Knowledge-Based Systems 22 (2009) 496–501

Contents lists available at ScienceDirect

Knowledge-Based Systems

journal homepage: www.elsevier.com/locate/knosys

Designing a feedback component of an intelligent tutoring system for foreign language

Anita Ferreira [b], John Atkinson [a,*]

[a] Department of Computer Sciences, Universidad de Concepcion, Concepcion, Chile
[b] Department of Spanish Linguistics, Universidad de Concepcion, Concepcion, Chile

ARTICLE INFO

Article history:
Available online 19 January 2009

Keywords:
Intelligent tutorial systems
Computer-assisted language learning
Natural-Language Processing
Feedback generation

ABSTRACT

In this paper, we provide a model of corrective feedback generation for an intelligent tutoring system for Spanish as a foreign language. We have studied two kind of strategies: (1) Giving-Answer Strategies (GAS), where the teacher directly gives the desired target form or indicates the location of the error and (2) Prompting-Answer Strategies (PAS), where the teacher pushes the student less directly to notice and repair their own error. Based on different experimental settings and comparisons with face-to-face tutoring mode, we propose the design of a component of effective teaching strategies into ITS for Spanish as a foreign language.

1. Motivation

The design of Intelligent Tutorial Systems (ITS) is founded on two fundamental assumptions about learning. First, individualized instruction by a competent tutor is far superior to the classroom style because both the content and the style of the instruction can be continuously adapted to best meet the needs of the situation. Secondly, students learn better in situations which more closely approximate the situations in which they will use their knowledge, i.e. they learn by doing, by making mistakes, and by constructing knowledge in a very individualized way. Empirical evidence has shown that tutorial mode is superior to normal learning experiences in traditional classroom settings, and it is mainly due to conversational dialogue patterns [8] which facilitate the treatment of errors and correction in tutorial mode. Chi and colleagues [3] have suggested that students have greater opportunities to be constructive in tutorial mode than in a traditional classroom.

Feedback and guidance moves (such as prompting, hinting, scaffolding, and pumping) have been investigated at some length by researchers working on Intelligent Tutoring Systems (ITS) for teaching procedural skills in domains such as algebra, geometry, physics and computer programming [2,3,10,15]. However, little attention has been paid to feedback in the domain of ITS for foreign languages. As suggested by Ferreira et al. [7], this situation seems to have arisen for at least the following reasons:

- *The specific and complex nature of errors and corrective feedback in ITS for foreign language:* The main finding of studies of error treatment is that it is an enormously complex process. This can be seen in the different models of feedback and the different taxonomies of feedback strategies that have been proposed. Some of these strategies are markedly different from those typically found in ITSs for procedural domains.
- *The relative merits of different types of feedback are still not fully understood in the area of Second Language Acquisition (SLA):* The results of empirical investigations indicate that the relative merits of different types of feedback are not fully understood. Furthermore, the relative effectiveness of feedback strategies depends on multiple variables, including the particular aspects of the language being corrected, conditions relating to the provision of teacher correction, and characteristics of the students (e.g., sophisticated grammatical explanations are not appropriate for beginning students).
- *The lack of empirical research on the effectiveness of ICALL for foreign language, in general, and feedback strategies in particular:* ITS and ICALL systems have not yet incorporated the strategies that are typically used by second and foreign language teachers and studied by SLA researchers.
- *The lack of awareness of results from SLA research by researchers in the ICALL and ITS communities:* Most ITS and ICALL systems appear to be created without reference to the many research studies concerning language learners' abilities, that is, how they may best learn languages, and how teachers deal with students' errors. We believe that to improve the effectiveness of ICALL systems for teaching foreign language, designers should pay more attention to the results emerging from SLA research.

* Corresponding author.
E-mail addresses: atkinson@inf.udec.cl (A. Ferreira), aferreir@inf.udec.cl (J. Atkinson).

0950-7051/$ - see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.knosys.2008.10.012

ITS systems for foreign language (FL) learning have incorporated Natural-Language Processing (NLP) techniques to analyze learners' language production or model their knowledge of a FL, in order to provide learners with flexible feedback and guidance in their learning process. These systems use parsing techniques to analyze the student's response and identify errors or missing items. This allows systems to produce sophisticated types of feedback, such as meta-linguistic feedback and error reports, to correct particular student errors [4,9].

In this paper, we have designed a model of corrective feedback based on the main tendencies suggested by results obtained from previous empirical studies [7]. Our main contribution is to experimentally identify the main factors that indicate which learning strategy to use for corrective feedback in a given tutoring situation. This aims at informing the design of intelligent CALL systems for foreign language learning.

2. Feedback in ITS for FL

ITS for FL have incorporated NLP techniques, e.g., analyzing language learners' language production or modeling their knowledge of a second language to provide the learners with more flexible feedback and guidance in their learning process [4,11]. An outstanding example is the E-Tutor, an online Intelligent Language Tutoring System developed by [9] for German. It provides error-specific and individualized feedback by performing a linguistic analysis of student input and adjusting feedback messages suited to learner expertise. The E-Tutor also provides individualized, context-sensitive help on the errors students are making. The web-based E-tutor system ranks student errors by using a flexible Error Priority Queue: the grammar constraints can be reordered to reflect the desired emphasis of a particular exercise. In addition, a language instructor might choose not to report some errors. The experience with E-tutor supports the need for a CALL system that addresses multiple errors by considering language teaching pedagogy.

Other successful ITS system called *BANZAI* [16] for Japanese employs NLP technology to enable learners to freely produce Japanese sentences and to provide detailed feedback concerning the specific nature of the learner's errors. The tutor incorporates 24 lessons covering the grammatical constructions encountered in a standard undergraduate curriculum. It accepts inputs in kana and kanji, and presents relevant photographic and graphical images of Japan and of everyday situations. In addition, BANZAI allows the learner to produce any sentence because it can identify parts of speech and syntactic patterns in the learner's sentence, on the basis of the general principles of Japanese grammar. Based on these grammatical principles, BANZAI determines whether the sentence is grammatical or not and generates intelligent feedback targeted to specific deficiencies in the learner's performance.

The BANZAI NLP analyzer consists of a lexicon, a morphological generator, a word segmentor, a morphological parser, a syntactic parser, an error detector, and a feedback generator. Japanese writing does not leave a space between words, so the BANZAI word segmentor divides the learner's input sentence (a typed character string) into lexical items, referring to the BANZAI lexicon. Several different segmentations and lexical assignments are often possible for one character string. For example, nihon can be identified as nihon 'Japan', ni 'two' and hon (counter for long objects), or ni (particle) and hon 'book', etc. The word segmentor finds all possible segmentations and lexical assignments. The BANZAI morphological parser combines segmented words into noun compounds or final verb forms (if any) in the input sentence. On the other hand, the BANZAI syntactic parser determines whether the input string is a grammatical (well-formed) or ungrammatical (ill-formed) sentence. The parser uses context free phrase structure rules to build words into phrases and phrases into sentences by means of a bottom-up parsing technique. If it cannot build all of the words in the given string into a sentence, the string is ungrammatical. The BANZAI syntactic parser includes 14 context free phrase structure rules, and each rule is consecutively applied to process the input.

3. Empirical studies in Spanish feedback corrective

Errors and corrective feedback constitute a natural part of the teaching–learning process in a FL. Errors can be defined as deviations from the norms of the target language. They reveal the patterns of learners' development of inter-language systems, showing where they have over-generalized a FL rule or where they have inappropriately transferred a first language rule to the FL [12]. Corrective feedback is an indication to a learner that his or her use of the target language is incorrect, and includes a variety of responses that a language learner receives. Corrective feedback can be explicit (e.g., "No you should say goes, not go.") or implicit (e.g., "Yes, he goes to school every day."), and may or may not include meta-linguistic information (e.g., "Don't forget to make the verb agree with the subject.") [12]. In our studies, we classified corrective feedback strategies identified in SLA [13] into two groups:

(1) *Giving-Answer Strategies (GAS):* Types of feedback moves in which the teacher directly gives the target form corresponding to the error in a student's answer, or shows the location of the student's error. These include:
   (a) *Repetition* of the error or the portion of the learner's phrase containing the error, using stress or rising intonation to focus the student's attention on the problematic part of the utterance, e.g., S: "Future" (Incorrect tense); T: "¢ Future?"
   (b) *Recast: Reformulation* of all or part of the student's answer, providing the target form, e.g,. S: "En el segundo piso, hay cuatro dormitorio y dos baño." (*On the second floor, there are four bedroom and two bathroom.*) T: "Qué grande es tu casa! Tiene cuatro dormitorios y dos baños." (*What a big house you have. It has four bedrooms and two bathrooms.*)
   (c) *Explicit correction:* The teacher provides the correct target form, e.g., S: "Cuando ella andó." *(When she went)*; T: "andaba." This differs from recast because the teacher directly corrects the error without rephrasing or reformulating the student's answer.
   (d) *Give answer:* Used in cases when the student does not know or is unsure of the answer, e.g., S: "Ella compró mucha fruta y..." (Student can not finish his answer because he does not know how to say vegetables). T: "Fruta y verduras." (Teacher completes the answer with the word verduras.)

Our definitions of the repetition and recast strategies are based on those used in Doughty and Varela's [5] study.

(2) *Prompting-Answer Strategies (PAS):* Types of feedback moves in which the teacher pushes students to notice a language error in their response and to repair the error for themselves. We have called this group Prompting-Answer Strategies because of the similarity these strategies bear to the notion of "prompting" described in [3]. This group includes three types of strategies:
   (a) *Meta-linguistic cues:* The teacher provides information or asks questions regarding the correctness of the student's utterance, without explicitly providing the target form, e.g., S: "Compra" (to buy); T: "Tienes que poner un condicional." *(You have to use a conditional.)*

(b) *Clarification requests:* Questions intended to indicate to the student that his/her answer has been misunderstood due to a student error, or that the utterance is ill-formed in some way and that a repetition or a reformulation is required. Clarification requests often include phrases such as "Pardon me.", "What?", "What do you mean?", e.g., S: "Me gustaría un jugo de cilantro." (*I would like a coriander juice*); T: "¢ Qué cosa?" (*What do you mean?*).

(c) *Elicitation:* The teacher encourages the student to give the correct form by pausing to allow the student to complete the teacher's utterance, by asking the student to reformulate the utterance, or by asking questions to elicit the correct answer, such as "How do we say that in Spanish?", e.g., T:"¢ Qué debe hacer Roberto?" (What does Roberto need to do?) S: Brush his teeth. T: "How do we say that in Spanish?"

We have carried out three types of empirical research [6,7] with the purpose of establishing the most frequent and effective feedback strategies in different teaching modes, with a view towards informing the design of feedback strategies for an ITS for Spanish as a second language. Our studies included:

- *An observational study of face-to-face classroom interactions:* An analysis of naturalistic data from traditional classrooms. The aim was to investigate, at a fine level of structure, how human teachers deal with particular issues, such as the treatment of errors, and learning.
  Specifically, this study involved two types of positive feedback: Repetition (i.e teacher repeats the student's correct answer) and rephrasing (i.e., the teacher displays a new structure which rephrases the correct answer given by the student). For corrective feedback, two groups of strategies were investigated: Giving-Answer Strategies (GAS) and Prompting-Answer Strategies (PAS).
- *An case study of one-on-one tutorial interactions:* A case study in which we compared the feedback between traditional and tutorial mode. We studied feedback strategies in tutorial interaction by comparing tutoring sessions with classroom interactions. Our approach considered the use of empirical data on student–teacher interactions to guide the design of feedback strategies in the context of ITS for learning Spanish as FL.
- *An experimental study:* Involved a longitudinal experiment aimed at looking for further evidence about the effectiveness of the two classes of feedback strategies (GAS and PAS).
  In order to determine whether the tendencies found in the first two studies can be experimentally reproduced, we carried out a longitudinal experiment on grammar aspects. We controlled feedback strategies so as to observe the results in learning gain after a treatment process. We used a Web tutoring interface to gather empirical data on students' interactions.

The results of these three studies [6,7] suggest as shown in Table 1 that although GAS are the most frequently used strategies for all error types in both teaching modes, PAS are more effective for dealing with grammatical and vocabulary errors, whereas GAS are more effective for dealing with pronunciation errors. For grammar and vocabulary errors, an ITS should implement ways to prompt students' answers using meta-linguistic cues, elicitation and clarification-requests. There is a tendency for Prompting-Answer Strategies feedback (PAS) to be more effective than Giving-Answer Strategies (GAS) for dealing with grammar errors. The prompting strategies seem to promote more constructive student learning in a tutorial context [3] because they encourage the student to respond more constructively than when the teacher gives a simple repetition of the answer or a correction of the error.

Table 1
Rate of GAS and PAS repair in classroom and tutorial mode.

	GAS	Repair	PAS	Repair
Classroom error type				
Grammar	74	36/74 (48%)	49	39/49 (80%)
Vocabulary	23	9/23 (39%)	19	18/19 (95%)
Pronunciation	80	67/80 (83%)	0	0
Total	177	112/177 (63%)	68	57/68 (84%)
Tutorial error type				
Grammar	24	13/24 (54%)	21	16/21 (76%)
Vocabulary	13	3/13 (23%)	5	4/5 (80%)
Pronunciation	64	56/64 (87%)	1	0/1 (0%)
Total	101	72/101 (72%)	27	20/27 (74%)

The top part of Table 1 shows the rate of GAS and PAS repair in classroom mode. Overall, the proportion of repairs after PAS was higher than that after GAS. A statistical analysis considering the number of repaired and non-repaired errors following GAS and PAS for each type of error showed that for grammar ($\chi^2 = 11.86$, $p < 0.0005$) and vocabulary errors ($\chi^2 = 14.01, p < 0.0001$), PAS are more effective than GAS. For pronunciation errors, GAS are the only strategies used and they elicit a high rate of repair.

The lower part of Table 1 shows that there is a similar pattern in tutorial mode. When we look at effectiveness broken down by error type, we see that a higher percentage of grammar errors are repaired after PAS than after GAS, but the results are not significant. For vocabulary errors, PAS are more effective than GAS ($\chi^2 = 4.92, p < 0.05$). Finally, virtually all pronunciation errors invite GAS feedback, and there is a high rate of repair. Note that the chi-square analysis on vocabulary feedback in tutorial mode is right at the margin of valid application due to the limited amount of data.

In summary, these results indicate that PAS are more effective than GAS in eliciting repair for the errors they were used to treat. Despite this, teachers use GAS more frequently for all error types in both classroom and tutorial mode. With regard to repair, there seems to be agreement in the pedagogical literature that self-repair (i.e., students correcting their own linguistic errors) is more effective for learning than teacher-repair for several reasons. First, self-repair leads to knowledge construction as students actively confront errors and extend or revise their hypotheses about the target language. Second, self-repair allows students to automatize retrieval of the target language knowledge they already have. And finally, self-repair may be more conducive to acquisition than other-repair because it is less likely to result in a negative affective response. Therefore, when considering the effectiveness of feedback strategies, it is important to distinguish other-initiated self-repair (teacher notices student's error and prompts repair but the student generates the correct form him/herself) from other-initiated other-repair (teacher notices the student's error and the teacher corrects the error).

For the purposes of informing the design of ICALL systems for FL, it is important to identify the factors that indicate which strategy to use for corrective feedback in a given situation. We have already seen that the type of error is one factor that influences this

Table 2
Proportion of repair of GAS and PAS by learner level.

Level	Beginner	Intermediate	Advanced	Total
GAS	82/110 (75%)	15/36 (42%)	15/31 (48%)	112
PAS	25/27 (93%)	22/32 (69%)	9/9 (100%)	56
All	107/137 (78%)	37/68 (54%)	24/40 (60%)	168

decision. We then analyzed our data broken down by learner level as well as the type of error. As we can see from Table 2 for the different learning levels (Beginner, Intermediate and Advanced). Overall, the results show that PAS are more effective than GAS for learners at all levels. However, the following are the main trends that we observed.

First for the treatment of grammar errors, among GAS, recast was the most frequent strategy at beginner and intermediate levels, whereas explicit correction was the most frequent strategy at the advanced level. However, recast led to repair just 36% of the time overall. Give answer evoked a high rate of repair among learners at beginner and intermediate levels, but was not used to correct grammar errors of advanced learners. Explicit correction was used at all levels, and evoked a high rate of repair from intermediate students, but was less successful with beginner and advanced learners. Finally, there are too few cases of repetition to draw any conclusions.

Among the PAS strategies for grammar errors, elicitation is the most frequently used strategy, however, whereas [14] found this to be the most effective strategy, we observed it leading to repairs less often than meta-linguistic cues or clarification requests. Meta-linguistic cues are extremely effective for beginning and advanced students, but less so for learners at the intermediate level. A more detailed look at the instances of meta-linguistic prompts showed that they were especially effective for improving aspects of grammar (i.e., the subjunctive mood) in high-intermediate and advanced levels (experimental study). Our corpus did not include any instances of clarification requests for beginners, but this strategy always led to repair in the few cases where it was used for intermediate and advanced learners.

For vocabulary errors, the situation is less clear due to the small number of occurrences of this type of error in our corpora. Overall, although recast was the most frequently used strategy of the GAS group, it yielded only 27% repaired errors. Explicit correction was the most effective strategy with 71% of the errors repaired. The results for the PAS group indicate that all strategies are used with similar frequency, and that all strategies evoke high rates of repair. This is consistent with the high rates of uptake for PAS strategies found by [14].

For pronunciation errors, we focus on the strategies in the GAS group because the overwhelming majority of these errors were corrected by GAS. Overall, explicit correction is the most frequently used strategy and leads to repair 85% of the time. Give answer and recast were used with similar frequency, but give answer was much more effective at eliciting repairs (92% versus 58%). At the beginner and advanced levels, give answer and explicit correction were the most effective GAS strategies for treating pronunciation errors. There were too few repairs at the intermediate level to draw any conclusions. The results of this provide useful guidance for the design of feedback in ICALL systems, which we discuss further in Section 4.

4. A model for generating effective strategies in Spanish as a FL

The implementation of strategies in our PAS group requires that the ITS for FL be able to carry on an appropriate interaction with the student. Although unconstrained conversation of the type that human teachers employ is beyond reach, recent advances in tutorial dialogue systems research make the interactive techniques we propose more feasible than they were at the time many ITS for FL were designed. This research shows that sophisticated interactions can be carried on in domains for which rich underlying models have been developed [17], or for which possible correct and incorrect responses have been enumerated and feedback moves for each case have been authored [8,18]. In addition, recent work has shown that an ITS in which students produced self explanations by making selections from a menu led to learning outcomes that were equivalent to a version of the system in which students explained their problem-solving steps in their own words [1].

We defined a model for the design of a feedback component for ITS for Spanish as a FL, which takes into account the type of error the learner has made (grammar, vocabulary or pronunciation error), and the learner's level of proficiency (beginner, intermediate, advanced). In our model, we assume that error analysis is performed by an interpreter/analyzer.

In our model, the feedback sequence starts when a student's answer contains at least one error. If the answer contains more than one error, the system must determine which error should be treated first, and in our model this decision is based on the learner level. For beginners, grammar and pronunciation errors are the most frequent, and thus we suggest that priority should be given to the treatment of these types of errors. For intermediate and advanced learners, grammar and vocabulary errors should be addressed first. Once an error is identified, a feedback strategy must be chosen.

Using the data obtained from the above-mentioned empirical studies, we built a decision tree (see Fig. 1) aiming to drive the generation of feedback strategies for the treatment of errors according to the different learning levels. The selection of a GAS or a PAS type of feedback after the first error is then performed by following the branches of the obtained decision tree.

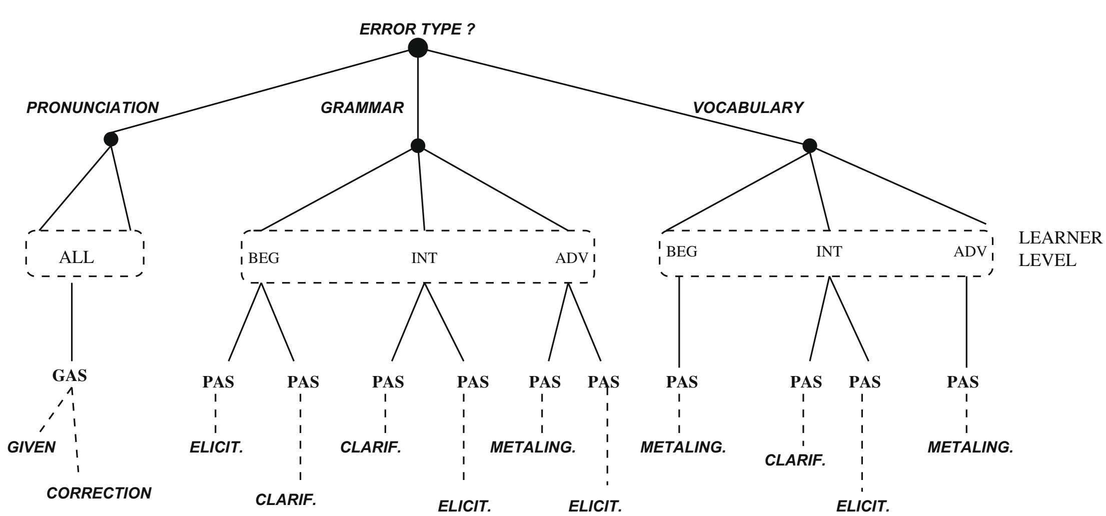

Fig. 1. Decision tree for feedback generation after the first error.

Table 3
Effectiveness table for strategy per learning level (ES).

Error type *e*	Strategy	
	PAS	GAS
Level		
Beginner	$ES_{(e,b,pas)}$	$ES_{(e,b,gas)}$
Intermediate	$ES_{(e,i,pas)}$	$ES_{(e,i,gas)}$
Advanced	$ES_{(e,a,pas)}$	$ES_{(e,a,gas)}$

Table 4
Effectiveness table for type of strategy per learning level (ET).

Error type *e*	Individual strategy (i.e., PAS)		
	PAS_1	PAS_2	..
Level			
Beginner	$ET_{(e,b,pas_1)}$	$ET_{(e,b,pas_2)}$	..
Intermediate	$ET_{(e,i,pas_1)}$	$ET_{(e,i,pas_2)}$	..
Advanced	$ET_{(e,a,pas_1)}$	$ET_{(e,a,pas_2)}$	..

After the feedback has been generated, the student may produce several types of responses (uptake):

(1) An immediate uptake in which the student modifies his/her answer correctly, either by self-repair (if PAS was generated) or by other-repair (if GAS was generated). This indicates that the student has noticed the error and the given assistance, and the correct answer may indicate a first step towards improvement.
(2) An uptake which still contains the error. This may occur because the student did not notice the target form provided by the teacher's feedback or the student does not know how to correct the error. In cases such as this, our human teachers either try an alternative feedback strategy or continue the discussion with the next question, an accept turn, or a domain turn.
(3) An uptake in which the student repairs the original error, but his/her answer contains another error. In this case, a feedback strategy is selected according to the algorithm for presenting the first corrective feedback move over an error given above.

4.1. Example of feedback generation

In order to produce feedback based on the students' errors in an ITS context, we propose a simple semi-deterministic mechanism which uses the resulting data concerning effectiveness from our studies. The input to our procedure is basically summarized by two tables whose values are extracted from our results in observational and experimental studies:

(1) Table of effectiveness of strategy versus learning level (*ES*) per error type (Table 3), where $ES_{(e,l,s)}$ represents the effectiveness value (between 0 and 100%) for the error type (e), for the level (*l*), and using a given strategy (*s*).
(2) Table of effectiveness of individual strategies versus learning level (*ET*) per error type (Table 4), where $ET_{(e,l,t)}$ represents the effectiveness value for the error type (*e*), for the level (*l*), and using an individual strategy (*t*).

From this input data, assume that the procedure is embedded in an ITS as a tutorial interface which contains the following steps:

```
Let L be the student's learning level
Let Sq be the set of questions
FOR each question Q in Sq DO
  Generate Question Q
  Get Answer Ans
  IF Ans is correct THEN
    DISPLAY repaired
  ELSE
    Eq = Detect type of error
    Produce_feedback(Ans,Eq,L)
  END-IF
END-FOR
```

Here, `Produce_feedback(Ans,Eq,L)` is the process that produces the feedback given the current answer *Ans* and handles any subsequent error for this question, the detected error *Eq* and the student's level *L*. This first determines whether a PAS strategy must be given (GAS otherwise) and then produces the corresponding type of strategy:

```
PROCEDURE Produce_feedback(Ans,Eq,L)
OUTPUT: Type of Strategy (T)
  Let AllowedErrors be the fixed number of
      allowed errors (2)
  Current_Error = 0
  WHILE (Current_Error < AllowedErrors)
     AND (Ans is not repaired) DO
   IF  give_PAS(L,Eq)  THEN
      T = select_feedback_type(PAS,Eq,L)
   ELSE
      T = select_feedback_type(GAS,Eq,L)
  END-IF
  DISPLAY feedback depending on type T
  Determine Effect (uptake):
      Get new Answer Ans
  IF (Ans is repaired) THEN
   student's effect is self_repair
        if strategy is PAS
     or other_repair if strategy is GAS.
  END-IF
  ELSE student's effect is"unrepaired"
   Current_Error = Current_Error + 1
  END-while
END-Procedure
```

When the first error is detected, the feedback is given based on the strategy with the highest effectiveness value in input table ES. Next, the type of feedback is generated in decreasing order of effectiveness of table ET providing that the generated type is not repeated for the same question.

When an error is made for the second time, the strategy with the highest effectiveness value is produced if the current error is the same as the previous one. If there is a new type of error, a probabilistic selection of a strategy is performed by choosing the strategy whose effectiveness value exceeds a randomly generated value between 0 and 1. The probability of choosing PAS or GAS is given by a real value which is proportional to each strategy's effectiveness. For example, the probability of selecting PAS as the next produced strategy will be given by:

$$Prob(\text{``}pas\text{''}) = \frac{\langle Effectiveness\_of\_PAS \rangle}{\langle Total\_effectiveness\ (PAS + GAS) \rangle}$$

For example, the probability for choosing a PAS feedback considering grammar errors at beginner level in Table 2 is calculated as:

$$Prob(\text{``}pas\text{''}) = \frac{91}{91 + 53} = \frac{91}{144} = 0.63$$

Accordingly, the procedure to determine whether a PAS strategy should be produced or GAS otherwise, proceeds as follows:

```
FUNCTION give_PAS(L,Eq)
OUTPUT: TRUE if PAS is given
        FALSE otherwise
  IF (<first error>
      OR (Eq = <previous error>) THEN
    IF ES(Eq,L,pas)>ES(Eq,L,gas) THEN
        return TRUE
    ELSE return FALSE
  ELSE ** Probabilistic Step **
    Let TES be the
        total effectiveness for L:
    TES = ES(Eq,L,pas)+ES(Eq,L,gas)
    Let P_pas be the probability of
        choosing a PAS strategy
    P_pas = ES(Eq,L,pas)/ TES
    P_random =
      <random value between 0 and 1>
    ** Determine whether PAS is chosen **
    IF (P_random < P_pas) THEN
      return TRUE
    ELSE return FALSE
  END-IF
END
```

Once the strategy (S) is selected, the specific type of feedback is generated according to S, the error type (Eq) and the level (L) by using the following procedure:

```
ALGORITHM   select_feedback_type(S,Eq,L)
INPUT: Strategy (S), Error type (Eq),
     Learner Level (L)
OUTPUT: type of strategy T
Let St be the values of effectiveness
  of possible individual strategies for
  S from ET(Eq,L,t)
Select the type of strategy with
  effectiveness value T from St
  such that:
  1) T is the highest effectiveness
        value in St
  2) The type of strategy with
        effectiveness T has not been
        used before in the same question
END
```

A remaining issue that must be addressed in any implementation of our model is how the feedback strategies should be realized in natural language and presented to the student. This will depend on aspects of the overall ICALL system, such as whether the student interacts with the system using speech or typing (or a combination) and whether the ICALL system is taking a Focus on Forms or Focus on Meaning approach.

5. Conclusions

In this paper, we provided guidelines for researchers developing feedback strategies for ITS systems. To this end, we focused on identifying the factors that should be taken into account in order to determine the feedback strategy that is most likely to be effective in any given situation. From these results, we were able to provide an initial approach for a feedback component for an ITS system for Spanish as FL. However, this model is necessarily simplified, and leaves several issues for future research.

Preliminary results using the model for generating feedback strategies (i.e., GAS, PAS) show the promise of the approach in dealing with different types of error correction in tutorial dialogues. This is strongly due to the decision making process to select the most effective feedback strategy. Unlike other approaches, this also considers different learning levels and error types from real tutoring and classroom experiences.

The necessity of implementing feedback strategies in ITS for FL can expand our understanding of this key issue and enable us to envisage the kind of contribution that can be useful for ITS for FL systems, as well as teaching training in the context of FL instruction.

Acknowledgement

This research is sponsored by the National Council for Scientific and Technological Research (FONDECYT, Chile) under Grant No. 1080165 "*A Blended Learning Task-based Model and Cooperative Approaches for Teaching Spanish as Foreign Language*"

References

[1] V. Aleven, O. Popescu, A. Ogan, A formative classroom evaluation of a tutorial dialogue system that supports self-explanation, in: V. Aleven (Ed.), Proceedings of the 11th International Conference on Artificial Intelligence in Education, 2003, pp. 345–355.
[2] J. Anderson, A. Corbett, K. Koedinger, R. Pelletier, Cognitive tutors: lessons learned, Journal of the Learning Sciences 4 (2) (1995) 167–207.
[3] Michelene T.H. Chi, Stefanie Siler, H. Jeong, T. Yamauchi, Robert G. Hausmann, Learning from human tutoring, Cognitive Science 25 (4) (2001) 471–533.
[4] M. Dodigovic, Artificial intelligence in second language learning: raising error awareness, Multilingual Matters (2005).
[5] C. Doughty, E. Varela, Communicative focus on form, in: C. Doughty, J. Williams (Eds.), Focus on Form in Classroom Second Language Acquisition, Cambridge University Press, 1998, pp. 114–138.
[6] A. Ferreira, Estrategias efectivas de feedback correctivo para el aprendizaje de lenguas asistido por computadores, Revista Signos 40 (65) (2007) 521–544.
[7] A. Ferreira, J. Moore, C. Mellish, A study of feedback strategies in foreign language classrooms and tutorials with implications for intelligent computer assisted language learning systems, International Journal of Artificial Intelligence in Education 17 (4) (2007) 389–422.
[8] A.C. Graesser, S. Lu, G.T. Jackson, H. Mitchell, M. Ventura, A. Olney, M.M. Louwerse, Autotutor: a tutor with dialogue in natural language, Behavioral Research Methods, Instruments, and Computers 36 (2004) 180–193.
[9] T. Heift, M. Schulze, Errors and Intelligence in Computer-Assisted Language Learning: Parsers and Pedagogues, Routledge, 2007.
[10] G. Hume, J. Michael, A. Rovick, M. Evens, Hinting as tactic in one-on-one tutoring, Journal of Learning Sciences 5 (1) (1996) 23–47.
[11] M. Levy, G. Stockwell, CALL Dimensions: Options and Issues in Computer Assisted Language Learning, Lawrence Erlbaum Associates, London, 2006.
[12] P. Lightbown, N. Spada, How Languages are Learned, Oxford University Press, 1999.
[13] R. Lyster, Differential effects of prompts and recasts in form-focused instruction, Studies in Second Language Acquisition 26 (4) (2004) 399–432.
[14] R. Lyster, L. Ranta, Corrective feedback and learner uptake: negotiation of form in communicative classrooms, Studies in Second Language Acquisition 19 (1) (1997) 37–66.
[15] D. Merrill, B. Reiser, M. Ranney, J. Trafton, Effective tutoring techniques: comparison of human tutors and intelligent tutoring systems, Journal of the Learning Sciences 2 (3) (1992) 277–305.
[16] N. Nagata, Banzai: computer assisted sentence production practice with intelligent feedback, in: Proceedings of the Third International Conference on Computer Assisted Systems for Teaching and Learning/Japanese (CASTEL/J), 2002.
[17] E. Owen, K. Schultz, Empirical foundations for intelligent coaching systems, in: Proceedings of the Interservice/Industry Training, Simulation and Education Conference, Orlando, Florida, 2005.
[18] C.P. Rosé, P. Jordan, M. Ringenberg, Interactive conceptual tutoring in atlas-andes, in: J.D. Moore (Ed.), AI in Education: AI-ED in the Wired and Wireless Future, IOS Press, 2001, pp. 256–266.