

Concept Mapping as a Form of Knowledge Assessment and Instruction in the Domain of Information Systems

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Introduction

This paper focuses on applications of the concept mapping (CM) approach, a cognitive learning and assessment tool invented at Cornell University, for curriculum planning and student assessment in the domain of information systems knowledge. Learning is not only the acquisition and understanding of concepts but also a multiparametric synthesis of a system of meaningful links between concepts.

To this extent, the CM approach helps to address the gaps between the traditional forms of assessment and curriculum-building concerned mostly with declarative (i.e., knowing what) and procedural (i.e., knowing how) types of knowledge and more comprehensive forms that incorporate conditional knowledge (i.e., knowing why and under what assumptions and limitations).

The pilot studies conducted at National University for selected courses on networking (LAN, WAN, Wireless Networks) utilized the CM methodology for assessing what students know and developing better strategies that help students to integrate diverse competencies across the Information Systems curriculum.

Concept Mapping Fundamentals

As the tools for organizing and representing knowledge, concept maps (CM) include *concepts* (defined as “a perceived regularity in events or objects, or records of events or objects, designated by a label¹”) and relationships between concepts or *propositions* designated by a connecting line between two concepts to form “a meaningful statement¹”.

Two important features of CM are: 1) The concepts may be represented mostly in a hierarchical fashion (and sometimes as a non-hierarchical, randomly arranged setting), with the most inclusive, most general concepts at the top of the map and less general concepts arranged hierarchically below, and 2) Inclusion of cross-links, or relationships (propositions) between concepts in different domains of the concept map.

Thus, these two CM features are essential in facilitating the elements of critical thinking due to a combination of the hierarchical (or non-hierarchical) structure representing different concepts and a continuum of cross-links indicating relationships between different domains represented on the CM.

Concept Mapping of Knowledge Assessment and Instruction

Information Systems courses typically are organized (as are the courses in many other disciplines) around traditional methodologies of instruction and assessment with main intention on tapping into just two important types of knowledge. These types of knowledge may be described by cognitive psychologists as declarative (knowing *what*) and procedural (knowing *how*)².

Recognizing that these forms of IS assessment and instruction sometimes ignore the third and quite essential asset of problem-solving - a so called conditional knowledge (knowing *why* and *when*) - research at the Department of Computer Science and Information Systems at the La Jolla, California-based National University has been addressing the issue of bridging the gaps between traditional forms of problem-solving in the classroom and the prevailing practices and expectations within a highly competitive IS industry environment.

Since learning is not limited only to the acquisition and understanding of concepts but, to a greater extent, actually relies on construction of meaningful links among them, the concept maps can be looked at as

- a learning strategy,
- curriculum planning strategy, and
- a student assessment tool.

Especially valuable this approach might turn out to be in the situations when students with diverse experiences and levels of prior knowledge would enroll in the same class, so that it might become difficult for an instructor to assess what students do and do not understand.

In general, concept mapping approach as a form of assessment might offer instructors the opportunity to recognize a student's impediments to learning that traditional (*declarative* plus *procedural*) assessments may not always detect.

Needless to say that CM approach allows a great scale of "dynamic range" for instruction and assessment since the denser is the "CM network", the more effective might be both instruction and assessment.

Applications of Concept Mapping in the Domain of Information Systems

Proliferation of CM methodologies, strategies and techniques as a useful tool for science education³, as cognitive learning and assessment tools⁴, as web-based applications and web design tools⁵, as an alternative technique for assessing students⁶, as tools for constructing knowledge models⁷, as tools for assessing classroom learning effectiveness⁸, or as tools for design instruction and assessment⁹, has helped us at National University to apply similar strategies for addressing quite unique needs of IS education.

Uniqueness of Information Systems field of study can be derived from several perspectives:

- diversity of data generated, transmitted and received,

- diversity of networking access types,
- diversity of processes associated with both single and multiple transactions,
- diversity of standards and protocols governing telecommunications,
- diversity of multiple links between business needs, user objectives and specific computational, algorithmic, hardware and software configurations, and
- time-dependent dynamics affecting infrastructure, architecture, processes and procedures associated with Information Systems environment.

Needless to say that traditional CM approach that taps a “one-dimensional” picture representing generic problem in any field, might not be sufficient enough for assuring adequate solution for IS case studies. Thus, rather than trying to simplify IS models for better match of available CM tools, our research has been focused on expansion of the traditional CM approach into the multidimensional concept mapping.

Multidimensional Concept Mapping Construction

As an example of a one-dimensional CM approach, Fig. 1 illustrates conceptually constructed IS curriculum. The concepts or nodes, shown as rectangles, constitute the primary content of CM. Connectors or links in the form of arrows help in identifying both relationships and the flow of information from a node to node. Connecting or linking words – propositions - are used along with connectors to further clarify relationships between the nodes.

The most commonly used propositions (italicized in Fig.1) would include such as *based on, but if, controlled by, demand, for, including, involves, may lead to, prevents, recognizes, such a, supported by, stored in, through, to enhance, using, validates*, to name a few.

Proposed multidimensional approach of CM infrastructure for Information Systems adds several important features in support of extremely broad areas of applications extending well beyond the traditional boundaries of Information Systems. From a curricular perspective, one of the most profound changes over the past decade has been the considerable broadening of the focus of IS to include a substantial number of other academic disciplines, as well as different competency skills and knowledge areas.

Some of the important features highlighting multidimensional aspect of the proposed CM infrastructure are:

1. integration of the color into the nodes structure might signify the levels of importance and relationships within and between different CM domains,
2. connectors or links in the form of unidirectional arrows might be supplemented with curves or arcs to help in identifying hierarchical levels of relationships between different domains of knowledge represented by the nodes; especially valuable could be utilization of arcs to better illustrate a circular flow around some sets of nodes,
3. supplementing the solid lines with the dotted ones would help to distinguish between strong and weak linkages thus enabling to emphasize a degree of (logistical or functional) correlation between different domains,
4. supplementing unidirectional arrows with two-directional ones (as shown in the left bottom corner of Fig.1) would allow for embedding both causal relationships and those of reciprocal nature.

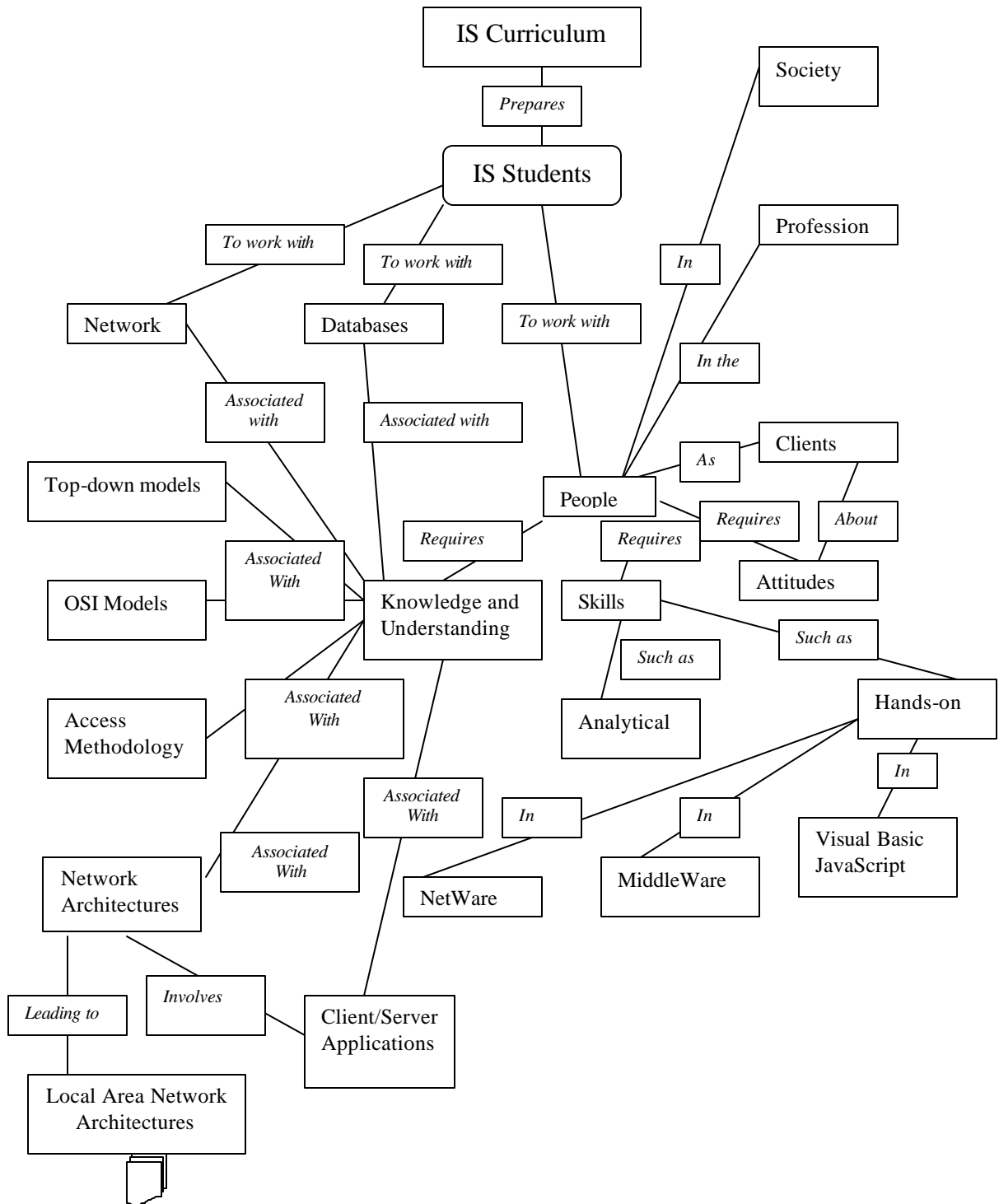


Fig.1. Conceptually Constructed IS Curriculum

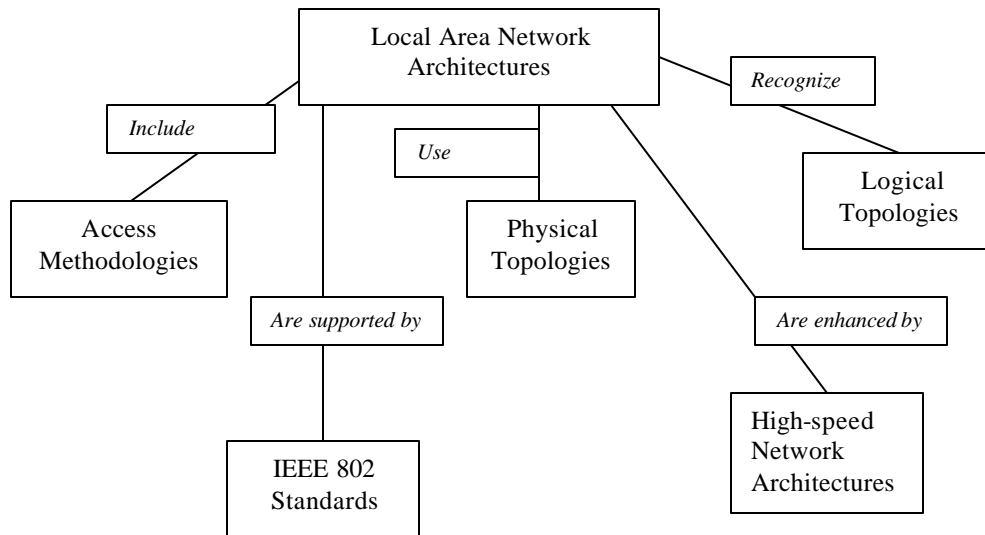


Fig.2. Example of a Linked *Local Area Network Architectures* Subset as part of the IS Curriculum Concept Map

Most importantly, in the case of large domains, a single concept map might become unmanageable for the student or instructor to comprehend, display or apply it. To facilitate construction of large subsets of the IS concept map, we practiced implementation of collections of concept maps by linking via special icons attached to the respective nodes on the main CM. This added feature enables better navigation between the subsequent IS concept maps.

For demonstration purposes, a linking icon is displayed in conjunction with a node titled “Local area network architectures” in the left bottom corner on Fig.1. Just to follow up with this example, as a result of clicking on this icon, its extension would appear similar to that shown in Fig. 2. Certainly, such an array of subsequent subsets of knowledge in the particular domain could be extended as needed.

To further explore the multidimensional CM strategy, we are planning to include (within the electronic CM versions) clickable icons for linking particular domains of knowledge to other

types of resources, such as images, videos, sound clips, or additional text, that might be instrumental in explaining and complementing the content of the IS concept map(s).

The next level of multidimensionality adopted for IS concept maps involves their possible utilization for better assessment of the two-way transformation between the tacit and explicit types of knowledge within the IS domain. In particular, the main point of interest in this research is evaluation of effectiveness and efficiency of the CM methodology as it relates to the conversion of the *tacit* knowledge concerned with subjective, cognitive and experiential aspects of learning (IS expertise, know-how, ideas, organizational culture, informational values) into the articulated and measurable *explicit* knowledge dealing with objective, rational and technical knowledge (policies, IS standards, protocols, strategies, white papers).

Conclusion

An ongoing research that focuses on development of concept mapping as a form of knowledge instruction and assessment in the domain of Information Systems makes it possible to organize and structure specific IS knowledge, retain this knowledge for relatively long periods of time, use knowledge within many new and evolving contexts, and creatively apply such structured knowledge for solving extremely complicated IS problems and cases.

Multidimensional nature of CM development adopted in this research allows also to handle multiple dimensions associated with IS-related domains of knowledge by controlling and assessing a process of generating competency skills as a result of a two-way transformation between the tacit and explicit types of knowledge in the IS domain.

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