

Characterizing the Temporal Dynamics of Student-Teacher Discourse

Linda P. Salamanca, Amber R. Carini, Monique A. Lee, Karmen Dykstra, Jacob Whitehill, Daniel Angus, Janet Wiles, Judy S. Reilly and Marian S. Bartlett, *Member, IEEE*

Abstract—Student-teacher verbal communication contributes to successful learning outcomes. In this study we explore the use of conceptual-based recurrence plots to characterize the dynamics of student-teacher interaction. The results indicate: 1) Individual differences in teachers' speech styles 2) Teacher speech may reflect strategies that are sensitive to student performance and 3) Student-teacher discourse dynamics may influence learning outcomes. Findings have educational implications, particularly in classroom settings where teachers depend on verbal interaction to communicate to students; they also provide the foundation for modeling student-teacher interaction and creating automated tutoring systems that respond sensitively and effectively.

Index Terms—Discourse, Social-interaction, Education

I. INTRODUCTION

During student-teacher interaction, verbal communication contributes significantly to successful learning outcomes. Speech provides teachers with real time information about the student's knowledge, and the opportunity to prompt or give further explanation [1-3]. While previous studies on student-teacher discourse have mainly focused on identifying individual speech patterns (e.g., teacher question-and-answering behaviors), few studies have addressed the interactional dynamics of student-teacher discourse. Understanding how teachers and students use speech in a learning context can help identify successful teaching strategies and form the basis for automated tutoring systems. The present study aims to characterize student-teacher discourse during one-on-one tutoring sessions using Discursis, (a computer- based speech analysis tool that uses recurrence plots, an information visualization technique that can reveal trends and features in complex time series data). Recurrence plotting techniques have been previously applied to textual data; however, previous approaches plotted recurrence using term-based similarity rather than conceptual similarity of the text [4]. In this study we explore how the descriptive power of

the conceptual recurrence plotting technique can be used to discover patterns of interaction during teaching discourse.

II. PROCEDURE

Participants were 20 middle school-age students (10 male, 10 female; age 13 years) and two middle school math teachers (one male, one female). Each student participated in a 10-minute pretest on logarithms, followed by a 40-minute one-on-one teaching session focused on logarithms, then a 10-minute posttest. All sessions were recorded via video cameras and transcribed using the Child Language Data Exchange System (CHILDES) [5]. Transcripts of verbal data were then uploaded into Discursis for analysis and extraction of speech metrics (quantitative measures of concept usage).

III. RESULTS

The results indicate: 1) Individual differences in teachers' speech styles. Specifically, Fig 1 shows that the male teacher tends to be iterative in style, recalling previously mentioned topics throughout the tutoring session, and is goal oriented in presenting new topics to the student. In contrast, the female teacher responds more to topics initiated by students, suggesting a more conversational style. 2) When student-teacher interactions are grouped by student improvement (the difference in pre- and post-test scores), results demonstrate distinctive verbal strategies when interacting with low improvement students versus high improvement students. Fig 2 shows that when the male teacher interacts with the lower improvement students, he is more likely to return to the same topics throughout the session; he also responds to topics initiated by the lower improvement students in the immediate time frame, reflecting conversational engagement. In contrast, when he interacts with the higher improvement students, over the long time frame, he is more likely to refer back to topics initiated by the higher improvement students than the lower improvement students, suggesting that he is summarizing concepts. 3) Finally, also of interest is a case study of a student with low overall improvement. The discourse dynamics of this particular student-teacher interaction more closely resembled a dyadic conversation rather than a directed teaching session as demonstrated by the student's tendency to introduce new topics and her propensity to repeat her own topics; these suggest that she, rather than the teacher,

Manuscript received June 29, 2012. This work was supported by NSF grants IIS-0905622, IIS-0905661, and NSF REU.

L.P. Salamanca, A. R. Carini, M. A. Lee and J. S. Reilly are at San Diego State University (corresponding author email: Salamanca.Linda@gmail.com)

K. Dykstra, J. Whitehill and M.S. Bartlett are at the University of California San Diego.

D. Angus and J. Wiles are at the University of Queensland, Brisbane.

controlled the conversation [Fig 3 and 4]. Her overall lack of improvement coupled with these interaction dynamics suggest that when a student carries more of the conversation during a tutoring session, the learning outcome may be low. Similarly, a previous study on doctor-patient conversations found that when a doctor dominates the conversation, as this student did with the teacher, it results in an erroneous diagnosis [6].

IV. CONCLUSION

Overall, our findings show distinctive dynamic patterns of student-teacher discourse, varying by individual teaching style, student prior knowledge and performance. Findings have educational implications, particularly in classroom settings where teachers depend on verbal interaction to communicate to students; they also provide a foundation for modeling the dynamics of student-teacher interaction and creating automated tutoring systems that respond sensitively and effectively to students.

ACKNOWLEDGMENT

We would like to thank the students and teachers who participated; without them this study would not be possible.

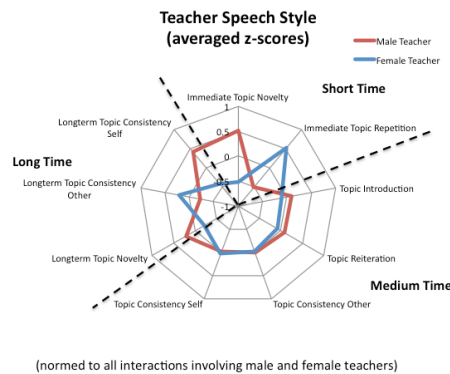


Fig. 1. A radar plot shows teacher interactions averaged across students. The male teacher tends to repeat topics previously mentioned during the tutoring session as indicated by his higher longterm topic consistency score, and he is most likely to be the speaker that introduces new topics as indicated by his higher immediate topic novelty score. Conversely, the female teacher tends to repeat concepts initiated by the student as indicated by her higher immediate topic repetition score.

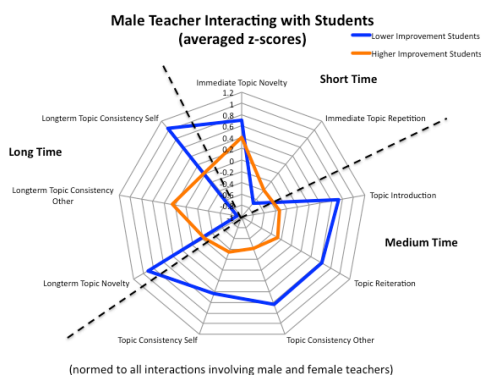


Fig. 2. A radar plot showing the male teacher's verbal behavioral characteristics when interacting with both lower and higher improvement

students. Results suggest that when the male teacher interacts with students who showed lower improvement he is more likely to repeat topics he introduces as well as topics initiated by that group in the immediate time frame. When interacting with students who showed higher improvement, the male teacher is likely to refer back to topics initiated by that group in the long time frame.

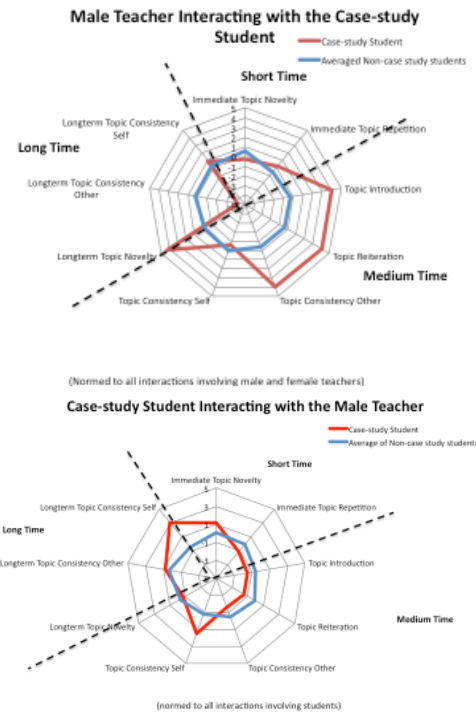


Fig 3 and 4. Radar plots comparing the case-study student to the average of all other students. When interacting with the case-study student, the male teacher exhibits speech behaviors that are repetitive throughout the session while still introducing new topics into the conversation. Meanwhile, the case-study student introduces new topics during the session and is on-topic with herself and the teacher throughout the tutoring session.

REFERENCES

- [1] O. G. Aguiar, E. F., Mortimer and P. "Learning from and responding to students' questions: The authoritative and dialogic tension," *Journal of research in science teaching*, vol 47(2), pp 174-193, 2010.
- [2] L. R. Smith. "Aspects of teacher discourse and student achievement in mathematics," *Journal for research in mathematics*, vol 8(3), 195-204, 1977.
- [3] L. T. Louca, Z. C. Zacharia and D. Tzialli. "Identification, interpretation, evaluation, response: An alternative framework for analyzing teacher discourse in science," *International journal of education*, pp 1-34, 2012.
- [4] D. Angus, A. E. Smith, and J. Wiles. "Conceptual Recurrence Plots Revealing Patterns in Human Discourse. *IEEE Transaction Visual and Computer Graphics*," vol 18(6), pp 988-997, 2012.
- [5] B. McWhinney and C.E. Snow. "The Child Language Data Exchange System," *Journal of Child Language*, vol 12, pp 271-296, 1985.
- [6] D. Angus, B. Watson, A. Smith, C. Gallois, and J. Wiles. "Visualizing conversation structure across time: Insights into effective doctor-patient consultations," *PLoS ONE* 7(6): e38014.doi:10.1371/journal.pone.0038014, 2012.