

## USING CONCEPT MAPPING IN VOCATIONAL EDUCATION

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**Abstract.** In recent years concept mapping has become a powerful tool that is widely used in different contexts in education. This paper describes the using of concept mapping in professional education. Concept mapping is a graphic technique that represents ideas, helps to think, solve a problem, plan a strategy or develop a process. Concept mapping is used in professional education, although not so widely as in science education. The main areas of using are learning and knowledge assessment. There are many different subject fields of using concept mapping e.g. learning in veterinary and law of real property, medical 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 which are directly connected to natural or exact sciences. In professional education concept mapping is most often used in medical education and engineering education. The main area of use is as an learning tool, often combined with assessment tool. In most articles the faculty and students feedback has been positive and the authors suggested the method of concept mapping for both - further use in classroom and research.

### 1 Concept mapping in education

“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).

Today concept mapping is widely and successfully applied in many different fields of education, e.g. concept mapping is widely used in science education (Behrendt et. al. 2000; Fischer et.al. 2001; Reiska 1999, 2005).

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).

Beside the acquisition of new knowledge the testing of achievements is another frequently used area where concept mapping has been applied to teaching process. Outside of teaching process brainstorming and knowledge management are the most used areas of concept mapping.

### 2 Using concept mapping in professional education: data and method

We researched 311 scientific articles about concept mapping and found 18 in which the using of concept mapping in professional education was described. 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 using of concept mapping in different subject fields and using areas.

### 3 Subject fields of using concept mapping in professional education

#### 3.1 Law education

As a learning and assessment tool in law of real property the concept mapping is used in one study 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 a group work. At the end of the lecture series the concept mapping was used for assessment in final examination. Fong also studied the students’ attitudes to concept mapping as an learning and assessment tool. Three fourth of the students (74%) agreed that concept mapping made learning easier for them. Fong explains the disagreed 26% with the time that students need to be able to construct the good map. For majority of students (74%) it was difficult to find the best linking word for the map. The 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 using concept maps assisted students in understanding the subject and revising for the examination. For using concept mapping as an assessment tool the response was not clearly positive.

### 3.2 Medical education

In professional education the method of concept mapping is mostly used in the field of medical education. Below are described several studies about using 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 the medicine and veterinary students' knowledge structure gathered with concept maps with their final examination scores. They could not find the 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 shows changes in the conceptual framework of resident physicians during the training and they also compared the concept mapping scores with the scores of standard in-training examination. West got evidence that concept mapping assessment reflects differences in the conceptual framework (Fig. 1). However his research group could not find correlation between concept mapping scores and the standardized testing. They came to conclusion that concept mapping and in-training examination could measure different cognitive domains.

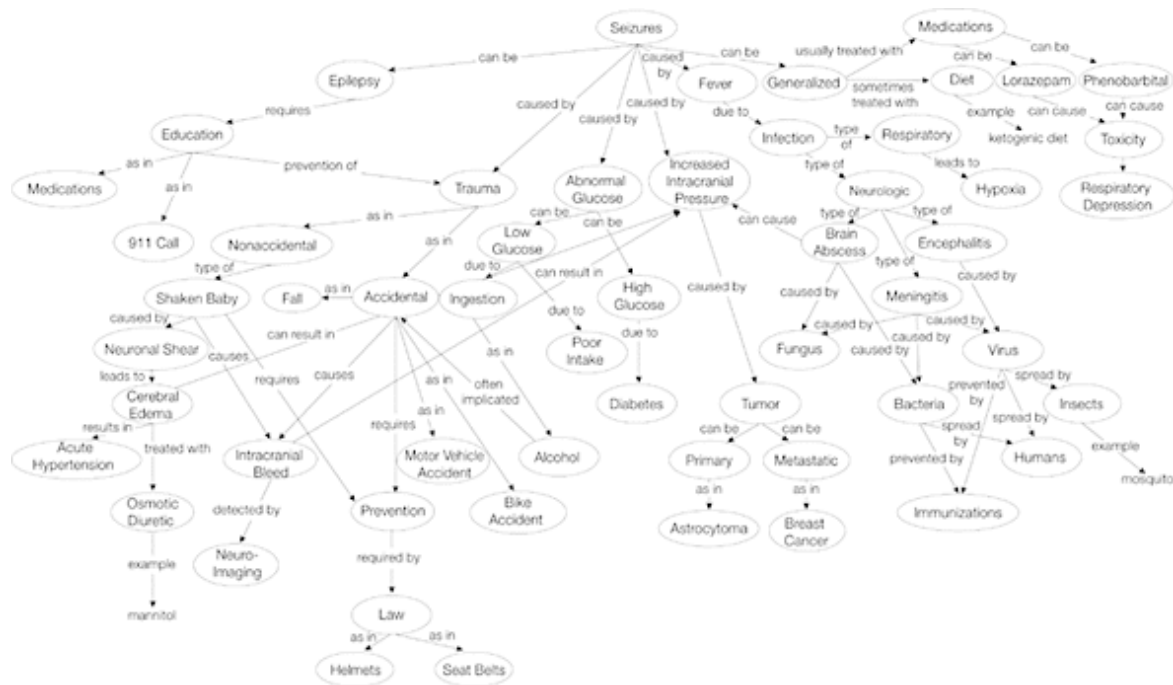


Figure 1. Reproduction of a hand-written high-scoring concept map of seizures by a resident (West et al, 2000, 1108p).

Schmidt (2006) comments the reliability and validity of concept mapping of two different above mentioned approaches using concept mapping as an assessment tool in medical education (McGaghie, et al, 2000 and West et al, 2000). Based on studies of Bordage (1994), Ericsson (1980) and others she agrees that "knowledge organization influences the efficiency and effectiveness of recall and problem solving within a domain, and that domain experts have more coherent, well structured knowledge than novices" (Schmidt, 2006, 69p). 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, 72p) of using concept mapping as an assessment tool. She arises couple of further research questions from which some are relevant not just for medical education (e.g. how does pre-given concepts or stimuli influence the nature of maps and are the more complex maps associated with better problem solving ability). Nevertheless the raised skepticism about the reliability and validity she admits that concept mapping as the method of developing meaningful assessment and approaches to teach can substantially advance medical education.

Jitlakoat (2005) used concept mapping as a learning tool with fourth year nursing students. The purpose of using concept mapping was to develop students' critical thinking skills including gathering and selecting relevant information and relating this information to the care of patient. The study was based on assumption from literature 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 information and old one. The pre- and post-test design with concept mapping as supporting learning instrument between these tests 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, p120). Jitlakoat recommended nursing instructors to adopt concept mapping into theoretical and practical teaching process.

Ford, Coffey, Cañas et al. (1996) used concept mapping in a knowledge-based expert system NUCES. This system was developed to aid interpretation of radionuclide imaging in the heart. They used NUCES also to train clinicians. Concept maps are guides to traversal of logical linkages among clusters of related objects and they help to solve the navigation problem in hypermedia system. NUCES is intended as a diagnostic expert system and a training environment.

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 interview and maps developed from the course syllabus. After the construction of maps on the bases of students' interviews each student was asked if they like to change some concepts or linking phrases. Just one of them wanted to 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 between elements of nursing process, clinical preparation was not linked to preparation for the unit of oxygenation and basic anatomy and psychology concepts were also missing. From initial of the study 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 also be used to assess and evaluate students, to plan the curriculum.

Schuster (2000) described the using concept mapping as the tool for clinical care planning. Concept mapping helps to promote learning and critical thinking about patient problems and problem solving. Based on clinical data the students compose concept maps and the faculty can review and discuss the maps to evaluate the students' understanding. The method has been successfully used with students in their early hospital experiences. Both the students and faculty were very pleased with the results of using concept mapping in care planning.

Baugh and Mellott (1998) developed the method of clinical concept mapping (CCM) to help nursing students learn concepts and help them to apply these concepts in 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 to organize complex patient data and process complex relationship. Baugh and Mellott asked in their study the students to develop at least one clinical concept map per week for their patient clinical settings. By the evaluation of students' concept maps faculty could assess the level of their understanding and also to recognize how the students see the big picture. As conclusion of their study they suggest clinical concept mapping as effective tool to improve meaningful clinical learning and encourage 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 used research design with pre and post tests and experimental and control groups. Experimental groups used also 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 irrespectively if they used simulation or not. The researcher came to conclusion that although they used concept mapping as a performance measure, it 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 - to 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 identify 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.

### *3.3 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 that concept maps can be a valuable tool for addressing assessment issues, which arise in engineering education. Although the authors came to 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. (2004) 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. (2002) 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). As the result of current use they assume that with the extended use of concept maps in teaching process, more systematic assessment of student conceptual understanding will be implemented.

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 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 conclusion that concept mapping is a useful tool to portrait the process of knowledge transformation from novice to expert. They find also concept mapping an appropriate tool of student assessment and instruction while introducing them model-based reasoning within the domain of bioengineering.

### *3.4 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. Usually first the students constructed their own maps and after that they could compare these maps with the instructor's map. To evaluate the students' maps they used a scoring method which included quality and quantity of relations, concepts and they also took account of the hierarchy. Leauby and Brazina got generally positive reactions from students: concept maps helped students to see better the relationship among concepts and thereby supplement other learning approaches. They also came to a result that concept maps may have helped the lower -performing students to do better. Finally Leauby and Brazina pointed out eight benefits of using concept mapping which are similar to other educational areas.

Maas and Leaby (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. The developed step-by-step approach includes eight steps for successful concept mapping exercise in class. In their study Maas and Leaby compared traditional instructional methods with the instruction method that involves end-of-unit concept mapping activities. As a result of the study the group, which used concept mapping achieved significantly higher scores as the control group. In conclusion Maas and Leaby mentioned two constraints of using concept mapping in accounting education. The main is the big amount of time that instructors need to implement concept mapping in the classroom effectively. The second constraint is related to nature of concept mapping activities: mapping is highly individual and creative process. To discuss and evaluate the students' maps requires the ability of instructors to accept and gain comfort in this creative process, it requires instructor to become more visually oriented and possibly develop their own creative abilities.

#### **4 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 most studies, which were about using concept mapping in professional education the method was used as a learning tool. The main idea of using this method is to develop meaningful learning by students. The concept mapping method was used 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 was mentioned.

Besides the learning tool the method of concept mapping is in professional education 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.

#### **5 Conclusions**

Concept mapping has been used in professional education, although not so widely as in science education. The main areas of using this method are learning and knowledge assessment. There are many different subject fields of using concept mapping e.g. learning in veterinary and law of real property, medical 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 which are directly connected to natural or exact sciences. In professional education concept mapping is most often used in medical education and engineering education. The main area of using the method is as an learning tool, often combined with assessment tool. 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.

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