Conceptualizing Student Models for ICALL

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Abstract. Student models for Intelligent Computer Assisted Language Learning (ICALL) have largely focused on the acquisition of grammatical structures. In this paper, we motivate a broader perspective of student models for ICALL that incorporates insights from current research on second language acquisition and language testing. We argue for a student model that includes a representation of the learner's ability to use language to perform tasks as well as an explicit activity model that provides information on the language tasks and the inferences for the student model they support.

1 Introduction

In Intelligent Computer-Assisted Language Learning (ICALL), language acquisition has generally been modeled in terms of learning grammatical forms and structures. CASTLE (Murphy and McTear 1997), ICICLE (SLALOM; Michaud, McCoy and Stark 2001, and E-tutor (Heift 2004) are examples of ICALL systems which include student models that keep track of students' production in terms of the grammatical accuracy of their performance.

At the same time, research in the field of Second Language Acquisition (cf., e.g., Canale 1983, Ellis 2003) has established language acquisition as a process encompassing significantly more than the linguistic knowledge, in particular the ability to use language in a given context to achieve certain goals.

For ICALL systems to include activities that are meaning-based and contextualized, the student model needs to be extended to include the learner's abilities to use language in context for specific goals, such as scanning a text for specific information, describing situations, or using appropriate vocabulary to make requests. Such an extension also makes it possible to model the learners' linguistic abilities relative to particular tasks, such as whether a learner can use proper morpho-syntactic agreement in a simple task or construction only.

Inspired by Bachman (Bachman and Palmer 1996), who refers to the set of non-linguistic properties to be acquired by learners that play a role in their language production as the *strategic competence*, we thus propose to extend ICALL student models with a representation of the relevant aspects of strategic competence. The direction of our approach thus is related to that of Bull et al. (1995), who argue for extending the scope of student models to incorporate aspects outside the boundary of the domain knowledge. However it is motivated by the specific nature of the language acquisition process we are focusing on.

We explore this conceptual issue in the context of developing TAGARELA, an ICALL system for Portuguese designed to be used in the Individualized Instruction Program at the Ohio State University. TAGARELA is an intelligent electronic workbook which analyzes student input for different activities and provides individual feedback. The activity types are similar to the ones found in traditional workbooks: *reading*, *listening*, *description*, *rephrasing*, and *vocabulary*. Crucially, each of the included activities requires the learner to use the foreign language with regards to meaning, as opposed to activities that only require the manipulation of linguistic forms.

2 TAGARELA's Student Model

To extend the student model with the learner's ability to use language in context for specific goals, we propose the architecture in Figure 1.

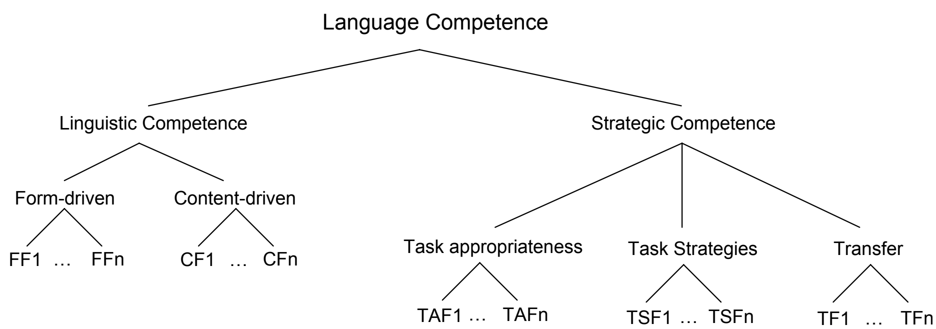

Fig. 1. The TAGARELA student model (domain-knowledge aspects only)

The student model comprises the linguistic and the relevant strategic (non-linguistic) competencies that have to be developed by the learner to use language in order to perform the tasks in TAGARELA.[3] Linguistic competence is divided into *form-driven* and *content-driven*, reflecting two types of linguistic analysis that are performed by the system's natural language processing (NLP) modules: form analysis of spelling and morpho-syntactic errors, and shallow content analysis providing information about the semantic appropriateness of the input. The properties that can be observed and identified by the NLP are represented by the leaves of the linguistic competence tree in the depicted student model. Form features (FF), for example, include spelling, determiner-noun and subject-verb agreement, and word order properties determined by the syntactic processing. Content features (CF) represent, for example, the result of extra/missing content word detection, required concept matching, or synonym identification.

[3] In addition to the domain knowledge discussed here, the TAGARELA student model also includes the student's personal information and interaction preferences.

The strategic competence newly added to the model is divided into *task appropriateness*, *task strategies*, and *transfer*. Task appropriateness stores information about the performance of the student relative to the activity classification. Each activity is classified in terms of its type (e.g., listening, reading), level, nature of the input (word, phrase, sentence), and complexity of content manipulation required. Task strategies keeps track of specific abilities students have to use to complete a given activity, e.g., scanning a text to locate specific information or getting the gist of listening passages. Transfer stores information about indicators of structural and lexical transfer from the native language of the student into the second language (cf., e.g., Odlin 2003).

The TF leaves in the student model in Figure 1 are the transfer features which are specified in a separate NLP module that identifies potential instances of negative transfer in the learner input. The TAF and TSF leaves are the relevant features for task appropriateness and task strategies, which are hand-specified in an explicit activity model provided for each exercise. This provides information about the activity and the strategies the student must master to complete it.

2.1 Explicit Activity Models and Assessing Learner Knowledge

An ICALL system architecture including explicit activity models for each exercise is directly relevant for the extension to the student model proposed in this paper. Student models are built and modified based on observations of learner performance (or using information explicitly provided by the learner). The student model does not store properties of the learner input as such, but inferred information about the knowledge the learner used to construct these sentences. Research in ICALL has paid little attention to the validity of the inferences about a student's current state of knowledge. Developers usually take for granted that linguistic errors are caused solely by a lack of linguistic knowledge and do not acknowledge the fact that the task being performed can play a significant role in determining the students' production. To build a model that takes into account the linguistic and the strategic competence of a student, it is necessary to provide mechanisms ensuring that the system's inferences about a student's state of knowledge are valid.

Describing the concept of validity for language tests, Bachman and Palmer (1996, p. 21) state that "construct validity pertains to the meaningfulness and appropriateness of the interpretations that we make on the bases of test scores" and that "in order to justify a particular score interpretation, we need to provide evidence that the test score reflects the area(s) of language ability we want to measure". In the case of ICALL systems that present specific exercises, there are two issues related to the validity of system inferences that we need to pay particular attention to. The first one is known as *content validity*, which McNamara (2000, p. 50) characterizes as the concept that explains the "extent to which the test content forms a satisfactory basis for the inferences to be made from test performance." For ICALL system design, this means that it is important to ensure that the exercise types and contents offered by the system are sufficient to make the necessary inferences about students' state of knowledge.

The second issue on validity of inferences relates to the methods used to obtain information about students' state of knowledge. There are two ways in which properties of exercises affect the result of the system's observations, which we can characterize using notions from assessment theory (cf., e.g., McNamara, 2000). *Construct irrelevant variance* occurs when a given exercise introduces factors that are not relevant to measure the ability we want to observe. *Construct under-representation* occurs when the exercise is too easy for the student, jeopardizing the observation of a given ability. Particular care needs to be taken when the knowledge or skill observed is embedded in contexts that are unfamiliar to the student's experience or irrelevant to what is being assessed. Bachman and Palmer (1996, p. 21) emphasize that the analysis of a student's performance has to be interpreted with respect to a "specific domain of generalization". Thus, when we consider the validity of an interpretation, "we need to consider both the construct definition, and the characteristics of the test tasks".

In sum, in order to guarantee valid interpretations of student performance it is not enough to keep track of students' production; it is vital to have information about the task environment where it occurs. Without a clear description of the exercise items that triggered the student's input, our interpretations about levels of proficiency may not be accurate.

3 Using the Information from the Student Model

As mentioned in the introduction, the TAGARELA system provides individual feedback based on the students' input to an exercise. Feedback is provided on the semantic appropriateness as well as on the grammatical accuracy of the input. The choice of the feedback strategy and contents is based on the student input, the activity model for the exercise the student was dealing with, and the student model. The general feedback strategy uses scaffolding techniques to help the learner develop self-editing skills (cf., e.g., Hyland and Hyland 2006).

Most relevant here is how the content of the scaffolding message is determined. The content depends on identifying the likely source of the error. Based on the learner input annotated by the NLP modules, the student model, and the activity model, the system distinguishes between three possible error sources:

Firstly, an error can result from a student's lack of a specific linguistic ability, e.g., when a given student has not mastered subject verb agreement. This is the classical case handled by ICALL systems, whereas the next two rely on the extensions proposed in Section 2.

Secondly, an error can result from the student's lack of a strategic ability needed for a given task. For example, if the learner has problems scanning a text to locate the relevant concepts, they cannot correctly answer a reading comprehension question asking for those concepts. To diagnose such an error, the system compares the concepts that the activity model identifies for a given text with the corresponding concepts identified in the learner input by the NLP modules. The learner model provides the information whether the learner has been able to pick up the relevant concepts in reading comprehension before.

Thirdly, an error can result from an insufficient mastery of a specific linguistic ability, which allows the student to use it only in certain tasks or constructions. For example, a student may be able to formulate simple sentences with correct subject-verb agreement as part of a picture description task, but fail to use correct agreement forms when answering listening comprehension questions that require more complex content, form, or otherwise increased cognitive load. As in the previous case, the student model and the activity model are essential for determining whether the problem lies in the use of the linguistic forms in general or whether there is a correlation with the use of these linguistic forms only in particular tasks.

4 Conclusion

We motivated the need to extend student models for ICALL to more comprehensively reflect the language acquisition process. To do so, we argued for adding a representation of the strategic competence of a student which represents factors outside of the linguistic competence per se. This makes it possible to model the learner's abilities to use language in context for specific goals and the learner's abilities relative to particular tasks. Updating the model currently requires hand-specification of explicit activity models, which however are well-motivated by the need to support valid inferences about the student's state of knowledge. In future work we intend to explore deriving some of these properties via additional natural language processing and resources.

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