An Intelligent Tutoring System for Adult Literacy Enhancement

Sowmya Ramachandran, Richard H. Stottler
Stottler Henke Associates, Inc.
San Mateo, CA, 94402
(650) 655-7242
sowmya@shai.com

1. Introduction

While a high school diploma is a requirement for enlisting in the Navy, a significant percentage of the enlisted crew have weak reading skills. Since about 25% of Navy's enlisted population can only read at the eighth grade-level or less, the Navy is interested in using computer-based literacy enhancement software that will allow the enlisted men and women to improve their reading skills independently. The Navy has been unsuccessful in finding an off-the-shelf solution to this problem since existing literacy software either targets truly illiterate adults, or targets children. The former is inappropriate because most Naval personnel are not totally illiterate and have mastered some basic literacy skills such as print decoding. The latter is inappropriate because the reading materials that they offer are of no interest to adults.

Furthermore, the Navy requires a software solution that can be used in a setting where there will be no literacy instructors and no traditional classroom instruction. In effect, the instructional software designed for this purpose should take the place of human instructors. Most existing literacy software is designed for use in traditional classroom settings, under the assumption that instructors will be available on hand to help the students. Finally, the Navy would also like their literacy training software to use documents of importance to the Navy, such as technical manuals, for providing reading practice. Therefore, it is important that any solution to this problem should include authoring tools that facilitate the addition of such documents to the tutor.

Here we describe an Intelligent Tutoring System (ITS) designed to address the above needs. An equally important aspect of the project is the development of an authoring tool to facilitate the creation of the ITS course content (i.e. placement tests, reading lessons and exercises). Due to space limitations, we will not discuss the authoring tool here.

2. Overview of the ITS

Literacy ITS, based on research on reading processes and instruction [1,2], performs the two following, inter-related functions:

1. Assessment of reading skills: A mark of a good tutor is keeping a realistic estimate of his student's strengths and weaknesses with respect to the skill being taught, which, in this case, is literacy. Therefore, assessing a student's skills is a very important functionality of the tutor. The Literacy ITS tutor uses the following means to maintain an up-to-date model of a student's reading abilities: 1. By using initial placement tests to determine the grade level of the material appropriate for the student, and to form an initial assessment of his reading skills, and 2. By diagnosing weak skills through reading exercises. The tutor uses various kinds of reading exercises to probe a student's mastery at various reading skills and updates the student model based on the student's response to these diagnostic reading exercises. Figure 1 shows an example of a reading exercise used by the ITS.

2. **Enhancement of reading skills***:* Assessing a student's mastery of skills is an important tool for achieving the more important objective of improving the student's reading abilities. Our tutor uses scaffolded exercises to accomplish this objective. It provides reading practice where a

student is presented with exercises that cover a broad range of skills. The tutor uses the student model to determine the student's weak skills. Reading practice exercises are targeted towards these weak skills. However, before presenting the student with exercises requiring the use of weak skills, the tutor provides instructional support in the form of exercises involving simple skills that are not as difficult for the student. Thus, our tutor is designed to improve a student's weak skills by building upon his strengths at simpler skills. This is embodied in the sequence of questions that the student is required to answer during reading practice. The student is first presented with questions that involve lower-level skills. The exercises then gradually increase in complexity to include questions involving more complex skills that build upon lower-level skills. Such a sequence of questions helps students establish a basis of comprehension, and build upon it progressively. In this way, the student builds towards questions that he could not have answered had they been presented first. Consider the paragraph shown in Figure 1, and the following questions.

Q1. Who ruled over the people in a monarchy?

Q2. What was the role of the people in a monarchy?

Q3. Who gave a monarch the right to rule?

Q4. Is it true that everyone was considered equal in a monarchy?

A student may not be able to answer Q4 directly, but may arrive at an answer to the question when presented with questions Q1, Q2, and Q3, first. The ITS also uses such structuring for diagnosis. Thus, if a student is given question Q4 first, and he answers it wrong, the ITS will use questions Q1 through Q3 to diagnose the skill deficiencies that led to the error.

> England and most of Europe were monarchies, which means that they were ruled by a king or queen. These monarchies ruled by "divine right" - the belief that God had given them the right to rule. The power of government came from God to the monarch. The people existed to serve the monarch and the government. As a representative from God, the monarch's job was to take care of the people. The people were responsible to God and the monarch. In short, the power of government came from God and resided in the monarch, and the people served the government.

Figure 1: An example of a reading exercise

The ITS also uses the student model to provide specific remedial exercises which target specific skills. For example, the ITS has specific remedial examples and exercises for specific skills such as anaphora resolution, identifying the main idea, logical inference, etc.

2.1 Student Modeling

To build a truly intelligent reading instructor would involve building a literate computer. Since current state-of-the-art NLU techniques are far from this goal, our aim is to make the tutor as intelligent as possible without making it AI-complete.

To this end, we investigated cognitive science literature to identify a set of skills and processes that contribute to effective reading [2]. These skills are arranged in a hierarchical network such that the skills at the bottom of the hierarchy support those at the top (Figure 2). The questions posed to the students are heuristically mapped to the specific skills that they address. Thus, a question asking for a meaning of a word in a given text would be associated with vocabulary and word-recognition skills. A question asking for the main idea of a given text would be associated with higher-level comprehension skills. Each skill is associated with a measure of the student's proficiency at that skill. The hierarchy shown in Figure 2 is mapped on to an equivalent Bayesian network [3], where each node in the network represents the probability that the student is strong in that skill. The student's performance on each exercise serves as evidence

of strength/weakness in the corresponding skills. The ITS uses Bayesian inference, based on this evidence, to maintain an up-to-date estimate of the student's reading skills. These skill estimates are used to provide tailored, scaffolded exercises and remediation as described earlier.

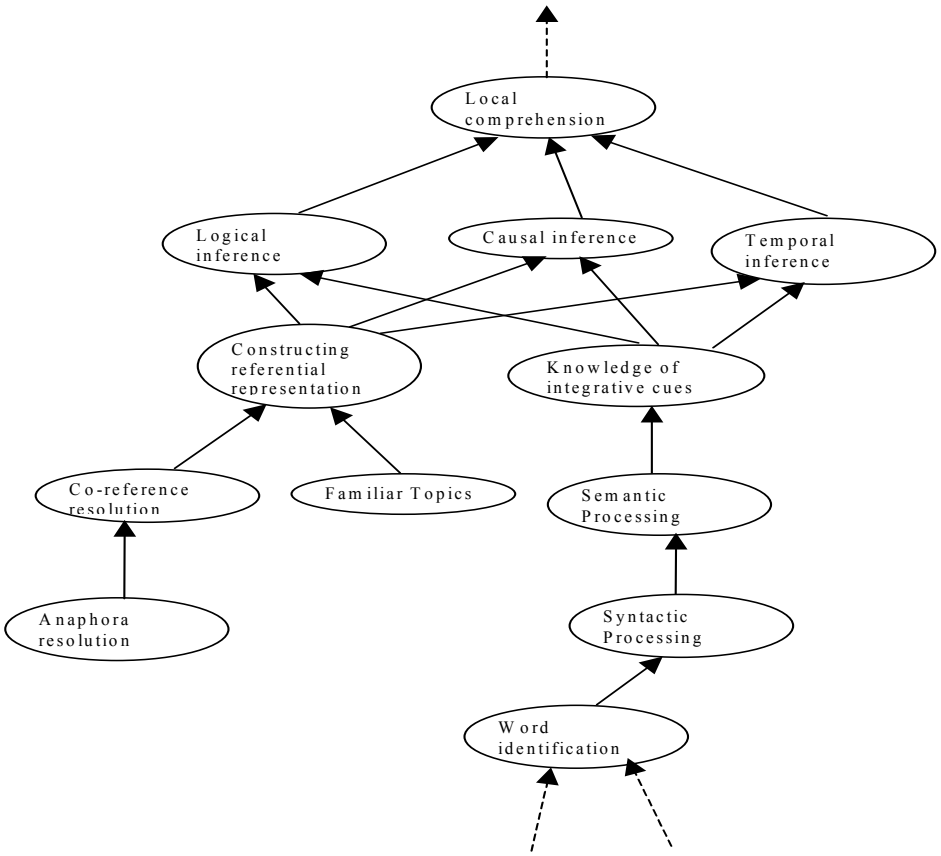

Figure 2: Part of the Reading Skills Model

3. Results and Conclusion

The first version of the ITS has just been completed. Preliminary tests show that the Bayesian network approach to the modeling of the student's reading expertise is effective. A preliminary evaluation of the ITS using the target users (i.e., enlisted crew members of the Navy) is scheduled for March 2000. The results from this evaluation will be used to refine the ITS. A final evaluation of the system will be conducted in January, 2001.

4. References

[1] Reading Diagnosis for Teachers: An Instructional Approach, Rebecca Barr, Camille L. Z. Blanchwicz, and Marilyn Wogman Sadow, Longman Publishers, USA, 1995

[2] The Psychology of Reading and Comprehension, Marcel Adam Just and Patricia A. Carpenter, Allyn and Bacon, Inc., 1987

[3] Probabilistic Reasoning in Intelligent Systems: Networks of Plausible Inference, Judea Pearl, Morgan Kaufmann, 1988