An Annotated Bibliography of Concept Mapping

GNA Garcia

University of Connecticut

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Concept Mapping

The use of concept mapping, also referred to as cognitive mapping and concept mapping, spans across many disciplines and settings including educational research, clinical psychology, classroom teaching, and field research. The articles reviewed in this annotated bibliography represent only a portion of the diversity of approaches to mapping, the uses of mapping, and the analyzing of maps employed by scholars and researchers. Some common themes within the literature reviewed are:

- Concept maps represent the creator's domain-specific knowledge at the moment of the maps creation,
- Concept maps are most robust (i.e. statistically significant) as a research method when pre-post measures are collected and compared,
- Concept maps are most valid and reliable when the subject has received training on how to create a concept map (seeing examples of maps is most helpful),
- The act of creating a concept map further deepens the subject's knowledge of the domain, and
- Using computer-based mapping tools may provide map creators greater agility in exhibiting their understanding of the concept and its relationships with other nodes of information.

Bitoni, C. (1993). Cognitive mapping: A qualitative research method for social work. Social Work Research and Abstracts, *29*(1). Retrieved on November 1, 2007, from http://search.ebscohost.com/login.aspx?direct=true&db=aph&AN=9609194537&site=ehost-live

The author, a clinical social worker, used cognitive mapping (read: concept mapping) as one of several qualitative research techniques to investigate changes in self-esteem among women in relation to cognitive and environmental factors (*N*=13). Concept mapping in Bitoni's study served as a projective measure of the subject's self-esteem at the moment when the research was conducted. That data was collected from respondents over four hours in three separate interviews. Bitoni employed concept mapping as technique to collect data on the subjects' cognitive "self-schema." She contended the maps, used in conjunction with other data (e.g. interview data and self-report questionnaires), would generate "additional self-reflection" on self-esteem from the respondents.

A unique feature of this study was Bitoni's use of "concept cards."[1] The concept cards were generated by the researcher for each subject based on a previous interview during which the researcher asked the subject to create a list of questions pertaining to their self-esteem. The researcher then used the concept cards during the mapping exercise; which consisted of the subject sorting and organizing the cards into categories and themes, and then describing the map. No results from the study were reported in this article because its main purpose was to describe the use of cognitive mapping as a research method in the field of social work. However, the researcher concluded the use of cognitive maps in the field of social work to be an excellent way to create grounded theory which may inform practice.

Boxtel, C., Linden, J., Roelofs, E., & Erkens, G. (2002). Collaborative concept mapping: Provoking and supporting meaningful discourse. *Theory Into Practice, 41*(1), 40-46.

According to the findings of Boxtel, Linden, Roelfs, and Erkens creating concept maps as a classroom-based collaborative exercise among 15-16 year old science students contributes significantly to learning because of several reasons including providing students the opportunity to talk about the phenomena via the picture (aka the concept map). Furthermore, according to the authors, concept maps when created collaboratively, offer students the opportunity to practice skills such as negotiation and reflection. Jointly creating a concept map means students engage in questioning, reasoning, and resolving disagreements. The authors state, "When peers work on a common task, mutual understandings must be created and sustained…" Mutual understanding means shared meaning achieved through reflecting on both individual knowledge but also integrating and building upon the knowledge expressed through the contributions of their co-creators.

Boxtel et al. share similarities with other authors reviewed here in their belief that one of the major strengths of using concept maps in the classroom is the ability for students (and teachers) to compare students' conceptions of new information prior to instruction to those after instruction. The pre-post cognitive dissonance as manifest on the concept maps by knowledge gaps and inconsistent reasoning (read relationships) affords opportunities for instructional

[1] This is unique because typically concept maps are drawn or created on a computer by the subject.

strategies or other types of interventions which assist students directly to clarifying misconceptions.

Carley, K., & Palmquist, M. (1992). Extracting, representing and analyzing mental models. *Social Forces, 70.* Retrieved on November 1, 2007 from http://search.ebscohost.com/login.aspx?direct=true&db=psyhref&AN=SF.GJ.FJA.CARLEY.ERAMM

Carley and Palmquist describe a dearth of research methodology, theory, and tools available to adequately describe the cognitive functions of social behavior. Their interest in the arena of mental models (read: concept maps) focused on three areas: "the relationship between mental models and language, the relationship between words and meaning, and the nature of social knowledge or shared meaning." The goal of the research described in this piece was to create a systematic way for others (i.e. researchers) to analyze, including cross-model comparisons (e.g. expert vs. novice, pre-post) and quantify, mental models created during the analysis of text.[2] The researchers proposed a four-step process using one of two different computer-based mental modeling tools (STARTUP or CODEMAP). The process entails: identifying a set of concepts, defining types of relationships thought to exist between concepts, coding the text (with the aid of the aforementioned software) based on concepts and relationships, and lastly displaying a map and analyzing it statistically (e.g. strength of relationships i.e. correlations). Certainly the most obvious benefit of this type of approach to creating mental models is the predetermined, finite amount of possible concepts and relationships available to code each text which makes comparisons possible. The downside to this type of approach is the limitation it places on the researcher and/or subject's ability to include nuanced or unique concepts and relationships not unearthed during the creation of the original list. I am reticent to call this approach to creating mental models a projective measure because of the limitation previously cited.

Jacobs-Lawson, J. M., & Hershey, D. A. (2002). Concept maps as an assessment tool in psychology courses. *Teaching of Psychology, 29*(1), 25-29.

In a small study (N=17) of undergraduate psychology students Jacobs-Lawson and Hershey found statistically significant differences in students' inclusion and elaboration of key course concepts on pre- and post concept maps.[3] The researchers provided students with specific instructions and training in creating concept maps—believing that measuring change between pre- and post maps is only valid when subjects are provided with the tools and experience necessary to adequately represent their knowledge. The pre-concept map was created during the first week of a one hundred-level psychology course. The main topic for the map was "psychology." The post-concept map was created at the end of the course. The students experienced statistically significant change rates across several variables including the total number of concepts included (t=7.14, p<.01) and usage of key course concepts e.g., memory, (76.5% increase, zScore=3.61, p<.01) and learning (64.7% increase, zScore=3.05, p<.01). The researchers concluded concept mapping is an excellent evaluative measure. They further recommended the use of concept mapping as an instructional method throughout the course

[2] Text in the case of this research refers to both written text and text aka transcripts derived from subject interviews.
[3] Jacobs-Lawson and Hershey define concept maps as, "…a graphic, hierarchically arranged knowledge representation that reflects the content of an individual's semantic long-term memory."

because it allows for deep elaboration of domain knowledge and, citing theory from cognition and learning, state, "… this active exploration process leads to the refinement and synthesis of one's knowledge structures; thus, the mapping process is a learning experience in and of itself."

McAleese, R. (1998). The knowledge arena as an extension to the concept map: Reflection in action. *Interactive Learning Environments, 6*(3), 251–272.

In the opening of his essay, McAleese asserts, "Maps of concepts and relationships have been used by many researchers and practitioners to help diagnose misunderstanding, improve study methods and glimpse how learners *come to know*." Throughout the remainder of the piece McAleese describes the history of concept maps (also referred to throughout the article as cognitive maps), relates the mapping process to self-regulation and "self-confrontation," and provides a simple process for creating concept maps (using paper and pencil or computer-assisted[4]), among other sub-areas frequently discussed in the literature of concept mapping.

For the purposes of this review and my overall research interests I gleaned four thought-provoking kernels of information from the author's work.

1. Concept maps are symbolic representations of knowledge. The creation of the artifact itself i.e. the concept map leads to the resolution of "a tension" between what the creator knows and what is stored within the creator's schema.
2. Although the concept map represents the creator's "truth," as in their understanding of the subject, they may hold what McAleese calls "non-truthful understandings" referring to the accuracy or validity of the map creator's understanding of the objective truth as evidenced by scientific experimentation and/or experts.
3. The author posits two laws in reference to the boundaries of concept maps: He states, "Concept models are represented using the least number of concept labels and relationships—for the current understanding." And, "Each and every concept label signifies an indeterminate number of other related concept labels." In other words, concept models/maps are inherently the most parsimonious representation of the creator's domain-specific knowledge, while at the same time because they are created within a two-dimensional space (i.e. a page or computer screen) they can never thoroughly represent the infinite number of multidimensional relationships between concepts.
4. Following up on #3 above McAleese affords that his philosophical position about the role of concept mapping a tool for teaching and learning is one of constructivism. If one believes concept mapping is a dynamic process, one of "off-loading" thinking, then they must consequently believe creating a concept map is "engaging in knowledge construction."

[4] McAleese believes there to be little or no difference in the outcomes i.e. artifacts creating during the concept mapping process. However, he contends using a computer-assisted approach allows the creator an opportunity to generate a more robust list of concepts.

Nadkarni, S., & Narayanan, V. K. (2005). Validity of the structural properties of text-based causal maps: An empirical assessment. *Organizational Research Methods, 8*(1), 9-40.

Looking to organizational behavior and management research, the authors present findings of a study focusing on what they refer to as "text-based causal maps (TBCMs)."[5] The TBCM is a concept map generated from coding textual data (mostly from subject interviews). The goal of the study was to investigate the psychometric properties of TBCMs through comparing them to other quantitative measures in the areas of complexity and centrality, two areas they believe to be central to establishing construct validity. The researchers also looked at the internal consistency, dimensionality, and predictive validity of TBCMs.

The two main variables in the study were complexity defined as capturing the "level of differentiation and integration in the map, that is, "the breadth and comprehensiveness in the articulation and elaboration of domain knowledge," and centrality which according to the researchers, "reflects the degree to which the map is hierarchical and focused on a single concept or few concepts in the map."

Nadkarni and Narayanan tested several hypotheses in their research; however for the purposes of this review the results of only one will be described. TBCM complexity and complexity will predict student academic performance. To test their hypothesis the researchers collected texts from a large sample of college students (N=204). The texts were coded by one group of researchers then another group of researchers applied the coding schema on the texts to establish interrater reliability. At the same time other data, cognitive ability (measured by the Wonderlic test) and academic performance (measured by a student's grade in the course) was collected. Correlations were performed on the salient variables. They ranged between .37 and .58 ($p<.0001$) between TBCM complexity and centrality and academic performance. And in a regression analysis holding all other variables constant, complexity and centrality predicted performance (adjusted $R^2=.27$, $p<.0001$).

The conclusion of the piece proved to be the most illuminating for the purposes of this review. The authors stated in regards to study limitations that to assume the domain knowledge of individuals can be captured in the form of a TBCM may be inherently flawed because it could lead to the exclusion of important cognitive structures not captured by the coding schema. [Note: I cited a similar limitation in the Carley and Palmquist research.] Also worth mentioning is the potential for bias within the coders; a strong potential for any type of qualitative research no matter how quantitative it intends to be.

[5] The authors describe TCBMs as, "rich in descriptive detail and portray individuals' thinking about their environment in operational terms."