Results of a Case Study of an Intelligent Tutoring System for Analyzing Student Projects Presented as Research Papers

Jesús Miguel García Gorrostieta[1], Samuel González López[2], Aurelio López-López[2]

[1] Universidad de la Sierra, Moctezuma, Sonora, Mexico
[2] Instituto Nacional de Astrofisica, Optica y Electronica, Mexico

jmgarcia@unisierra.edu.mx,{sgonzalez, allopez}@inaoep.mx

Abstract. At "Universidad de la Sierra", projects of the end of a course are conducted. These projects are requested to have the structure of a research paper. In order to improve the quality of the assignment and guide the students in developing such work, an intelligent tutoring system was used. In this paper, we show a web-based intelligent tutoring system (ITS) to provide student advice in structuring research projects. We propose a student model based on a network to follow the progress of each student in the development of the project and personalized feedback on each assessment. This tutor includes a module for assessing the lexical richness, which is done in terms of lexical density, lexical variety, and sophistication. We present the empirical evaluation results indicate that students found this tool useful and improve their writing.

Keywords: E-learning, natural language processing, intelligent tutoring system, lexical richness.

1 Introduction

Performing well structured research work is a complex process which requires the support of the teacher. For this task technologies such as tutoring systems can be the solution. An intelligent tutoring system (ITS) is a system that provides personalized instruction or feedback to students without much involvement of instructors. Advances in ITS includes the use of natural language technologies to perform automated writing evaluation and provide feedback as presented in the article by Crossley [1]. Writing Pal (WPal) is an ITS that offers strategy instruction and game-based practice in the writing process for developing writers. There are also intelligent virtual agents able to answer questions for the student related to an academic subject [2]. A dialogue-based ITS called Guru was proposed in [3], which has an animated tutor agent engaging the student in a collaborative conversation that references a hypermedia workspace, displaying and animating images significant to the conversation. Another dialogue-based ITS Auto Tutor uses dialogues as the main

learning activity [4]. All these ITS use Natural Language to interact with the student similarly to the ITS we present in this paper.
At "Universidad de la Sierra", projects of end of course are conducted, this projects are requested to have the structure of a research paper, in order to improve the quality of the assignment and guide the students in developing such work, an intelligent tutoring system was used to assist students. In this paper, we present a web-based intelligent tutoring system (ITS) to provide student advice in structuring research projects. We propose a student model based on a network to follow the progress of each student in the development of the project and personalized feedback on each assessment. This tutor includes a module for assessing the lexical richness, which is done in terms of lexical density, lexical variety, and sophistication.

There are certain methods to evaluate the use of vocabulary in a document. One of them is to measure the sophistication using a list of 3000 easy words in spanish [5]. For Spanish, some studies use the list provided by the SRA (Spanish Royal Academy) of 1000, 5000 and 15000 most frequent words. Others works have used Yule's K to measure the richness in texts [6], where this kind of measures focuses on the word repetitions and it's considered a measure of lexical variety.

The process of drafting the research projects is usually not an easy task for students. Therefore, our proposed system intends to assist the work of the instructor and to facilitate and guide students through this process. We also apply an empirical evaluation with students to verify the effectiveness of the proposed system and present its results.

2 Writing Evaluation Model

The intelligent tutor presents material concerning the different elements of the project, such as the problem statement, hypothesis, objectives and justification in the Domain Module. For each element, a test is applied to validate the reading of materials and practical exercises are applied using the richness Lexical Analyzer to achieve a high level of density, diversity and sophistication in the student text productions. The results of the test and lexical analysis are sent to the Student Progress Module to update the knowledge state of the student in a network. Figure 1 shows the intelligent tutor model.

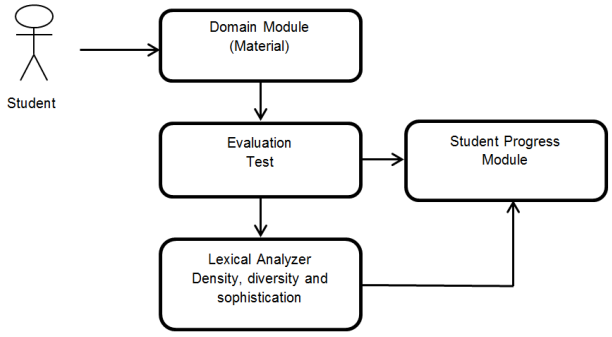

Fig. 1. Intelligent Tutoring System

The Student Progress Module (SPM) records the student's progress in the network which is depicted in Figure 2, when the student completes the test, the value of the test node element is updated and the SPM calculates the student's progress for the parent node using the weights assigned to each question in the test [7].

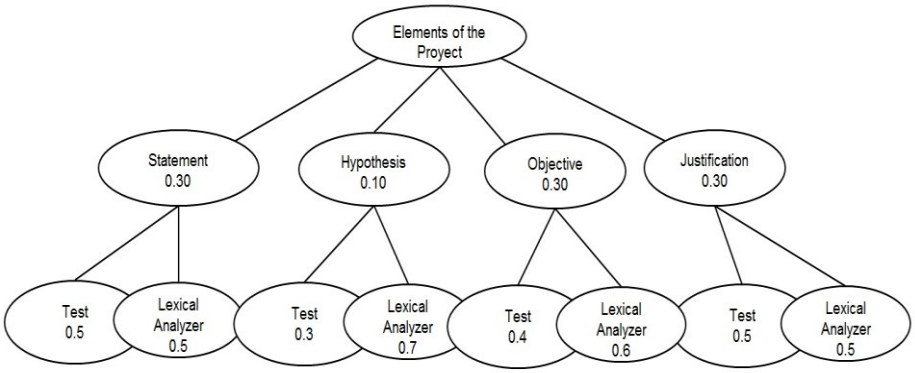

Fig. 2. Network used in Student Progress Module

Similarly as when performing the exercises with the lexical analyzer, the corresponding node in the network is updated and the SPM estimates the student's progress for the parent node using the weights assigned to the lexical density, variety and sophistication in the Lexical Analyzer.

Figure 2 illustrates the weights assigned to each node according to the experience of the teacher. For instance, in the Test node of the Objective, a weight of 40% of the parent node Objective is assigned, which includes 5 questions to verify that the student has read the material. Once the student has correctly answered questions, this will enable him to use the lexical analyzer to perform three exercises which have a combined weight of 60% of the parent node, which is distributed as follows: 20% to lexical density, 20% to lexical diversity, and finally 20% for lexical sophistication.

In Figure 3 we show the model of lexical Analyzer, the lexical analysis focuses on the evaluation of three measures: lexical density, lexical variety and sophistication, which together assess lexical richness. The first measure, lexical variety, seeks to measure student ability to write their ideas with a diverse vocabulary. This feature is computed by dividing the unique lexical types (Tlex) by the total of lexical types (Nlex). Tlex refers to the unique terms of content, while Nlex represents total terms of content, both ignoring empty words [8].

The lexical density aims to reflect the proportion of content words in the complete text. This measure is calculated by dividing the unique lexical types or content words (Tlex) by the total words of evaluated text (N), i.e. the number of words before removing stop words.

The third measure is sophistication, which attempts to reveal the knowledge of technical concepts and is the proportion of "sophisticated" words employed. This measure is computed as the percentage of words out of a list of 1000 common words, provided by the SRA. All the measures take values between 0 and 1, where 1

indicates a high lexical value, and values close to zero mean a low value of the lexicon of the evaluated section.

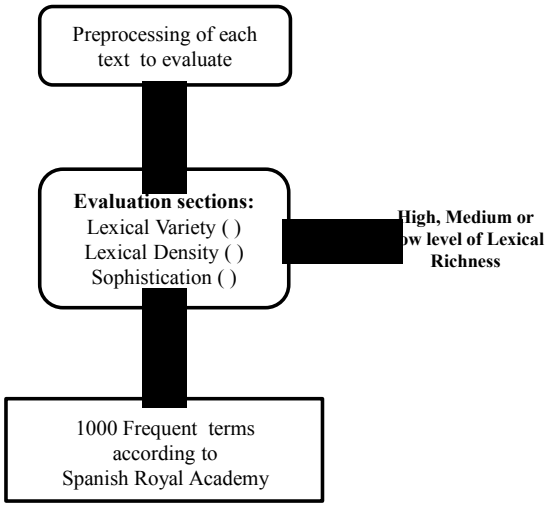

Fig. 3. Model of Lexical Analyzer

The preprocessing of the text was filtering and removing empty words from a list provided by the module of NLTK-Snowball. Stop words include prepositions, conjunctions, articles, and pronouns. After this step, only content words remained, which allowed the calculation of the three measures. Finally, the results produced by the Lexical Analyzer are sent to the Student Progress Module, so the intelligent tutor manages the results achieved by the student.

A scale ranging in High, Medium and Low in lexical richness has been established based on our previous work [9], where we analyzed research proposals and thesis of graduate and undergraduate students.

3 The Intelligent Tutoring System

The system was developed in PHP and MySQL with XAMPP package to have a web access, the lexical analyzer is developed in Python because of the ease access to processing tools of natural language. The analyzer uses the open source tool FreeLing[1] for stemming words and then analyzes the density, diversity and sophistication in the text. Figure 4 shows the graphical interface of the tutoring system in which we observe the button to the main menu to access the elements of the project (in Spanish *Elementos del proyecto*) inside we find links to access the problem statement, hypothesis, objectives and justification. For each element, there are three sections: material, test and practical evaluation. In this figure, we can also notice the progress section (in Spanish *Avance*) in the left side, reporting the progress in the

[1] This software is available at http://nlp.lsi.upc.edu/.

concept with 70% and 21% of the complete course. As we can observe, to enter the practical evaluation, the student must first successfully complete a test of basic knowledge of the concept.

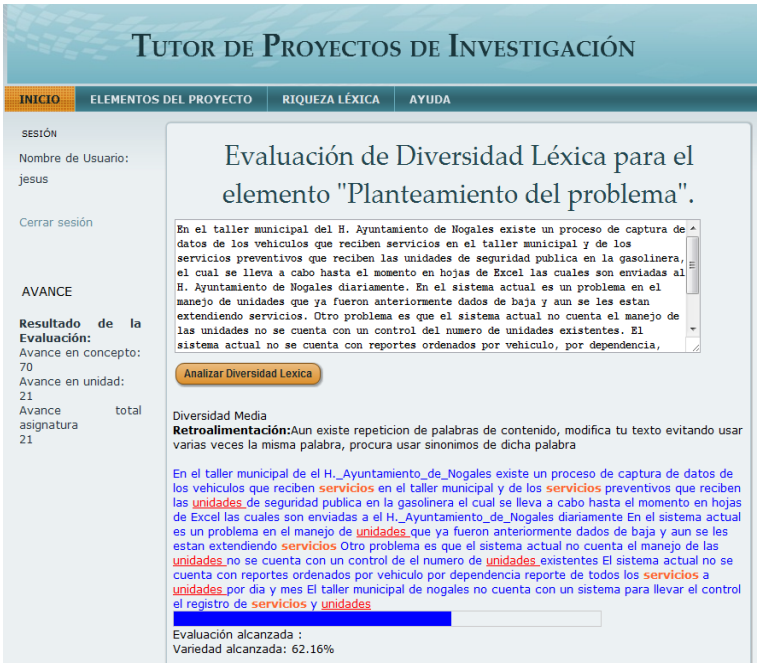

Fig. 4. Lexical Analyzer for Diversity (in Spanish)

The section of practical evaluation is also depicted in figure 4, where the student writes his problem statement to be analyzed, first density analysis measures the balance between content words and stop words; if the text has too many stop words it will have a very low density. Then the lexical analyzer for diversity which are content words that are repeated several times such as "services" (in Spanish *Servicios*) and "units" (in Spanish *unidades*) as we can see in figure 4. This case has a medium level of diversity with a feedback to the student "There are still repetitive words of content, modify your text, avoid using the same word several times, try using synonyms for such word" (in Spanish *Aún existe repetición de palabras de contenido, modifica tú texto evitando usar varias veces la misma palabra, procura usar sinónimos de dicha palabra*) with a 62.16% of progress in diversity, that is graphically illustrated by the progress bar at the bottom of the figure.

At the end of the exercise of lexical diversity, the student can access the exercise of sophistication which measures the degree to which the student uses uncommon words, hopefully specialized to the domain of computer science.

Once completed the three lexical analyses, the student can move on to the next item of the project and the teacher can review a more refined statement of the problem.

4 Results of the Empirical Evaluation

An empirical evaluation was applied to verify the effectiveness and acceptance of the system at ABC University in a Computer Science Career. Two groups were formed of 14 students, both groups were requested to do the same product, write the preliminary draft of their final project which consisted in the statement of the problem, hypothesis, justification and objective. The first group named control group, they received the printed material concerning to the elaboration of the preliminary draft, they were told not to use a lot of empty words and avoid to repeat the same word several times; they can consult with the teacher about the doubts concerning the work. On the other hand the second group called Experimental group, they were requested to use the intelligent tutoring system and the teacher explained how to use it. The time for the experiment was one week.

At the end of the experiment the results were analyzed, it was observed that the control group did not consult the teacher to review the work before final delivery, since they were not obligated to make revisions with the teacher, the students skipped this opportunity and they handed the document at reach the deadline. On the other hand, the experimental group used the intelligent tutor; they consulted more the material and the teacher to improve their drafting and get a higher score in the system and finish all the project elements. As we can see Figure 5 shows average results of lexical analysis for density, variety and sophistication of the problem statement of the experimental group and the control group. We can see that the experimental group had higher scores on all three lexical aspects.

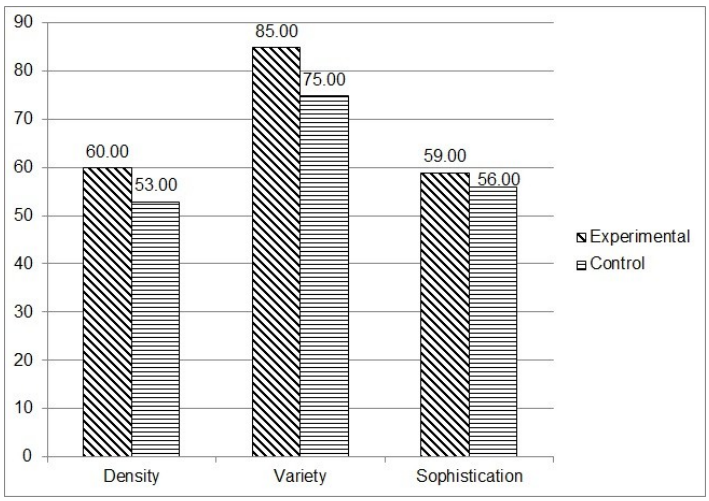

Fig. 5. Lexical analysis of the problem statement

The ranges established in the system to provide a textual feedback to the student in the density lexical analysis to the problem statement are: for a "low" value less than or equal to 52%, to a "medium" value greater than 52% and less than 59%, finally for a "high" value greater than or equal to 59%. According to these ranges we see that the control group obtained an average of 53% corresponding to a "medium" value and the

experimental group with 60% which corresponds to a "high" value in the lexical density of the problem statement.

We also apply a satisfaction survey based on TAM model [10] (Technology Acceptance Model) to know the opinion of the experimental group in using the intelligent tutoring system in the aspects of system usefulness, system ease of use, system adaptability and intention to use the system.

Students answered based on a scale of five-point Likert scale ranging from 1 as "strongly disagree" to 5 as "strongly agree". We can see in Figure 6 the averages results by aspect of the satisfaction survey in which it is observed that the preference of the students is over 4 point equal to "agree" to all aspects, so we can conclude that the system is useful, easy to use, adapted to their level and they have the intention to keep using it.

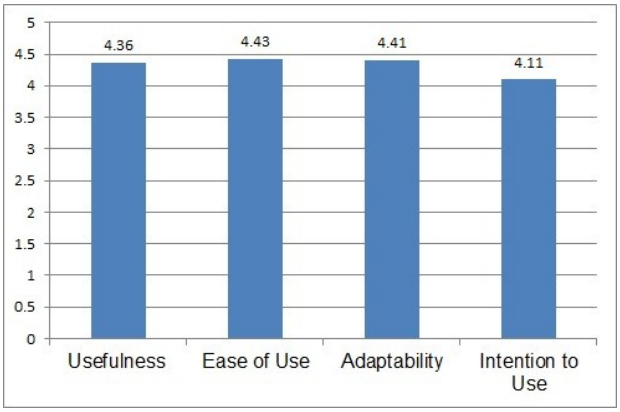

Fig. 6. Satisfaction survey results

5 Conclusion and Future Works

The use of intelligent tutoring system for research project drafts aims to support teachers in reviewing research projects providing material to the student, by tracking their progress and lexically analyzing the drafting of their writings. As we can see the use the ITS improved the three lexical aspect: density, variety and sophistication, in the experimental group and according to the satisfaction survey it has a good acceptance among the students.

In future work, we intend to implement in the ITS the use of SCORM Learning Objects with RELOAD editor software and supported by an open source LMS to improve the portability of digital resource and improve the content assimilation in students. Expecting enhance the structuring of the student research projects.

References

1. Crossley, S.A., Varne, L.K., Roscoe, R.D. and McNamara, D.S.: Using Automated Indices of Cohesion to Evaluate an Intelligent Tutoring System and

an Automated Writing Evaluation System. In: Proceedings 16th International Conference, AIED 2013, Memphis, TN, USA. Springer, pp. 269−278 (2013)
2. Rospide, C.G. & Puente, C.: Virtual Agent Oriented to e-learning Processes. In: Proc. of 2012 International Conference on Artificial Intelligence. Las Vegas, Nevada (2012)
3. Olney, A.; D'Mello, S. K.; Person, N. K.; Cade, W. L.; Hays, P.; Williams, C.; Lehman, B., and Graesser, A.C.: Guru: A Computer Tutor That Models Expert Human Tutors. In: Stefano A. Cerri; William J. Clancey; Giorgos Papadourakis & Kitty Panourgia, eds., ITS , Springer, pp. 256−261 (2012)
4. Graesser, A.C., D'Mello, S.K., Craig, S.D., Witherspoon, A., Sullins, J., McDaniel, B. and Gholson, B.: The Relationship between Affective States and Dialog Patterns during Interactions with Autotutor. J. Interactive Learning Research, vol. 19, no. 2, pp. 293−312 (2008)
5. Schwarm, S. and Ostendorf, M.: Reading level assessment using support vector machines and statistical language models. In: Proc. of the 43rd Annual Meeting on Association for Computational Linguistics (ACL '05), pp. 523−530 (2005)
6. Miranda, A. and Calle, J.: Yule's Characteristic K Revisited. Language Resources and Evaluation, 39(4) 287−294 (2005)
7. Sucar, L.E., Noguez, J.: Student Modeling. In: O. Pourret, P. Naim, B. Marcot (Eds.), Bayesian belief networks: a practical guide to applications. Wiley, pp. 173−186 (2008)
8. Roberto, J., Martí, M. and Salamó, M.: Análisis de la riqueza léxica en el contexto de la clasificación de atributos demográficos latentes. Procesamiento de Lenguaje Natural, No. 48, pp. 97−104 (2012)
9. González López, S. and López-López, A.: Supporting the review of student proposal drafts in information technologies. In: Proceedings of the 13th annual conference on Information technology education (SIGITE '12), ACM, New York, NY, USA, pp. 215−220 (2012)
10. Tobing, V., Hamzah, M., Sura, S. and Amin, H.: Assessing the Acceptability of Adaptive E-Learning System. In: Proc. of Fifth International Conference on Learning for Knowledge-Based Society, December 11−12, 2008, Bangkok, Thailand, 10 p. (2008)