AC 2010-2153: CENTERING RESONANCE ANALYSIS AS A TOOL FOR ASSESSMENT

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Using Centering Resonance Analysis to Assess Student Reports

Introduction

Knowledge is organized according to the meaning of words that defines the relationships established among the ideas that the word represents. Mental schemas are networks of these interconnected and interrelated ideas. In order to represent the knowledge structures that humans have in their minds, they can be represented spatially as concept maps. The mental schemas in memory and the concept maps that represent them consist of nodes, or ideas, and labeled links that represent the relationships among them [6].

The construction of concept maps aids student learning by requiring students to analyze the underlying structure of the concepts they are studying [10]. This process of creating concept maps engages a learner through her identification of the important concepts in the knowledge domain under study, arranging those concepts spatially, identifying the links or relationships among those concepts, and labeling the nature of the links between concepts. The construction of concept maps leads to meaningful learning—the restructuring of new concepts with previously acquired knowledge. Either hand-drawn or computer-based tools can be used to externalize students' mental schemas [6].

This paper posits another means of representing mental schemas—using a written text, such as a project report, to represent an individual's knowledge. Assuming that explicit textual artifacts are a reasonable representation of an individual's mental schema, then network text analyses can be used to summarize and represent the text. The basis of network text analysis is that the co-occurrence of concepts within a textual artifact represents a network of meaning. According to [2], the concepts in the text become nodes, and the nodes are linked if their corresponding concepts co-occur in the text. Once text is formed into a network, the text can be manipulated and analyzed.

Centering resonance analysis (CRA) is an approach for text analysis that uses the premises of centering theory [3]. A center is defined as an utterance that serves as a link to other utterances in the discourse segment that contains it [5]. Centering theory describes coherence as "a backward and forward reference to 'centers' of linked meaning and emphasizes noun phrases as the basic centers of reference" [9, p. 275]. CRA analyzes text by creating word networks of nouns and noun phrases that represent main concepts, their influence, and their relationships [8]. CRA calculates two scores for each individual word network—influence and resonance. Influential words are described as facilitating "the connection of meaning among many different words, across very different parts of the overall word net" [9, p. 278]. The influence of words is measured by their "betweenness centrality" within the word network. The betweenness centrality

index is measured by how often a node or word is on the shortest path in the word network connecting all other pairs of words [6].

The second score that CRA calculates is the resonance or similarity of two word networks in using the same influential words. Resonance is described as "a measure of the mutual relevance of two texts based on their CRA networks. The more they resonate, the more their CRA networks are similar" [9. p. 189]. CRA can also compare all individual word networks by generating resonance clusters.

The capabilities of CRA inspired three research questions for the initial limited study reported here. The research questions addressed are as follows.

- Research Question 1: What are the top influential words among word networks of student project reports?
- Research Question 2: How do student reports compare across application domain solutions?
- Research Question 3: How to student reports compare across report grade levels?

Method

The reports used in this study were created by students to describe results for an individual database application project in an introductory information systems course. The first half of course activities were devoted to a brief review of the role of information systems in organizations, with the remaining time devoted to fundamental database concepts involved in the requirements analysis, design, and implementation of a database system. The last half of course activities focused on reinforcing the concepts of the course through the creation by each student of a working prototype database for a real client. Because the process of database design and development was the focus of the course, once a client was chosen and the requirements analyzed, the students identified two different templates that could be used as a model for their database. In the final analysis, three types of database application templates were used—events management, membership, and orders management. The instructor recommended that the students undertake minimum adaptations to the templates. Each student wrote a report documenting the results of their project.

Each student report was from 12 to 20 pages in length and included numerous diagrams and tables related to the database design process.[1] Each report was created based on a teacher-provided outline that offered structural elements for report organization. The database and report counted for 30 percent of a student's final grade, with each weighted equally. In addition, the report process was divided by milestones so that students could turn in drafts for the major phases of the project. Two weeks after the demonstration of a prototype, the final database and

[1] Contact Dr. Cheryl Willis at clwillis@uh.edu for a sample of a student report.

the project report was due. The grades for the course were submitted a year before the reports were used in this study. A software application program has been designed specifically for use with CRA. Crawdad [4] calculates an index of betweenness centrality as a measure of the influence that nouns and noun phrases have in documents, as well as the resonance between two word networks. Crawdad also can compare all individual CRA word networks by generating resonance clusters. In addition, concept maps of individual word networks are created in which influential words and their links to other influential words are displayed. Prior to generating any CRA statistics, the individual project reports had to be converted to text files with tables, diagrams, and appendices removed, as well as any mention of the organization or student involved. The text files were named with a pseudonym indicating the grade level (A, B, C) of the report, the rank of the report within the grade level (1, 2, 3, etc.) and the application domain solution used—EM for Events Management, M for Membership, or OM for Orders Management.

With the use of Crawdad, the set of text-only files extracted from formatted student reports was converted to a Crawdad-specific format (.cra). The special format files were used in the remaining analyses. Using the Visualizer module, a concept map and influential words were produced for each file. The top 30 most influential words for each report were identified based on their betweenness centrality index. Then the individual scores for each word were averaged to determine the overall class score for each word. Finally, the Classifier module in Crawdad was used to perform a hierarchical cluster analysis to statistically analyze the resonance among the 20 word networks (each one representing a student report).

Results

Research Question I asked “What are the top influential words among this network of student reports?” Table I lists the top 30 most influential words, each word’s overall average score in descending order, and an indication of whether the word represents a course concept (knowledge domain) or an application domain concept. Influence scores range from 0 to 1. A score of 0.05 or higher is considered significant by leading researchers in the area, and a score above 0.1 is considered very significant [4]. For this set of student networks, all 30 terms in Table I have very significant values. Twenty-two of the terms refer to concepts covered in the course (knowledge domain). Eight words refer to an application domain concept. Almost all of the 30 words identified were nouns, which the exception of “new” (as in new system) and “friendly” (as in user friendly).

The faculty member who taught the course examined the list of influential words and found that it includes terms from most of the major concepts that were to be conveyed. The eight influential words from application domains are also expected and appropriate because the project report used in the analysis was a report about applying the knowledge domain to solve a practical problem.

Table I

Overall Influential Words

Word	Average	Domain
database	0.177726	Knowledge
order	0.164338	Application
customer	0.140893	Application
event	0.140893	Application
system	0.132956	Knowledge
member	0.127245	Application
data	0.123438	Knowledge
information	0.122327	Knowledge
product	0.091697	Application
prototype	0.087630	Knowledge
organization	0.086156	Knowledge
friendly	0.085940	Knowledge
report	0.083557	Knowledge
employee	0.080243	Application
work	0.080010	Knowledge
inventory	0.076440	Application
business	0.075392	Knowledge
table	0.071648	Knowledge
sale	0.068573	Application
track	0.067380	Knowledge
form	0.065012	Knowledge
menu	0.060300	Knowledge
company	0.059909	Knowledge
template	0.059791	Knowledge
new	0.059540	Knowledge
purpose	0.058903	Knowledge
file	0.058625	Knowledge
application	0.054943	Knowledge
result	0.052850	Knowledge
user	0.050872	Knowledge

An example of a concept map generated from one student's influential words is shown in Figure 1.[2] The darker shaded ovals are highly significant; the gray shaded ovals, significant. The darker shaded lines represent more frequent occurrences of pairs of words. The length of the lines represents how closely connected the terms are [8]. The student's influence scores (betweenness centrality index) for the top five influential words are as follows: information (0.16509), system (0.16395), database (0.14378), event (0.13221), and table (0.126).

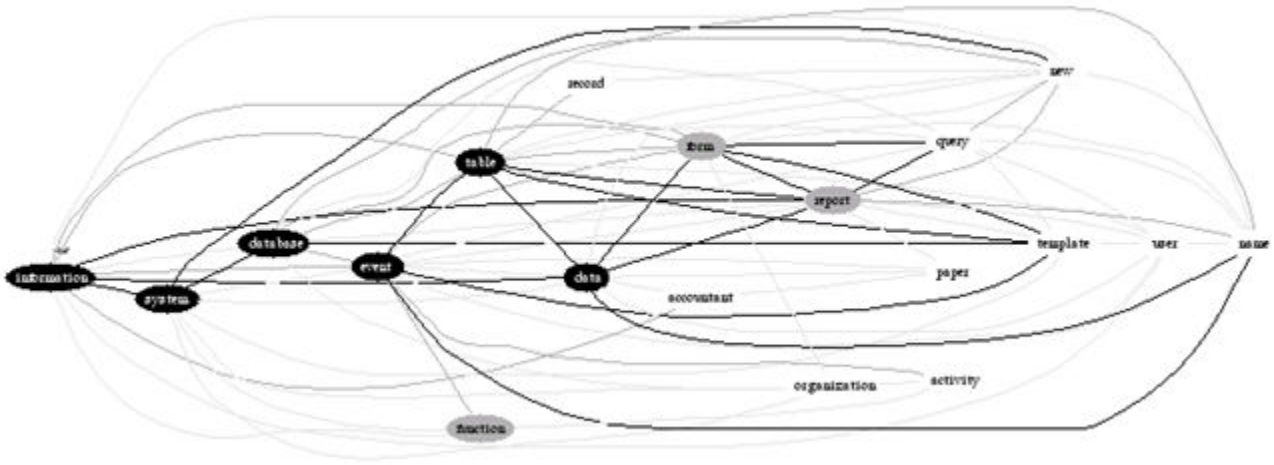

Figure 1. Student Concept Map of Influential Words

To address Research Questions 2 and 3, the reports were analyzed for resonance scores across both the application domains and across grade levels. The Classifier module of Crawdad was used to provide a hierarchical cluster analysis which describes the similarity or resonance between the 20 CRA word networks [4]. Figure 2 displays the results of the analysis. The optimal solution consists of one cluster containing 18 networks, with an overall resonance of .12. Much like correlations, the closer the resonance score is to 1.0, the stronger the size of the resonance. This resonance score is not strong—the networks are dissimilar across both application domains and grade levels.

[2] The quality of the concept maps is limited by the Crawdad software.

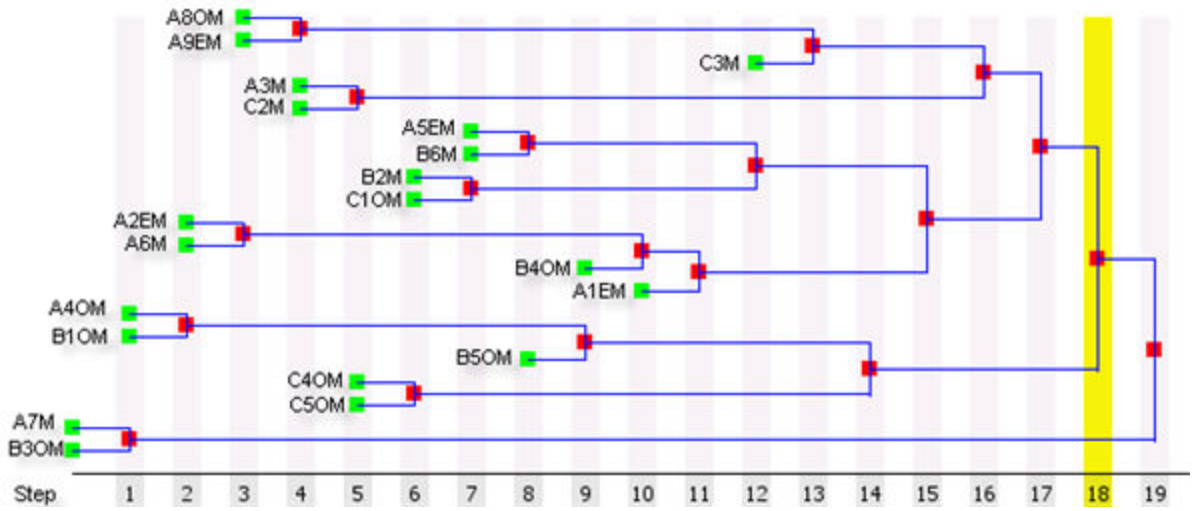

Figure 2. Resonance Cluster Analysis

Discussion

This study was conducted to analyze whether the concept maps generated from the individual word networks were adequate representations of the students' mental schemas. Analysis of the 30 most influential words overall showed that 22 words indicated course concepts (knowledge domain), although five of the top ten words indicated an application domain emphasis and had higher influence scores than many of the course concepts. What is perhaps more interesting is an analysis of the course concepts that are missing from the top 30 words— relationship, requirement, query, field, integrity, and ERD. All but "requirement" were typically "described" by students with tables, diagrams, or figures—which were removed before converting the files to plain text. What the students did not do was include any narrative explaining the table, diagram, or figure to follow. This error in writing style may explain the absence of these important concepts from the top 30 words. However, the missing concepts provide future areas of additional emphasis in the last half of the course.

The fact that the top 30 overall influential words had scores in the "very significant" or "significant" range would indicate that all students used similar influential words. The differentiation in grades cannot be explained by different mental schemas. A more likely scenario involves a differentiation in writing ability, with poor writing skills overriding the occurrence of the "right" words.

In terms of the resonance cluster analysis, looking at the two sub-clusters could potentially provide more clues into the similarity of the word networks. Cluster 18 contains two sub-clusters—Clusters 14 and 17. Cluster 14 had an overall resonance of .10 and a within-cluster resonance of .10, while Cluster 17 had an overall resonance of .11 and a within-cluster resonance of .07. Cluster 14 contains five networks from the Orders Management application domain. Unfortunately, Cluster 1 also had one and Cluster 17 had three Orders Management word

networks. Cluster 17 did have all but one of the Membership networks and all four of the Event Management networks. Cluster 14 seemed to lean toward the application domain concepts while Cluster 17 contained more influential words from the course concepts.

Conclusions

Results of this study have practical implications for all faculty, especially those who use writing activities to assess student's attainment of concepts. STEM faculty are being encouraged more and more to include writing activity in courses, and thus they are faced with the problem of assessing writing for content and form. CRA can be used as a tool to evaluate coherence of and to compare the content of textual artifacts or other forms of discourse. An application scenario is the assessment of essay question answers for large-enrollment sections. The instructor has key points she is looking for in the essay answer. CRA text-analysis software can be used to generate a concept map of what each student wrote and resonance cluster analysis can be used to group similar results. Each map presents the highly influential words in the essay. After grouping, the instructor could read sample answers from each cluster and assign a grade range to the entire cluster. Teaching assistants could then add or deduct points to each individual essay for eloquence of writing.

In addition to evaluating student work, CRA might be used to support continuous course or program improvement. Lists of influential words from final exams or reports could be examined to determine if a course is conveying concepts key to the field's body of knowledge. If maps indicate otherwise, then they serve as indicators of needed course revision. Existing research examines the applicability of the network comparison statistic of resonance as it relates to the internal network statistic of influence. These statistics need further study and others may need to be developed. In the present, CRA can serve as a tool for assessment of performance from an individual and a course perspective, when used in conjunction with other tools. While this study is hampered by a small sample size, it does provide an example of another tool that faculty might consider for instructional improvement.

References

[1] Canary, H., & Jennings, M. (2008). Principles and influence in Codes of Ethics: A centering resonance analysis comparing pre- and post-Sarbanes-Oxley codes of ethics. *Journal of Business Ethics , 80*, 263-278.

[2] Carley, K. (1997). Extracting team mental models through textual analysis. *Journal of Organizational Behavior* , 533-558.

[3] Corman, S., Kuhn, T., McPhee, R., & Dooley, K. (2002). Studying complex discursive systems: Centering resonance analysis of communication. *Human Communication Research , 28*, 157-206.

[4] Crawdad Technologies, L. (2005). Crawdad Text Analysis System version 1.2. Chandler, AZ.

[5] Grosz, B., Weinstein, S., & Joshi, A. (1995). Centering: A framework for modeling the local coherence of a discourse. *Computational Linguistics , 21*, 203-225.

[6] Isbell, M., & Davis, J. (2007). "Organizations are made to tick through talk:" A network comparison of conversation centers, influential words and network centrality. *Annual Meeting of the NCA 93rd Annual Convention.* Chicago, IL.

[7] Jonassen, D. (2000). *Computers as mindtools for schools: Engaging critical thinking.* New Jersey: Prentice Hall.

[8] McLaren, T., Vuong, D., & Grant, K. (2007). Do you know what you don't know? Critical reflection and concept mapping in an information systems strategy course. *Communications of the Association for Information Systems , 20*, 892-908.

[9] McPhee, R., Corman, S., & Dooley, K. (2002). Organizational knowledge expression and management: Centering resonance analysis of organizational discourse. *Management Communication Quarterly , 16*, 274-281.

[10] Willis, C. & Miertschin, S. (2006) Mind maps as active learning tools. *The Journal of Computing Sciences in Colleges. 21 (4).* 266-272.