An automated measure of group knowledge structure convergence

Current advances in the automation of knowledge structure measurement allow and necessitate new measures to describe this kind of knowledge. The very terms ‘knowledge structure’ and ‘knowledge map’ connote visualization and bring to mind some uncommon visual concepts such as conformation, congruence, and convergence. Purpose: This presentation describes an automated method for analyzing essays as a measure of knowledge convergence in collaborative online learning using *ALA-Reader* software to derive group knowledge representations. In particular, based on a graph theory and a network analysis perspective, we propose a measure of knowledge structure called *degree centrality of a graph*. Degree centrality of a graph is a fairly easy to calculate measure of graph structure that ranges from 0 to 1, with 0.1 representing a ‘linear’ form, 0.4 a ‘hierarchical’ or ‘tree’ form, 0.6 representing a ‘network’ form, and 1 representing a ‘star’ or ‘hub and spoke’ form (see Figure 1; Yin, Vanides, Ruiz-Primo, Ayala, & Shavelson, 2005).

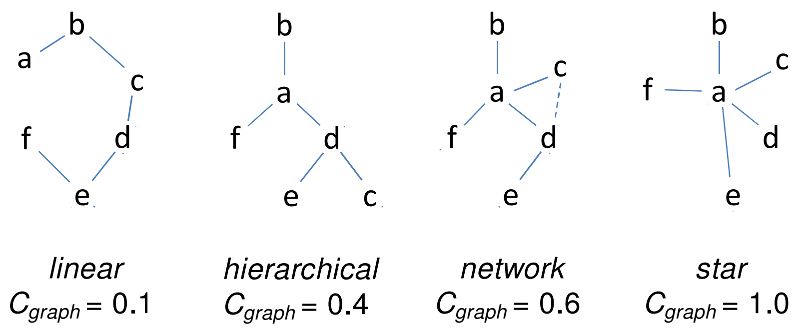

Figure 1. Measures of degree centrality of a graph for several network structures.

Here are the equations for calculating node and graph degree centrality values (Wikipedia, 2010).

Equation 1, Degree centrality of a node: $C_D(v) = \mathrm{deg}(v)/(n-1)$

Equation 2, Degree centrality of a graph: $C_D(G) = \Sigma_{(i=1 \text{ to } V)} [C_D(v^*) - C_D(v_i)]/(n-2)$

Table 1. Example of node and graph degree centrality for the ‘linear’ and ‘star’ graphs from Figure 1.

	node degree count		→		*Equation 1*		→		*Equation 2*		
	linear	star			linear	star			linear	star	
a	1	5		a	0.20	1.00		a	0.05	0.00	
b	2	1		b	0.40	0.20		b	0.00	0.20	
c	2	1		c	0.40	0.20		c	0.00	0.20	
d	2	1		d	0.40	0.20		d	0.00	0.20	
e	2	1		e	0.40	0.20		e	0.00	0.20	
f	1	1		f	0.20	0.20		f	0.05	0.20	
								degree centrality of a graph =	0.10	1.00	Σ (sum)

Method and Data sources: In a recent dissertation (Draper, 2010), auto sales industry service representatives (N = 121) working at dealerships in the field enrolled in an online course over several months worked either alone on a self-paced module (SP) or on the self-paced module plus participation in an online community of practice (CoP). All participants completed a case-based essay as part of the course final assessment. The essays were quantified into PFNET knowledge maps (i.e., pathfinder network graphs) using *ALA-Reader* software. Next, in order to randomize the participants into two comparable groups, the individual participants' PFNET data were numbered from 1 to 121 simply based on their order in the SP and CoP datasets and then participants were assigned to either the 'even' or the 'odd' group based on this number; this process obtained four separate groups including: SP_{even} (n = 28), SP_{odd} (n = 28), CoP_{even} (n = 32), and CoP_{odd} (n = 33) groups. The average PFNET representations for these four groups were then calculated using Pathfinder *KNOT* network analysis software (see Figure 2). It required about 1 hour to set up the software files and then 1 hour to run the 121 essays (i.e., 2 hours total time from raw essays to the final PFNET graphical representations).

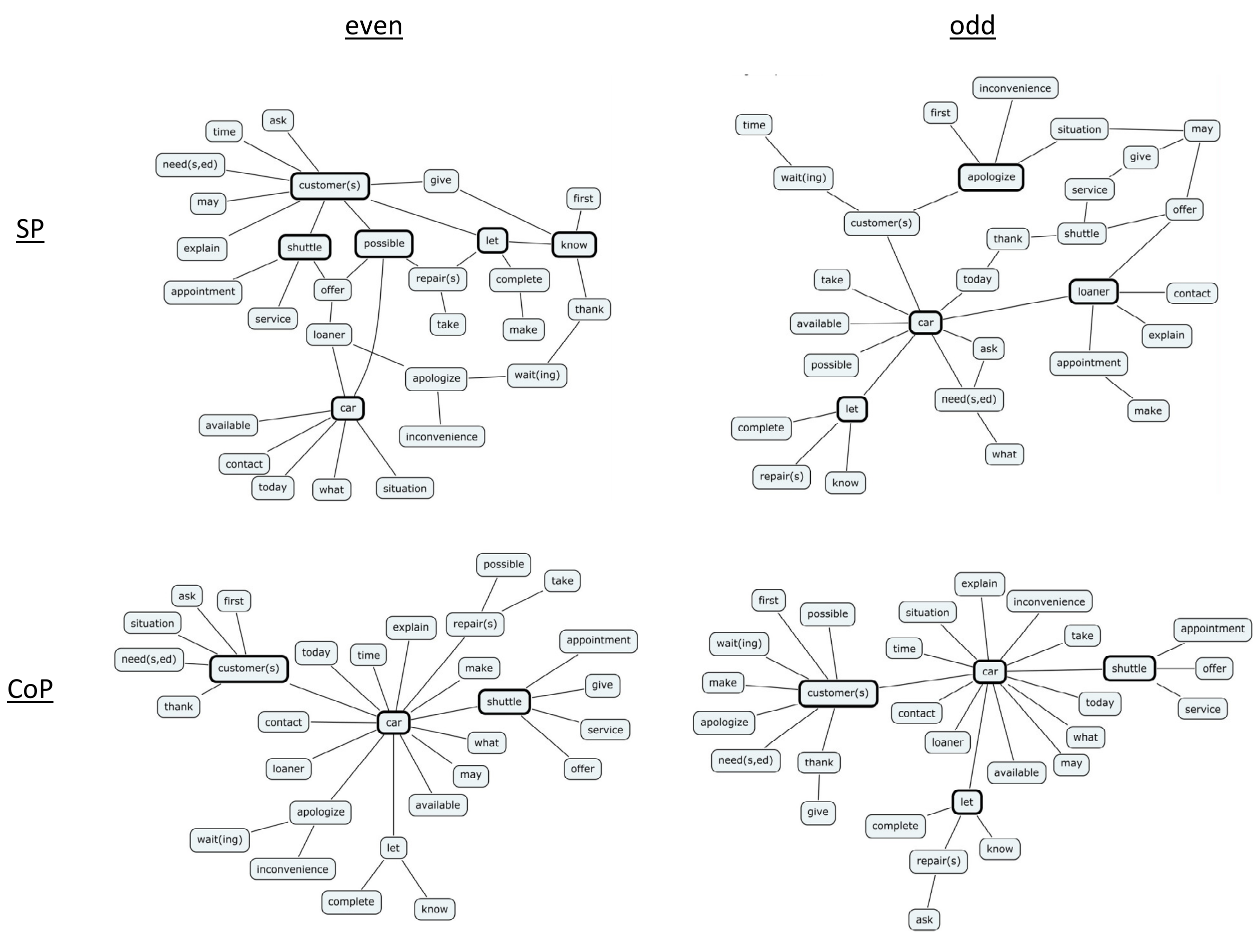

Figure 2. The four group average PFNETs, even and odd groups for SP and CoP.

Results: Results show that the even and odd CoP group PFNETS had a larger graph centrality (CoP: even group's centrality = 0.446 and odd group's centrality = 0.446, thus both CoP groups are more hierarchical in form) compared to the SP groups (SP: even group's centrality = 0.249 and odd group's centrality = 0.251; thus both SP groups are more linear in form). Also the even and odd CoP group PFNETs were twice as similar to each other (66% overlap, with 19 of 29 links in common) relative to the even and odd SP group PFNETs (33% overlap, with 11 of 33 links in common). The even and odd CoP PFNETs also 'looked' more alike. The CoP groups had three *very* high degree nodes, "customer", "car", and "shuttle", while the SP groups also included these three plus the nodes "possible", "let", "know", and "apologize".

Conclusion: In this investigation, these results for graph degree centrality by inference indicate that the group average knowledge structure of the participants in the collaborative online community of practice converged towards a more hierarchical structure relative to the self paced group that did not collaborate online.

Significance of the study: These findings provide support for using node and graph degree centrality, which is an easy to calculate and easy to understand measure of visual structure, for measuring convergence of knowledge structure representations in online and other settings that could be applied not just to end-of-course essays but also to concept maps and other graphical approaches for eliciting knowledge structure. Honestly, the visual similarity and the equivalence of the calculated graph degree centrality between the two CoP and the two SP average group PFNET representations (i.e., even compared to odd) is astonishing! Obviously we need to replicate this

References

Draper, D.C. (2010). *The instructional effects of knowledge-based community of practice learning environments on student achievement and knowledge convergence*. Available online from http://etda.libraries.psu.edu/theses/approved/WorldWideFiles/ETD-5128/Darryl_C_Draper_Dissertation_Final1.pdf

Wikipedia (2010). *Centrality*. available from http://en.wikipedia.org/wiki/Centrality#Degree_centrality

Yin, Y., Vanides, J., Ruiz-Primo, M. A., Ayala C. C., & Shavelson, R. J. (2005). A comparison of two construct-a-concept-map science assessments: Created linking phrases and selected linking phrases. *Journal of Research in Science Teaching, 42* (2), 166–184. (also available online as http://www.eric.ed.gov/PDFS/ED483390.pdf)

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An automated measure of group knowledge structure convergence

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Abstract: This presentation describes an automated method for analyzing posttest essays as a measure of group knowledge convergence in a collaborative online learning setting using a Pathfinder network based approach and *ALA-Reader* software. Based on graph theory and network analysis perspective, *degree centrality of a graph* is used as a measure of essay convergence. Results show that knowledge convergence occurred for participants in the community of practice.