*Chapter 10*

# ENHANCING KNOWLEDGE FLOWS USING CONCEPT MAPS IN HEALTHCARE PROFESSIONAL DEVELOPMENT

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Preprint of:

Trentin G. (2017). Enhancing Knowledge Flows using Concept Maps in Healthcare Professional Development. In R.V. Nata (Ed), *Progress in Education*, vol. 47, cap.10, Nova Science Publishers Inc., Hauppauge, NY, ISBN: 978-1-53611-009-8.



## ABSTRACT

A possible approach to mix formal and informal learning processes in continuous professional development is the creation of conditions for grafting the typical dynamics of informal learning onto formal educational paths. One such approach was the object of the experiment described in this article, having the aim to analyse and discuss the use of concept mapping for enhancing and empowering informal knowledge flows within a group of professionals participating in formal training sessions.

The major findings were: (a) graphic representations can be more useful as a tool for self-assessing one's learning than as a study aid proper; (b) it is useful to employ graphic knowledge representation as a support tool for informal collaborative learning.

## INTRODUCTION

In his book *Informal Learning* (2005), Jay Cross pointed out a sort of paradox: although "formal" education still absorbs about 80% of total investment in education, most of the knowledge people need for their work is learnt through "informal" channels.

Cross's theory is that this all depends on the persistence of an old-fashioned conception of education. To this we have to add the tendency to keep formal and informal learning processes in temporal sequence, as if there were two specific moments: a moment (a) when learning takes place mostly by means of formal recognition, attending a course (formal process); a moment (b), generally after the course, when learning occurs through experience and interaction with others (informal process), moreover without receiving any type of formal acknowledgment of this newly acquired knowledge being received in exchange.

For this reason, many years have been dedicated to the study of how to create a firm integration and complementarity of these two moments, trying to introduce the typical dynamics of informal learning into formal learning paths (Csanyi et al., 2008; Fukuhara et al., 2010). These dynamics involve individuals tackling their own learning needs autonomously, both by using the info-documental sources available (also) online, and through networked interactions within professional communities, whose purpose is to extend the sharing of knowledge and good practices.

One of the possible approaches is to recreate within a formal learning path the same situations which professionals are generally called upon to resolve during their actual work.

For this at least two conditions must be guaranteed. The first requires the introduction of the concept of "hybrid learning process" (Hou & Lu, 2011). The learning moment must be seen as the convergence point of various processes: (a) self-study material management; (b) learning process management; (c) professional knowledge management and sharing (Figure 1) (Trentin, 2005).

The second condition is that formal learning processes become a basis and incubator for non-formal and informal learning processes.

In view of the continuous need for learning throughout one's professional life, the quality of an educational process will in fact increasingly depend on its capacity for "meta-educate," i.e., enabling users to independently provide for their own continuous education in the specific knowledge domain (Trentin

2005). This should be done by consolidating the habit of using the multiple resources available from communication technologies (particularly Web 2.0 and mobile technology), ranging from the specific computer applications for knowledge management and sharing to interaction in online communities of professionals.

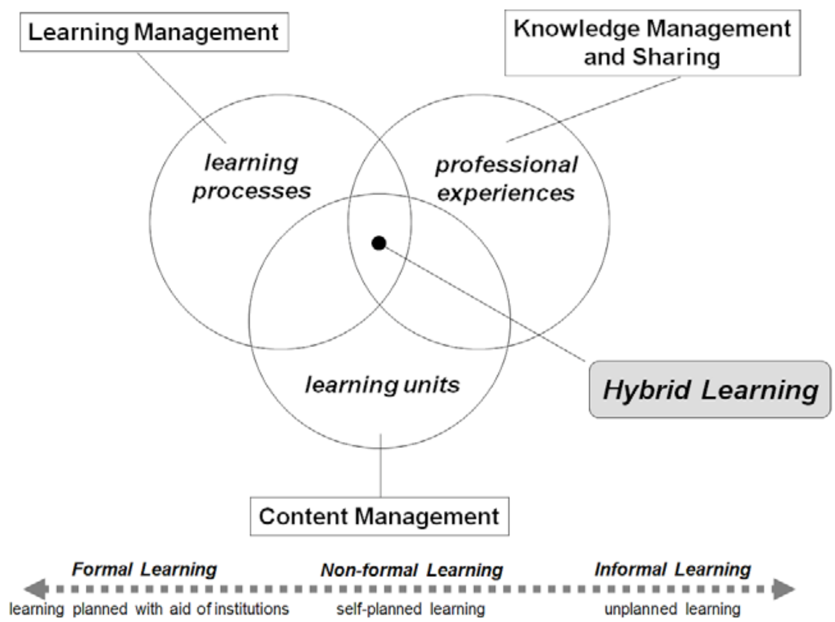



Figure 1. Hybrid learning process.

## The Theoretical Basis of the Experiment

Knowledge is the result of a constructive process where subjective factors, such as pre-existing knowledge and experiences, individual and organisational cultures, and individual talents play a role of paramount importance. As a result, knowledge (1) is distributed across individuals, groups and organisations in an inhomogeneous way and (2) has a natural tendency to remain at least partially at a tacit level. This is especially true of professionals who in most cases are not fully aware of their mental models and of the methods they apply when accomplishing a given task. Usually it is difficult for professionals to transfer knowledge from the tacit to the explicit realm.

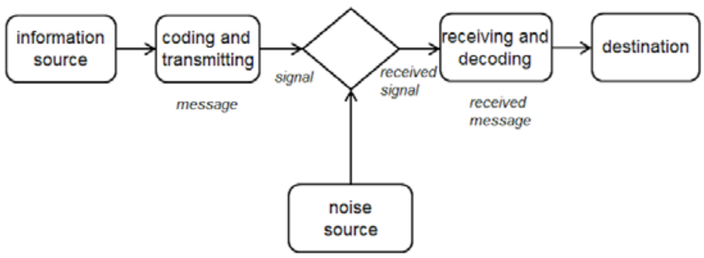
Expertise in fact consists of a very complex, though pragmatically efficient, structure involving different types of knowledge which are activated by the professionals within the context of specific tasks (Basque et al., 2008; Stemberg, 1999).

When discussing these themes there is a tendency to use the term "knowledge flow". However, if interpreted literally, this term is intrinsically contradictory. Knowledge is subjective in nature; only data and information and, at most, knowledge representations can flow, and those representations only make sense in relation to human cognition, i.e., communication is only achieved when the data received become meaningful for the receiver as the result of the action of his/her cognition faculty (Carvalho & Araújo Tavares, 2001).

Representations are something different from actual knowledge, but they can be an important aid for supporting the processes of thinking and communication.

## Communication, Information and Knowledge Flow

Figure 2 is a diagram of a communication system as conceived by Shannon and Weaver (1949): an information source, an information codification and transmission unit, a transmission channel with noise[1] interference, an information receiver and a decodification unit, the destination of the information.




[1] In communication theories the concept of "noise" is understood in its broader sense. Besides the actual physical noise introduced by technology (e.g. electromagnetic perturbations), it includes noise caused by the following: semantic factors (i.e. different interpretations of the meaning of what is being communicated); entropy and overabundance of information transmitted; difference in interlocutors' cultural levels; technical jargon of the specific communication context, etc.

Figure 2. Communication flow according to the model of Shannon and Weaver (1949).

This type of communication is at the basis of both dialogic interaction (sms, e-mails, forums, social networks, etc.) and artefact-mediated interaction (documents, wikis, concept maps); in other words, every piece of information needs to be first coded then decoded in order to pass through the communication channel.

Clearly, the principle by which it is coded must be the same as the one by which it is decoded, and this leads to the need for a syntax which all the interlocutors (mediated by technology) must respect.

The syntax may be that of the natural language in which a text artefact (e.g., a wiki) is written, or in which a verbal exchange occurs, or it may be a formal language, as in the case of graphic representations (e.g., concept maps).

Apart from its need for codification, the process illustrated in Figure 3, information transmission, does not differ greatly from the flow of a liquid from one container to another. And this is why it is often defined as an information flow.

While Figure 3 adequately represents an information flow process, it is inadequate for representing knowledge flow processes. In fact as Steen Larsen states (1986):

> "Information can be transmitted but knowledge must be induced."

In support of his theory he listed the three key stages which in his opinion bring about the flow of knowledge from a source to a receiver:

- *transformation of personal knowledge into public information* - The senders transform and organise their knowledge into public information to be transmitted to the receiver;
- *information transfer* - The senders transmit their knowledge, transformed into public information;
- *transformation of the public information into personal knowledge by the receiver* - The receiver transforms the information provided by the sender into personal knowledge.

In other words, the mechanisms for the acquisition of new knowledge must not so much be compared to the decanting of a liquid from one container (the sender's head) to another (the receiver's head), as rather to a process involving absorption, integration and systematisation of the information received by the receiver into his/her own pre-existing cognitive structures, which are the result of personal experience, earlier knowledge, etc.

In formulating this hypothesis, Larsen clearly espouses some established learning theories, in particular the theory of Meaningful Learning proposed by Ausubel (1968), which describes how new knowledge must be constructed based on the learners' previous knowledge, named "superordinate concept." Gagne (1985) also suggested that prior knowledge is the necessary internal condition of learning. Thus, the provision of meaningful learning activities which fit learners' conceptualisation capacities is an important, challenging aspect of the improvement of learning efficacy.

On the basis of these considerations, the scheme of Figure 2 should thus be extended as shown in Figure 3 in order to provide a better representation of a knowledge flow process (Trentin, 2011). Thus, the key point is to create the conditions for stimulating and favouring the process of *assimilation* and *accommodation* (Piaget, 1977), by proposing both individual and collaborative learning activities, problem-solving and artefact development, etc.

In this context, an interesting approach to the fostering of collaborative knowledge building (Stahl, 2000) is the integration into the virtual community environment of face-to-face and online interactions, in other words putting into practice what is described in Kimmerle and colleagues' *co-evolution model* (Kimmerle et al., 2010), centred on the use of technologies which favour social interaction.

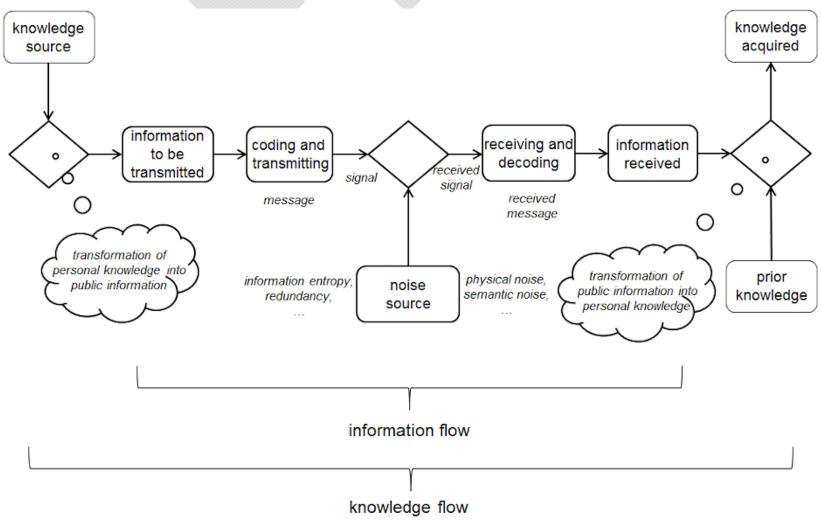


Figure 3. From Information Flow to Knowledge Flow.

## Graphic Knowledge Representation for Fostering Knowledge Flow and Haring

When we speak of social interaction, we are often referring to resources such as forums, wikis and social networks, but we should not forget other tools which equally effectively foster dialogue, collaborative interaction and *knowledge maturing* (Kaschig et al., 2010) within the professional communities.

Of these tools, those for graphic representation have often shown their versatility in illustrating concepts, processes and other forms of knowledge (Donald, 1987; Trentin, 2007; 2011).

Graphic representations facilitate alignment of the participants' varying conceptual images, helping reduce what is often defined as "semantic noise" (Shannon & Weaver, 1949), i.e., the different ways of understanding a word, a sentence, a concept, especially when communication is limited to the verbal, moreover mostly in an indirect form like computer-mediated communication (CMC). We should in fact not forget that knowledge flows are markedly affected by the context in which they are developed (school, company, amateur associations, etc.) and by the features of the users (age, education, culture, professional skills, etc.).

This paper will refer to a specific tool for the graphic representation of knowledge: concept maps.

A concept map is a coherent, visual, logical representation of knowledge on a specific topic, which encourages individuals to direct, analyse and expand their analytical skills (Novak & Wandersee, 1991; Halimi, 2006).

The approach was developed by J.D. Novak (1991), based on Ausubel's theories (1968) and Quillam's studies on semantic networks (1968). Concept maps use diagrams which highlight meaningful relationships between concepts in the form of *propositions,* also called *semantic units,* or *units of meaning*. A proposition is the statement represented by a relationship connecting two concepts.

Therefore, there are two basic features used to construct concept maps: *concepts* and their *relationships* (Figure 4).

Besides the two basic features, a concept map is characterised by hierarchical relationships between concepts and by cross-links between concepts belonging to different domains of the same map.

By proceeding in such a way, one can obtain graphic representations like the one reported in Figure 5, showing one of the maps produced by the Audit community during the experimentation described here.

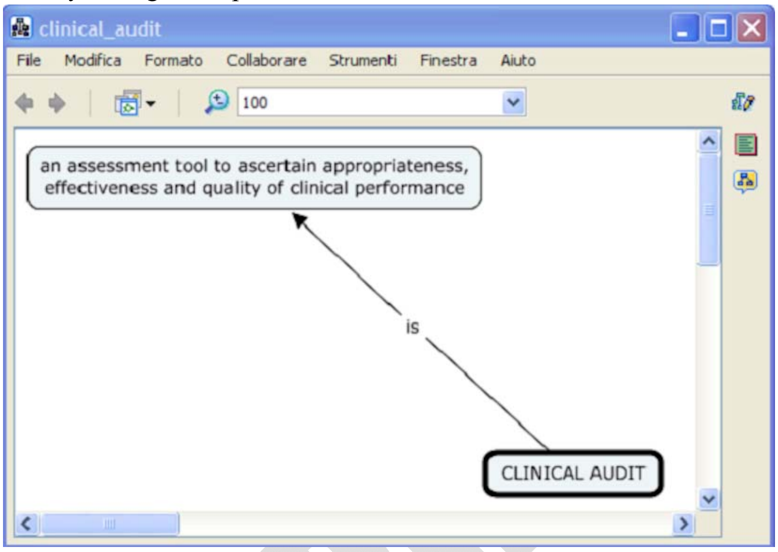



Figure 4. Description of concepts and relation type.

Concept maps are *de facto* a language of communication and, like any language, syntactic rules are needed for them to act as a medium in communication between two or more individuals (Donald, 1987).

The question is: when are concept maps useful for professional communities?

A first consideration regards their effectiveness in facilitating the multi-perspective study of a given knowledge domain and/or area of exploration: new knowledge, the solution to a problem, the functionalities of a complex system. In the eyes of the interlocutors, the representation of concepts through graphics amplifies the existence of multiple interpretations of one subject of study or debate (Cunningham, 1991).

A second consideration concerns the community's need for technological aids to improve the flow and organisation of community knowledge (Prusak, 1994; Haldin-Herrgard, 2000).

We are aware that theoretical and procedural knowledge-sharing processes are favoured by two types of technological support: one for interpersonal communication and the other for the collection and management of information and knowledge (Auger et al., 2001). Both need to give a conceptual schematic representation of the knowledge domain of reference (or portions of it) for a given community.

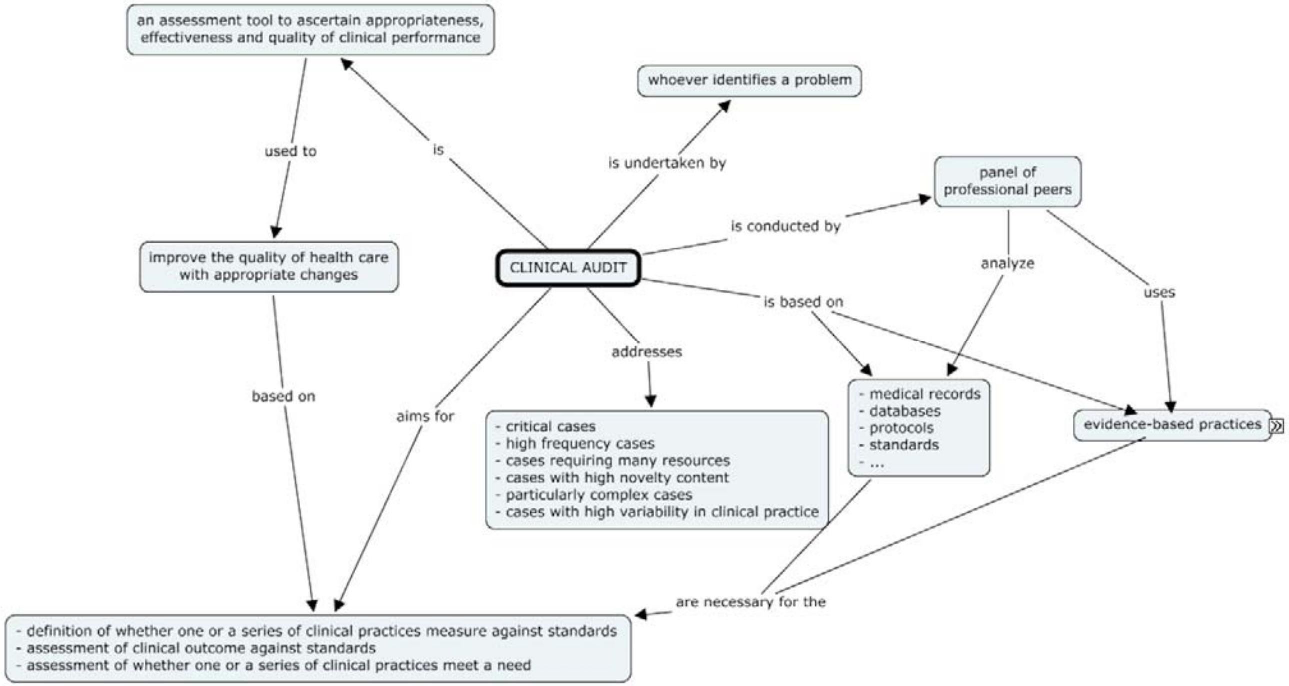



Figure 5. A concept map on the clinical audit developed during the experiment.

Graphic representation can give an inside view of the conceptual interconnections between the elements making up the knowledge that is being discussed and shared. It is therefore an effective way to facilitate the communication of conceptual images as well as the semantic organisation of informative, documentary and factual material contained in the community memory (Lave & Wenger, 1991). The latter aspect is particularly interesting, as many search engines now use conceptual representations of the knowledge domain in which they work for the selective recovery of information.[2]

## RESEARCH ISSUE

The main aim of this research was to experiment the use of graphic approaches to professional knowledge representation. We wished in particular to analyse and discuss their actual usability and effectiveness in fostering collaborative interaction, information- and knowledge-sharing during a process for the investigation of a specific professional issue.

An experiment in the integration of formal and informal learning was conducted during two specific highly-specialist/professional training sessions which involved two distinct professional communities. The first (Audit community) was made up of 33 head physicians and health care managers (15 and 18, respectively) pertaining to Local Health Unit 11 of Leghorn (Tuscany Region), whose task was to present the Clinical Audit, the key elements characterising it and the working methods required to carry it out. The second (Alert community) was formed of 18 technical staff from the Department of Nutrition and Food Hygiene coming from all the health care units in Tuscany. In their case, the task was to define the organisation of a Regional Working Group for managing food alerts.

In the two training sessions just a few face-to-face lessons were organised, most of the activity being concentrated on training participants to be independent, both in consulting authoritative sources (explicit knowledge), and in sharing personal experience (i.e., tacit or at least non-explicit knowledge) on the subject and the practices which had so far been adopted (at least by those who had had the opportunity to do so). Since the participants were spread out over the territory, all this was done mainly with the aid of network and mobile technology.



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[2] For example http://www.webbrain.com/.

The key point was the choice of the educational strategy to be adopted and consequently of the most suitable technology for applying it.

In order to spur the two learning communities to act as online professional communities of practice, a collaborative strategy was adopted, i.e., a strategy aimed at creating the conditions for individual knowledge growth as a result of group interaction.

The strategy was thus implemented by proposing that the two learning communities collaboratively develop a sort of online handbook, one on clinical auditing and the other on food alert management, as the final product of their work. The handbook had to be in a form which (a) could be easily added to and updated and (b) offered a structured presentation of information acquired through consultation of the specialist documentation and through the sharing of experiences and practices inside each community.

For the planning and development of the online handbook, integrated use was made of conceptual maps and wikis, and specifically:

- maps were used to support the horizontal knowledge flows (Trentin, 2011) within each community, thus fostering the process of convergence towards a shared network structure of the artefact;
- wikis were used for collaborative online implementation of the artefact (i.e., the handbook on the assigned theme). Wikis were proposed because we wished to create an artefact which could be easily added to and updated beyond the first version developed during the experimentation.

The next part of this paper will examine the part of the collaboration supported by formal graphic languages, which fostered dialogue and the sharing of the community members' various conceptual images regarding the topic to be studied[3].

## Organisational Aspects

Concept maps were proposed to both communities as methods for graphic knowledge representation. The development of each graphic representation was divided into three stages (Trentin, 2007):

[3]. For the part concerning wiki development, see Trentin, G. 2012.

- a face-to-face meeting for preliminary familiarisation with the graphic approach and related editing software;
- two weeks of collaborative online activities in sub-groups;
- a final meeting to evaluate and compare the graphic representations produced, and to discuss the collaborative online process implemented to produce them.

The participants were divided into sub-groups of 5-6 units and were asked to structure their work into two one-week periods:

- individual drafting of the graphic representation;
- sharing of graphic representation and convergence towards one single sub-group version of it.

To co-construct the graphic representations the following applications were used:

- CMapTool[4] for the development of concept maps;
- Moodle as the environment for running interpersonal group communication and for sharing documents and in-progress graphic representations.

## METHOD

At the end of the collaborative activity the participants were given a questionnaire divided into 4 sections (Trentin, 2007):

- *Learnability,* to pinpoint the times and possible learning difficulties of the approaches to formal representation of knowledge used in the experimentation.
- *Study and/or problem-solving*, to research the perception of the general usefulness of concept maps for the study activities, analysis and search for solutions.
- *Usefulness on an individual level in one's own professional practice*, to investigate the perceived usefulness of concept maps in relation to individual use in one's own professional practice.

[4] http://cmap.ihmc.us/.

- *Usefulness in facilitating collaborative group work,* to discover the perceived usefulness of concept maps in fostering group work when dealing with aspects related to one's own professional practice.

In the questionnaire, two questions are associated with each survey indicator: one with a closed-ended answer based on attributing a score (on the Likert 1-5 scale); the other with an open-ended answer asking the compiler to explain the attribution of the above-mentioned score or to give further information about that indicator.

## THE DATA COLLECTED AND THEIR DISCUSSION

The survey data revealed positive evaluations regarding the professional use of proposed graphic formalisation methods. However, there were various differences in what was expressed by the two communities. This is likely to be related to the different roles covered by the respective individuals: on the one hand, positive but lower scores were given by the Audit community, made up mainly of people with a managerial role; on the other hand, higher scores were assigned by the Alert community, made up of staff with a more technical role.

A more analytical examination of the participants' answers is provided in the next section.

### Learnability

As shown by Table 1, both groups judged it to be fairly simple to enter into the logic of concept maps and acquire their syntax.

**Table 1. Average data relating to answers on learnability of concept maps**

| Learnability | Audit (M) | Audit (P) | Alert |
|---|---|---|---|
| How easy has it been for you to master the logic and syntax of the concept maps? | 3,1 | 3,2 | 3,7 |
| var | 0,92 | 0,89 | 0,50 |

(M = Managers Audit Community/P = Physicians Audit Community).

The free answers given by the participants indicate that the use of concept maps efficaciously mirrors their way of coping with professional problems, i.e., considering the elements characterising them as a whole and simultaneously.

The mean value expressed by the Alert group is seen to be considerably higher and with lower variance. Participants' comments suggest this is due to the technicians' prior familiarity with using graphic representations such as flow charts.

## General Usefulness for Study Activities, Analysis and Problem-Solving

Graphic representations are considered particularly useful for analysis and problem-solving activities and less useful for study activities (Figure 6).

In this regard, 8 members of the Audit community justified the low score by claiming that a concept map can be drawn up on a given topic only if one already has sufficient knowledge about it. They therefore think that the use of concept maps can be more useful as a self-check tool of learning than as an aid to studying (in the sense of formal learning). On the other hand, the rather high score attributed by the Alert community is attributable to their idea of using concept maps as a tool to support collaborative study processes.

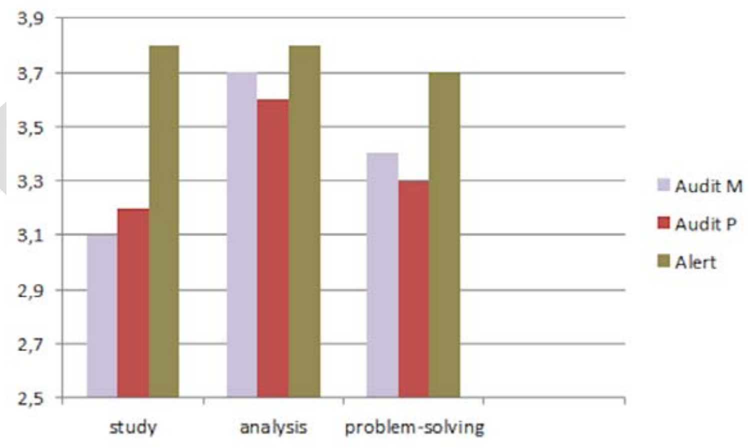


Figure 6. Quantitative comparison between the average scores assigned by the participants concerning the usefulness of graphic representations in their profession.

## Usefulness of Graphic Representations on a Personal and Group Level

After the general considerations described in the previous sections, participants were asked to evaluate the perceived usefulness of the concept maps for both personal and group use in their professional practice. Here are their evaluations.

**Table 2. Average data relating to the personal usefulness of concept maps**

| Personal usefulness of graphic representations | Audit (M) | Audit (P) | Alert |
|---|---|---|---|
| How useful do you think concept maps can/could be in your personal professional practice? | 3,3 | 3,2 | 3,8 |
| var | 1,21 | 0,89 | 0,6 |

(M = Managers Audit Community / P = Physicians Audit Community).

As can be seen, both communities gave between average and high average scores regarding the personal usefulness of concept maps. The only important observation is the significant variance in the assessments of the Audit community managers. This is linked to the similar variance in managers' professional backgrounds (economic, scientific, technological etc.).

The attitude changed when the same tools were instead considered for collaborative group activities (Table 3).

**Table 3. Average data relating to the usefulness of concept maps in group work**

| Usefulness of graphic representations in group work | Audit (M) | Audit (P) | Alert |
|---|---|---|---|
| How useful do you think concept maps can/ could be in group work? | 3,7 | 3,6 | 4,1 |
| var | 0,95 | 0,83 | 0,50 |

(M = Managers Audit Community / P = Physicians Audit Community).

A comparison between Table 2 and Table 3 shows that participants underline the greater usefulness of concept maps in group than in individual work. Here, both communities showed a certain convergence of opinion, although there are the usual deviations in average values and variance values.

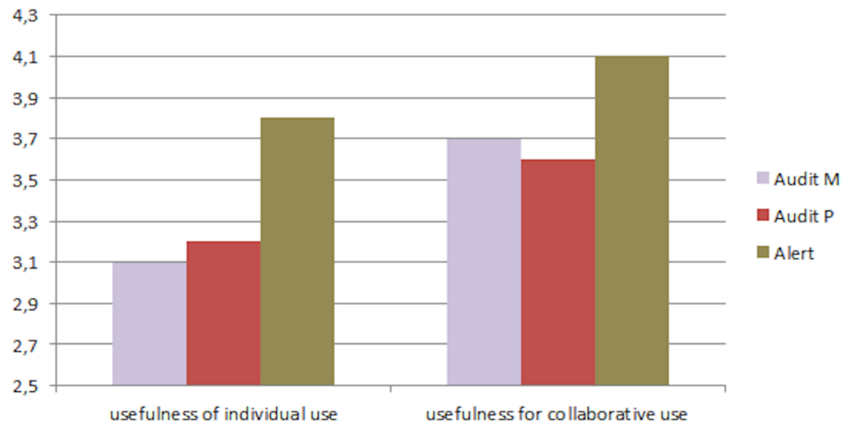


Figure 7. Comparison between the average scores assigned by the two groups regarding the usefulness of concept maps for individual and collaborative use, respectively.



## CONCLUSION

The construction of a graphic representation of knowledge develops communicative skills as well as favouring high-level cognitive processes which in turn foster deeper learning of the study topics (Villalon & Clavo, 2011).

Cognitive visualisations can also be used as part of learning activities as a form of scaffolding, or to trigger reflection by rendering conceptual understanding visible at different stages of the learning process. One cognitive visualisation technique is concept mapping.

In the experiment described in this article, concept maps were used as a tool for favouring: (a) study of and personal reflection on the theme assigned to the study group; (b) communicative interaction within the group itself during the development of the assigned task; and (c) the generation of horizontal knowledge flows among community members.

Although the activity was proposed as part of a formal learning course, an ad hoc situation was created for it, with reproduction of a knowledge co-construction process centering on the informal learning dynamics typical of professional communities of practice.

The most substantial results can be summarised as follows. Participants pointed out that: (a) in learning processes, graphic representation of a topic can only be achieved if one possesses sufficient knowledge of that topic; (b) graphic representations can be more useful as a tool for self-assessing one's learning than as a study aid proper (i.e., in formal learning); (c) it is also useful to employ graphic knowledge representation as a support tool for informal collaborative learning.

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