Organisation, representation and localisation of knowledge with concept mapping tools

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Learning situation has changed

> Explosion of knowledge and knowledge resources
> Change in learning and ID-theories
> Change in learning and teaching styles
  - Constructivist learning
  - Resource-based learning
  - Problem-based learning
  - Goal-based scenarios

Problems for learners:
  - Limited memory capacity
  - Cognitive overload
Learning strategies and representational capabilities of learners have to be adapted

General requirements:

• Need for more effective organisation and representation of knowledge
• Need for tools supporting self-regulated resource-based learning
• Use of external representations as ...
  > extensions of individual memories (augmenting memory capacities)
  > individual content and resource repositories
  > cognitive tools for enhancing learning, reducing cognitive load, managing knowledge, …
Need for cognitive tools for enhancing the capacity of the human brain

Tools are needed …

- for support coping with requirements of self-regulated resource-based learning
- for facilitating the coherent organisation and representation of both conceptual and resource knowledge
- for fostering comprehension of complex subject-matter domains
- for helping constructing task-appropriate mental models
- for reducing task complexity and cognitive load (Sweller, 1994)
- for facilitating locating content knowledge and knowledge resources with the help of structured conceptual knowledge about the domain
- which function as an extension of the human memory
Spatial representation of knowledge with maps

Surveys on mapping technologies:

• Jonassen et al., 1993;
• Jüngst & Strittmatter, 1995
• Fischer, 1998
• Mandl & Fischer, 2000
• O´Donnell, 2003

Concept maps / knowledge maps: most used approaches in teaching and learning
Assumed advantages of spatial representations (1)

Spatial representations …

• are configurations or ways ideas are „spread out“ on a page or a display
• provide a framework to structure and organise information (O´Donnell, 2003).
• match the central tendency of the brain for structuring and visualising knowledge in mental images and mental models (Kosslyn, 1980; Johnson-Laird, 1993; Kintsch, 1998)
Assumed advantages of spatial representations (2)

Spatial representations …

• facilitate cognitive processing by allowing for artifact-based reasoning (Norman, 1991)
• are easier to search and navigate than traditional text displays (Larkin & Simon, 1987)
• can provide spatial and verbal cues that aid both storing and remembering information (Paivio, 1986)
What are concept / knowledge maps?

Definition:

Concept / Knowledge Maps are spatial arrays of nodes and links, the nodes representing knowledge elements and the links relations between elements (Wiegemann, Dansereau et al., 1992)
Hierarchical concept map

Lebewesen

- Wasser
  - besteht aus
  - benötigt von

Molekülen

- Bewegung
  - sind in
  - bewirkt von

Wärme

Zustand

- flüssig
  - Kann sein

Gas

- fest
  - z.B.
  - ist im

Behälter

Eis

- Nebel
  - kommt vor

unserer Heizung

unser Hund

- Eiche
- Beispiel

im Winter

Gasflasche

Bodensee

- Beispiel
- Beispiel
Example concept map
Concept mapping homepage - http://users.edte.utwente.nl/lanzing/cm_home.htm
Knowledge Manager

Concept maps

An advanced concept of concept maps

Active concept maps!! Accelerate the knowledge acquisition process!!

Concept maps are a simple and intuitive model to communicate ideas and for the visual organization and representation of knowledge.
Inspiration Software Inc.

See first hand how Inspiration® helps students grade 6 to adult develop strong thinking skills!

View the interactive demonstration, a comprehensive tutorial illustrating the key features of Inspiration. You'll see how easy it is for students to brainstorm, plan, organize, outline, diagram, and write. Plus learn how Inspiration’s integrated diagramming and outlining environments work together to help students comprehend concepts and information across the curriculum.
Smart Ideas

Elements of Tragedy

- Audience experience of catharsis
- Chorus characters commenting on hero's fall

Fall of hero

- Cause of downfall
- Social barriers

- Hubris (excessive pride)
- Evil characters

Examples

Smart Technologies
Expert Concept map with PreSERVe (Coffey et al., 2002)
Pattern notes / Mind Mapping

Pattern notes (Buzan, 1974)

Starting from a main idea (a central node) other associated ideas (either nodes or relations) may be put down by drawing and labeling lines.

Mind Mapping (Mind Manager)

Mind Maps are used to organise ideas hierarchically in a tree-like structure. There is one central node.
Mind Map created with „Mind Manager“
Virtual Knowledge Builder

VKB Sample Data Files

- iui2000.zip
  These are the notes taken at IUI2000 (Intelligent User Interface) conference.
## Reviewed mapping Tools

<table>
<thead>
<tr>
<th>Tool</th>
<th>Company/Developer</th>
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<tr>
<td>Mind Manager</td>
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<td>Visual Knowledge Builder (VKB)</td>
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<td>SmartDraw</td>
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<tr>
<td>MindMapper</td>
<td>SimTech USA Corp.</td>
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<td>Visual Mind</td>
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<tr>
<td>The Brain</td>
<td>The Brain Technologies Corp.</td>
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</tbody>
</table>
Organisation of knowledge in concept maps

The term „organisation“ focuses on the basic rationale for the spatial configuration of knowledge elements

Spatial configurations
(Wiegmann, Dansereau et al., 1992)

- Chain structures
- Cluster structures
- Hierarchical structures
- Web-like structures
- Web-structures
Types of spatial configuration (1)

Chain structure

Cluster structure
Types of spatial configuration (2)

Hierarchy
Types of spatial configuration (3)

Web-like organisation (see Wiegemann, Dansereau et al., 1992)
Types of spatial configuration (4)

Web-representation
Representation of knowledge in concept maps

The term „representation“ focuses on:

...the kind of knowledge elements

- conceptual knowledge
- multi-media content knowledge
- annotations
- knowledge resources (URLs)
Representation of knowledge in concept maps

... the kind of relation between knowledge elements

- single lines connecting two nodes
- lines with arrowhead
- semantic links (labeled links)
- hyperlinks
Representation of knowledge in concept maps

... the manner and means used for depicting and highlighting ...

- the kind of knowledge elements
- The links between nodes
- the relevance and semantic properties of knowledge elements
Representation of knowledge in concept maps

… the way of making accessible and locating knowledge for individual use by means of

- browsing (visual search)
- interactive access (hyperlinks)
- Searching
- Backtracking with playback-mode (SmartIdeas)
Additional features

- Interactive access to...
  - annotations
  - local and web-based resources (text, graphics, audio, video) by means of hyperlinks
- Use of submaps
- History
- Export-functions (a.o. jpg, html)
Use of concept mapping techniques in learning and instruction

Concept-mapping techniques are being used as:

- Instructional strategy (lecture aid)
- Instructional strategy for fostering complex problem solving
- Learning strategy for fostering comprehension, knowledge acquisition, self-regulated learning
- Tool for knowledge diagnosis and evaluation of learning success
- Navigational tools in hypermedia-based programs (Gaines & Shaw, 1995)
Use of concept mapping techniques for knowledge management

Concept mapping techniques are being used:

- for comprehensive modeling of knowledge (Alpert & Gruenenberg, 2000)
- for capturing and retaining knowledge of an enterprise (Canas, Leake & Wilson, 2003)
- for knowledge communication and knowledge sharing in collaborative work (Mandl & Fischer, 2000)
- for providing direct interactive access to knowledge and knowledge resources (Coffey et al., 2002)
- for maintaining and updating knowledge (Coffey et al., 2002)
General research questions

> Are mapping techniques effective for fostering resource-based self-regulated e-learning?

> What kind of features contribute to fostering comprehension, knowledge acquisition, and localisation of knowledge resources?

> What kind of preconditions and scaffoldings are necessary in self-regulated resource-based learning with concept maps?
Concept, content and resource mapping

Cognitive level

Concept mapping

Content / resource mapping

Links to Contents and Resources

PC-files

Online-Repository

Weblogs

Resources in WWW

Annotation

Type-Link

Referential Link

Concept mapping

Content- / Ressource-Level

Annotation

Annotation

Annotation

Annotation

Annotation
Specific research questions
(Experiment in progress)

1. What effects has the semantic labelling of relations in a concept map on the comprehension of subject-matter content, mental model construction, and location of resources?

2. What effects has the concept-based resource access on the comprehension of subject-matter content, mental model construction, and location of resources?

3. What effects have individual prerequisites like domain pre-knowledge, verbal ability, spatial ability?
## Research design

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<th>Semantic labelling of links</th>
<th>Map-based resource access</th>
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Research design

Map-based resource access

<table>
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</table>
| Yes | Concept map plus resources  
- organisation  
- labelled links  
- hyperlinks | Concept map only  
- organisation  
- labelled links |
| Yes | Resources only  
- organisation  
- hyperlinks | Node map only  
- spatial organisation only |
Group 1: Concept map plus resources
Group 4: Node map only
Research cooperation

- Knowledge Media Research Center (KMRC) Tübingen, Germany (Coordination)
- Leibniz-Institut für die Pädagogik der Naturwissenschaften (IPN) Kiel, Germany
- University of Augsburg (Philosophisch – sozialwissenschaftliche Fakultät) Augsburg, Germany
- Penn State University – Instructional Systems Pennsylvania, USA
Thank you for your attention!!

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