Temporal Analysis of Productive and Improvable Knowledge-Building Discourse

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Background

Temporal aspects of teaching and learning are extremely important (Kapur, 2011; Mercer, 2008; Wise & Chiu, 2011).

However, "time" is found playing almost no role as a variable in educational research (Barbera, Gros & Kirschner, 2014; Suthers, 2006). This phenomenon could be attributed to a theoretical gap, in that learning theories generally do not take temporality into consideration (Roth, 2006). It is also related to a methodological gap, since little guidance is available for gathering and analyzing temporal data (Littleton, 1999).

Goals

The present study attempts to bridge the methodological gap by:

- advancing Lag-sequential Analysis as an analytic method emphasizing temporality; and
- showcasing its application in studying knowledge building dialogues

Lag-sequential Analysis

The central goal of Lag-sequential Analysis (LsA) is to identify contingency relationships in a sequence of observed behaviors and enables researchers to explore cross-dependencies occurring in complex interactive sequences of behaviors (Sackett, 1979; Faraone & Dorfman; 1987).

To make LsA more accessible to educational researchers, we implemented an R program based on previous studies. LsA usually involves computation of the following measures step by step:

1. **Transitional frequency**: how often a particular transition from behavior A to behavior B occurs for a specified sequential *lag* (i.e., the frequency of behavior B happens behind behavior A after a specific *lag*)
2. **Transitional probability**: a conditional probability indicating the likelihood of, for example, behavior B occurring, given that behavior A occurred
3. **Adjusted residual**: *z* score representing the statistical significance of a particular transition (to adjust for the base rates for the two behaviors involved)
4. **Yule's Q**: *Yule's Q*, a standardized measure ranging from -1 to +1, to indicate the strength of association (to further adjust for the number of data points)

Comparing with the widely applied *frequent sequence mining* (Zaki, 2001), LsA has an important strength in doing significance tests on identified temporal or sequential patterns (Bakeman & Gottman 1997).

A Case of Studying Knowledge Building Dialogues

A case study of LsA was conducted in the context of knowledge building (KB), a renowned constructivist pedagogy created by Scardamalia and Bereiter (2003). It puts ideas at the center and engages students to take cognitive responsibility for improving them through communal discourse, in which students contribute in various ways. One key question, then, is what's the makeup of a good or productive KB dialogue in terms of *contribution types* (Chuy et al., 2011).

While prior work depended on the "coding-and-counting" approach, the case study aimed to apply LsA to uncover temporal relations among different contribution types that distinguish productive KB dialogues. This study used secondary data consisted of a total of 1101 Knowledge Forum notes collected from Grade 1-6 students who were studying science. The following analyses had already been conducted prior to this study:

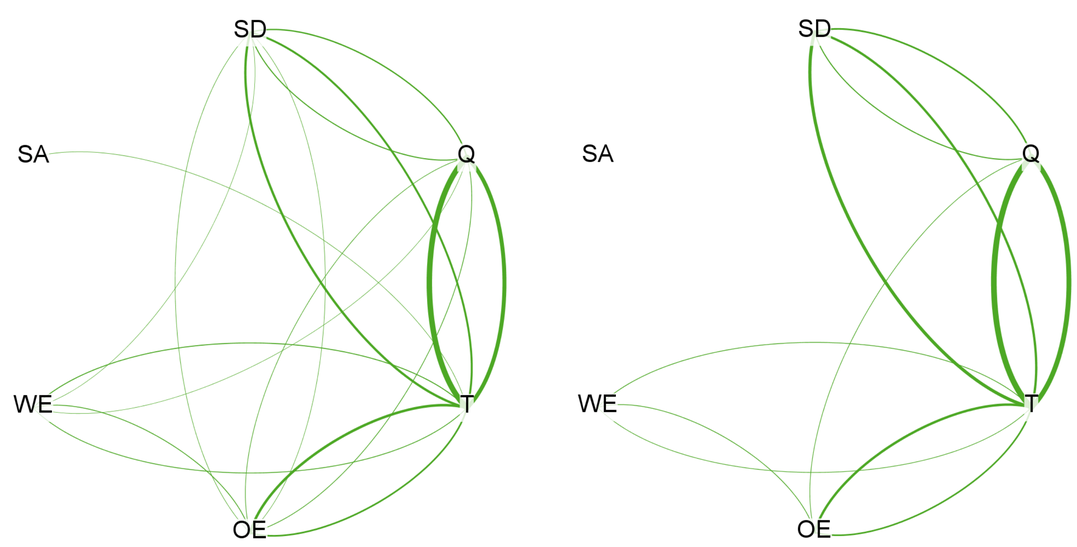
- Coding ***contribution types*** in each note, which included *questioning*, *theorizing*, *obtaining evidence*, *working with evidence*, *syntheses and analogies*, and *supporting discussion*
- Identifying ***inquiry threads***, by clustering notes according to shared principal problems
- Categorizing ***productivity*** of each inquiry thread, into *productive* or *improvable*, based on whether there was any occurrence of improving an explanation

With these analyses already accomplished, LsA was applied to detect differences between productive and improvable threads in terms of temporal patterns among contributing types.

Results of Analysis

Comparisons of Basic Contribution Measures. Comparisons made on a set of basic contribution measures, such as *numbers of discourse units*, *occurrences of contribution types*, and *percentages of contribution types*, did not find any significant difference.

Transactional Frequencies. The figure below visualizes transactional frequencies among six contribution types. Interesting temporal differences between productive (left) and improvable (right) KB dialogues are becoming readily apparent.



Advanced LsA Measures. Through further mathematical computation, LsA identified temporal patterns that were significantly different between two types of dialogues. The table below summarizes uncovered differences measured by *Yule's Q*, with *lag* = 1 or 2. In this table, "+" indicates transitional relations that happened significantly more frequently in productive dialogues, whereas "-" denotes the other way around. Briefly, productive threads of inquiry involved significantly more transitions among *questioning*, *theorizing*, *obtaining evidence*, and *working with evidence*, while improvable inquiry threads showed more transitions involving *giving opinions*, a sub-category of *supporting discussion*.

	Next Move					
Current Move	1	2	3	4	5	6
1. Questioning			+			-
2. Theorizing	+		+			-
3. Obtaining Evidence	+					
4. Working with Evidence		+				
5. Syntheses & Analogies						
6. Supporting Discussion	-	-				

Significance

This study builds on previous research that highlights the importance of temporality. It contributes to learning analytics literature by introducing KB perspectives and to KB research by uncovering temporal patterns worth further investigation. By developing an R program, it also makes LsA more accessible for educational researchers.