

Mind Map and Concept Map as Complementary Tools for Teaching

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ABSTRACT

In this article, Novak's concept mapping technique is compared to Tony Buzan's mind mapping technique. The application parameters and the respective advantages and disadvantages for two formats for learning and knowledge sharing are reviewed and discussed. It is argued that the combination of these two visualization types can play to the strength of each one. The article then provides real-life examples from such a use in undergraduate and graduate university teaching. The results provide first indications that the different visualization formats can be used in complementary ways to enhance motivation, attention, understanding and recall. The implications for a complementary use of these visualization formats in class room and teaching contexts are discussed and a future research agenda in this domain is articulated.

Keywords: *Concept map; mind map;*

The extensive use of concept maps in class rooms and related learning and knowledge sharing contexts (e.g. trainings, meetings, problem solving discussions) has shown that numerous benefits can be achieved by applying visual mapping techniques that foster the graphic reconstruction of knowledge. Concept maps have demonstrated their positive effects on student learning for various topics and in various teaching situations. Concept maps (for a definition see Table 1) are, however, not without drawbacks 15–17 and they may not fit all types of target groups (such as non-academics), learning tasks (i.e. developing procedural skills), application situations (such as rapid note taking) or topics (such as processes or developments over time). There are, in our view, several reasons for these application restrictions: the relatively strict formal rules that need to be adhered to when drawing a concept map and the emphasis on identifying concepts (and their multiple relationships) do not make it a simple, seamless or very rapid visualization technique. In addition, the general top-down (from concepts to examples) structure of concept maps may not be adequate to represent or structure sequential content such as processes, timelines, or developments.

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Mind Map and Concept Map as Complementary Tools for Teaching

The boxes and arrows format may also make it difficult to efficiently represent a great number of related items in an accessible format. Students or practitioners who are confronted with ready-made complex concept maps may initially feel overwhelmed or de-motivated by the complex web of relations.

Concept mapping is also not the only available qualitative visualization technique that fosters learning or knowledge sharing in a constructive and systematic manner. There is a myriad of node-link mapping methods from such diverse areas as psychology, computer science, requirements engineering, or business administration. Examples of such systematic methods that employ geometric figures for items, activities or concepts, and arrows for relationships are: cognitive mapping, mind mapping, entity-relationship models, flow charts, Toulmin maps, IBIS argumentation maps, semantic networks, swim lane diagrams, clustering, UML diagrams, system dynamics, evocative knowledge maps, soft system modelling, or process event chains.^{4–6,10–12,32} All of these methods relate (boxed, circled, or otherwise framed) items to others through (labelled or unlabelled) arrows based on explicit and sequential rules. Nevertheless, there are also mapping methods that do not make use of the node-link paradigm. Examples of such mapping methods are: Venn and Euler diagrams, Robert Horn’s infomulas, radar charts, Zwicky’s morphological boxes, Vee diagrams, knowledge cartographies, tree maps, 3D-cubes, S-curves, impact wheels, or graphic facilitation. Rather than highlighting individual items and their relationships, these visualization methods focus on ‘the big picture’, that is, on an overall structure to map or position information meaningfully. In these methods, the overall graphic structure is usually provided by a conceptual diagram, a visual metaphor or a mix of the two. Based on this premise, this paper examines the potential of complementary visualization with regard to concept maps, that is to say the combination of concept maps with other visualization formats. This combined use of different visualization methods should compensate for the limitations of different individual mapping methods and enable a richer learning experience for students using the methods either actively (in a drawing mode) or passively in a viewing mode.

Table: 1 A comparison of concept map and mind map

Format Parameters	Concept map J.D Novak)	(Mind map (T. Buzan)
Sample thumbnail representation		

Mind Map and Concept Map as Complementary Tools for Teaching

Definition	A concept map is a top-down diagram showing the relationships between concepts, including cross connections among concepts, and their manifestations (examples)	A mind map is a multi-coloured and image centred, radial diagram that represents semantic or other connections between portions of learned material hierarchically
Main function or benefit	Shows systematic relationships among sub-concepts relating to one main concept	Show sub-topics of a domain in a creative and seamless manner
Typical application context	Classroom teaching, self study and revision	Personal note taking and reviewing
Application guidelines	Use it as a learning support tool for students, that is, to summarize key course topics or clarify the elements and examples of an abstract concept	Use it for pre-analytic idea jostles or rapid note-taking, or to structure the main contents of a course or topic hierarchically
Employed graphic elements	Boxes/bubbles with text and labelled connector arrows	Central topic bubble and collared (sub-) branches with text above branches, pictograms
Reading direction	Top-down	Centre-out
Core design rules or guidelines	Start with main concept (at the top), and end with examples (bottom, without circles); boxes/bubbles designate concepts, arrows represent relationships; include cross-links among elements	Start with main topic (centre) and branch out to sub-topics, employ pictograms and colours to add additional meaning. Write text above the branches
Macro structure Adaptability	Flexible, but always branching out	Somewhat flexible, but always radial

Mind Map and Concept Map as Complementary Tools for Teaching

Level of difficulty	Medium to high	Low
Extensibility	Limited	Open
Memorability	Low	Medium to high
Understandability by others	High	Low
Typical software package supporting the visualization format	www.inspiration.com	www.mindmanager.com

Methods: systematic comparison along application parameters and exploratory use cases

The domain of visual methods for learning and knowledge sharing is a broad one and the diverse learning needs and styles of students may make it necessary to use concept maps only as one type of learning support tool among others. Hence, it seems worthwhile to review the application parameters and the relative advantages and disadvantages of concept maps, as they have been discussed in the existing literature, and compare them to the application benefits and parameters of other mapping methods. For this comparison, we have chosen one widely used method, mind mapping. Below, we briefly describe our understanding of mind mapping approaches.

The graphic formats discussed above are obviously not the only visualization techniques that can be used to foster learning, yet they provide a number of advantages for knowledge construction that other, more complex visualization methods – such as flow charts, cognitive maps, loop or system diagrams – may not be able to provide (i.e., reducing complexity, providing mnemonics, and facilitating rapid group communication).

Besides the comparison of the application parameters of concept maps, mind maps (in order to highlight potential complementarities), another method that is employed in this paper is the exploratory use of these methods in class room teaching. Different real-life examples of such maps will be shown to illustrate the benefits of combining various mapping techniques sequentially during a course. The examples can also illustrate the potential drawbacks when relying only on mind mapping method.

Results and discussion: a comparative view of two mapping methods

In this section we present the results of the comparison among the four approaches and the exploratory use of complementary mapping in university teaching. In the next section a synthetic table is presented and discussed which compares the application parameters of the two methods. An overview of the main advantages and disadvantages and a relative positioning (with regard to their use) is derived from this comparison. Based on these considerations a possible application sequence for teaching and learning purposes is suggested. In the succeeding section we present examples of the methods' use in classroom teaching.

A comparison between the two methods regarding their application parameters

While Novak's concept maps, Buzan's mind maps, theory driven with embedded text have a number of attributes in common (such as the integration of text and image, the stepwise completion and the rule-based approach), they nevertheless differ with regard to their specific benefits and constraints. These differences are explored in Table 1. It summarizes the key features and main application parameters of two methods. The first row of the table provides a thumbnail representation of each format to give an impression of the overall shape of the visualization method. The second row contains a short definition of the method. The three following rows position each method in terms of its typical application (main benefit or function, typical application context and application guidelines). The next two rows specify the visual vocabulary of the method in terms of the graphic elements, their reading logic, and their use (guidelines). The rows from 'macro structure adaptability' to 'understandability' qualify the methods in terms of their flexibility and complexity. These factors will be further discussed in a subsequent table that focuses on the advantages and disadvantages of each method. The final row indicates one possible software package for each format that can be used to draw or use an electronic version of the method.

A first glance at the key features of the four visualization methods reveals that their profiles are quite distinct: whereas concept maps and mind maps are great personal learning tools that result in individual solutions are tools for knowledge communication and joint knowledge construction. While mind maps result in attractive, colourful and memorable results, and concept maps tend to be less memorable, because most of them look very much alike a collection of boxes and arrows (with occasional icons). These generalizations do not apply to each and everyone's use of these formats; they nevertheless tend to follow the advantages and disadvantages of the four formats as they are discussed in the literature. Four main advantages and disadvantages of each method are summarized in Table 2.

From these profiles we can generate a first tentative positioning that can help us in using the two visualization techniques in complementary ways or even combine them into new visualization formats (as discussed in the conclusion). One possible way of positioning the two methods is by their ability to support the remembering of learned content and whether they are more geared towards personal or group use. Following this reasoning, mind maps would be best

Mind Map and Concept Map as Complementary Tools for Teaching

used for in class, personal note taking, while concept maps should be used at home for review purposes (also because they take longer to develop).

One important common feature that all two visualization formats share (besides their common purpose of facilitating understanding), is that their electronic use allows for the linking or embedding of related additional material, such as other maps or diagrams, internet hyperlinks, documents or pictures. This opens the opportunity to use such maps as navigational aids to electronic learning content or simply annotate entries with additional personal comments. The electronic use of these methods also makes it possible to use the methods as ad-hoc collective maps in class rooms or meeting contexts via a laptop and beamer.

Table: 2 advantage and disadvantage of the two visualization formats

Format	Concept map	Mind maps
Main advantages	<ol style="list-style-type: none"> 1. Rapid information provision¹⁵ 2. Systematic, proven approach to provide overview¹⁵ 3. Emphasizes relationships and connections among concepts¹⁷ 4. Ability to assess quality of concept map through evaluation rules² 	<ol style="list-style-type: none"> 1 Easy to learn and apply⁶ 2 Encourages creativity and self-expression⁵ 3 Provides a concise hierarchic overview⁶ 4 Easy to extend and add further content⁶
Main disadvantages	<ol style="list-style-type: none"> 1. Not easy to apply by novices; requires extensive training¹⁷ 2. Concept maps tend to be idiosyncratic¹⁷ 3. Time consuming evaluation through tutors¹⁷ 4. The overall pattern does not necessarily assist memorability 	<ol style="list-style-type: none"> 1 Idiosyncratic, hard to read for others 2 Represents mostly hierarchic relationships⁶ 3 Can be inconsistent 4 Can become overly complex (loss of big picture)

Application examples and experiences

As mentioned in the previous section, a complementary way to use the two visualization methods uses mind-mapping for in-class note taking, concept mapping for personal student reviewing at home. This didactic logic is consistent with the relative advantages and disadvantages discussed in Table 2. Shows this didactic approach which uses the two methods in a complementary way and describes their application. This logic has been applied in two bachelor classes (on knowledge management) and in two Ph.D. courses (on research methods):

Table- 3 A Complementary use of the two methods based on their unique features

Didactic steps Didactic application mode	Applied visualization format	Didactic application mode
1	Mind map	During the subsequent explanations and further elaborations, the students take notes by drawing personal mind maps.
2	Concept map	To test their understanding and recall, the students are asked to develop a concept map (at home) of the main contents and submit this map at the beginning of the next lesson. They can use the introductory mind map key elements and then structure them using the rules of concept mapping.

First, a special type of concept map has been used to structure complex content during class presentations (see Figure 1) and lectures. At the beginning of the session, the diagram contained only the concept label; all other boxes were interactively filled in with occasional contributions from the students who had heard about the concept previously. Figure 1 depicts the completed diagram after approximately 20 min of discussion.

The picture depicted in Figure 1 is a specific type of Mind map that helps to explain the nature of an academic or abstract concept. Its benefit can be described as follows: Whereas Novak’s concept maps mainly serve the purpose of student learning by having them list and connect various concepts through explicit labels, the main function of a concept skeleton is one of summarization and elicitation, and these tasks only regarding one single concept at a time: concept skeletons of this type thus help to transform sketchy ideas into systematic thoughts. Consequently, we define a concept skeleton as a one-page abstract diagrammatic representation of an abstract concept, its label, definition, elements, examples and implications, as well as its kind. The depiction also includes pointers to related concepts. A concept according to Novak is a mental image of a thing or object. Our understanding of a concept is a bit more focused: A concept in this context refers to an elaborate abstract idea that has implications for action. The concept skeleton’s elements can be characterized as follows:

- Concept name or label: A concise set of terms that gives the concept a label by which it can be referred to.
- Related concepts: This box lists similar, but nevertheless different concept labels that are closely related to the outlined concept.
- Concept definition: This box includes a few sentences that define the key idea behind the concept. Typically the definition also includes the key elements of the concept that are then also isolated in the element boxes below the definition box.
- Elements: This section lists the different sub constructs or sub concepts of the main concept.

Mind Map and Concept Map as Complementary Tools for Teaching

- The examples or manifestation boxes provide real-life instances of the concept.
- Implications: This section summarizes the practical consequences of the concept or in other words how it should be applied and used.
- Concept type, area and modality: These three sections indicate the nature of the concept that is described. In terms of type we distinguish whether the concept is a scientific concept (such as a research construct) or a practical one (such as an action principle) or both. The area describes the topic domain to which the concept can be related to. If the concept type is scientific this domain can be any scientific discipline, such as biology, physics, or geography. If the concept type is practical, then domain may refer to an operational area, such as project management, cooking, or architecture. The concept modality finally describes the nature of the concept's claim: is it describing a goal one should strive for, then the label given to the concept is normative, if it outlines the way something is actually done, it is descriptive, if it explains the way something works it is explanatory, and if it outlines a way to resolve a problem it is a prescriptive concept.

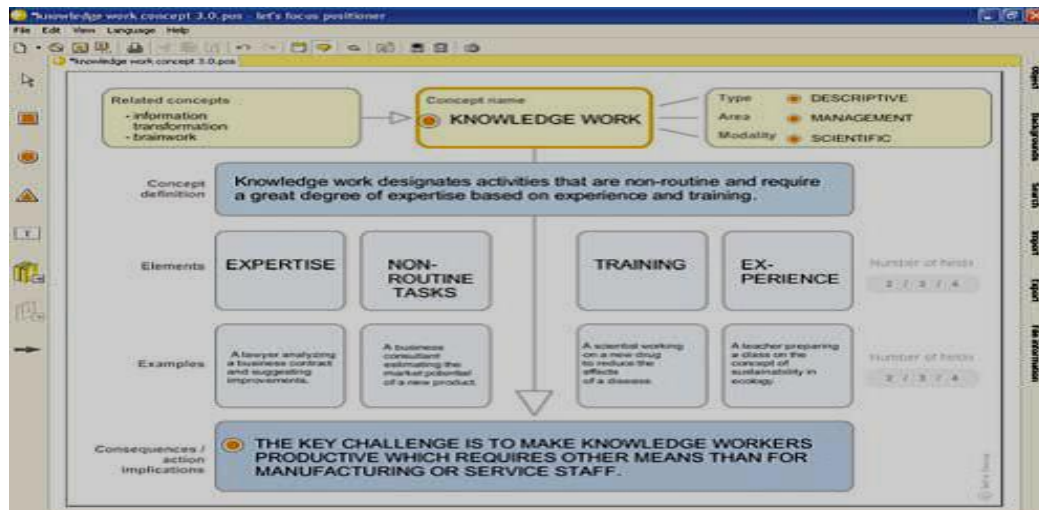


Figure 1 A concept skeleton used to jointly develop the notion of knowledge work in a bachelor class on knowledge management (drawn with lets-focus.com).

The main benefit of such a concise depiction of a concept is that one can gain a systematic overview quickly and not only describe the concept but also analyse it in terms of its epistemic nature.

After this initial discussion with the help of a concept skeleton detail content has been presented in a regular lecturing style. For this phase, **Mind maps** have been used for individual note taking during the class by the students (the mind maps have not been collected). Several studies have already highlighted the beneficial use of mind mapping for the purpose of note taking and Buzan developed the method with note taking in mind as an explicit application area.

Mind Map and Concept Map as Complementary Tools for Teaching

In a third didactic step, **Concept maps** have been used as take-home assignments, where 30 students needed to individually summarize a module of the class (on knowledge work) with the help of concept mapping (see a sample concept map submitted by a student in Figure 2).

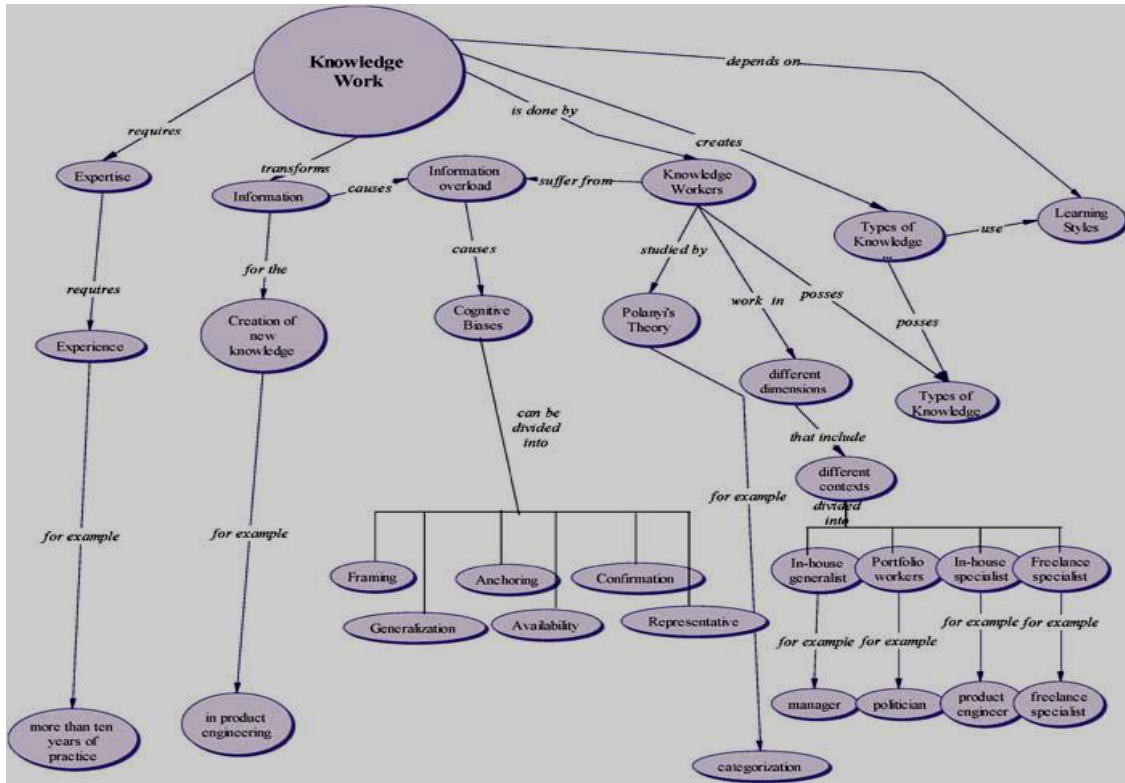


Figure 2 A concept map drawn by a student as an assignment and review tool for a class module (from a bachelor class on knowledge management, drawn with inspiration.com).

The preliminary results from these tests have been positive in the sense that students responded very favourably to this mix of visual methods. After an initial distraction due to the interactive whiteboard technology, the students remained focused and attentive, more than they would usually be in this type of discussion. The visual methods have kept them engaged and gave them ownership of the class content. In follow-up lessons, the discussed concepts seemed to be remembered better than usual. The fact that the students also asked for electronic copies of the jointly devised visualizations is another sign of their interest. Future follow-up studies should test these stipulated benefits and they should show whether this assumed higher level of attention, engagement and recall also translates into better learning results (and this even after the ‘newness’ of the complementary visual approach has worn off). In the current study, the course evaluation form and the final exam were used to assess the satisfaction and learning effects of the students, yielding positive results compared to prior courses. In addition, an independent Ph.D. student conducted half hour to interviews with 14 students of the class asking them about the experience with the concept mapping assignment. The results of these interviews showed that the students require a lot of time, systematic assistance and feedback in order to devise high quality

Mind Map and Concept Map as Complementary Tools for Teaching

concept maps. They revealed that some students had problems understanding the concept maps of others. They also highlighted the fact that the students' concept maps did not incorporate many of the provided multimedia material because I did not discuss that material in detail in class and I did not encourage them extensively to use that material. Two-thirds of the students chose to draw the concept map with mapping software inspiration.com while one-third produced concept map posters or paper versions. As a major benefit, the students mentioned that they were able to check their understanding and learning, to see new connections, and to repeat the key contents. In future studies, a questionnaire on what the students have specifically liked or disliked about all of the visualization sessions and exercises will be issued.

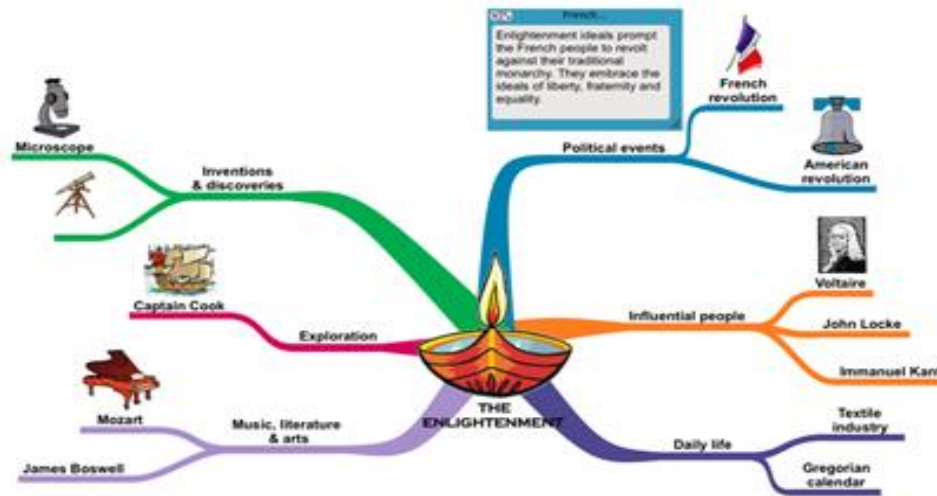


Figure 3 A mind mapping concept of learning methods

Conclusion: Towards a complementary use of mapping methods

The systematic comparison of the four methods in terms of their application parameters and their exploratory use in teaching has shown that the combined, sequenced use of the two methods can provide a number of benefits that go beyond the possibilities of each individual method alone. In future research these exploratory findings should be examined using an experimental design with follow-up surveys among participating students in order to measure more accurately how the effects of the two methods differ. Such experimental studies could also reveal differences in student learning styles and a more adequate matching with respective visualization methods. In this way, one can analyse whether the additional cognitive load (and additional time investment) resulting from teaching more than one visualization technique has paid off in terms of a sustainable learning effect.

A different future research route is to develop mixed mode visualizations that combine the strong points of the two methods, as for examples the straight forward rules of concept maps, the simplicity of mind maps. Yet such 'hybrid formats' are probably limited in their application scope: they make sense only for specific topics, as in this case story plot visualization for

Mind Map and Concept Map as Complementary Tools for Teaching

procedural knowledge (to teach project management concepts). It is doubtful whether such formats could ever compete with the simplicity and application scope of concept maps or mind maps. Nevertheless, inventing such hybrid forms could also be a new way to foster the visual literacy of students: Besides applying ready-made visualization techniques to learning tasks, students could venture to create their own methods to represent and study learned content visually. They could, for example, develop re-usable graphic templates to be used by their peers in subsequent classes to structure key content of the class systematically. Related to this topic is another future research question regarding the differences between the software-based use of visual methods, and their ‘analogue’ application using pen and paper: Future studies should examine under which conditions and for which relative benefits software-based approaches (as the ones depicted in Figures 1–3) should be used, and in which contexts simple pen-and-paper methods may be superior. One obvious advantage of the software-based approach is that it lends itself easily to e-learning contexts where the visual methods can be viewed or edited remotely by all learners via application sharing.

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Mind Map and Concept Map as Complementary Tools for Teaching

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