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CREATING, ASSESSING, AND UNDERSTANDING THE USE OF CONCEPT MAPS AS A TEACHING AND ASSESSMENT TECHNIQUE

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Abstract

Concept maps, a specific kind of mental model, are one method of representing and measuring an individual's knowledge. They are an alternative tool for teaching through building relevant associations, as well as a method for measuring knowledge and recall over time. Concept maps provide a visual representation of conceptual and relationship knowledge within a particular domain. Concept maps look like a spider web, consisting of many nodes (i.e., key concepts) connected to one another by lines that indicate relationships. In the learning process, students can develop concept maps as an alternative to traditional note-taking by building associations of non-linear key concepts and organizing them to fit with their individual learning styles and frames of reference. The presence of concepts and relationships on a map can provide an instructor with a snapshot of student knowledge and understanding. The proximity and connection of key concepts provide insight for instructors attempting to evaluate how ideas from class have been incorporated. Conversely, the absence of concepts or relationships on a map provides clues about what information students failed to internalize or incorporate. Concept maps may aid the instructor in assessing what students understand and how they relate the material to the overall course goals. They are easily taught and can be incorporated in introductory units, mid-term reviews and assessments, or end-of-course reviews and assessments.

Keywords: Mental models, concept mapping, teaching technique, assessment technique

Introduction

Concept mapping is not new to academia, but is most often used in Education- and Psychology-related courses where the technique originated and developed. While previous conference presentations and papers (Fisher et al. 1990, Freeman and Urbaczewski 1999, 2001, 2002, 2003, Gaines and Shaw 1995, Hoover and Rabideau 1995, Markham et al. 1994, Taber 1994) focused primarily on the empirical results of using concept maps as teaching and assessment tools, this tutorial focuses primarily on their creation and application within the classroom. Instructors who understand how to use concept maps understand better how students incorporate and organize knowledge and information. This shared understanding allows both instructors and students to navigate the torrents of technology with greater ease.

While part of this tutorial focuses on the technique itself, a significant part of the tutorial is devoted to how participants can create and assess their own concept maps. This hands-on approach further aids in creating a greater awareness of the potential benefits and applications of concept maps within the classroom. Having said this, the remainder of this paper focuses mostly on the theoretical background of concept mapping, the actual creation of a concept map, and some of the applications of concept maps within the classroom (including coverage of assessment techniques and issues).

Concept Mapping Theory

Concept mapping was originally developed as a research technique in 1974 to make sense of data gathered in clinical interviews (Novak and Musonda 1991). Since then, concept mapping has been used in numerous ways in education, psychology, and organizational settings (Fraser 1993, Novak 1995). Concept mapping enables people to visualize the specific relationships among concepts as well as the hierarchical structure and organization of these relationships.

Two cognitive theories of memory have been used to support concept mapping – Ausubel's (1968) Assimilation Theory and Deese's (1965) Associationist Theory. Assimilation theory states that memory is hierarchical, and new information is processed and stored as either a more general or more specific concept to other, related concepts, i.e., assimilated into the existing structure (Fraser 1993). For example, if someone already knows the concepts of dog, bird, cat, and human, when the concept of animal is learned, it is put into the hierarchy "above" these others already present. Also, if this same person were to learn the concepts of eagle and canary, they would both be placed "under" bird as new branches of the hierarchy.

Associationist theory states that memory consists of a network of concepts that is not hierarchical, though is supportive of hierarchies. Relationships between concepts are formed naturally when two concepts overlap on some dimension. This is akin to word association games, though in these games the relationships are not labeled. As learning occurs, this network of concepts and relationships becomes more and more elaborate and complex. In the end, the memory structure in Associationist Theory is extremely similar to that of Assimilation Theory, except that hierarchies are not required.

Both theories "eventually arrived at the same place" – a concept map (Shavelson et al. 1994, p. 16). The concept map is intended to externalize an individual's cognitive structure, regardless of the theory behind it. The method for developing concept maps depends on which of the two theories is being followed and will be presented in more detail below.

Concept Map Creation

A concept map is a pictorial representation of a domain that consists of concepts represented as nodes that are connected to each other by arcs. The concepts are words or ideas that represent events, objects, or even emotions and feelings. The connecting arcs represent the conceptual links – stating that the concepts are conceptually and logically related in some manner – between two or more concepts within the concept map (Dorough and Rye 1997). Fraser (1993) provides the following "rules" to govern the construction of concept maps, supported by Novak and Gowin (1984) and Shavelson et al. (1994), and based on Ausubel's (1968) Assimilation Theory:

1. Concepts are located in rectangles or other geometric forms. Concepts can be represented by single key words or phrases or simple drawings. Lines connect the concepts. Linking words are written on the lines that describe the relationship between the two concepts.

2. The linking words should specifically explicate the relationship between the two concepts. Together with the two concepts, the linking words form a "proposition" – such as "the grass is green" from the concepts 'grass', 'green', and the linking word 'is'. It should be noted that the literature views these linking words as optional in terms of concept map construction.

3. There is no "right" map as all maps are idiosyncratic to each individual. Different people may produce very different maps for the same conceptual domain. A concept map can be wrong, however, if there are propositions that are incorrect, such as "the bear speaks English."

4. The interconnections between concepts give rise to the power of the concept map. More interconnections and cross-linkages are an indication of a greater complexity and sophistication of understanding.

Concepts and key words may vary in their relevance to a lecture topic. Often times, map creators have quite a bit of latitude in using the terms they see fit in developing their maps. However, some words may be more "creative" – words that are consistent with some personal perspective or predisposition. At a point in time, these creative key words may be meaningful, but over time they tend to loose their relevance. Pre-constructed "expert" maps can be provided to students as a teaching tool. The maps are used in the tradition of lecture outlines or PowerPoint presentations. Providing pre-drawn maps can create biases in the number of key words on a map and in the way the associations are defined between nodes. However, when using concept maps for

imparting knowledge, the structure provides consistency more aligned with teaching goals and pedagogy. This may be particularly important longitudinally when considering recall (vs. assessment). We have not examined differences in free form creative maps vs. structured expert maps, but this is an area for future research.

Specific Instructions

There are several ways to create concept maps, but the easiest and most straight-forward is to do the following: 1) determine the topic or domain of interest to be modeled, 2) write that term (concept) in the middle of a sheet of paper, 3) think of related concepts to that initial one and begin writing them down on the paper near the first term, 4) connect the concepts that are related with lines, and 5) keep adding more concepts and relationship lines to the map as it grows. There is no minimum or maximum size to a concept map – the size will depend on your understanding of the topic and what you think relates to the initial term.

So, for example, to create a concept map of Information Systems, one would start by putting the phrase "Information Systems" in the center of a piece of paper. Then one would think of related concepts and begin writing them down. So, in terms of information systems, concepts such as "organizations," "people," "applications," "technology," and "education" are possible. Using these concepts just mentioned, a concept map could now look like Figure 1.

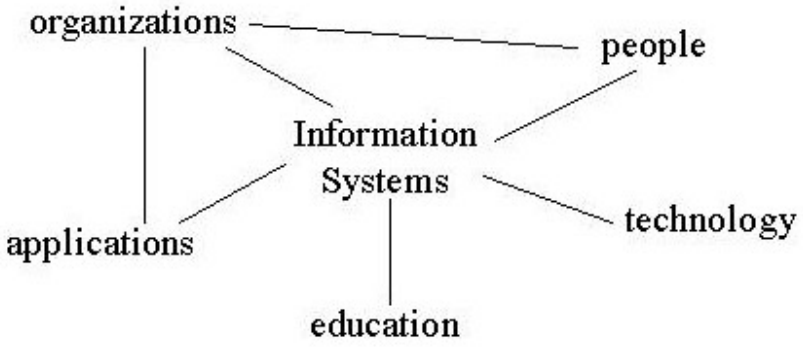

Figure 1. Initial Concept Map of Information Systems

The concept map would then continue to be "built" by adding more terms and connecting them to each other and to the previous terms already on the map. There is no limit to the number of relationships a single concept can have, though too many relationships create a very cluttered and "noisy" map that is hard to read and understand. It can be hard to find the right balance as many of the concepts could legitimately be related to many others. After adding more concepts, the concept map could now look like Figure 2.

Assuming no more concepts were to be added, the concept map of Information Systems would be complete. When someone looks at this particular map, they will gain an understanding of the topic of Information Systems (according to the map's creator), what concepts and issues are important, and also some of the things that are not so important since they were not included. This map can be compared to other concept maps to understand the creator's point of view much better than if it were just explained in words. As they say, a picture can be worth a thousand words!

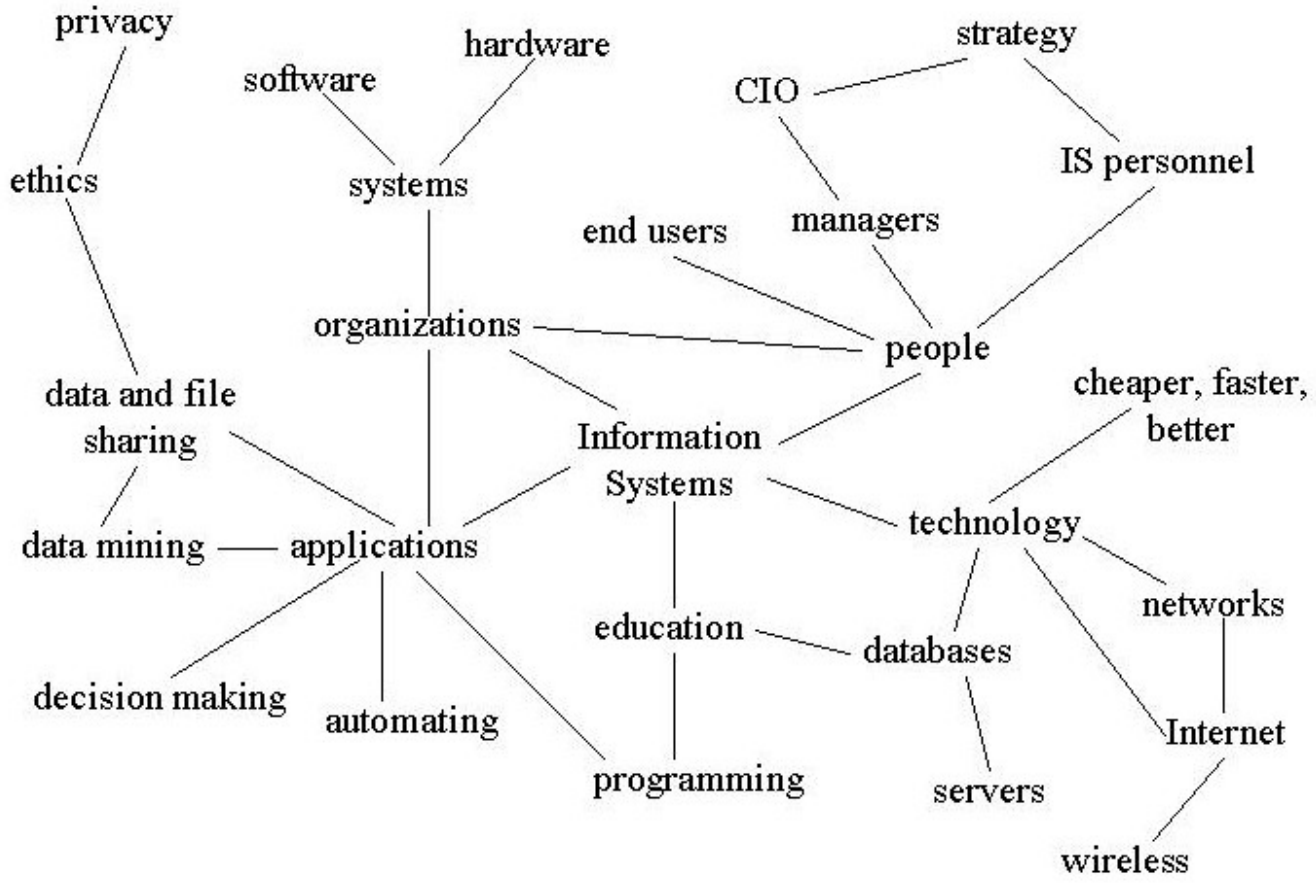

Figure 2. Final Concept Map of Information Systems

Concept Maps for Teaching and Assessment

Concept maps are primarily used within a classroom as teaching aids and as alternate assessment techniques.

Introducing a Topic Domain or Course

At the beginning of the course, or even at the beginning of a major unit or topic within a course, concept maps can be useful as a means of conveying to the students what will be studied and providing them with a big-picture overview of the topic. The instructor could create a concept map on the board (or computer), and the students could follow it and comment on it. The students could all create individual or small-group concept maps (following some explanation of what they are and how to create them) based on their understanding of the topic at that point in time. These student concept maps could then be collected and shown to the rest of the class as a way of informing everyone of the similarities and differences across the maps, and therefore also across students' own understanding of the topic. Such maps, whether student- or instructor-created, can then be used as a reference point for the course or unit, as appropriate.

As a Learning Tool

In the learning process, concept maps can be developed as an alternative to traditional note-taking by building associations of non-linear key concepts and organizing them to fit with individual learning styles and frames of reference. Using traditional linear note-taking methods, key information is disguised, disconnected, and cluttered with informationally irrelevant words (Buzan 1991). Concept maps help learners think holistically as they work to understand the interrelatedness of ideas. One outcome of

these visual representations is a focus upon developing and recalling relevant associations rather than memorizing concepts recorded in a more linear fashion. Concept maps vastly improve the recall and application of important concepts. The advantages of concept maps over linear note taking are:

- Recall is easier using associated key concepts because less time is required and the recall itself is more complete.
- Main ideas are more clearly defined, and the relative importance of each idea is clearly indicated.
- Links between concepts are immediately recognizable because of their proximity and connection.
- Recall and review are more rapid and more effective.
- The structure allows for easy addition of new information.
- The open-ended nature of concept map construction enables connections to be made more readily.

Throughout the semester, students can use concepts maps as a means to aid their learning within the classroom. As an alternative to note-taking, students can create "on-the-fly" concept maps during lectures and discussions. These maps can then be compared to their own maps created earlier and later within the semester and used for review and examination preparation. Expert maps can be provided to augment lectures in addition to or in lieu of more traditional classroom outlines (e.g., PowerPoint). Providing maps in advance of a lecture may bias the number and types of associations generated by students in post hoc assessments.

Mid-Term Assessments and Reviews

As the semester progresses, it is important for instructors to know how e students are doing with the content of the course. This information may be with regards to an actual assessment of their knowledge, or it may be with some form of review of the material already covered. With either case, a concept map can be quite beneficial.

The presence of concepts and relationships on a map can provide an instructor with a snapshot of student knowledge and understanding. The proximity and connection of key concepts provide insight for instructors attempting to evaluate how ideas from class have been incorporated. Conversely, the absence of concepts or relationships on a map provides clues about what information students failed to internalize or incorporate. Difficulties can arise in evaluating maps when students construct their maps using synonyms, homonyms, and key words or phrases that are slightly dissimilar from those used in lecture. In such cases, teachers and evaluators may need to translate maps using a thesaurus constructed from the body of concept maps constructed by the class.

End-of-Course Assessments and Reviews

Just as with the mid-term assessments and reviews, concept maps are beneficial for end-of-course assessments and reviews. Many institutions, colleges, and majors are now conducting not only end-of-course assessments, but also end-of-program assessments, or exit interviews, in an effort to see what the students are learning over the course of their collegiate careers and how they can apply it. A concept map is a useful tool to assist in this process, complementing or even replacing the traditional multiple choice exam. An earlier study (Freeman and Urbaczewski 1999) did such an assessment with the MIS major at a large midwestern university. Students in their capstone course were required to create concept maps with "MIS" as the root term. Students generally used posterboard or other similar large sheets of paper to complete this task. In this case, students do not have to study for an exam, which may produce unreal representations of their knowledge of MIS due to recency effects. Furthermore, the concept map allows for more synthesis of seemingly disparate topics than the traditional examination would allow.

Overview of Analysis Options

Concept map analysis comes in many forms. For course assessments, the analysis may consist of counting the total number of concepts, counting the total number of relationships, measuring the map complexity (number of indicated relationships beyond the minimum needed to connect all concepts linearly), comparing the maps to that of an expert or an instructor, or comparing the maps from the beginning or middle of the semester to the maps created at the end of the semester. These highly quantitative analyses can be combined with more qualitative analyses that seek to understand how concepts are mapped and where they appear on the map.

From a teaching perspective, one might argue that the goal is to generate a "reasonably accurate" map. To facilitate this goal, the maps can be 1) provided, 2) generated during lecture, or 3) self-generated outside of class in concert with lecture notes or textbooks. When the notes are provided or generated during lecture there is more structure (however biased) that attempts to ensure that the "proper" nodes are identified while the necessary and appropriate associations are being made. This process can be augmented by small group study interactions that serve to review, compare, and modify maps based on the learning perspectives of the group. The goal here is to try and ensure that the maps are "correct" from a learning perspective so that recall down the road is accurate. No single map is "correct", and students have latitude in how to construct the maps to ensure the best recall/learning for them as individuals. This distinction may be subtle, but it is an important distinction between the analysis of maps used for assessment and those used for teaching and learning.

Conclusion

We introduce concept mapping to show one more technique by which students can be assessed, as well as a means by which teachers can convey information to their students. Just like the many methods for systems analysis and design, we do not claim that concept mapping is a silver bullet, appropriate to all situations at any given time. However, we do state that there are times where the concept map is an appropriate tool for assessing learning and synthesis of major areas, either as an additional tool to use alongside more traditional assessment methods or as a replacement for them. It is also a helpful tool on many occasions for the teacher to use in representing material to the class.

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