and female learners were also investigated (see Table 6).

Table 6
Comparison of **TLS** Evaluation by Gender

Gender		Learning Motivation	Learning Satisfaction	Speech Voice	System
Male (N = 16)	Mean	3.23	3.05*	3.09	2.91
	SD	0.76	0.86	0.89	0.84
Female (N = 11)	Mean	3.37	2.66	3.20	2.96
	SD	0.71	1.02	0.90	0.88

*$p < .05$

Both male and female students rated learning motivation and speech voice higher than the others, and male learners rated learning satisfaction significantly higher than female learners.

An important qualification needs to be made to this result. The difference between the group of men and women concerning learning satisfaction was affected by the learners who accessed **TLS** on campus versus those who accessed it at home. Because the percentage of men using **TLS** on campus was 81.25% versus only 18.19% of the women, t-tests were conducted on this variable (see Table 7).

Table 7
Comparison of **TLS** Evaluation by Location

Place from which the Internet was accessed		Learning Motivation	Learning Satisfaction	Speech Voice	System
On campus (N = 15)	Mean	3.28	3.02*	3.03	2.94
	SD	0.72	0.90	0.91	0.83
At home (N = 12)	Mean	3.31	2.71	3.30	2.93
	SD	0.79	0398	0.85	0.90

*$p < .05$

Learners who accessed **TLS** on campus rated learning satisfaction significantly higher than those who accessed it at home.

CONCLUSION AND FUTURE DIRECTIONS

The **Thai Learning System** was developed as an intelligent CALL system to help learners acquire Thai word order and to input sentences correctly, taking advantage of the merits of Prolog. Offering **TLS** on the web allows learners to access the system at any time from any location. Evaluation of the system shows that learners rated learning motivation and speech voice highly. Older learners and Liberal Arts students especially gave learning motivation high ratings. These results supply evidence that TLS reached its objective of offering a user-oriented interface, handling learners' input, and being useful in learning Thai. Learners who accessed TLS on campus rated learning satisfaction higher than those who accessed it at home. It

should be noted that the on-campus facility had high speed access and that learners at home had slower speeds of access.

As the industry and technology in Thailand have developed and the relationship between Thailand and other countries has deepened, opportunities for communication with Thai speakers have increased considerably. Not only have Thais been learning the languages of industrialized countries, but people of these countries have also started learning Thai. Research into teaching and learning Thai as a second language has only just begun. **TLS** is helping to meet this need. In the future, **TLS** will be extended and redesigned to help develop learners' oral and written language skills within multiple perspectives.

NOTES

[1] **TLS** was developed on an apache server, SICStus3.0 Perl for win32, and MS-Access. MS-Access was used for learners' histories. As a Perl module, ODBC for the database, CGI interface, and GD for syntactic trees was used.

[2] The Intelligent Systems Laboratory used Sicstus Prolog; the Swedish Institute of Computer Science was used for **TLS**. **TLS** runs on Netscape 3.0 and later versions.

[3] In this study, roman transcriptions recommended for "social Thai culture" were used.

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