



## **Concept mapping as an empowering method to promote learning, thinking, teaching and research**

## **Los mapas conceptuales como un potente método para promover el aprendizaje, la enseñanza y la investigación**

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### **Concept mapping as an empowering method to promote learning, thinking, teaching and research**

### **Los mapas conceptuales como un potente método para promover el aprendizaje, la enseñanza y la investigación**

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#### **Abstract**

Results and underpinning of over twenty years of research and development program of concept mapping is presented. Different graphical knowledge presentation tools, especially concept mapping and mind mapping, are compared. There are two main dimensions that differentiate graphical knowledge presentation methods: The first dimension is conceptual explicitness: from mere concepts to flexibly named links and clear propositions in concept maps. The second dimension in the classification system I am suggesting is whether there are pictures or not. Åhlberg's and his research group's applications and developments of Novakian concept maps are compared to traditional Novakian concept maps. The main innovations include always using arrowheads to show direction of reading the concept map. Centrality of each concept is estimated from number of links to other concepts. In our empirical research over two decades, number of relevant concepts, and number of relevant propositions in students' concept maps, have been found to be the best indicators and predictors of meaningful learning. This is used in assessment of learning. Improved concept mapping is presented as a tool to analyze texts. The main innovation is numbering the links to show order of reading the concept map and to make it possible to transform concept map back to the original prose text as closely as possible. In Åhlberg and his research group's research, concept mapping has been tested in all main phases of research, teaching and learning.

#### **Resumen**

Presentamos los resultados que sustentan más de veinte años de investigación y desarrollo de programas centrados en los mapas conceptuales. Se comparan diferentes herramientas gráficas de presentación del conocimiento, especialmente mapas conceptuales y mapas mentales. Hay dos dimensiones fundamentales para diferenciar los métodos de representación gráfica del conocimiento. La primera dimensión es la claridad de los conceptos: desde meros conceptos hasta los denominados enlaces flexibles y proposiciones claras en los mapas conceptuales. La segunda dimensión en el sistema de clasificación que sugiero es si existen o no imágenes. Las innovaciones y desarrollo de los mapas conceptuales de Novak realizados por Åhlberg y su grupo de investigación, son comparados con los tradicionales mapas de Novak. Las principales innovaciones incluyen el uso de puntas de flecha para indicar el sentido de la lectura. La importancia o papel central de cada concepto se estima a través del número de enlaces con otros conceptos. En nuestra investigación empírica a lo largo de dos décadas, el número de conceptos relevantes y el número de proposiciones relevantes en los mapas de los estudiantes, se consideraron como los mejores predictores del aprendizaje significativo. Esto se utiliza para la evaluación del aprendizaje. Otra innovación importante es la numeración de los enlaces, para mostrar el orden de lectura del mapa conceptual y para hacer posible su transformación en un texto tan parecido al original como sea posible. En Åhlberg y en los estudios de su grupo, los mapas conceptuales han sido probados en todas las fases principales de la investigación, la enseñanza y el aprendizaje.

#### **keywords**

Improved concept mapping, graphical knowledge presentation methods, mind mapping, research methods, text analysis, meaningful learning, theoretical underpinnings.

#### **Palabras clave**

Mapas conceptuales mejorados, métodos de representación gráfica del conocimiento, mapas mentales, métodos de investigación, aprendizaje significativo, fundamentos teóricos.

## 1. Introduction

I first read about concept mapping in the beginning of 1980s, over 30 years ago. The strongest memory is when I found just published Novak & Gowin (1984) in the Academic Bookstore in 1984. At that time, I was a lecturer in the Department of Teacher Education at University of Helsinki. My work involved teaching research methods for becoming classroom teachers. They did not like so much about learning about research methods, because “we are becoming teachers, not becoming researchers”. I often repeated to them that teachers ought to monitor and make research on their own pupils’ learning in order to promote it, to give valid and reliable feedback, evaluations and grades (Åhlberg 1992). Novak & Gowin (1984) made me think that concept maps and Vee heuristics are versatile tools, which can be used to promote meaningful learning, teaching and research on learning and teaching.

I experimented with concept mapping over four years and developed my own versions of Novakian concept mapping for different purposes. Results of my concept mapping design experiments were first published in Finnish (Åhlberg 1989a). At the same year I had a chance to publish two short papers also in English (Åhlberg 1989b and 1989c). Already in these three papers I presented my version of Novakian concept mapping, that I have called improved concept mapping, and new theoretical underpinnings based on modern science and philosophy of science (for details and references: Åhlberg 1993). The 1993 paper was published when I was a visiting scholar at Cornell University for three months. Professor Joe Novak was my mentor there. After that I have taught concept mapping as a research method for thousands of people all around the world where I have travelled. I have developed a method for how in five minutes to learn to make excellent concept maps. In five minutes the whole classroom or auditorium can learn the main principles of concept mapping. Concept mapping is a skill. It takes plenty of practice to become an expert concept mapper.

Since 1984, I have become convinced that concept mapping can be used successfully in education and in research on and for education practically always and everywhere. Everything that can be talked and/or written can be concept mapped. The benefit of concept mapping is showing externally, explicitly, hidden and implicit conceptual and propositional structures. This promotes shared understanding, learning, thinking and acting. One of the most important events in my personal history, is publishing with Dr. Johannes Wheeldon a textbook of research methods (Wheeldon & Åhlberg 2012), in which research on concept maps and Mind Maps are analyzed and presented in detail.

## 2. Comparing different graphical knowledge presentation tools, especially concept mapping and mind mapping

Nowadays different types of graphic representation tools have become very common. Many terms are used, e.g. concept maps, mind maps, spider maps, spider diagrams, clustering etc. Often the same term is used for many different methods or techniques. It confuses, if you are not an expert in this field. In this paper theoretical background for concept maps, mind maps and other similar graphic representation tools will be presented.

From viewpoint of human evolution, it is clear that first humans learnt how to speak, then how to write and finally how to create graphical representations based on writing. First those presentations were made by pens. Nowadays there are also digital options. On the 21st century these graphical representations may include sound, speaking, video clips etc. At least CmapTools software makes it possible for every computer user, free of charge.

As Paivio (1986) clearly shows in human mind there are at least (1) concepts and propositions and (2) images, sense memories of sight, hearing, touch, smell and taste. Only concepts and propositions are easy to share. Private sense memories are in our minds, but extremely difficult or even impossible is to share them.

Two of most used graphical knowledge presentation methods are probably Novakian concept mapping and Buzanian mind mapping. I have met many people who are not able to make a difference between Novakian concept maps and Buzan type mind maps. That is why I have used the same concepts and created from them both a concept map and a mind map (e.g. Åhlberg & Ahoranta 2002 and Åhlberg 2008). The following two figures are from Åhlberg (2008). The concepts

are clearly circled in the concept maps in the Figure 2. Creating a Mind Map using these concepts, is a very revealing experiment. It makes clear that concept mapping is an accurate method to present thinking and mind mapping is just a mapping of associations using a tree analogy, not revealing how the concepts are linked accurately to form propositions/statements/claims of the world.

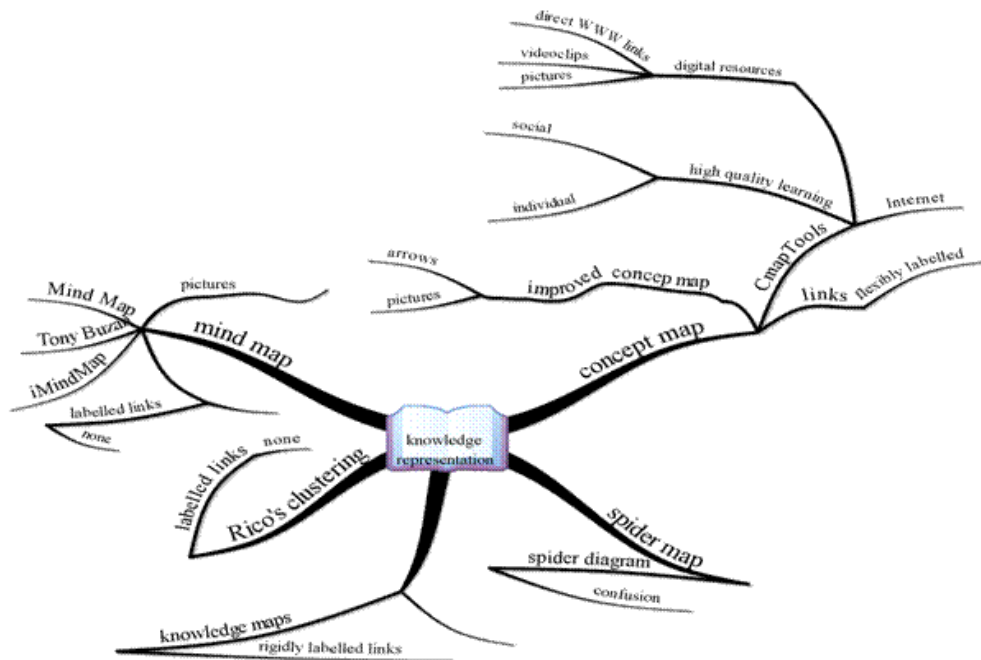


Figure 1. A mind map created using the same concepts as in the following concept map (Fig. 2). It is impossible to transform this to ordinary meaningful prose text.

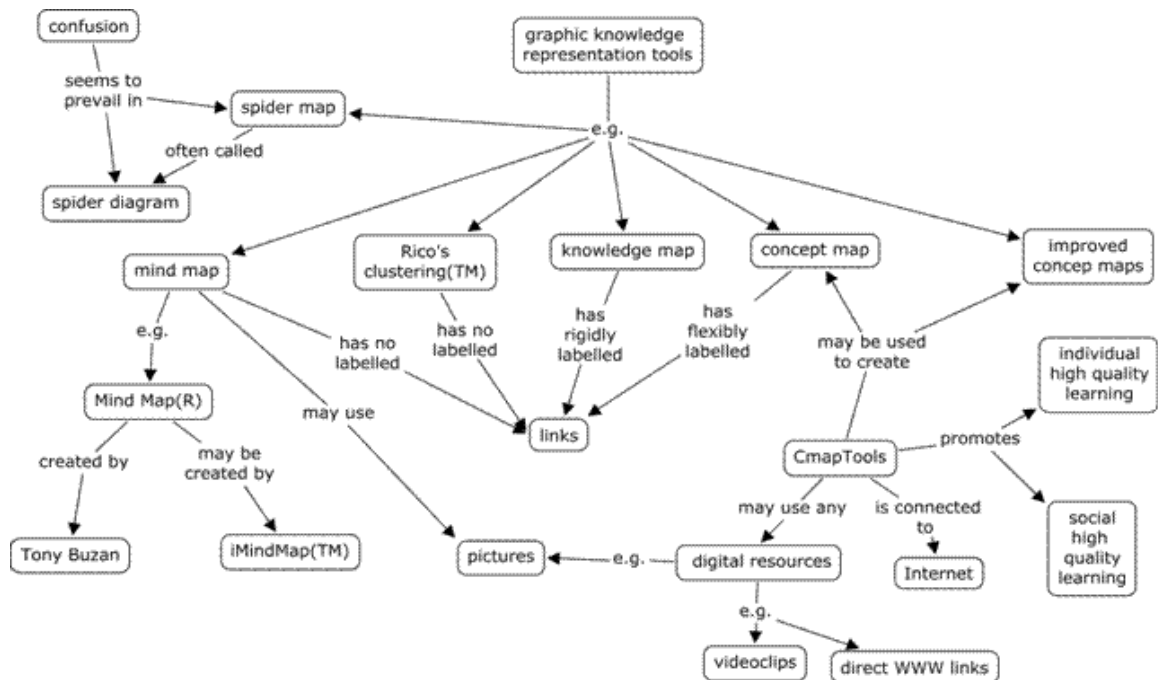


Figure 2. Concept map created from the same concepts as used in the mind map of the Figure 1.

I have compared different methods that people nowadays use to present knowledge externally (Åhlberg 1990, 1993 and 2008). In the following comparison table (TABLE 1.) have not included those kinds on methods that use propositions as basic elements and call them “concept maps” (e.g. Palmer 1995). There are no cumulative research for the benefits of circling propositions, and calling them “concept maps”. It creates only intellectual confusion and chaos. The results are presented in the following table (TABLE 1). I found two main dimensions that differentiate graphical knowledge presentation methods: The first dimension is conceptual explicitness: from mere concepts to flexibly named links and clear propositions in concept maps The second dimension in the classification system I am suggesting is whether there are pictures or not.

	NO PICTURES	PICTURES
<b>CONCEPTS AND FLEXIBLY NAMED LINKS</b>	Type 7: Novak (1981): concept map; Novak & Gowin (1984) concept map; Ahlberg (1989a, b): concept map; Fisher (1990): semantic networking	Type 8: Åhlberg (1988): concept maps; Fuata'i (1985, 90): concept map; Heinze-Fry (1987, 263) concept map
<b>CONCEPTS AND RIGIDLY NAMED LINKS</b>	Type 5: Fridja (1972, 4); Dansereau & al. (1979): network; Anderson 1985: network of concepts; Wiegman & al. (1992): knowledge mapping	Type 6: Greeno (1976): network of propositions
<b>CONCEPTS AND UNNAMED LINKS</b>	Type 3: Collins & Quillian (1969): illustration of hypothetical memory structure; Rico (1983- 2008) clustering; Heimlich & Pittelman (1986): semantic mapping; Grice & Skinner (1993, 110): visual brainstorming; Tillema (1993) network of concepts	Type 4: Glass, Holoyak & Santa (1979); Glass & Holoyak (1986, 158) <i>conceptual network</i>
<b>ONLY CONCEPTS AND NO PROPER LINKS</b>	Type 1: Hanf (1971): mapping; Schaefer (1979, 91); Trochim (1985 – 1989) Wandwersee (1987) concept circles	Type 2: Buzan (1974 – 2006): <i>brain pattern</i> (1974), mind maps (later on) ; Russell (1979): <i>mind maps</i>

Table 1. Comparison of different types of graphic knowledge representation tools in which conceptual level is prominent. Based on Åhlberg (1993) and (2008) in which these are described in more detail.

### 3. Varieties of concept mapping, in particular traditional Novakian concept mapping compared to Åhlberg's improved concept mapping

I have compared different varieties of concept mapping (Åhlberg 2004) comparing in particular original Novakian concept mapping and versions that I have developed from it.

Most articles published that describe the use of concept mapping refer to Novak and Gowin (1984) In their book, the most common version of concept mapping is as follows: There are circled concepts with links connecting them, and the links are labeled or phrased in order to create meaningful statements. The ideal concept map has hierarchy. Links flowing from the top concept to other concepts are mostly lines. It's only when links are horizontal or are read upwards that arrows are used. This formatting style for concept maps is presented as his pending trademark in Novak (1998). It is remarkable that Wandersee (2000, p. 136) criticized one of the figures in Novak's (1998) book because the “concept map on rhizobotany ... fails to follow the Novakian Standard Concept Mapping Format.”

Novak (1998) has applied for a trademark of his style of concept mapping: Concept Maps™. However, many of Novak's own students and research partners do not follow all the rules. Neither does Novak himself (e.g., Novak, 2002). According to Novak and Gowin (1984, p. 182): “Lines connecting concepts were not labeled in our earlier work.” They referred to manuscripts and publications from the 1970s. Now a research question arises: When did the first labeled links appear in concept maps? This is an important question because everything in the world is somehow



connected. It does not tell very much about somebody's thinking and learning if s/he only lists words, arranges them spatially, circles them, and links them by lines. But if links are labeled, then meaningful statements about the world are created and everybody knows what that person thinks or has learned about the world, and considers important enough to express. As far as we know, Novak (1981, p. 14) was the first publication in which the links were named and meaningful propositions were created out of concepts. This is the form of Novakian concept maps that has been spread globally.

"The Novakian Standard Concept Mapping Format" (expression from Wandersee 2000, p. 136) is used on the IHMC CmapTools (Cañas et al. 2004) Web site (IHMC 2004) Web site as well as the Web site of the First International Conference of Concept Mapping (CMC2004 2004). The links are mainly lines, and arrowheads are used only according to "the Novakian Standard Concept Mapping Format."

Safayeni, Derbentseva, and Cañas (2005) presented an idea about cyclic concept maps, which are hierarchical. This is a special case of an improved method of concept mapping in which the concept map can be constructed in any way that is the best justified option. This is because according to modern science, the world is a system and everything in the world is connected. That is why a concept map can be interpreted as a tentative theory of a part of the world. Hierarchies or circles may sometimes be natural and economical, but sometimes a network can be an even better option.

Elements of an improved method of concept mapping Ahlberg (2001) presented a list of commonalities differences between improved concept maps and traditional Novakian concept maps. Applying (Åhberg 2004) an improved list from the viewpoint of research methodology is as follows:

- 1) All concepts are interpreted as main elements of thinking and learning, and they are always inside frames. In Novak and Gowin (1984, pp.14, 22, 52) and Novak (1998, p. 100) concepts are sometimes inside frames and sometimes not.
- 2) Novak and Gowin (1984) and Novak (1998) prefer very short verbal labels for concepts. However, concepts sometimes require many words in order to be correctly labeled. There is no accurate limit on how many words may be included in a concept label. In an improved concept map as many words as are needed are used to name the concept accurately.
- 3) In order to have a meaningful proposition, all links between concepts have arrowheads to show in which direction the connection from one concept to another is to be read. However, if they were following their own rule, in Novak and Gowin (1984) and Novak (1998), only the concepts that are either horizontal or are to be read upwards should have an arrowhead. Thus, this complex rule is not always remembered even by those who use the traditional Novakian concept mapping (e.g., Novak & Gowin, 1984, p. 176; Novak, 1998, pp. 52, 84,121). Novak (2002, p. 553) presented a concept map "showing the nature and structure of concept maps." In this concept map all links have arrowheads, not only horizontal or upward links. Already Novak and Gowin (1984, p. 102) presented a concept map in which all links had arrowheads, and they called it "a good concept map." We agree, it is a good one.
- 4) The expressions connected to links may be short or long, but they must accurately express the thinking of the person whose thoughts are concept mapped. Novak and Gowin (1984) and Novak (1998) favor very short verb expressions. The essential point is that the link includes a verb expression and the resulting proposition is meaningful and more or less true, plausible, probable, et cetera.
- 5) You may connect pictures, videos, sounds, et cetera to concept maps (e.g., Ahlberg, 1993; IHMC, 2004). Novak and Gowin (1984) and Novak (1998) never do this.
- 6) Novak and Gowin (1984) and Novak (1998, 2001) stress the importance of Ausubel's learning theory. Ahlberg (1993 and 2002) came to conclusion that whatever learning theory is used, you may still use concept mapping because it is as general a method as is speaking or writing. Everything that is spoken or written may be transformed to concept maps, and all good concept maps may be easily transformed back to ordinary speaking or writing.
- 7) Novak and Gowin (1984) and Novak (1998) argued that concept maps should always be hierarchical. This is often sound and economical, but not always. For instance, Novak and Gowin (1984, pp. 16-18) demonstrated how the same concepts can be arranged hierarchically in three different ways. The same effect could be better achieved if the most important concept is sometimes in the center of the concept map but sometimes somewhere else, as long as that choice can be justified to be the best option. Then, we

may imagine the center of the concept map as the top of a pyramid seen from above. It is good to remember that the world is a system, and therefore, sometimes the best presentation for the world and its part systems are conceptual systems, which are not always hierarchical. Novak and Gowin (1984, p. 16 - 18) presented three concept maps illustrating the same concepts. They look hierarchical, but there is no way to show that the topmost concept is either the broadest or most inclusive one, as it should be in a real conceptual pyramid according to Novak and Gowin (1984, p. 33) and Novak (1998, pp. 3, 227). There are also ontological and epistemological reasons why good concept maps may not be always hierarchical. The world is a system, and therefore, the best conceptual representation of it is a conceptual system, a concept map, which may not always be hierarchical. A similar idea has come into the minds of Safayeni, Derbentseva, and Cañas (2003) who presented an argument for cyclic concept maps, which are not hierarchical.

- 8) In a good concept map each concept is mentioned only once, similar to a good geographical map in which each place is named only once. Novak (1998, e.g., pp. 14, 66-67, 121) does not always follow that simple and elegant rule. Nicoll, Francisco, and Nakhleh (2001, p. 864) showed that there may sometimes be practical reasons not to follow this rule. Sometimes there is a concept that has so many links to other concepts that the only imaginable option is to have this concept twice in the concept map, but this kind of exception needs a good explicit explanation.
- 9) If each concept is only mentioned once on the concept map, then it is easy to count how many links each concept has to and from other concepts. The number of links with other concepts is a good estimate of centrality of that concept in the thinking of the person whose thoughts are concept mapped. Let's explore a "Gedanken" experiment: If you would remove from the concept map, the concept with the most links to other concepts, this would result in the greatest possible damage to the concept map. That is to say, that concept is, in this sense, the most central concept in the concept map. This idea has also been tested and presented by Ahlberg and Ahoranta (2002), Ahlberg, Turja, and Robinson (2003), and Ahlberg, Aanismaa, and Dillon (2005).
- 10) Sometimes it is useful to be able to read a concept map only in the order that you intend it to be read. It may not always be from top to bottom. For example, it may be a transformed part of a textbook, and the order in which propositions are read is important. Then you may add to each link a number showing the order according to which the propositions should be read.

#### 4. Concept mapping as a tool to analyze texts

I have developed concept mapping as a research method to analyze texts, such as textbooks and/or interview transcripts (e. g. Åhlberg 1989, 1991, 1993 and 2012). The main point is to number propositions in the order, they are in the original text. The numbers can be added either near to the arrowheads of links or linking phrases as in the example below.

The following excerpt is from the interview the Director General of the National Board of Education is from (Siirilä & Ahlberg 2012). It is an answer to the question focused on how the interviewee understands concept of Education for Sustainable Development (ESD):

*"(1) In ESD thinking, thinking skills, sense of community etc. will be promoted. (2) Pupils will learn to create, learning by doing, integrating ideas broadly. (3) ESD is focused on creation of a worldview, integration of personality, and creating sufficient capabilities, in order that pupils will become able to flourish in this world.(4) ESD is not rote learning, and is not learning those kinds of contents that do not have any practical value, learning those kinds of contents that do not have any practical value. (5) This is the way, how sustainable development becomes a value, that influences the whole societal change via behavior of individuals."* Numbering statements from (1) – (5) is done in order to show, how a concept map can be created that follows the original text as closely as possible. This text can be transformed into a concept map in the following way (Fig. 3).

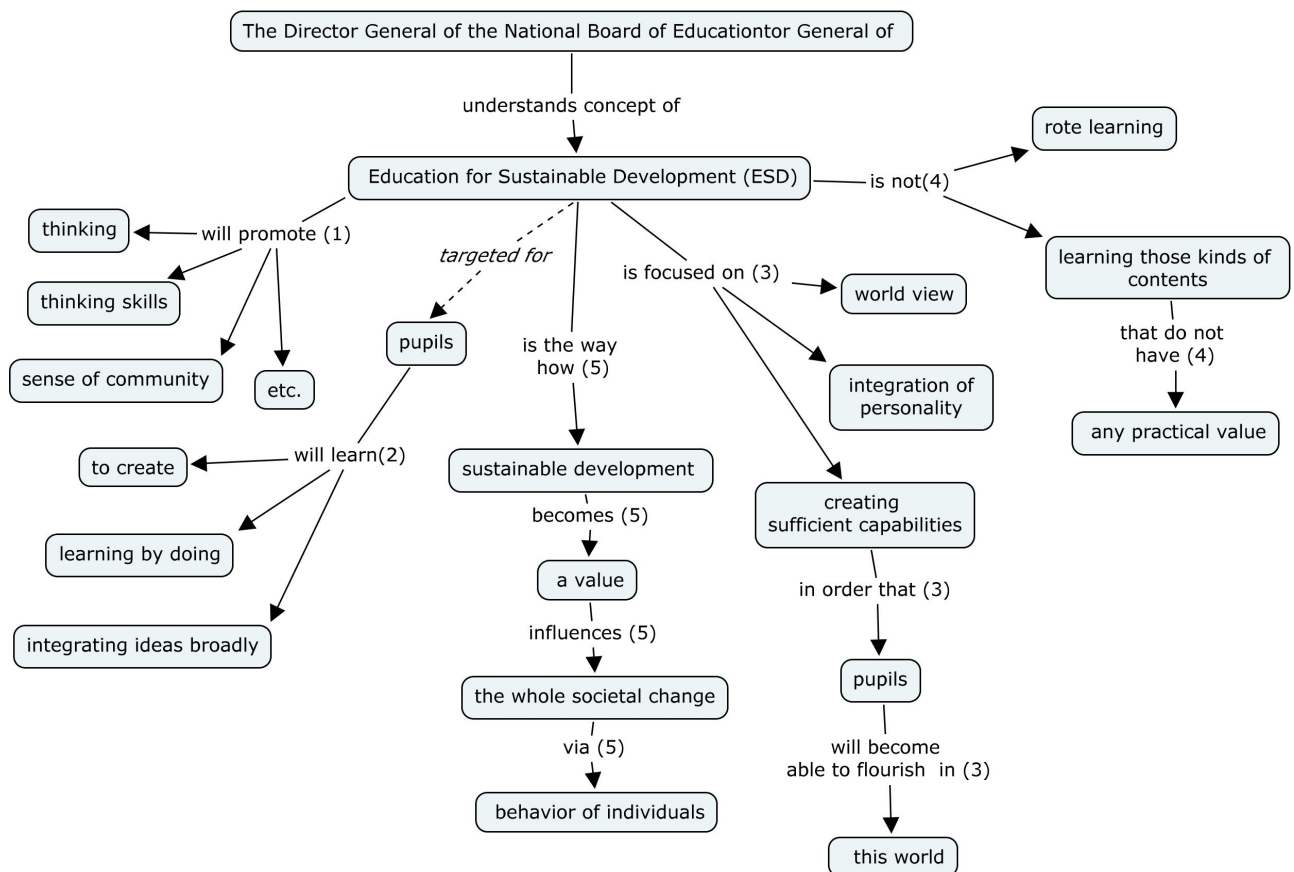


Figure 3. The text has transformed into a concept map, in the way that it can be transformed back into the original text. The most central concept in this concept map is 'Education for Sustainable Development (ESD)'. It has at eleven links with other concepts. More than any other concepts have links with other concepts.

## 5. Conclusion

In Åhlberg's and his research group's research, concept mapping has been tested in all main phases of research, teaching and learning. Theories, theoretical frameworks and research designs have been explicated with improved concept mapping. Student learning has been monitored and promoted by improved concept mapping. Texts have been analyzed with improved concept mapping. Concept map has been used as a quality tool in Continual Quality Improvement of organizations. Based on research and development results and experiences new applications and development for concept maps have been created. The following are some of the main documents of this development over two decades: Åhlberg (1998, 1989a, 1989b, 1990, 1991, 1992, 1993; 1997; 2008), Åhlberg & Ahoranta (2004), Åhlberg, Turja, & Robinson (2003), Åhlberg, Äänismaa, & Dillon (2005), Wheeldon & Åhlberg (2012).

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