VP^2: THE ROLE OF USER MODELLING IN CORRECTING ERRORS IN SECOND LANGUAGE LEARNING*

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ABSTRACT

This paper describes a system, VP^2, that has been implemented to tutor non-native speakers in English. The system differs from many tutoring systems by employing an explicit model of its users. This model contains knowledge of the student's native language which enables the system to customize its responses by addressing problems due to interference of the native language. The system focuses on the acquisition of English verb–particle and verb–prepositional phrase constructions. Its correction strategy is based upon comparison of the native language model with a model of English. VP^2 recognizes syntactic variation in English sentences, allowing freer translation. VP^2 is a modular system: its model of a user's native language can easily be

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replaced by a model of another language. The problems and solutions presented in this paper are related to the more general question of how modelling previous knowledge facilitates instruction in a new skill.

1. INTRODUCTION

Many sophisticated, intelligent tutoring systems have been developed for Computer Assisted Instruction (CAI) (Collins *et al.*, 1975; Brown *et al.*, 1975; Weischedel *et al.*, 1978), that use Artificial Intelligence (AI) techniques. These systems have been developed with the hope that AI techniques will play an important role in education. The fundamental motivation for building intelligent computer tutoring systems is the immense success that human tutors have on an individual basis as compared to group or classroom instruction. Human tutors working individually with students are generally more effective in their teaching than instructors in the classroom (Bloom 1984). The expectation then, when building intelligent tutors, is to find ways of emulating individual human tutors with computers.

Cooperative CAI systems should include a *model* of relevant aspects of users' prior knowledge to predict and prevent errors or detect and correct them more easily. A well-known claim is that people often rely heavily on their previous knowledge when learning a new skill (Winston, 1980; Rumelhart and Norman, 1981). This previous knowledge can sometimes hinder their learning (Halasz and Moran, 1982). In other words, people reason by analogy from a previous skill and these analogies are sometimes incorrect. Many errors caused by such reasoning can be predicted if prior knowledge is taken into account.

The development of the system described here, VP^2, makes an interesting claim about language understanding and knowledge representation—namely that speakers' grammars can serve as user models. VP^2 addresses the following question: How can correspondences between the grammars of two languages provide an account of grammatical errors made by native speakers of one language attempting to learn the second language?

VP^2 focuses on the acquisition by non-English speakers of English verbal constructions formed from a verb plus particle or verb plus prepositional phrase. The system is provided with forms in both languages, from which it deduces the reasons for errors and tailors its response accordingly. Thus, it deals with the problem of the influence of previous knowledge when learning material that may be similar to already known material. The ultimate goal of VP^2 is not only to identify particular mistakes and point out their possible causes to the student but also to explain the differences and similarities between the verbs of the two languages in focus.

VP^2 allows some flexibility in the English translations it will accept as correct. That is, the order of the words in the sentence that the student enters does not have to be exactly the same as the order of the given sentence. Further more, VP^2 is a modular system: its model of a user's native language can easily be replaced by a model of another language.†

2. IDENTIFYING THE PROBLEM

According to Cowie and Mackin (1982), familiarity with a wide range of idiomatic expressions, and the ability to use them appropriately in context, are among the distinguishing marks of a native speaker of English. Expressions such as **go over** (to review, to be received), **look on** (to watch), and **get ahead** (to make progress, to succeed) are part of the everyday conversational exchanges, and the tendency, especially in everyday use, to prefer these combinations over their single equivalence—review, watch, succeed—helps to explain the widely-held view that idioms such as these are among the most characteristically 'English' elements in the general vocabulary. Cowie and Mackin claim that 'to say that such expressions are used widely does not necessarily imply that their meanings are always self-evident' [p. vi]: a Spanish speaker would most likely understand **watch** better than **look on**, while a native English speaker may have some difficulty in explaining the sense of the combination in terms of its constituent parts.

One theory of second language acquisition—the theory of Contrastive Analysis (Lado, 1957)—predicts that non-native speakers of a language will tend to use forms that exactly match 'those of their native language. For example a native speaker of Spanish may talk of (1–1)‡

(1–1) * thinking *in* buying a house
(1–2) pensando *en* comprar una casa

since it appears to be a direct translation of (1–2) instead of (2–1) or (3–1), while the direct translations in (2–2) and (3–2) are ungrammatical in Spanish.

(2–1) thinking *of* buying a house
(2–2) * pensando *de* comprar una casa

(3–1) thinking *about* buying a house
(3–2) ? pensando *acerca* de comprar una casa

In VP^2 we demonstrate how a tutoring system can rely on the principles of Contrastive Analysis to assist a non-native speaker of English in his/her learning of the usage of verbs and prepositions and/or particles.

3. SCOPE OF PHENOMENON

Traditionally, constituents of sentences in a given language have been

†Note that one would not replace the target language, since the use of certain verbs with prepositions/particles is a feature of a particular language, namely English. The system would have to be changed somewhat to tutor a different grammatical phenomenon.

‡The symbols used in the examples for grammaticality judgement are as follows:
no mark –acceptable;
? – marginally acceptable;
* – unacceptable

divided into open and closed class items. Open class items include nouns, adjectives, adverbs, and main verbs. Closed class items include prepositions, particles, conjunctions, determiners, quantifiers, complementizers, possessives, pronouns, and auxiliary verbs.

Acquisition of the closed class items has been shown to be particularly problematic (Kean, 1979) for second language learners. Evidence for this is the large number of incorrect uses of closed class items observed among non-native speakers of English.

For the purpose of this system we will characterize English verbs and preposition/particle as follows:†

Verb–Particle—sometimes called two-word verbs, these consist of a lexical verb followed by a modifier. These verb-particle forms cannot be 'created' by arbitrarily combining any verb with any preposition or particle. For example:

(5–1) Vanessa *ran into* Moris in the street.
(5–2) Raquel and Tania will *talk over* our proposal
(5–3) She *filled up* the container.

In a sentence like *She filled up the container*, *up* serves as a particle. It can appear after the verb or after the object as in *She filled the container up*. If the object is a pronoun, it must precede the particle as in *She filled it up* —not *She filled up it*. A verb–particle combination is a grammatical unit which fulfills normal verb functions in English sentences. Like other verbs, it may be transitive, intransitive or bi-transitive, depending on whether it is followed by zero, one or two noun phrase objects. It is also a semantic unit that has a meaning which often differs from the sum of its parts.

Verb–Preposition—these are any other verb-prepositional phrase sequences. For example,

(6–1) Vanessa *ran* into the street
(6–2) Raquel and Tania usually *talk* over the fence.

This construction allows syntactic movements — that is, the prepositional phrase can be fronted as in the following:

(7–1) *Into the street* ran Vanessa
(7–2) *Over the fence* Raquel and Tania talk.

4. GOALS OF THE APPROACH

Tutoring systems which do not retain user models might behave inadequately in teaching different subjects. Without such a model, the system may not realize the causes of errors and hence it may be unable to provide

†*The Key to English: Two-Word Verbs*, Collier-Macmillan: New York, 1977.

the most adequate explanation for its occurrence. Consider the following interaction between a tutor for English and its student:

Tutor: TRANSLATE THE FOLLOWING SENTENCE
Pensaba en estudiar Inglés.
Student: I thought in studying English.
Tutor: Incorrect. The correct answer is 'I thought of studying English. or 'I thought about studying English'. In English, you can use the verb <to think> as in the following cases:
— 'There is little opportunity to <think out> what the long-term solution may be'.
— 'With the beginning of the new day we had to <think> things <over> again'.
— 'She has to <think up> a catchy name for this system'.

The system here provides the correct answer but it fails to recognize the source of the student's error (using a word by word translation strategy) and to offer corrective advice. The system's assumption is that there is a correct answer and that answer is the one it expects without any further issues being considered. Here, the tutor could have provided a 'more adequate explanation' by informing the user of where the error is. The system could have added:

Note that <en> is often translated as <in> in English but here it is not.

In order to provide 'the most adequate explanation', the tutor must be able to retain some model, no matter how simple, of the user's knowledge, especially of the user's knowledge of related domains that may *interfere* in their learning. This is the point of departure of this work: to see what role users' familiarity with one language (Spanish) plays in their learning a new language (English). This study provides the basis for the main features that must be included in the development of tutorial systems in order to: (1) detect errors when they occur; (2) adequately correct errors when they occur; (3) tailor the response to the user. Farrell *et al.* (1984) have claimed that human tutors can give good tutorial assistance because they can infer a model of the student's knowledge. In this work, we hope to use the user model actually to achieve the most satisfying results.

5. FORM OF INSTRUCTION

VP² is designed to interact with students who have acquired most of the English vocabulary and syntax and who have a basic knowledge of grammatical terms. All instructional information is given in English. VP² presents the student with translation exercises which are designed to provide additional practice in using language constructs rather than to substitute for classroom instruction.

In this set of exercises, the student is presented with a sentence in Spanish and is asked to translate it into English. After the student translates the sentence, the tutor looks for errors in the use of two-word verbs, i.e. the use of a wrong verb–preposition combination or incorrect particle. If the tutor finds such an error, it examines its model of the student's native language to locate the source of the error. Given this information it can then correct the error and explain to the student its probable cause. It may also make general comparisons between the verb forms used in Spanish and English. If an error is not seen as coming from the native language, the tutor provides the correct answer and proceeds to the next exercise.

6. USER MODEL IN VP²

Instead of having a stereotyped user model or individual user models for each user, VP² has a canonical user model, that is, a more general model describing the grammar of the student's native language. The user model consists of a Spanish grammar. This information is assumed to be standard for all Spanish speakers. One may argue that there are several dialects of Spanish and that the grammar represented in the system does not exactly correspond to the one the user has. We have considered a grammar of standard Spanish to be the universal for this system because the issues addressed in this work do not focus on idiomatic expressions but on specific language structures: the use of verb and prepositions, and verb with particles. These constituents do not typically vary between idiolects.

A student's knowledge of Spanish may either *enhance* or *hinder* his/her current learning of English. The latter is of primary interest here: because of his/her knowledge of Spanish, the student tends to draw inferences that may cause incorrect English forms.

6.1. Knowledge facilitates performance

First let us consider the case in which the student's knowledge of Spanish (and basic English words) facilitates the student's performance:

TUTOR:	TRANSLATE THE FOLLOWING SENTENCE: Yo escribo con el lápiz.
STUDENT:	I write with the pencil.
TUTOR:	Correct! Notice that the preposition <con> corresponds to the English <with> and it appears in the same position in the sentence.

In this example, the student provides the correct answer and the tutor responds with additional information within the context of what the student **knows**. VP² uses the information in its user model in order to provide more adequate and 'customized' answers.

We cannot tell whether the student has translated from Spanish or not in this sentence. All the system can do is point to the fact that indeed if direct translation was used for this sentence, it worked. This example demonstrates that at least sometimes, 'the knowledge that the speaker brings with him facilitates rather than hampers his second-language performance (Dommergues and Lane, 1976, p. 121)'.

6.2. Knowledge hinders performance

There are times when the influence of the student's previous knowledge causes him/her to answer incorrectly. When the student's previous knowledge affects the learning of new information the tutorial system should be able to recognize his/her errors and correct them. Consider the following:

TUTOR:	TRANSLATE THE FOLLOWING SENTENCE Moris pensó en comprar un carro.
STUDENT:	Moris thought in buying a car.
TUTOR:	You used the incorrect preposition <in>. In English you can use <think of> or <think about> in this sentence. Note that the direct translation of *<think of>—<pensar de>—* *does not exist in Spanish.* In English you can also use <think up> (an excuse, invent); <think over> (review); <think out> (consider, examine).

A response as in the previous example is not only more helpful but it reassures the student that the tutor is responding to his/her particular error. This situation requires the system to maintain a model of the student's native language or at least of the way verbs and prepositions are paired in Spanish. Tutorial systems that do not have user models may leave the students to determine the relationship between the use of certain structures or patterns in the new domain (or language) by themselves. We have also seen (Schuster, 1983) that users of some help systems pose their questions in the framework of their previous knowledge, leading us to believe that the learning experience could be enhanced by a system that explictly describes similarities and differences.

7. DESIGN OF VP²

VP² has been implemented in Prolog†. Prolog was chosen as an implementation vehicle because it provides good pattern matching mechanisms and linguistic analysis tools. Prolog has a convenient grammar rule formalism, the *Definite Clause Grammar* (DCG) (Pereira and Warren, 1981). DCGs not only provide a description of a language but an effective means for

†Currently in UNH Prolog 1.3 (University of New Hampshire) on a VAX-11/785.

analysing strings in that language. VP^2 uses two grammars: one grammar for Spanish and one for English. These grammars include the dictionary of words that are part of the system. The complete grammars with their dictionaries appear in Schuster (1984). VP^2 parses the English sentence that the student types and extracts its verb and any prepositions in order to check for the correct translation and checks it against the information provided in the user model about those verbs and prepositions in Spanish.

The control structure of VP^2 handles the interaction with the student and works in the following way. It begins by displaying an introductory message and an explanation of the possible commands that s/he can type. VP^2 has information about the verbs in each language and their prepositions. In English, the entries for verbs have six arguments, indicating form, root, tense, number, aspect, and prepositions that may be used with that particular verb. In Spanish, they have an additional entry indicating their regularity. For example:

IN ENGLISH:

is-verb(dreams, dream,inf,sing3,tran,of).

IN SPANISH:

is-verb(sueña,soñar,present,sing3,tran,irr,con).

In addition, a parse tree is stored for the correct answers to each exercise. These parse trees are matched against the user's answers in order to locate any errors in those answers. For now, we have chosen to store these parse trees because the system only has a few exercises.† The system also has a table of direct translations of verbs and prepositions.‡ In addition VP^2 has grammar rules for both Spanish and English.

VP^2 goes through the following procedure in order to figure out the answer and provide the most adequate response.

— It presents the student with the Spanish sentence to translate.

— It accepts as input the student's English translation, which it attempts to parse using the English grammar. The parse will fail if the input contains unknown words and mis-spellings or unknown constructions outside the verb phrase. Sentences without particles or with the wrong prepositions, which cannot be parsed by the standard English grammar, are parsed using the Spanish grammar rules, providing the system with a parse.

— If a parse is obtained (using the English grammar and if not successful, the Spanish grammar), the system compares it with the store parse tree for this sentence in order to make sure that it is indeed the appropriate

†If the system is expanded to work with a larger number of exercises, we will allow the system to generate the correct parse trees instead of having them stored.

‡Remember that by 'direct translation' we mean the most common translation used for a certain word, the one one would find in looking up that word in a dictionary. This is different from the 'corresponding translation' which is the actual translation of the words and which varies in the context of the sentence. For example, the direct translation of <con> is <with> while the corresponding translation of <con> when used with the verb <soñar>, <to dream>, is <of> or <about>.

translation. If the translation that the student provides can be parsed but it is not the translation of the given sentence, the system allows the student to try again. If the parse has succeeded and corresponds to the stored parse tree, VP^2 takes its verb phrase, looks up the direct translation of the verb and its preposition and matches this translation against the verb in the user model (i.e. the Spanish lexicon). Based on this it can indicate to the user any differences in the translations and any additional information about the verb in English or Spanish. For example, if the student types:

TUTOR: TRANSLATE THE FOLLOWING SENTENCE:
Yo soñé con los angeles.
STUDENT: I dreamed of the angels.

the system provides an answer such as:

Correct!
Note that the direct translation of <soñar con>
—<dream with>—does not exist in English.
In English you can also use <dream about>
in this sentence.

— If the parse does not correspond to the stored parse and it is correct by Spanish rules, the system matches the verb phrase from the failed parse against the previously stored correct parse to determine the differences between the correct stored parse and that of the student's. From this comparison, it finds the wrong prepositions and/or missing particles. If it finds an incorrect preposition with a correct verb, it looks up the direct Spanish translation of the incorrect preposition. For example, if in the previous example the student typed:

I dreamed with the angels.

the system obtains the incorrect pair <dream with>, looks it up in its table of direct translations and finds it to be <soñar con>. VP^2 proceeds to its user model and finds this pair in it. Therefore it is able to explain the incorrect preposition. It generates an error message indicating the error as being due to interference from Spanish. It then goes to the English grammar and looks up the correct preposition(s) that go with the verb and provides the student with more information, e.g. other prepositions that can be used and so on. For example, VP^2 provides the student with information about other preposition(s) that may be used with a verb:

In English you can use <dreamed of> or
<dream about> in this sentence.

Whether or not errors are found, VP^2 looks at the user model to provide additional information that may prove helpful to the student. As described earlier, VP^2's user model currently consists of a grammar of Spanish. This certainly contains more information than is needed to perform the current

task—recognizing and responding to student errors in translating two word verbs. It is our goal to extend this system by incorporating additional specialists which can use *the same user model* to recognize and respond to other errors, such as verb-subject agreement, correct verb tense and number agreement.

8. RECOGNITION OF ERRORS

The errors that students produce in using verbs with their prepositions in English can be categorized into three different types:

8.1. Missing particle

Where Spanish uses a single verb and English uses a verb particle combination, it is likely that native speakers of Spanish translate the verb from Spanish without including the particle. For example

TUTOR: Vanessa pone el disco.
STUDENT: Vanessa puts the record
TUTOR: You did not use the particle that goes with <puts>.
The corresponding complete translation of the verb is <puts on>.
Even though the verb can be translated into a one-word verb in Spanish, in English you need both the verb and the particle

In this example, the system obtains the parse of the English sentence that the student has typed along with the stored parse tree of the correct sentence. The system then matches the two to figure out the differences. From here, the system can notice that the particle that goes with the verb is missing—that is, it obtains the pairs <put>-__ and <put>-<on> and notices the differences. VP^2 then looks up in its translation table the direct translation of <put>, finds it to be <poner>. Next it looks at the information about the verb <poner> and preposition in its user model, finds that the <poner> verb in Spanish has no particle for this meaning. It then deduces the cause of the error, that there is a missing particle.

8.2. Additional Preposition

In Spanish, the verb <ir> —<to go>— requires a preposition after it, e.g. <a> and <con>, which correspond to <to> and <with> respectively. Sentences that include the verb <ir> with <a> usually imply 'going to do something' as in the following example:

(8–1) Se fué a correr.
(8–2) He went to run.
(8–3) He went running.

It may be the case that a native speaker of Spanish would use the additional preposition <to> and produce sentences such as:

(9–1) * He went to running.
(9–2) ? He went to run.

as translations to (8–1). In this case, the system checks the parse of the student's input, compares it with its own stored parse, and obtains the pairs <went>-<to> and <went>-__. It looks up the translation of <went> and <to> in its table, finds them to be <fué> and <a> respectively and looks up this pair in the user model to deduce the occurrence of the additional preposition <to>. It then provides an appropriate answer indicating the redundancy.

8.3. Incorrect preposition

Where both English and Spanish use a verb + preposition, but the prepositions don't correspond, another set of errors occur. For example, <pensar en> is translated as <think in>, <soñar con> is translated as <dream with>.

VP^2's approach to handling these errors is again by first finding out if the sentence is correctly translated into English. Note that the English sentence may be grammatical but not the correct translation. If it is not, it obtains the 'correct' translation for the sentence, matches it against the one the student types and notices the differences. VP^2 then looks at the user model to obtain information about the verb and preposition in Spanish and then matches that information with the 'incorrect' English sentence from which it can find the errors caused by direct translation of the preposition from Spanish to English.

9. CONCLUSIONS

Earlier work (Douglas and Moran, 1983; Schustack and Anderson, 1979) has shown that people often rely on their knowledge of one domain when learning a new similar domain. That seems to be the case for language learning where students learning a second language use much of the knowledge they have of their native language (Lado, 1957).

VP^2 has addressed the question of how we can represent the knowledge of certain aspects of a language in a computer system and use this knowledge to provide the student of a second language with information tailored to his/her knowledge. In particular, it has focused on the problem of how correspondence of grammars of two languages can provide a sufficient basis for explaining the possible origin of grammatical errors made by native speakers of one language when learning a second one.

VP^2 provides some insights into how instruction in a second language might be augmented. With the system being able to determine the errors

in the usage of verbs and prepositions and/or verbs with particles and explain them in terms of the student's native language, it is hoped that the learning process will become more efficient and therefore more satisfactory for the student.

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