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Using Concept Mapping in Professional Education

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Abstract

Concept mapping is a powerful tool of thought representation. This paper reveals the trends and best usages of concept mapping especially in professional education. As defined here, concept mapping is a graphical display of thinking, a technique for idea representation, and a process for, among other things, problem solving, strategy planning, and thought development. Viewed as a methodological process, concept mapping allows a person to construct relations among different aspects of a subject, to make connections, and to display relations of ideas and constituent parts of thoughts. The concept mapping method is based on the theory of meaningful learning, which posits that knowledge-in-memory is saved in propositional and relative ways. The generation of a concept map allows the display of propositional knowledge in a form that can be inspected from various angles, revealing a variety of points of view, scenarios, and models of idea construction. The process is seen

to be beneficial for myriad types of decision-making.

Concept mapping is used in many fields of education, though in some more than in others. Concept mapping has gained a great deal of recognition in science education, both in the literature and in the practice. But how is concept mapping viewed in the professions? Has it been researched? What is the future of concept mapping in vocational and professional education? The intent of this article is to answer these questions. The approach is to find and cull success significant pieces of research on concept mapping within medical, veterinary, legal and engineering instructional contexts. We identified 311 such research articles and analyzed them. The analysis shows that the main usage of concept mapping in the professions is as a learning tool, often combined with assessment.

Method of concept mapping

Borrowing from cognitive psychology, here "concepts" are considered to be constructs activated in long-term memory. Concepts are relative, depending on one's experience and the meaning of and experiences with the information. Concepts are connected with each other in fluid ways activated by memory, experience and situation. For example, when a person makes a decision, concepts are activated from one's memory bank used to construct a plan of action. In such a formulation the word "*concept*" takes center place (Hoffmann, 1994). The point is instructional; the meaning of a concept in cognitive psychology is not identical with the meaning of a concept in education. The concept mapping method itself is based on the theory of meaningful learning (Ausubel, 1963) and on the assumption that knowledge is saved in the human brain propositionally. Concept maps represent this propositional knowledge saved in the brain (Atkinson, Shiffrin 1968, Norman, Rumelhart 1978).

According to Arbinger (1991) there are three kinds of knowledge presentations: declarative knowledge, procedural knowledge and analogical knowledge. Declarative knowledge is presented as a proposition. A sentence consists of two related concepts. Every sentence is meaningful; it can be evaluated and presented by its structure. Declarative knowledge can be divided into episodic and semantic knowledge. Episodic knowledge involves personal experience; semantic knowledge is more general and is a sum of single occasions of experience. According to Tergan (1986) knowledge is organized and structured. Like Arbinger, Tergan differentiates among three kinds of knowledge presentation, one of them being semantic spatial model. Semantic spatial models represent declarative knowledge. Knowledge is sorted by similarity of the concepts (psychometric model), is presented by sentences as a network structure (network model) or is visualized conceptually (conceptual model).

Concept mapping connects different kinds of thoughts of a subject and displays relations among them. The method was introduced in didactics by the American scientist Novak (1990) in the 1960s. Later on analogous methods have been developed by several research groups (see Scheele & Groeben 1984 or White, Gunstone 1992).

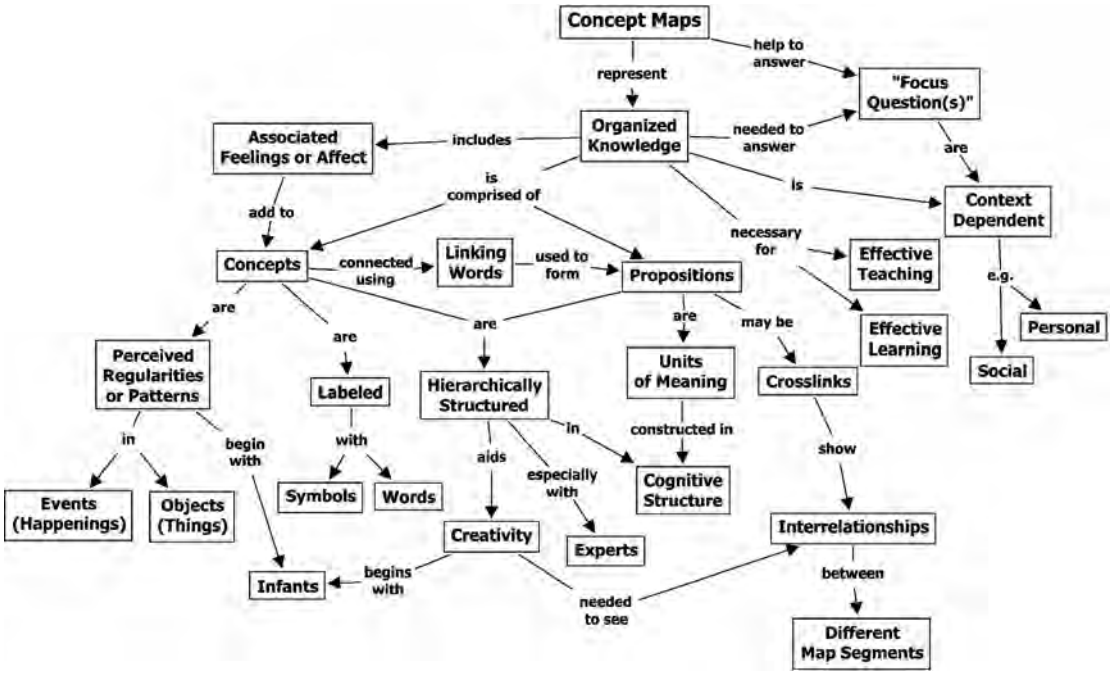

Figure 1. Concept map represent organized knowledge (Novak & Cañas, 2006).

"Concept mapping is a process of meaning-making. It implies taking a list of concepts – a concept being a perceived regularity in events or objects, or records of events or objects, designated by a label – and organizing it in a graphical representation where pairs of concepts and linking phrases form propositions. Hence, key to the construction of a concept map is the set of concepts on which it is based." (Cañas et. al. 2003).

Concept mapping in education

As argued earlier, today concept mapping is widely and successfully applied in many, though certainly not all, fields of education. Recently there has been a burst of investigation of concept mapping and science education (Behrendt et. al. 2000; Fischer et.al. 2001; Reiska 1999, 2005). Reiska (2005) describes some advantages of using concept mapping in education:

- Possibility to use concept mapping in every phase of teaching process (e.g. at the beginning of a lesson when a new concept in introduced, or at the end of lesson as part of the assessment process);
- Independence of age. Concept mapping can be used by children in kindergarten and also by adult students in the university and professionals in the field;
- The constructing of maps helps students to reflect on they own knowledge;
- Concept mapping helps students to concentrate themselves in the process of group work;
- Concept maps give teachers information about students knowledge, and
- Concept mapping could be used for lesson planning.

Much success has been achieved by the application of concept mapping in the teaching process to integrate new concepts into the existing system of knowledge (Novak 1990). Not only are their obvious advantages of concept mapping in teaching and learning new knowledge, but it also provides a critical pathway into improved assessment and achievement testing. Outside the context of teaching concept mapping is also valuable when there is a need for brainstorming and knowledge management, for instance in corporate human resource development situations or strategy initiatives.

Using concept mapping in professional education

Data and method

In the review of the 311 scientific articles about concept mapping were 18 centered on its use in professional education. We categorized the articles based on the subject field in vocational education (e.g. accounting education and medical education) and also based on the area of use (e.g. teaching and achievement testing). Based on this information we made conclusions about the of concept mapping in different subject fields and using areas.

Subject fields of using concept mapping in professional education

Legal education

Concept mapping is used as a learning and assessment tool in real estate law, at least with second year diploma students (Fong, E. L. S., 1999). The concept mapping method was used first by persons as the bases of discussion and then in group work. At the end of a lecture series concept mapping was used for assessment in the examination. Fong also studied students' attitudes in concept map format as part of the learning and assessment curriculum. Three fourth of the students (74 %) believed that concept mapping made learning easier for them though 26 % believed there was not enough time to do the job well. For the majority of students (74 %) it was difficult to find the best linking word for the map. A similar majority found that concept maps helped them to understand how the different concepts in the Law of Real Property are related. Fong comes to conclusion that as a method concept maps assisted students in understanding the subject and preparing for the examination. As for the use of concept mapping as an assessment tool the data were not conclusive.

Medical education

Concept mapping is used widely in medication education. Several studies are described here that investigated the use of concept mapping for assessment, learning and other purposes in medical education. McGaghie (McGaghie et al, 2000) uses concept mapping as an assessment tool and compares medical and veterinary students' knowledge structure gathered with concept maps with their final examination scores. They could not find a correlation between structural knowledge in concept mapping and knowledge assessed by standard examinations.

West (West et al, 2000) uses concept mapping as an assessment tool to enable teachers to find out students' knowledge at different points in training. They expected that concept mapping assessment reveals changes in the conceptual framework of resident physicians during the training and they also compared the con-

cept mapping scores with the scores of the standard in-training examination. West gleaned evidence that concept mapping assessment reflects differences in the conceptual framework. However his research group could not find a significant correlation between concept mapping scores and the standardized testing. They came to the conclusion that concept mapping and in-training examination could measure different cognitive domains.

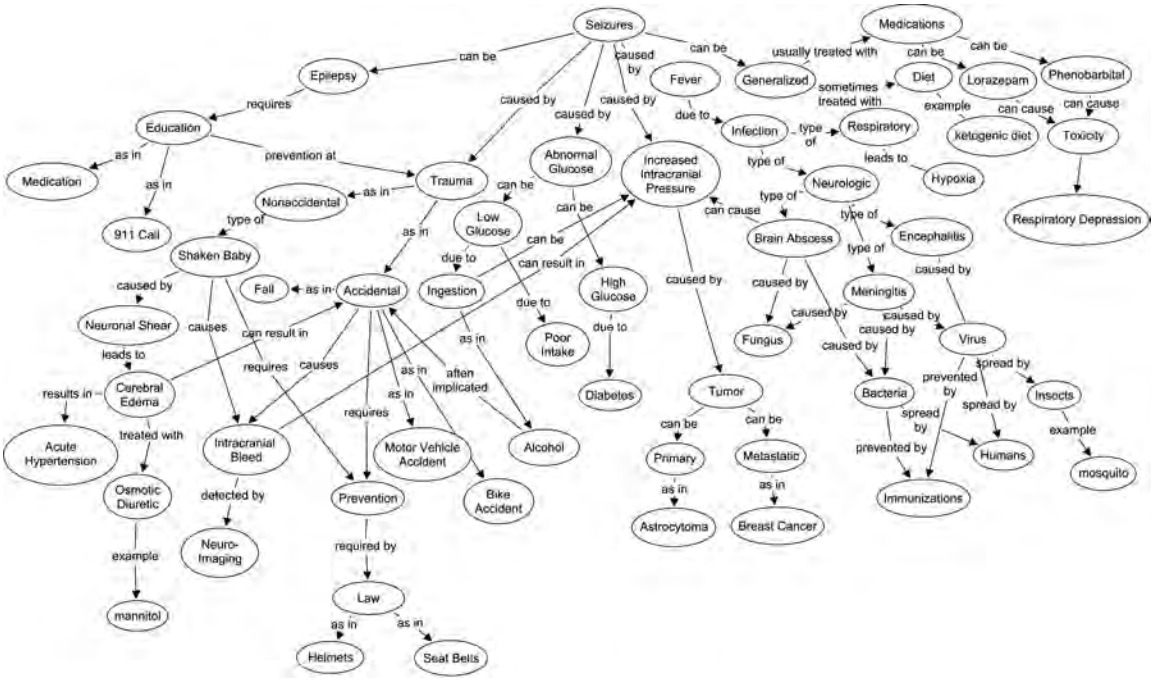

Figure 2. Reproduction of a hand-written high-scoring concept map of seizures by a resident (West et al, 2000, 1108).

Schmidt (2006) investigated reliability and validity of concept mapping as an assessment tool in medical education. Build on previous studies, McGaghie, et al, 2000, West at al, 2000, Bordage (1994), Ericsson (1980) and others she concurs that "knowledge organization influences the efficiency and effectiveness of recall and problem solving within a domain, and domain experts have more coherent, well structured knowledge than novices" (Schmidt, 2006, 69). However she shows many problems connected with the reliability ("concept mapping can provide a reliable measure of something – but just what that something is remains in question") and validity ("There is no convincing evidence in any of the studies that the differences in the concept maps are actually related to differences in the ability to retrieve knowledge or problem solve as would be expected based on the theoretical foundations" (Schmidt, 2006, 72). She raises further research questions some of which are relevant to contexts beyond medical education (e.g. how do pre-

supposed concepts or stimuli influence the nature of maps and are the more complex maps associated with better problem solving ability). Nevertheless though she raised skepticism about the reliability and validity factors of them, she admits that concept maps may well represent a meaningful assessment and teaching device that can substantially advance medical education.

Jitlakoat (2005) used concept mapping as a learning tool with forth year nursing students. The purpose of the concept mapping was to develop students' critical thinking skills including gathering and selecting relevant information and relating this information to patient care. The study was based on assumptions from literature, primarily that concept mapping is appropriate for undergraduate and graduate students, it can be used individually or in groups and the method is useful for assisting student to think critically about relation of new and old information. A pre- and post-test design that tested the extent to which concept mapping is a successful learning instrument was used in the study. The result was that the differences in all scores were highly significant. Jitlakoat came to conclusion that "concept mapping is a good education innovation for assisting nursing students to summarize their own concepts and improve their nursing core competency in primary medical care." (Jitlakoat 2005, 120). Jitlakoat recommended nursing instructors to adopt concept mapping into theoretical and practical teaching process.

Ford, Coffey and Turner (1996) used concept mapping in a knowledge-based expert system known as NUCES. This system was developed to aid interpretation of radionuclide imaging in the heart. They used NUCES also to train clinicians. NUCES is intended as a diagnostic expert system and a training environment—it shows that concept maps at once can be guides to traverse logical linkages among clusters of related objects and they help to solve the navigation problem in hypermedia systems.

Daley (1996) used concept mapping to determine how first year associate degree nursing students can apply their theoretical knowledge to clinical practice. She compared three different kinds of concept maps: maps developed from students interviews, maps developed from instructor interviews and maps developed from the course syllabi. After the construction of maps on the bases of students' interviews each student was asked if they would like to change some concepts or linking phrases. Just one of them wanted to make such changes or change the map. Daley also mentioned that using concept mapping helped to reduce the 20 page volume of one interview data to a manageable form of one concept map. As the results of the study Daley found that students had missing links among elements of nursing processes, clinical preparation was not linked to preparation for the unit of oxygenation and basic anatomy and psychology concepts were also missing. She came to conclusion that concept mapping can be used in nursing education to bridge the gap between theory and practice by integrating basic science concepts with nursing practice. Concept maps can be used to assess and evaluate students and to plan the curriculum.

Schuster (2000) described the use of concept mapping as the tool for clinical care planning. Concept mapping helps to promote learning and critical thinking about patient problems and problem solv-

ing. Based on clinical data the students compose concept maps and the faculty can review and discuss the maps to evaluate students' understanding. The method has been successfully used with students in their early hospital experiences. Both the students and faculty were pleased with the results of concept mapping in care planning.

Baugh and Mellott (1998) developed the method of clinical concept mapping (CCM) to help nursing students learn and apply concepts clinical situations. Based on Novak and Gowin (1984) they assume that concept mapping promotes critical thinking and prepares students for clinical experiences. Clinical concept mapping should help students organize complex patient data and process complex relationship. Baugh and Mellott, as part of data collection, asked students to develop at least one clinical concept map per week for their patients' clinical settings. Through evaluation of students' concept maps faculty could assess their level of their understanding and also recognize how the students see the big picture. A conclusion of their study was that concept mapping is an effective tool to improve meaningful clinical learning because it encourages both application and synthesis.

Parker-Jones and Pilkington (2002) used concept mapping as a support tool for medical students when learning from simulations. The main learning goals were to develop better conceptual understanding and diagnostic reasoning skills amongst students. They employed an experimental research design with pre and post tests and control groups. Experimental groups used simulation methods between two tests. Beside the traditional assessment method with multiple choice questions pre and post concept maps were used. After analyzing the maps it appeared that students improved their scores in post tests whether they engaged in simulation training or not. The conclusion was that concept mapping is a successful performance measure, but has also a role in promoting reflection.

Edmondson and Smith (1998) report on efforts to facilitate meaningful learning within the context of veterinary medical education. They used concept mapping to develop an integrated veterinary curriculum, to develop case-based exercises for problem based learning and as a learning tool for students working individually or in small groups. They used concept mapping for both - the design and delivery of the course and in the final examination. The use of concept mapping was well received by students and also by faculty. Students said that concept maps greatly facilitated their understanding of relevant pathopsychological mechanisms. From the faculty feedback it appeared that concept maps can help to make conceptual relationship explicit and identity errors and misconceptions in students' understanding.

Laight (2004) found in his study with pharmacology students that there was no statistically significant association between the usefulness of concept maps (self-reported by students) and preferred learning style dimensions (e.g. sensing vs. intuitive, visual vs. verbal, active vs. reflective, sequential vs. global). For that reason Laight came to conclusion that concept maps may offer flexible teaching and learning opportunities in large class teaching by teaching to all types of learners and may promote deeper student engagement and learning.

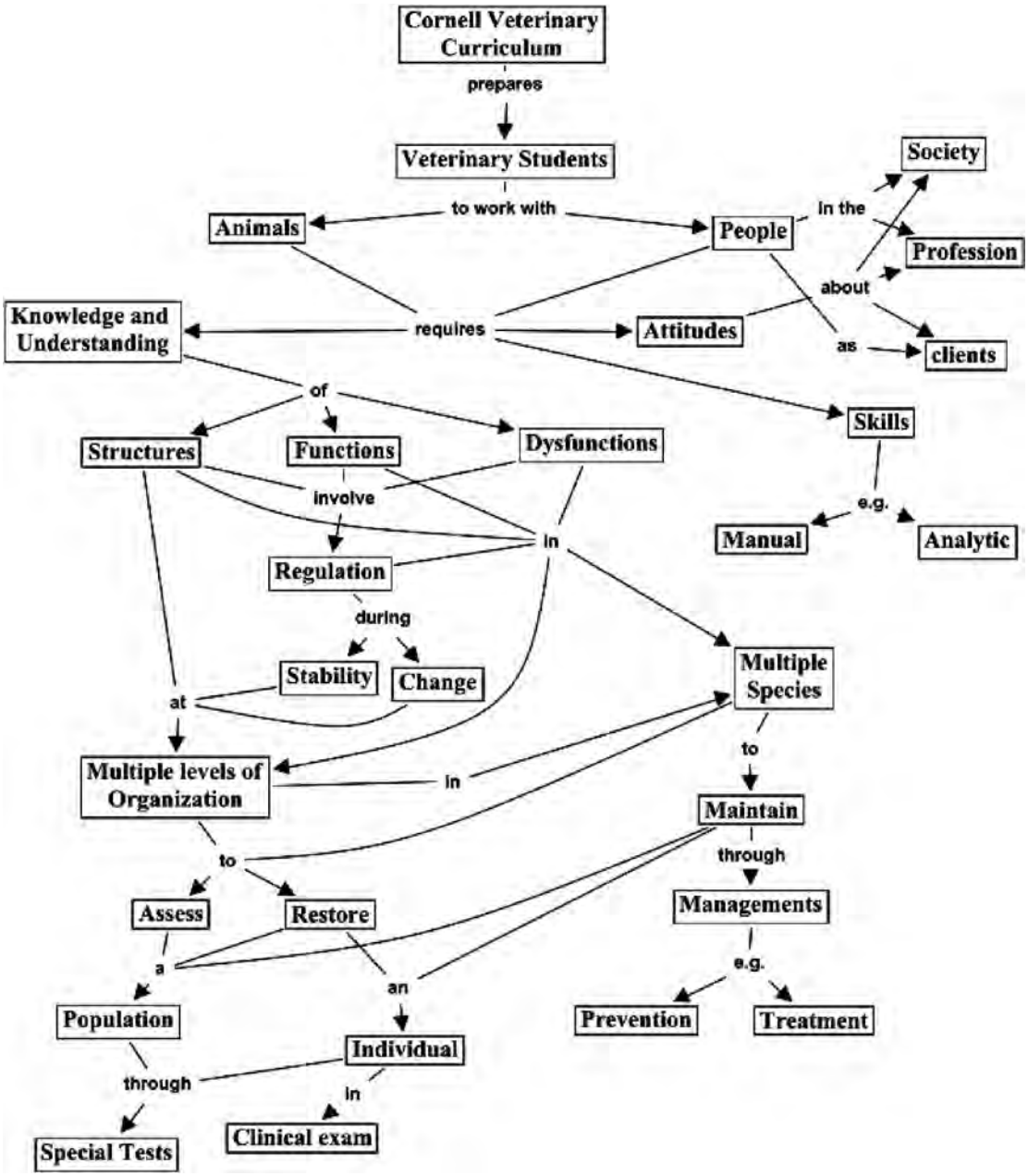

Figure 3. A concept map prepared cooperatively by the faculty of the College of Veterinary Medicine at Cornell University (Novak & Cañas, 2006).

Engineering education

Turns, Atman and Adams (2000) used concept mapping for both - course-level and program-level assessment in engineering education. The goal was to demonstrate the extent of value of concept maps when addressing assessment issues in engineering education. Although the authors came to the conclusion that concept maps are not the "perfect assessment solution" because they require extensive time to interpret and can still give an ambiguous result, they agree that concept mapping is a flexible tool and it should be seen as a "valuable component of an assessment toolbox."

Besterfield-Sacre et al. investigated the use of concept maps to assess knowledge integration by engineering students. For analyzing the maps they used traditional counting metrics proposed by other researchers but also a holistic approach developed for these studies themselves. The holistic approach was based on results of two experts reviewing each map. From the experts' comments on the maps three categories were emerged: comprehensiveness, organization, and correctness. The holistic approach was very useful and indicated that students improved through the program but the holistic approach also enabled faculty to identify weaknesses in program. Consequently they suggested that concept maps can be an effective way to measure a student's conceptual understanding in a meaningful, reproducible and efficient manner.

Darmofal et al. used concept maps in aerospace engineering in a multidisciplinary engineering course to identify and organize main engineering concepts and to map the relations between several key ideas within and between engineering areas (e.g. materials and structures, signals and systems, dynamics, thermodynamics, and fluids). Based on their data, they concluded that extended use of concept maps in teaching promotes increased systematic assessment of student conceptual understanding.

Walker and King (2003) carried out two pilot studies to investigate the use of concept mapping for assessing students' knowledge at a given point (novice-expert comparison) and over time (comparison among students). In the first study faculty generated networks were higher-order while students generated fewer connections among concepts. In the second study concept maps showed growth in individual students' conceptual understanding across time: later maps were more integrated and more differentiated. Walker and King came to the conclusion that concept mapping is a useful tool to build a portrait the process of knowledge transformation from novice to expert. They also determined that concept mapping is an appropriate tool for student assessment and instruction when introducing model-based reasoning within the domain of bioengineering.

Accounting education

Leauby and Brazina (1998) adapted concept mapping to the field of accounting education. They assumed that incorporating concept mapping into accounting courses benefits both the teachers and students. They used concept mapping in teaching process but also as an assessment tool. Students constructed their own maps and afterward compared their maps with the instructor's map. To evaluate the students' maps they used a scoring method which included quality and quantity of relations, conceptualizations, hier-

archy of concepts. Leauby and Brazina typically obtained positive reactions from students: concept maps helped students to better understand relationships among concepts and thereby supplement other learning approaches. They also came to a significant conclusion that concept maps may have helped lower-performing students to do better. Finally Leauby and Brazina pointed out eight benefits of using concept mapping, similar to those found in other areas of education.

Maas and Leauby (2005) described their own experiences with concept mapping in accounting classes. They introduced a step-by-step approach for implementing concept mapping in accounting education. They focused on the use of concept mapping as a conclusion to a unit of instruction. For this purpose they developed a number of ready to use maps for accounting educators. They developed an eight-stage exercise for successful in-class concept mapping. In their study Maas and Leauby compared traditional instructional methods with the instruction method that involves end-of-unit concept mapping activities. The group that used concept mapping achieved significantly higher scores then the control group. In conclusion Maas and Leauby mentioned two constraints of using concept mapping in accounting education. The main one is the amount of time that instructors need to effectively implement concept mapping in the classroom. The second constraint is related to nature of concept mapping activities: mapping is highly individual and creative process. To discuss and evaluate students' maps requires the ability of instructors to accept and gain comfort in this creative process, it requires instructors to become more visually oriented and possibly develop their own creative abilities.

Areas of using concept mapping in professional education

Using concept mapping as a learning and as an assessment tool

In professional education the method of concept mapping is used mostly for teaching and for assessment. In one article the use of concept mapping for curriculum development in veterinary was described. We could not find the use of concept mapping for brainstorming or knowledge management in the professions. That does not mean the practice is not there, it means that it is not well researched.

In most studies regarding concept mapping in professional education the focus was on learning and the use of concept mapping as a learning tool. But as a method, concept mapping was employed in very different ways, instructional phases, activity forms etc. In most cases the feedback for concept mapping was positive. The main constraint of using concept mapping the time consumption, as mentioned.

In addition to use as a learning tool in professional education, concept mapping is also widely used as an assessment tool. In some of the above described papers concept maps were used just for achievement measure but in most studies concept maps were used for both learning and assessment.

When the method of concept mapping is used in lessons or in research, a significant component of the application is the evaluation of concept maps. Reiska (2001) describes four different types of evaluation. They range from intuitive impressions only to computer-aided quanti-

tative evaluation. In addition, the possible stages are listed according to the type of evaluation and computer application:

1. *Intuitive evaluation*
2. *Semi-quantitative evaluation*
3. *Computer-aided quantitative evaluation*
4. *Quantitative evaluation using a computer only.*

Although Ruiz-Primo and Shavelson (1996) show also the problems in using concept mapping as assessment tool, there are many studies showing that concept mapping is an appropriate tool for testing students achievement (McGaghie et al, 2000; West at al, 2000; Fischler et al, 2001; Reiska 2005). Some of the studies also show that there is a high correlation between the concept mapping and other knowledge tests (Mikelskis, 1999) but some studies did not prove the correlation between concept map scores and e.g. multiple choice exam performance (McGaghie et al, 2000).

In professional education different levels of evaluation were used, however we could not find the fourth level of evaluation. The possible reason for this can be that there is not suitable evaluation tool for concept maps developed yet.

Conclusions

Concept mapping is prevalent in professional education, though not as widely as in other areas such as science education. The main uses of concept mapping are in learning and knowledge assessment. There are many different subject fields of using concept mapping e.g. veterinary medicine, legal studies, medicine, and accounting education. The analysis of 311 scientific articles about concept mapping shows that in professional education this method is more used in the subject fields that are directly connected to natural or exact sciences. In professional education concept mapping is most often used in medical education and engineering education. In most articles the faculty and students feedback was positive and the authors suggested the method of concept mapping for both - further use in classroom and research situations.

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