Assessing and Advising on Lexical Richness in an Intelligent Tutoring System

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Abstract. Guiding students on writing is a hard and time consuming chore for advisors, since requires several iterations before achieving an acceptable level. Normally, when advising students close to graduation, most questions are about the structure of the thesis project. Issues such as the correct wording or abuse of certain terms within a title, problem statement, objectives and justification become the main tasks of the instructor. In this paper, we present a web-based intelligent tutoring system (ITS) to provide student advise 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 also establish the methodology for future testing with undergraduate students.

Keywords: E-learning, Natural Language Processing, intelligent tutoring system, lexical richness.

1 Introduction

Guiding and instructing students on research or thesis writing is a hard and time consuming chore for advisors, since requires several iterations before achieving an acceptable level. There is a need to alleviate the burden of this task, possibly by technologies such as tutoring systems.

An intelligent tutoring system (ITS) is a system that provides personalized instruction or feedback to students without much involvement of instructors. Recent advances in ITS include the use of natural language technologies to analyze student writing and provide feedback as presented in the article by McNamara [1]. Writing Pal (WPal) is an ITS that offers strategy instruction, practice, and feedback 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.

Normally when advising students close to graduation, most questions are about the structure of the thesis or research project. Issues such as the correct wording or abuse of certain terms within a title, problem statement, objectives and justification become the main task of the instructor. In this paper, we present a web-based intelligent tutoring system (ITS) to provide student advise 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 a variety of methods to evaluate the use of vocabulary (lexicon) in text. One of them is to measure the sophistication of some papers using text word lists. In [5], they used a list of 3000 easy words. 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 focus on the word repetitions and this is considered a measure of lexical variety.

We also establish the methodology for future testing with undergraduate students. So we cannot ignore the use of language, especially in writing, when considering the formation of higher education students, one of these stages of formation is related to the generation and application of knowledge through research, which are usually placed in the last semesters of their programs of study.

Each institution adopts various mechanisms that allow students to enter in the field of research, either through business internships, professional practice or in the various forms of professional qualification that presents the possibility of doing a research. However, 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.

Tha paper is organized as follows. Section 2 describes the model underlying the tutoring systems while section 3 details the implementation with examples of draft evaluations. We conclude in section 4, discussing further works.

2 The Model

The intelligent tutor in the Domain Module presents material concerning the different elements of the project, such as the problem statement, title, objectives and justification. 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.

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].

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.

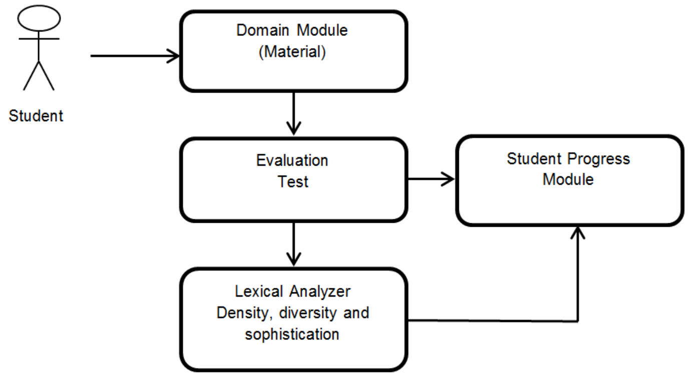


Fig. 1. Model of Intelligent Tutoring System

Figure 2 illustrates the weights assigned to each node according to the experience of the teacher. For instance, in the Test node of the Statement, a weight of 50% of the parent node problem statement is assigned, which includes 5 questions to verify that the student has read the material. Once the student has correctly answered questions, a 50% of advance in the concept is assigned, as shown in Figure 3. This will enable the student to use the lexical analyzer to perform three exercises which have a combined weight of 50% of the parent node, which is distributed as follows: 20% to lexical density, 20% to lexical diversity, and finally 10% for lexical sophistication.

So by completing the exercise of lexical density with a high grade, the student would have advanced 70% in the concept, as shown in Figure 6. Also when the student gets a high grade on the exercise of lexical diversity would have advanced a 90% in the problem statement concept, leaving only the exercise of lexical sophistication to complete the 100% of the concept.

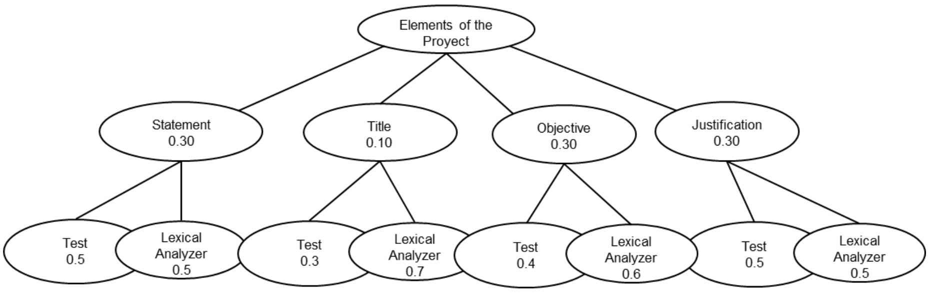


Fig. 2. Network used in Student Model

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 respect to 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.

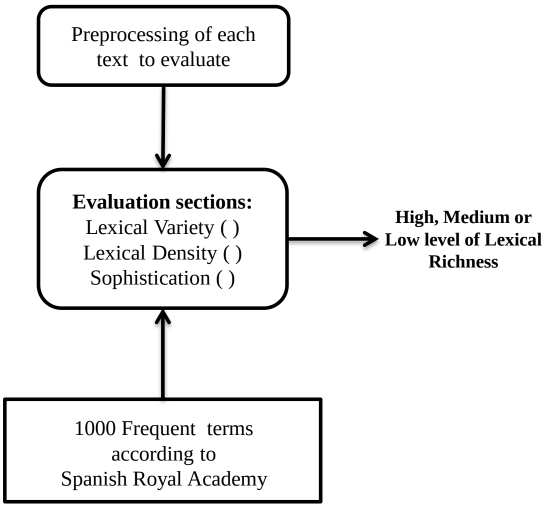

Preprocessing of each text to evaluate
Evaluation sections:
Lexical Variety ( )
Lexical Density ( )
Sophistication ( )
High, Medium or Low level of Lexical Richness
1000 Frequent terms according to Spanish Royal Academy

Fig. 3. Model of Lexical Analyzer

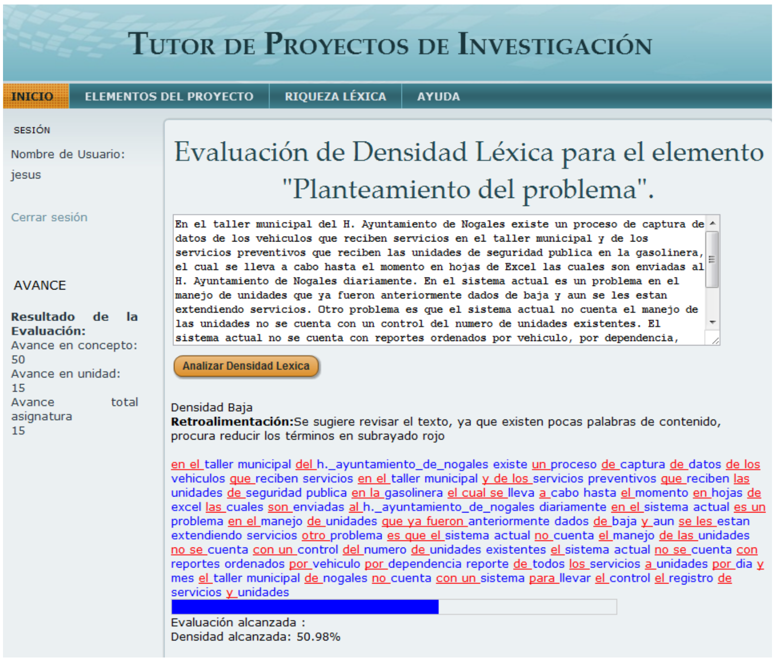
The preprocessing of the text was filtering and removing empty words from a list provided by the module of NLTK-Snowball. Stop words include prepositions, conjunctions, articles, and pronouns. After this step, only content words remained, which allowed the calculation of the three measures. Finally, 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 theses of graduate and undergraduate students.

3 The Intelligent Tutoring System

The intelligent tutoring system is developed in PHP for easy access via web and the network structure is stored in a MySQL database, 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 menu on the top to access the elements of the project (in Spanish *Elementos del proyecto*) in which we find the problem statement, title, 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 concept. As we can observe, to enter the practical evaluation, the student must first successfully complete the test receiving a 50% of advance in the concept and 15% in the complete project.



Nombre de Usuario:
jesus

Resultado de la Evaluación:
Avance en concepto:
50
Avance en unidad:
15
Avance total asignatura
15

Evaluación de Densidad Léxica para el elemento "Planteamiento del problema".

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En el taller municipal del H. Ayuntamiento de Nogales existe un proceso de captura de
datos de los vehiculos que reciben servicios en el taller municipal y de los
servicios preventivos que reciben las unidades de seguridad publica en la gasolinera,
el cual se lleva a cabo hasta el momento en hojas de Excel las cuales son enviadas al
H. Ayuntamiento de Nogales diariamente. En el sistema actual es un problema en el
manejo de unidades que ya fueron anteriormente dados de baja y aun se les estan
extendiendo servicios. Otro problema es que el sistema actual no cuenta el manejo de
las unidades no se cuenta con un control del numero de unidades existentes. El
sistema actual no se cuenta con reportes ordenados por vehiculo, por dependencia,
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Densidad Baja
Retroalimentación: Se sugiere revisar el texto, ya que existen pocas palabras de contenido, procura reducir los términos en subrayado rojo

en el taller municipal del h._ayuntamiento_de_nogales existe un proceso de captura de datos de los vehiculos que reciben servicios en el taller municipal y de los servicios preventivos que reciben las unidades de seguridad publica en la gasolinera el cual se lleva a cabo hasta el momento en hojas de excel las cuales son enviadas al h._ayuntamiento_de_nogales diariamente en el sistema actual es un problema en el manejo de unidades que ya fueron anteriormente dados de baja y aun se les estan extendiendo servicios otro problema es que el sistema actual no cuenta el manejo de las unidades no se cuenta con un control del numero de unidades existentes el sistema actual no se cuenta con reportes ordenados por vehiculo por dependencia reporte de todos los servicios a unidades por dia y mes el taller municipal de nogales no cuenta con un sistema para llevar el control el registro de servicios y unidades

Evaluación alcanzada :
Densidad alcanzada: 50.98%

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

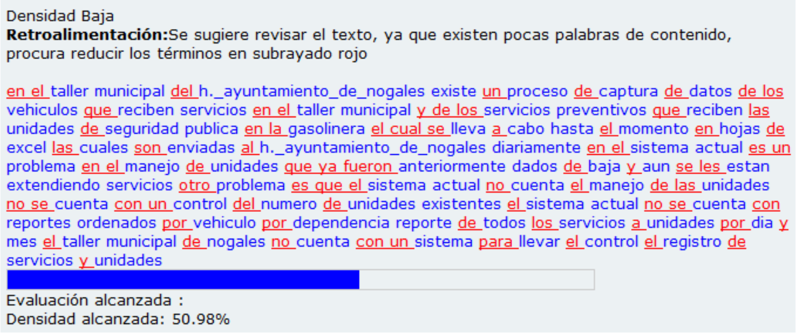
The section of practical evaluation is also depicted in figure 4, where the student writes his problem statement to be analyzed for lexical density. First, the analyzer performs a parsing of words then a classification based on the 1000 most common words of Spanish are done to identify stop words and the rest as content words. Den-

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

sity analysis measures the balance between content words and stop words, if the text has too many stop words will have a very low density, if the text has just few stop words compared to content words will have a high density.

The feedback of the lexical density analysis and the level assigned to the problem statement proposed by the student is "Low Density" (in Spanish *Densidad Baja*) due the large number of stop words relative to content words, the system sends a message to the student with a feedback according to the level assigned (see Figure 5).

The message displayed is "we suggested reviewing the text, there are few content words, try to reduce the terms outlined in red" (in Spanish *Se sugiere revisar el texto, ya que existen pocas palabras de contenido, procura reducir los términos subrayados en rojo*) in paragraph analyzed, we observe stop words underlined to indicate the student have to try to reduce them, and presents a progress bar to indicate graphically the progress of his writing, in this case a 50.98% of advance.



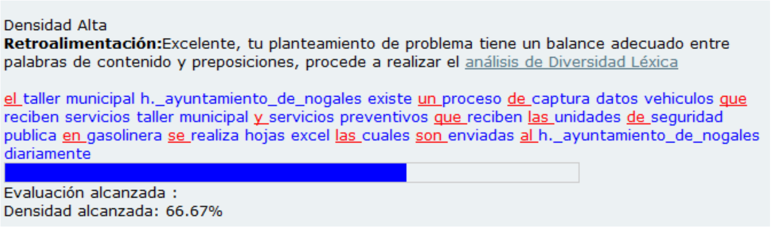
Densidad Baja
Retroalimentación: Se sugiere revisar el texto, ya que existen pocas palabras de contenido, procura reducir los términos en subrayado rojo

en el taller municipal del h._ayuntamiento_de_nogales existe un proceso de captura de datos de los vehiculos que reciben servicios en el taller municipal y de los servicios preventivos que reciben las unidades de seguridad publica en la gasolinera el cual se lleva a cabo hasta el momento en hojas de excel las cuales son enviadas al h._ayuntamiento_de_nogales diariamente en el sistema actual es un problema en el manejo de unidades que ya fueron anteriormente dados de baja y aun se les estan extendiendo servicios otro problema es que el sistema actual no cuenta el manejo de las unidades no se cuenta con un control del numero de unidades existentes el sistema actual no se cuenta con reportes ordenados por vehiculo por dependencia reporte de todos los servicios a unidades por dia y mes el taller municipal de nogales no cuenta con un sistema para llevar el control el registro de servicios y unidades

Evaluación alcanzada :
Densidad alcanzada: 50.98%

Fig. 5. Detailed feedback of Lexical Analyzer for Density (in Spanish)

After correcting the paragraph, the analyzer indicates a high level (in Spanish *Densidad Alta*) and activates the access link to the analysis of lexical diversity (in spanish *Análisis de diversidad léxica*), as shown in Figure 6, the feedback indicates that the statement problem is in balance between stop and content words, with a 66.67% of lexical density.



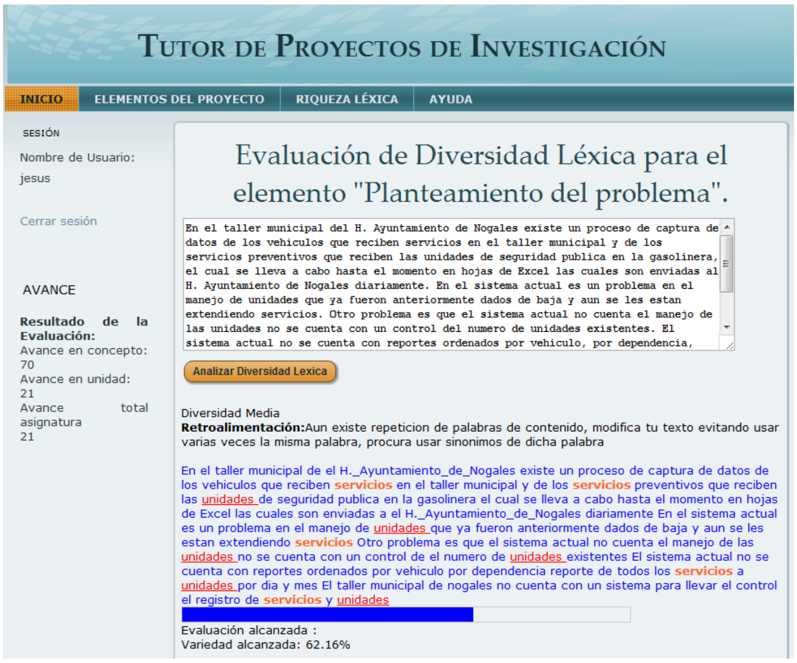
Densidad Alta
Retroalimentación: Excelente, tu planteamiento de problema tiene un balance adecuado entre palabras de contenido y preposiciones, procede a realizar el análisis de Diversidad Léxica

el taller municipal h._ayuntamiento_de_nogales existe un proceso de captura datos vehiculos que reciben servicios taller municipal y servicios preventivos que reciben las unidades de seguridad publica en gasolinera se realiza hojas excel las cuales son enviadas al h._ayuntamiento_de_nogales diariamente

Evaluación alcanzada :
Densidad alcanzada: 66.67%

Fig. 6. Detailed feedback from Lexical Analyzer, for High Density in text (in Spanish)

Figure 7 shows 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*). This case has a medium level of diversity with a feedback to the student "There are still repeating 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.



Nombre de Usuario:
jesus

AVANCE

Resultado de la Evaluación:
Avance en concepto:
70
Avance en unidad:
21
Avance total asignatura
21

Evaluación de Diversidad Léxica para el elemento "Planteamiento del problema".

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En el taller municipal del H. Ayuntamiento de Nogales existe un proceso de captura de
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servicios preventivos que reciben las unidades de seguridad publica en la gasolinera,
el cual se lleva a cabo hasta el momento en hojas de Excel las cuales son enviadas al
H. Ayuntamiento de Nogales diariamente. En el sistema actual es un problema en el
manejo de unidades que ya fueron anteriormente dados de baja y aun se les estan
extendiendo servicios. Otro problema es que el sistema actual no cuenta el manejo de
las unidades no se cuenta con un control del numero de unidades existentes. El
sistema actual no se cuenta con reportes ordenados por vehiculo, por dependencia,
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Diversidad Media
Retroalimentación: Aun existe repeticion de palabras de contenido, modifica tu texto evitando usar varias veces la misma palabra, procura usar sinonimos de dicha palabra

En el taller municipal de el H._Ayuntamiento_de_Nogales existe un proceso de captura de datos de los vehiculos que reciben **servicios** en el taller municipal y de los **servicios** preventivos que reciben las unidades de seguridad publica en la gasolinera el cual se lleva a cabo hasta el momento en hojas de Excel las cuales son enviadas a el H._Ayuntamiento_de_Nogales diariamente En el sistema actual es un problema en el manejo de unidades que ya fueron anteriormente dados de baja y aun se les estan extendiendo **servicios** Otro problema es que el sistema actual no cuenta el manejo de las unidades no se cuenta con un control de el numero de unidades existentes El sistema actual no se cuenta con reportes ordenados por vehiculo por dependencia reporte de todos los **servicios** a unidades por dia y mes El taller municipal de nogales no cuenta con un sistema para llevar el control el registro de **servicios** y unidades

Evaluación alcanzada :
Variedad alcanzada: 62.16%

Fig. 7. Lexical Analyzer for Diversity (in Spanish)

Upon completion 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 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.

In future work, we intend to use the ITS with college students who start with their research and observe the performance for future changes in the system. The experiment will use a control group and an experimental group to watch the progress in the two groups with respect to the recommendations of the tutor regarding their lexical richness. This pilot implementation will seek to measure if the student search has been concerned only to meet with a medium level of lexical analysis, or if he is looking to reach the highest level to improve their writing skills. Also we will adapt the interface of the ITS to have an improved use on mobile devices.

We also plan to extend the ITS assessing additional aspects in drafts such as coherence and specific language usage for particular sections of proposals.

Acknowledgements

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