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Concept Maps:
Theory, Methodology, Technology

Proceedings of the Fifth International Conference on Concept Mapping

Alberto J. Cañas
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FREEDOM VS. RESTRICTION OF CONTENT AND STRUCTURE DURING CONCEPT MAPPING - POSSIBILITIES AND LIMITATIONS FOR CONSTRUCTION AND ASSESSMENT

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Abstract. Concept maps consist of both content and structure. When working with concept maps, educators give instructions for the students to follow while working on concept mapping. These instructions are usually provided in terms of *conditions* on the structure and the content of the maps. While educators have expectations in terms of the result of the concept mapping activity, often they are not aware of how the *conditions* on content and structure that are given to the students often has strong effects on the type and quality of concept maps the students construct. In this paper we analyze how different *conditions* affect the concept maps constructed and discuss how educators must be aware of these possibilities and limitations when working with students and in particular during the assessment of their concept maps.

1 Introduction

Concept mapping has been shown to be an effective tool in facilitating learning (Novak & Gowin, 1984) particularly when integrated with software such as CmapTools (Cañas et al., 2004) to create a concept map-centered learning environment (Cañas & Novak, 2005; Novak & Cañas, 2004). The applications of concept mapping in education are diverse, and encompass all domains of knowledge and students of all ages (Novak & Cañas, 2010). Concept maps are used extensively as an assessment tool, and the literature is abundant with studies on the use of concept maps for assessment and on the assessment of concept maps themselves (e.g., Besterfield-Sacre et al., 2004; Daley, 1996; Fischler et al., 2002; Mcgaghie et al., 2000; Reiska, 2005; Rice et al., 1998; Schmidt, 2006; Strautmane, 2012; Turns et al., 2000; Walker & King, 2003; West et al., 2000). There are also studies that compare the use of other graphic representations, such as tree diagrams (Yin et al., 2008) and other tools for representing the structure of knowledge (Jonassen et al., 1993). However, we shall deal only with so-called Novakian concept maps.

The widespread use of concept maps is based on the notion that a concept map is a reflection of the builder's cognitive structure and thus portrays his or her understanding of the domain depicted in the map. For example, a concept map built by a student will show misconceptions as wells as concepts that are not clearly understood, and at the same time it makes evident what the student does understand.

We consider that using concept maps only for assessment is a narrow application of the tool, given the increased learning that can be attained, for example, through the negotiation of meanings that takes place during the collaborative construction of concept maps by groups of students or in the increased understanding developed through an iterative process of researching a topic and including the newly learned concepts in a companion concept map that is itself part of a concept map portfolio (Cañas & Novak, 2005). However, independent of the way we use the concept maps with our students, at some point we most likely have to analyze the quality of students' concept map(s). What the concept map "tells us" is always part of the educational activity. Nonetheless, our experience and the literature (references will be presented later) suggest that the conditions of structure and content under which a concept map is built affect the quality and type of map that students construct. If as educators we are relying on "what the concept map tells us" as part of the educational activity --whether the assessment is direct or indirect-- we need to be keenly aware of the impact that different specifications for the construction of the maps have on the resulting maps. We believe that most educators are not aware and inadvertently use different conditions when working with concept maps with their students. In this paper we provide an overview of how some variations in specifications for the content and structure can lead to very different concept maps.

2 Background: Seeking Complementarity between Assessment and Learning

One of the early efforts to show relationships between learning and assessment was Bloom's *Taxonomy of Educational Objectives: the Classification of Educational Goals* (Bloom, 1956). The taxonomy identified 6 kinds of test items that required progressively higher cognitive demands from the learner. Bloom and his colleagues also identified the affective domain dealing with feelings and psychomotor domain dealing with actions, but the latter two domains never attracted the attention garnered by the cognitive domain. Level one (1) of Blooms taxonomy were items that dealt with the recall of specific information, and because this is the easiest to test for using true-false or multiple choice questions, study after study has shown that these are the most common type of item used, resulting in learners focusing primarily on memorization of information. Other levels of Bloom's taxonomy were (2) comprehension, (3) application, (4) analysis, (5) synthesis, and (6) evaluation. The challenge for educators has been to design instruction that encouraged or enhanced student's "higher order thinking". The problem over the years has been that so much of school instruction emphasizes rote learning of information with the result that students perform poorly on test items that require much more than rote recall of information. Since test items with near chance passing rates have little discriminating power, test makers usually discard these. Novak (2010) refers to this as the *psychometric trap*, which leads to the usual "objective tests" that assess little more than information recall. Thus such testing results in rote learning patterns in students with all the attendant limiting consequences.

Bloom's 1956 *Taxonomy* was rooted in the behavioral psychology that dominated Western education for decades. There was little in this psychology that could lead to improved school instructional practices. As the psychology of learning moved toward cognitive learning ideas in the 1980's, there also emerged new instructional ideas, and with these an increasing recognition that assessment needed to be improved to encourage *higher order thinking* and instructional practices that required more than recall of information. Among the instructional practices encouraged were more inquiry practices, especially in science and mathematics, student project work, often with student teams of 2-4 students, and other more creative instructional strategies. These emerging practices were recognized in a revision of Bloom's taxonomy published in 2001 (Anderson & Krathwohl, 2001).

From the perspective of our concept mapping community, the most significant advance in instructional practices and assessment of learning arose with the invention of concept mapping in the early 1970's. When students use concept maps to help organize the knowledge they are learning, there is enhanced opportunity for higher levels of meaningful learning (also referred to as *deep* learning) with all the cognitive and affective benefits that derive from such learning. Moreover, when concept maps are used to facilitate learning, they can also be used as an assessment tool capable of assessing not only recall of information but also those higher order skills that are described in Bloom taxonomies. Even more important, the use of concept maps for learning and assessment can help students "learn how to learn" for real understanding (Novak, 2010; Novak & Gowin, 1984).

3 Graphical Structure vs. Content

A concept map consists of a graphical representation of a set of concepts, usually enclosed in circles or boxes of some type, and relationships between concepts indicated by a connecting line linking two concepts. Words on the line, referred to as linking words or linking phrases, specify the relationship between the two concepts. The two concepts with the linking phrases that join them form propositions. Propositions are statements about some object or event in the universe, either naturally occurring or constructed. Propositions contain two or more concepts connected using linking words or phrases to form a meaningful statement. Sometimes these are called semantic units, or units of meaning (Novak & Cañas, 2008). Concept maps therefore consist of "graphical structure" and "content". We examine each of these separately.

3.1 Concept Map's Graphical Structure

The graphical nature of concept maps permits a topological or structural analysis of the map. The hierarchical structure of knowledge in a particular domain usually leads to a hierarchical structure in concept maps, with more general concepts at the top and more specific concepts at the bottom. A well-organized cognitive structure is necessary for meaningful learning, and usually leads to graphically well-organized concept maps. We do need to clarify that the hierarchical structure may lead to other representations, such as a cyclic concept map (Safayeni et al., 2005). That is, a conceptual hierarchy of concepts does not necessarily lead to a hierarchical structure of the map. Another important characteristic of concept maps is the inclusion of *cross-links*. These are relationships or links between concepts in different segments or domains of the concept map. Cross-links help us see how a concept in one domain of knowledge represented on the map is related to a concept in another domain shown on the map. In the creation of new knowledge, cross-links often represent creative leaps on the part of the knowledge producer. There are two features of concept maps that are important in the facilitation of creative thinking: the hierarchical structure that is represented in a good map and the ability to search for and characterize new cross-links.

The graphical structure of concept maps provides the possibility of an objective *evaluation* of the concept map, and given the importance of a "well organized map" and the presence of cross-links, we fall into the trap of believing that the structural components provide a valid complete assessment of the concept map. By counting structural characteristics such as the number of hierarchical levels, the number of crosslinks, the number of propositions, etc., many rubrics have been developed that *assess* a concept map based on its structure, often as part of a more comprehensive rubric. Strautmane (2012) provides a comprehensive list of structural measures reported in the literature. In some particular cases, a structural-only appraisal can provide useful information, such as the topological taxonomy (Cañas et al., 2006) designed to evaluate the increase in complexity of a large number of concept maps in a nationwide project (Tarté, 2006) and that has also been used in automated software processes (Cañas et al., 2010; Navas & Chacón-Rivas, 2012; Valerio et al., 2008). Graphical information is of course pertinent in the assessment of the overall goodness of a concept map, for example the presence (or absence) of crosslinks that is indicative of a deeper understanding of the domain. The overall structure of the concept map provides an idea of the global organization of the map, showing for example clusters of concepts in subdomains, whether the concept map is 'balanced' or whether one subdomain includes a much large number of concepts and links than other subdomains. Concept mappers tend to 'agree' on what a 'well structured concept map' is, to the point that experts tend to agree whether a concept map is "good" by just looking at its structure without considering its content (Carvajal et al., 2006).

3.2 Concept Map's Content

Every concept map should respond to a *focus question* that provides the reference or context for the map. The main question that we ask ourselves when *assessing* a concept map is, "Does it respond the *focus question*?" A good map will explain the response to its *focus question* in a clear fashion. The concept map's content can be analyzed in several ways. The list of concepts can be analyzed for completeness (are any key concepts missing?), quality, and relevance with respect to the *focus question.* That is, the map could include a large number of concepts that are completely irrelevant to the *focus question* or topic of study. Similarly, each proposition can be evaluated for quality, completeness and relevance with respect to the *focus question*. Note the importance of evaluating the relevance of each proposition to the topic of study. There are rubrics in the literature that evaluate whether the proposition is 'true' or 'false', independent of the relevance to the topic of the concept map (Reiska, 2005). More in depth content analysis can examine clusters of concepts and relations between the concept within one cluster and also relations between the concepts from different clusters.

3.3 Graphical Structure and Content

Educators with experience using concept mapping with their students understand that both the graphical structure and the content, as well as the 'interaction' between the two need to be analyzed when determining "what does the concept map tell us?" about the student's understanding of the topic. By interaction we mean how the structure and content together integrate for a better expression of the student's knowledge. However, even when using the best rubrics that include both content and graphical structure, the educator needs to understand that the type and quality of the concept map may be more a reflection of the process and conditions under which the concept map was constructed than of the student's understanding of the domain.

4 Construction of Concept Maps: Freedom and Restriction of Structure vs. Content

When asked to construct a concept map, students are provided with instructions that include conditions (or a complete lack of conditions) for the process. These conditions are part of what Ruiz-Primo & Shavelson (1996) refer to as the task demands and task constraints: what the student has to do to complete the task and limitations that the student has to follow while solving the task. These pre-given conditions or specifications are usually provided in terms of structure and/or content. For both structure and content, the specification can cover a broad range of values, from complete freedom of structure and/or content to restricted structure and/or content. By freedom of content we refer to the liberty that the map builder has to determine the topic, the *focus question*, the concepts, etc. of the concept map. By freedom of structure we consider the liberty the map builder has to decide the graphical structure of the map.

Figure 1 shows a variety of conditions that combine different degrees of freedom for structure and content that can be set for the construction of a concept map. The x-axis corresponds to the freedom of structure, and the y-axis to the freedom of content. The maximum freedom of content and structure corresponds to asking that a concept map be built about any topic the user wants with no restrictions (upper right corner of the graph), while asking the student to memorize a concept map (possibly constructed by the teacher) corresponds to a complete lack of freedom of structure and freedom (lower left corner of the graph). In the graph we've placed examples of conditions that are commonly used in educational settings. We clarify that the placement of the conditions on the graph is completely subjective and is not the result of any type of formal evaluation, and that the graph is useful to show the relative position of the conditions and is not meant to represent any absolute positions. In fact, the "process" under which the map is constructed affects the location of each of these in the graph. Additionally, there are other conditions that could be added to the graph; we did not intend to provide an exhaustive list. The reader should therefore consider the graph as an example of how different conditions that are established in the instructions to construct concept maps lead to variations in the freedom of structure and content. We proceed to analyze examples of how different combinations of freedom of structure and content can result in variations of the type and quality of the resulting concept maps. We are not concerned in this paper with the scoring criteria that could be used for the different *conditions.* Strautmane (2012) provides an overview of different scoring criteria for common concept mapping tasks.

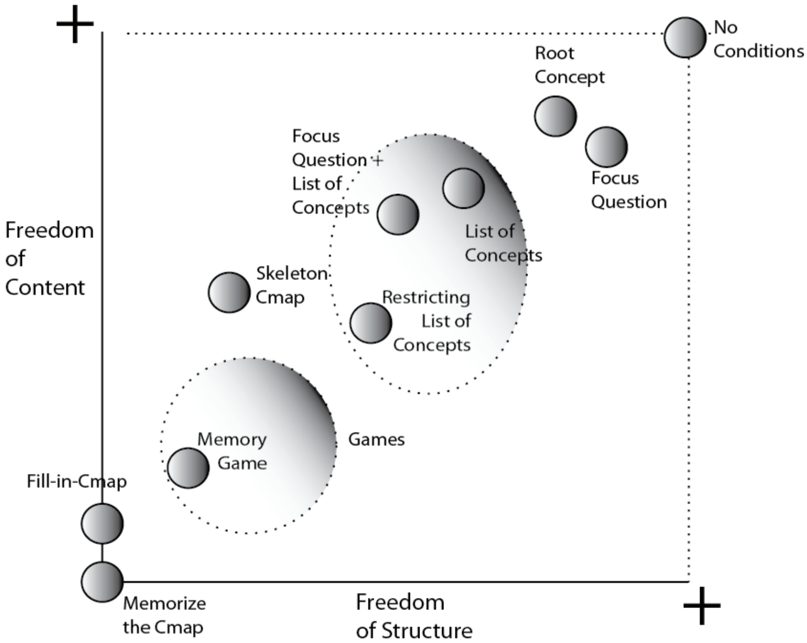

Figure 1. Freedom of Structure and Freedom of Content conditions during concept mapping.

4.1 No Conditions

Under *no conditions* the user is given the liberty to decide the topic of the concept map, and is not given a *focus question* or any other set of directions. This situation is typical of workshops for beginners where users from different disciplines build maps on topics of their personal interest. The lack of a well-formed *focus question* usually leads to a descriptive concept map instead of an explanatory map. As has been experienced by educators and workshop instructors, when faced with a blank canvas users are often intimidated and have difficulty constructing a concept map.

4.2 Focus Question

By providing a *focus question*, we restrict the student in both content and structure. Although one might think that the focus question only restricts the content, i.e. the topic, of the concept map, research has shown that the *focus question* may determine not only the content of the map, but also the structure of the map, and may lead to the construction of more explanatory maps (Derbentseva et al., 2006a) and cyclic concept maps (Safayeni et al., 2005). As educators we don't spend enough time preparing the *focus questions* that we provide our students. Our experience shows us that a good *focus question* is one of the conditions that can have a positive effect on the quality of the resulting concept maps, and the research mentioned above confirms it: we have found that the more open and dynamic the focus question, the more dynamic the propositions in the constructed concept map (Miller & Cañas, 2008a). This is probably one of the least used conditions that can have a substantial impact on the type and quality of the resulting concept map (we have discussed the *focus question* in detail in Cañas and Novak (2006)). For example, the focus question: "What is the structure of the circulatory system" will result in very different concept maps than those addressing the question: "How does the circulatory system provide oxygen to all body cells?" The latter question is more likely to indicate a deeper understanding.

4.3 *Root Concept*

Providing the student the *root concept* of the concept map is not a common condition even though research has shown that providing a quantified *root concept* has a stronger effect on the resulting concept map than providing a corresponding *focus question* (Derbentseva et al., 2006b). The *root concept* further restricts both the content and the structure of the map than the *focus question*, but a quantified *root concept* is more likely to result in more explanatory concept maps than other conditions, and we have previously explained the need to move from the commonly found descriptive concept map towards more explanatory concept maps (Cañas & Novak, 2006). Providing both a *focus question* and the *root concept* further increases the possibility of having a positive effect on the type and quality of the map constructed. For above example, providing the root concept "Quality of Education" will yield a different concept map than when providing the root concept: "Increase in Quality of Education". The latter is more likely to reveal knowledge of both quality of education and of the impact an increase in quality would have.

4.4 *List of Concepts*

Providing the student(s) with a *list of concepts* (also referred to as a *parking lot*) to include in the concept map is one of the most common conditions used by educators. It is well understood that among the key aspects that lead to learning during the construction of the map is the process of building the propositions, that is, determining the most adequate linking phrases when linking the concepts. Therefore providing the *list of concepts* does not 'give away' good propositions to the students. But experience and research has shown that the same students construct better maps when given a *list of concepts* than under *no conditions,* and better maps than when provided with a text that includes the concepts (Soika et al., 2012). More specifically, even if the number of concepts is similar in both cases (with the given *list* and without), the structure of the maps is different. Without the *list of concepts* the students tend to use one central concept and the maps have "star" structure. With the *list of concepts* the maps have mostly more than one central concept, they have more propositions and achieve higher taxonomy score.

A less restrictive version of this condition consists of providing the *list of concepts* as a suggestion, without the requirement that they be included in the concept map. However, as educators often we are interested in making sure the students understand each and all the concepts in the list and so making the inclusion of the concepts in the map optional does not achieve this goal.

4.5 *Restricting List of Concepts*

A more restricted variation of the *list of concepts* condition involves limiting the students to only using the concepts provided in their concept map, leading to a stronger restriction on both content and structure. Providing a *restricting list of concepts* is an effective way of determining the students' prior knowledge at the beginning of a study unit, and consistent with Ausubel's assertion that "The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly" (Ausubel, 1968, p. vi).

Before describing other conditions, we clarify that there are additional elements that need to be considered when planning the conditions for the construction of a concept map by students, in particular the *process* and *purpose* or *goal* for which the concept map is built. For example, as described above the objective of building the concept map is to determine the students' prior knowledge when beginning a unit of study, then providing a *restricting list of concepts*, even though more restrictive than a *list of concepts* or a *focus question* is appropriate. Furthermore, since we encourage that the construction of concept maps by students is a process and not a static, one time, activity (Cañas & Novak, 2005) the conditions can change during the process. For example, after beginning the unit with a *restricting list of concepts* to determine student's prior knowledge the condition can be relaxed as students move to research the topic.

It's important to emphasize the implications of using conditions such as the *focus question, root concept* and *list of concepts* when asking students to construct concept maps. It is clear that each of these has effects on the quality and/or type of the resulting concept map. If the concept map built by a student is a reflection of the student's understanding of a topic, the fact that different conditions lead to different maps is an aspect that educators must consider carefully.

4.6 Expert Skeleton Concept Maps

For difficult topics – whether difficult for the students as determined by the teacher's previous experience, or difficult for the teacher because of his/her background – using an *"expert skeleton" concept map* is an alternative. An *expert skeleton concept map* has been previously prepared by an expert on the topic, and permits both students and teachers to build their knowledge on a solid foundation. An *expert skeleton concept map* contains a small number of concepts selected by an expert that are key to the understanding of the topic. The intention is that the expert will be better at selecting the key concepts and expressing accurately the relationships between them. In general, it is much more difficult to build a good, accurate concept map about a topic with a small number of concepts (e.g., four or five) than with fifteen to twenty concepts. *Expert skeleton concept maps* serve as a guide or scaffold or aid to learning in a way analogous to the use of scaffolding in constructing or refurbishing a building (Novak & Cañas, 2008). The student uses the *expert skeleton concept map* as a starting point for constructing his or her concept map, often in conjunction with a *list of concepts*. Although it restricts both the freedom of content and structure, the *expert skeleton concept map* overcomes the difficulty students have of 'getting started' in front of a blank canvas.

The use of "expert skeleton" concept maps is not as extensive as we would have liked, possibly because of the extra effort required in constructing the expert skeleton maps themselves. However, O'Donnell, Dansereau & Hall (2002) have shown that "knowledge maps" can act as scaffolds to facilitate learning.

4.7 Concept Mapping Games

Using *games* as a means to introduce students to concept mapping (Cañas, 2009), in particular to the building of propositions from concepts, is an effective scheme that should be used more often by educators. Although not used extensively, the clear increase in the quality of the concept maps resulting from the use of *games* is worth analyzing.

We first used *games* as a means to introduce students to concept mapping at the Conéctate al Conocimiento Project in Panamá (Tarté, 2006). Both the Conceptual Deck (Giovani et al., 2008) and the Conceptual Dice (Hughes et al., 2006) report results of the use of a ludic environment where students are presented pairs of concepts and have to come up with a linking phrase that meaningfully links the concepts forming a valid proposition. Both *games* consist of very restrictive conditions in terms of freedom of content and structure, where students are given a set of concepts and their only input is the linking phrases that link the concepts. The concept map is formed from the propositions developed by the students as the game progresses. Figures 2 is the concept map resulting from an experimental setting where a group of students constructed the concept map while 'playing' the Conceptual Deck *game*. Figures 3 and 4 show control groups that were provided with the same concepts in the deck but presented as a *list of concepts.* The topic was the elementary school student's favorite cartoon, "The Fairly OddParents," with which all students were familiar. The reader certainly can ascertain the difference between the concept map in Figure 2 and the concept maps in Figures 3 and 4 is obvious. The significant difference between the maps as assessed using the topological taxonomy (Cañas et al., 2006) and the semantic scoring rubric (Miller & Cañas, 2008b) is reported by Giovani et al (2008).

The large difference in both structure and content between the concept map created through the *game* and the concept maps based on a *list of concepts* shows the danger of not really understanding "what the concept map tells us" regarding the student's understanding of the domain. In this case, the lack of experience in concept mapping by the elementary school children was easily overcome by the conditions limiting the structure and content that were part of the rules of the *game* resulting in a complex concept map, while at the same time were overwhelming for the students in the control groups that were presented with only a *list of concepts*. Given that all students had basically the same level of understanding of the domain, the differences in the resulting concept maps confirm our concern with understanding how the different conditions given to the process have an impact of the resulting concept maps. Ruiz-Primo *et al.* (2001) argue that low-directed tasks such as the cases of *no conditions* and *list of concepts* demand more content knowledge and may appear too difficult for students with less competency. In this case, these students, as competent student as those playing the game, could not deal with the *list of concepts* condition.

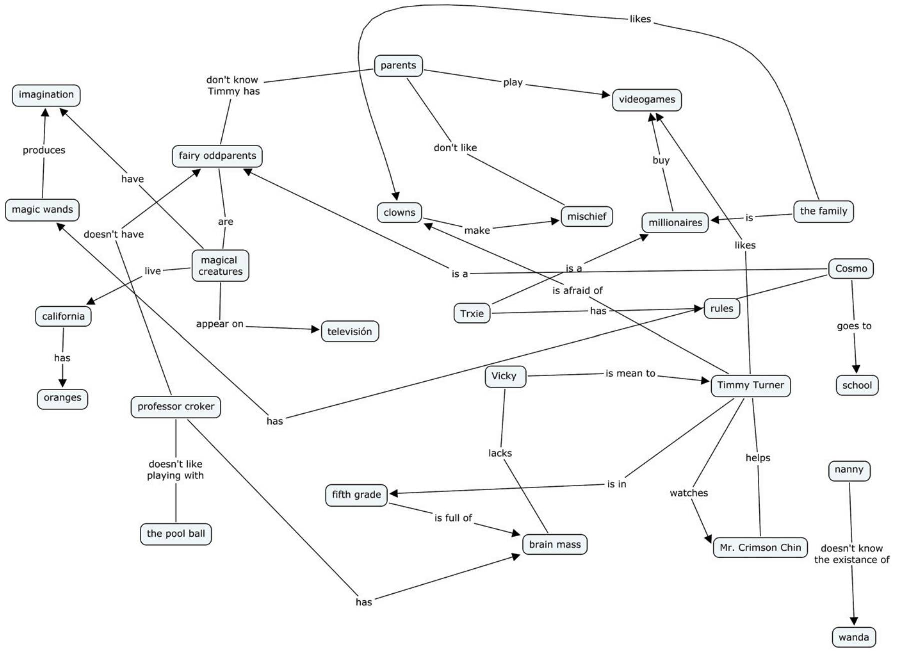

Figure 2. Cmap constructed collectively by the experimental group playing the conceptual card game (Giovani et al., 2008).

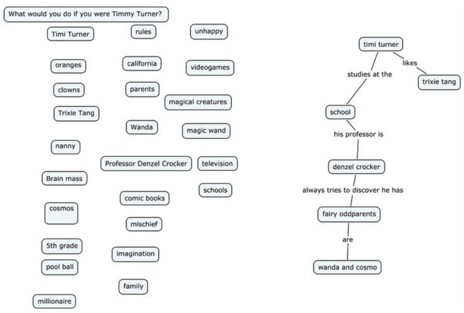

Figure 3. Cmap constructed by control group 1 playing the conceptual card game (Giovani et al., 2008).

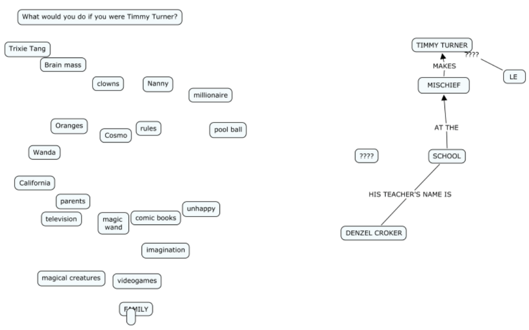

Figure 4. Cmap constructed by control group 2 playing the conceptual card game (Giovani et al., 2008).

4.8 Fill-in-the-Cmap

One approach for using concept maps without requiring student to learn how to build then is to provide a teacher-made concept map with empty cells instead of concept labels or linking phrases. Students are then required to fill in the correct concept label for each empty cell (Surber, 1984). This usually encourages rote learning, since it is usually not obvious where the correct labels should be. One variation of this technique is to provide a *list of concepts* to be used to fill in the empty cells, but this also can lead to essentially rote learning for a "correct" concept map. In general, we do not recommend either of these techniques, although their use appears in the literature (Schau et al., 2001) and have been incorporated into concept mapping software tools (Gouli et al., 2003). Under this *condition* there is no structural freedom as the concept map is already constructed; when students are given *the list of concepts* additionally there is no freedom of content. Ruiz-Primo *et al.* (2001) discuss how high-directed tasks like this *condition*, where students have little freedom to express their knowledge structure, are most likely to misinterpret the student's knowledge structure. Moon *et al.* (2010) have suggested a variation of this condition by offering multiple-choice options when filling the empty cells, providing some more freedom of content.

4.9 Memorize the Concept Map

Another approach that has been used to avoid student's need to learn how to construct good concept maps is to provide teacher-made concept maps and urging students to memorize these. The assumption here is that once students learn the hierarchical web of concepts and propositions, this knowledge will become part of their cognitive structures. Unfortunately, meaningful learning does not work this way. Information in memorized concept maps is not integrated with other relevant knowledge and enhancement of the learner's functional knowledge of this domain does not occur. Bogden (1977) found that expert-made concept maps provided to a sample of students in a college genetics course did not enhance learning, when compared with a "control" sample not receiving the maps. In fact, many from the first sample group reported that they made little use of the concept maps provided. Again we see evidence to support Ausubel's (1968) theory that describes the need for learners to be actively engaged in assimilating new concepts and propositions into their cognitive structures. Concept maps can facilitate this process only when students are engaged in the processes of good concept map construction. We are not surprised when students don't do well in tests after being given by their instructors an already constructed concept map to study (e.g., Baumgartner & Fonseca, 2012). Under this condition there is no structural or content freedom as the concept map is already constructed.

5 Discussion and Implications for Assessment

We have discussed how different *conditions* can affect the quality of the concept maps constructed by students. Educators who are aware of this can take advantage of it, using different conditions for different purposes. During the iterative concept mapping process proposed in the New Model for Education (Novak & Cañas, 2004) there is ample room to apply different *conditions* during the process. The impact of using different conditions must also be taken in account if the concept maps are being assessed. Although there are basic measures of structure and content which can be used under different settings, assessment of concept maps is highly dependent on the way the maps were created and the propose of assessment. The same measures don't have the same meaning under different settings. To use a simple example, a measure like "number of concepts" has different meaning depending on the task of map creation. If the task is to connect as many concepts to each other as possible, then the meaning is different than if the task is to find as many connections between 10 concepts as possible. This means that to correctly interpret the concept mapping data ("what does this concept map tell us?") we need to consider not just the maps' measures but also all the *conditions* of construction, in particular the freedom and restriction of structure and content as described above. As a result, it is extremely difficult to automate concept map assessment.

Educators using concept mapping for assessment should ensure that the assumptions underlying their approach are valid. It is not appropriate to compare maps from different studies if the conditions are not the same. But based on maps that are made under equal conditions, we can reach conclusions about the mapper's knowledge – persons with more knowledge make better maps. Even if it is difficult to fulfill criteria for validity under the different conditions, concept mapping is a useful tool for assessment.

6 Conclusions

The principal purpose for concept mapping in education is to assist learners in building powerful knowledge structures in whatever domain we choose to teach. The universe is made up of events and objects, and the central purpose of education is to help learners develop rich meanings for the concepts that label these events and objects. Concept maps were developed explicitly to aid this process and to serve as a tool to identify the extent to which a learner has succeeded in building powerful meanings. The kinds of *conditions* described in this paper we choose to use to assist our students in learning can radically influence the process of meaningful acquisition concepts and concept map construction. Similarly, the *conditions* we use will influence the quality of the assessments we make using concept maps. The saying "One hand washes the other" operates in education in that the quality of instruction influences that quality of learning and this in turn influence the quality of the assessment of learning that we can make. Simple as this may appear on the surface, in practice this is not always so easy.

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IMPACT OF AN INTERVENTION METHOD MEDIATED BY THE CONSTRUCTION OF CONCEPT MAPS IN A NEWS PRODUCTION NETWORK ON STUDENTS' CONCEPTUALIZATION OF WRITTEN LANGUAGE

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Abstract. This paper presents the evaluation of a proposal for the creation and implementation of an intervention method on students' conceptualization of written language. It rests on the integration of concept maps and texts created by fourth grade Elementary School students in an online news production network. The analysis of the textual development is carried out based on the triangulation of data concerning levels of development of linear writing, as well as topological and semantic taxonomies for concept maps. The results indicate a reciprocal development with regard to the conceptualization of linear writing and the construction of concept maps, favoring consciousness-raising in the process of revising texts, in order to improve semantic and structural aspects of written language.

1 Introduction

Brazil has substantially increased its investment in education and has made progress concerning the purpose of universal access to school. Nowadays, almost all Brazilian children are enrolled in educational institutions. However, grade repetition rates and the proportion of adolescents who leave school before completion of basic education remain high (IDEB, 2009). These results are corroborated by low levels of proficiency achieved in national and international assessment examinations (PISA, 2009; SAEB, 2009, IBGE, 2010). The difficulty of reading comprehension, identified in the tests described, is one of the main problems in Brazilian education. At the same time, students show writing deficiencies which lead to meaningless productions, unable to meet their communication objectives, according to PCNs (National Curriculum Parameters – Brazil, 1997, p. 49).

There seems to be a mismatch between national curriculum objectives and the students' effective reality. Despite the quantitative parameters adopted by most examinations, which do not allow an evaluation of each child's specificities, nor a deep analysis of the context in which the limitations are manifested, there is an emerging need to review practices and guiding principles of students' learning. This study considers the background presented as well as the necessity of a real functioning of written language in schools. It presents the creation and implementation of an intervention method that aims to face students' difficulties concerning conceptualization of written language based on two main proposals: their participation in a news production network and the construction of concept maps about the texts originated from this initiative.

2 Context and objectives

Since 2007, LEC/UFRGS[i] (Laboratory of Cognitive Studies, Institute of Psychology, Federal University of Rio Grande do Sul, Brazil) has participated in the federal Brazilian program PROUCA (One Computer per Student Program). It has the aim of examining the possibilities of distributing laptops to students and teachers of public schools in the country, integrated to connection to the Internet, as a means of improving education. Among the various activities carried out in order to create a field of study and application of a new approach to written language in schools, LEC/UFRGS started, during the first stage of PROUCA program, planning the creation of an integrated media network in which children and adolescents could organize themselves as authors and moderators of information targeted at their communities, taking advantage of mobility, connectivity and resources of the laptops. In 2011, the use of concept maps (CM) and the application of systematic interviews with guidance of Piaget's Clinical Method[ii] (PIAGET, 2005) were incorporated to the proposal, constituting the thesis project of one of the authors of this paper.

Concept maps integrated to the initiative work as a powerful resource to explicit logical connections of thought, enabling to assess the conceptualization processes about different subjects, since the research questions for the news production network are freely chosen by the students, such as in Learning Projects (FAGUNDES et al., 1999). Moreover, because of the possibility of a non-hierarchical format, the concept maps generate

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dynamic representations of knowledge, next to the operation of thought, always susceptible to changes and new connections.

This paper discusses possibilities of the intervention method described to contribute to develop students' conceptualization of written language. The main hypothesis of the work was that the method and the performance of clinical interventions on the constructions originated from it would encourage a conceptualization process regarding semantic and structural aspects of written language, favoring improvement of students' writing.

3 Method and theoretical framework

In order to examine possible impacts from the construction of concept maps and interventions related to them on students' conceptualization of written language, two stages were applied, shown in figure 1:

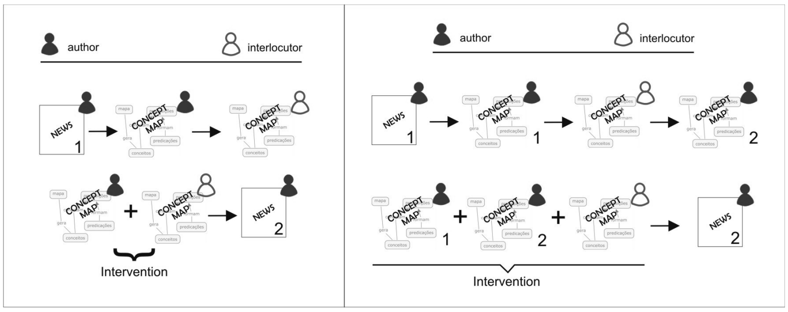

Figure 1: Stages of the intervention method

In the first stage of the implementation of the method, each student, after writing the first version of the news, created a concept map on his/her own text. After creating the map, without intervention, the student could review the text if considered it necessary. Another student was also asked to develop a concept map on his/her colleague's first version of the text. Finally, the intervention was performed in order to lead the student in writing a new version of the news to be published. This first stage of the method was applied with 16 fourth grade Elementary School students (9 to 11 years old), entitled, for the purposes of this paper, group 1. After carrying out the procedures described for group 1, the possibility of improvement of the method based on the inclusion of a second version of the concept map by the author himself/herself was observed. This second stage of implementation of the method was applied with six fourth grade Elementary School students (9 to 11 years old), entitled, in this paper, group 2.

Students' conceptualization of written language was assessed by considering both structural and semantic levels of the productions, focusing the construction of enunciations (BAKHTIN, 1997, 2003; KOCH, 2007; MARCUSCHI, 2008). Concerning the structural aspect, there was the aim of observing the development of cohesion and connections responsible for cotextuality, namely, the consistency of the relations that are internal to the text. Regarding the semantic analysis, the investigation had the aim of assessing the development oriented towards the enunciations meanings, focusing on the effort of children when operating with connections between meanings and communication context.

Based on the first findings of impacts of the production of concept maps on linear texts (as a previous step of the investigation – figure 4, section 4), it was possible to establish levels of written language development as well as a semantic and a topological taxonomy for concept maps in order to obtain a matrix of analysis that would allow both the investigation of data concerning each form of representation (linear texts and concept maps) and the triangulation of data originated from the comparison on them. The establishment of levels of changes related to structural and semantic aspects had its emphasis on textual continuity and on the implications on communicability and reading comprehension. They are shown in figure 2:

LEVELS OF STRUCTURAL AND/OR SEMANTIC MODIFICATION OF LINEAR TEXTS

- **Level 1** – Despite the existence of inconsistencies related to coherence or cohesion, the text is not revised or improved.
- **Level 2** – There are structural and/or semantic changes, in spite of remaining some gaps concerning coherence or cohesion (the revision would be necessary for a better communicability of the text).
- **Level 3** – There are structural and/or semantic changes with improvement of connections and meaning, in spite of remaining some gaps concerning coherence or cohesion (their maintenance doesn't have reflections on interpretability).
- **Level 4** – The revision of the text, concerning structural and/or semantic aspects, reveals new ways of referencing and textual organization, new argumentation operations (increasing cohesion), as well as improvement of connections among discursive topics (increasing coherence).
- **Level 5** – Adjustments of secondary importance concerning coherence and cohesion take place, what is justified by the high level of the alignment between semantic content and expressive element. Texts which dispense changes due to their high level of interpretability and communicability are also included in this category.

Figure 2: Levels of structural and/or semantic modification of linear texts

For the analysis focused on the structural construction of concept maps, the topological taxonomy developed by Cañas et al. (2006) and Miller (2008), widely used and validated by *Conéctate al Conocimiento Project* (Miller, 2008), was applied. The semantic taxonomy for concept maps was created with the support of Genetic Epistemology (Piaget, 1976). Beyond the understanding of the structure of concepts and propositions, the performance of interactions of type 1 (concerning exclusively the direct observables, accessible from the first experience of the subjects) and of interactions of type 2 (which also imply inferential coordinations) was considered. The levels of the topological and semantic taxonomies for concept maps are shown in figure 3:

TOPOLOGICAL TAXONOMY FOR CONCEPT MAPS (CAÑAS et al., 2006; MILLER, 2008)

- **Level 0**: (a) texts predominate over concepts; (b) no linking phrases; (c) linear structure (0-1 ramification points).
- **Level 1**: (a) concepts predominate over texts; (b) half or more linking phrases are missing; (c) linear structure (0-1 ramification points).
- **Level 2**: (a) concepts predominate over texts; (b) fewer than half of linking phrases are missing; (c) low ramification (2 ramification points).
- **Level 3**: (a) no texts; (b) not missing linking phrases; (c) intermediate ramification (3-4 ramification points); (d) fewer than 3 hierarchy levels.
- **Level 4**: (a) no texts; (b) not missing linking phrases; (c) high ramification (5-6 ramification points); (d) 3 or more hierarchy levels.
- **Level 5**: (a) no texts; (b) not missing linking phrases; (c) high ramification (5-6 ramification points); (d) 3 or more hierarchy levels; (e) 1-2 cross links.
- **Level 6**: (a) no texts; (b) not missing linking phrases; (c) very high ramification (7 or more ramification points); (d) 3 or more hierarchy levels; (e) more than 2 cross links.

SEMANTIC TAXONOMY FOR CONCEPT MAPS

- **Level 1**: the concept map denotes lack of understanding of the structure of concepts and propositions, and its elements don't show unit of meaning.
- **Level 2**: the concept map denotes lack of understanding of the structure of concepts and propositions, but its elements show unit of meaning.
- **Level 3**: some propositions are produced, in spite of the reduced number when compared to connections that do not generate sentences. The unit of meaning is kept.
- **Level 4**: the concept map indicates recognition of the structure of concepts and propositions in most connections, but direct observables prevail in the connections made.
- **Level 5**: the concept map indicates recognition of the structure of concepts and propositions in most connections, as well as the production of inferential coordinations.

Figure 3: Topological and semantic taxonomies for concept maps

In the next section, the results obtained with the implementation of the method are presented.

4 Results

The first step of the work consisted in investigating the presence or absence of impacts of the production of concept maps on the linear texts, as well as, if and when existing, their results on the text composition in order to implicate effective review or, on the other hand, slight changes with few reflections on its initial structure. The impacts under consideration covered the transposition, the analysis or the referencing of elements contained by the concept maps that didn't appear on the first text and were shown on the second version, as well as the adjustments derived from the consciousness-raising situations triggered or facilitated by the production of concept maps and the performance of interventions. The results are presented in figure 4.

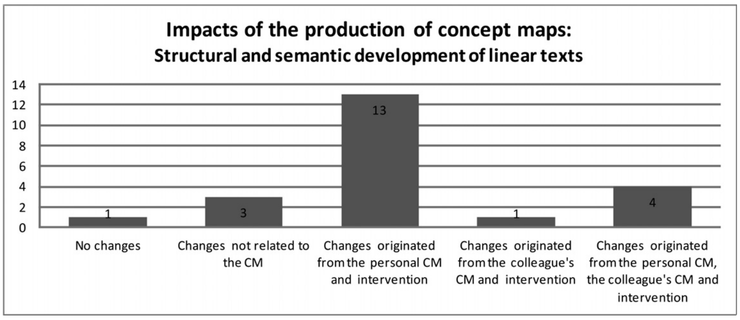

Figure 4: Impacts of the production of concept maps on linear texts

Of the total of 22 productions of students from groups 1 and 2, 18 have shown impacts from the construction of concept maps in the context of the news production network followed by the intervention. The largest portion of these productions – 13 of them – has presented impacts from the construction of concept maps on personal texts. Four of them have presented impacts derived both from the personal and the colleague's production. Only one production has shown exclusively impacts from the construction of the concept map by a colleague. The graph in figure 5 displays the frequency of levels of changes in linear texts, including both semantic and structural aspects.

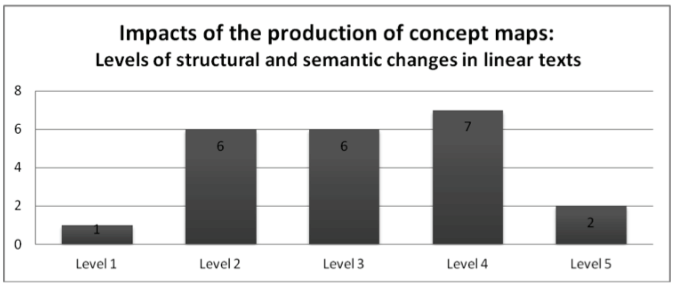

Figure 5: Levels of structural and semantic changes in linear texts

Only one student has shown, after the procedures and the interview, a production of level 1, in which we can observe the absence of review of inconsistencies related to coherence and cohesion, which would be necessary to obtain a higher text interpretability level. Six students have shown changes of level 2 and 3 in their productions, denoting concern about increasing quality of structure and semantic aspects through the procedure of review. Most of productions have shown changes of level 4: seven of the 22 students in groups 1 and 2. In these ones, there was a review procedure with improvement of interpretability based on adjustments in cotextual and contextual elements, such as the operation with new ways of referencing, textual organization and a better alignment of discursive topics. Also, two students have shown productions of level 5, although in these ones the maintenance of textual quality was observed (they have revealed a high level of coherence and cohesion since the first version of the text). In figures 6 and 7, an example of a production and the changes made by a student in group 2 is presented:

STUDENT A

TEXT - VERSION 1

Why eating carrots is important for our body?

The carrot has anticancer which helps protect the body from cancer, the carrot has beta carotene which helps the skin does not grow old, the carrot also fights infections and the carrot lowers cholesterol. The carrot has phosphorus potassium sodium calcium and vitamins A B2 B3 C Power fibers and Minerals.

Por que comer cenoura é importante para o nosso corpo?
A cenoura possui anticancerígeno que ajuda a proteger o corpo do câncer, a cenoura tem betacaroteno que ajuda a pele não envelhecer, a cenoura também combate as infecções e a cenoura diminui o colesterol A cenoura tem fósforo potássio cálcio sódio e vitaminas A B2 B3 C Fonte de fibras e Minerais.

TEXT - VERSION 2

Why eating carrots is important for our body?

The carrot has beta-carotene which helps vision and helps the skin and is also a powerful anti-cancer that prevents cancer. The carrot is a vegetable that helps to increase the immunity of our body, and the carrot lowers cholesterol in our blood, the carrot is a source of fiber, minerals, phosphorus, potassium, calcium, sodium and vitamins A, B2, B3 and C. The carrot has Beta carotene which helps the skin tanning and not growing older, and helps the eyes and the retina (which is part of the eye).

Por que comer cenoura é importante para o nosso corpo?
A cenoura possui betacaroteno que ajuda a visão e ajuda a pele e também é um poderoso anticancerígeno que previne o câncer. A cenoura é um vegetal que contribui para aumentar a imunidade do nosso organismo, e a cenoura diminui o colesterol do nosso sangue, a cenoura tem fonte de fibras, minerais, fósforo, potássiio, cálcio, sódio e vitaminas A, B2, B3 e C,A Cenoura tem Betacaroteno Que ajuda a pele a não envelhecer e ajuda no bronzeamento da pele,E ajuda os olhos e a retina (que faz parte dos olhos).

Figure 6: Example of a production and the changes made on linear texts – Student A

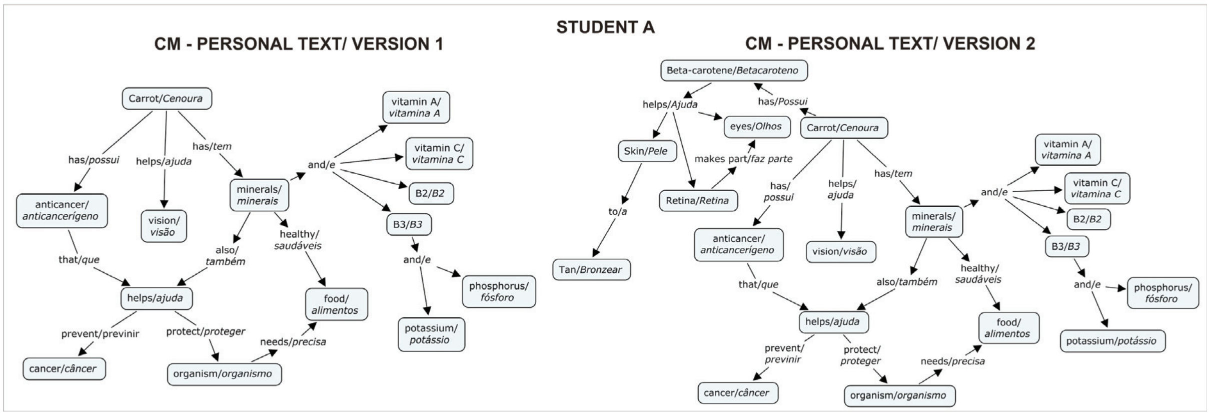

Figure 7: Example of a production and the changes made on concept maps – Student A

Student A has shown, both in the first and in the second version of the concept map, topological taxonomy of level 5. The second version was very close to level 6, not achieved only because of the number of ramifications (less than seven). Regarding the semantic level, there was an increase from 4 to 5 from the first to the second version. The concept map, since the first version, denoted unit of meaning and understanding of the structure of propositions. The student provided, in her productions, indicators of the extent of structural and semantic complexity, which impacted the textual production through the performance of inferential coordinations and the adding of new and important information, mainly in relation to Beta-carotene substance and its consequences for immunity and protection of the body, reflecting the achievement of level 4.

The graphs of figures 8 and 9 show the frequency of levels concerning topological and semantic taxonomies of concept maps on personal productions.

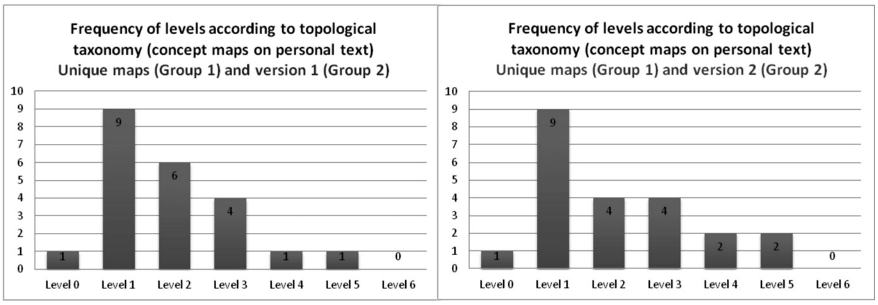

Figure 8: Frequency of levels according to topological taxonomy (concept maps on personal text)

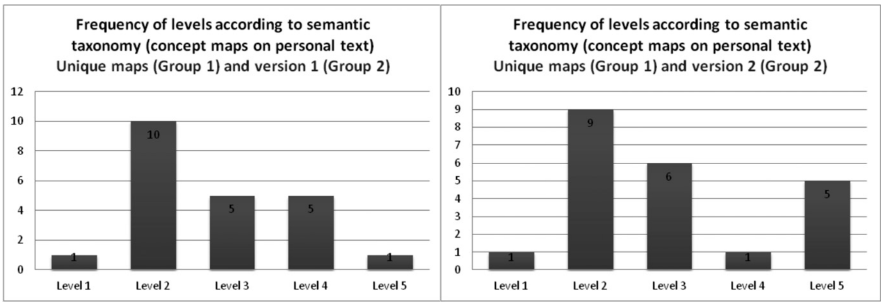

Figure 9: Frequency of levels according to semantic taxonomy (concept maps on personal text)

If the levels are considered individually, it is possible to observe the predominance of students – nine in all – in level 1 of topological taxonomy, which requires understanding, even if it is partial, of the structure of a concept map, since words or short expressions are used in the nodes instead of long texts, and linking phrases are also present. Only one of the students has shown misunderstanding of the basic topological structure of the concept map. The first concept maps (considering the first version of productions of group 2) have shown that more than half of the students – twelve of 22 – revealed in their productions level 2 or above, including linking phrases in more than half of the arcs and ramification points from concepts or linking phrases. Considering the second version of group 2, there was even a more homogeneous distribution of students among levels 2 and 5 – four students in levels 2 and 3 and two students in levels 4 and 5, respectively –, indicating a higher frequency of ramifications and hierarchy levels, the possibility of the occurrence of cross-links, and, from level 3 on, the absence of blanks related to linking phrases. None of the students has shown a topological taxonomy of level 6.

Considering the semantic aspect of the productions, similar results were observed. A high concentration of level 2 productions was performed, and half of the productions, considering both version 1 and version 2 of productions of group 2, have shown semantic level 3 or higher, denoting the skill of building propositions in at least part of the connections established and keeping the unit of meaning. From version 1 to version 2 of the concept maps of group 2, there was also progress in relation to the construction of inferential coordinations, showed in the transition of four productions from level 4 to level 5. In these ones, it was possible to observe, besides the recognition of the structure of concepts and propositions in most connections, the replacement of part of the direct observables by the performance of deductions on implicit issues. Once more, only one of the students has shown, in addition to misunderstanding the structure of concepts and propositions, lack of unit of meaning in his production.

Important consciousness-raising situations have been observed during the implementation of the method, despite some of them have not had immediate reflections on the structure of the concept map. The example shown in figures 10 and 11, with regard to the production of Student B (group 2), illustrates it:

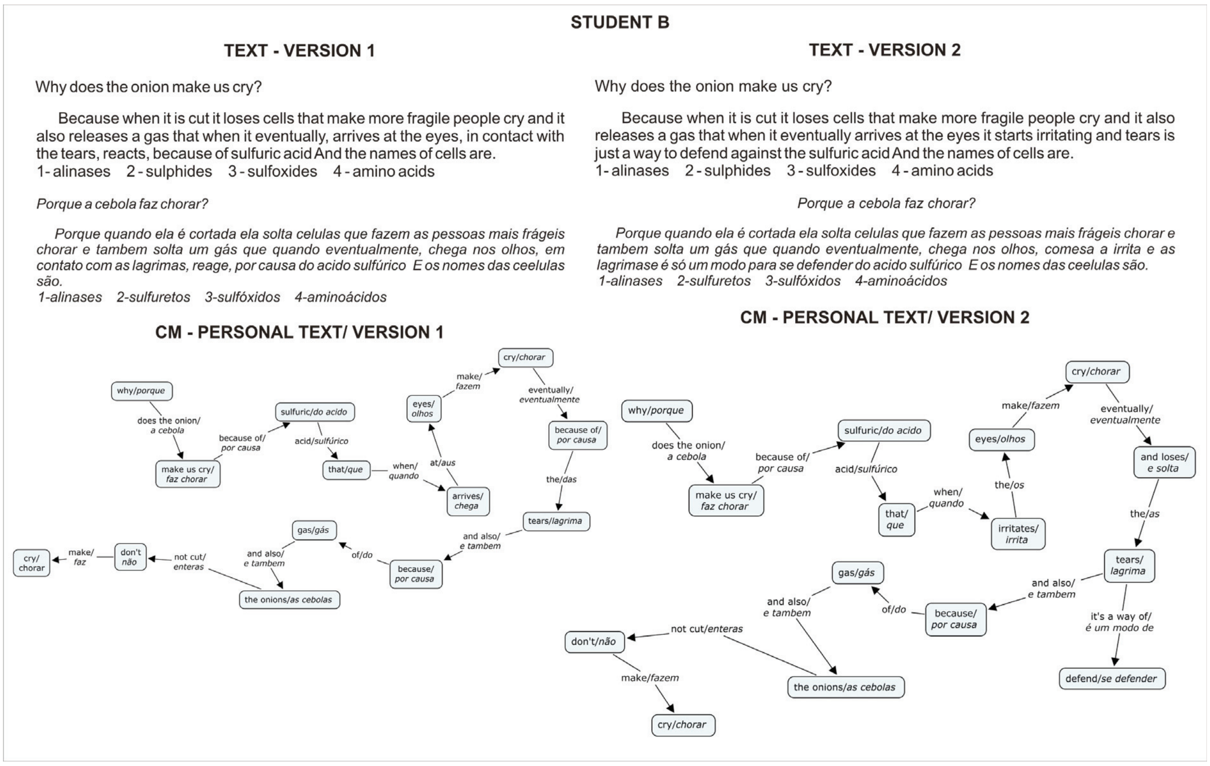

Figure 10: Example of a production and the changes made – Student B

STUDENT B: INTERVENTION - PERSONAL TEXT

R: What question has raised the issue?
S: It is here: onion makes us cry, why do onions make us cry, in case.
R: Ok. Did you find out why it happens?
S: Yes! It's because of the gas it releases.
R: Is it not because of the tears?
S: No.
R: And is there anything that can make us understand that it (gas) "causes" and is not "because of"?
S: That irritates the eyes!
R: Nice information.
S: It is because when the gas reaches the eyes, we cry to get rid of sulfuric acid. Tears are a way to protect ourselves.

Figure 11: Intervention on personal text – Student B

Student B had the aim, in his research, of answering the question "Why do onions make us cry?". His production has denoted comprehension of the theme, although there was an inconsistency related to the information available: in the first version of the text, as well as in the first concept map, the student declared that the sulfuric acid, when in contact with tears, would cause cry. During the intervention, though, he demonstrated understanding that tears would be the reaction to the sulfuric acid, produced by the onion. After the intervention, the student became aware of the need to explicit the relation of cause and effect. Such conduct was also reflected on the topological structure of the second version of the concept map, which started showing ramifications, becoming close to achieve level 2. In semantic taxonomy, the student has shown improvement from level 2 to 3. His text has also denoted level 3 of changes.

When analyzing the production of concept maps on the colleagues' texts, there was a predominance of slightly lower levels if compared to those resulting from the production on personal texts. In topological taxonomy, 12 of the 22 productions have shown level 1, and levels 4 and 5 were attributed to only one student each. Four students have had productions of level 2 and three students, productions of level 3. One student has denoted a production of level 0. Regarding semantic taxonomy, there were predominantly students at level 2 (11 students compared to 9 when considering productions on personal texts), one student else in level 1 and a more homogeneous distribution among levels 3 and 5 (two, four and three students, respectively). Despite the reduction of levels in the process of interlocution based on concept maps, it was possible to observe a construction effort that, at times, showed to be similar to the effort made to elaborate a second version of the concept map on the personal text. Such conduct is illustrated in figure 12.

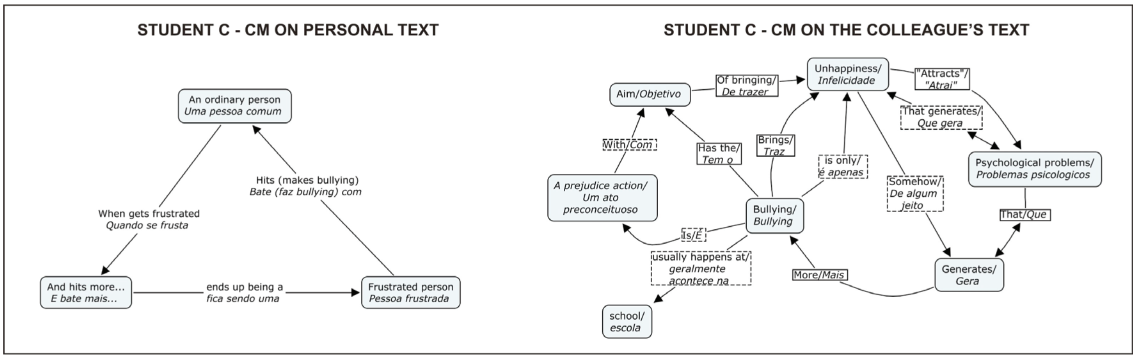

Figure 12: Example of productions of concept maps – Student C

The example refers to the production of Student C (group 1): concept maps on the personal text and on the colleague's text, respectively. The first production has shown topological level 1 and semantic level 3. The production on the colleague's text, in its turn, has denoted level 4 in topological taxonomy and level 5 in semantic taxonomy. One of the probable reasons for the development observed was the work on a common theme: both students – Student C and his colleague, author of the text he has represented as a concept map – have developed their researches based on the question "Why does Bullying happen?". The process of interlocution turned out being an opportunity to improve understanding related both to the topic studied and to the structure of the concept map.

Finally, in the analysis of levels of individual development, it was possible to observe the proximity of the results when comparing the different taxonomies implemented (for this analysis, levels 5 and 6 of topological taxonomy for concept maps were considered compatible with level 5 of semantic taxonomy for concept maps and textual taxonomy). Comparing the textual and the semantic taxonomy for concept maps, 19 of the 22 students from groups 1 and 2 have shown up to one level differences in their productions. Only three of the students have shown differences of two levels in the productions investigated. When comparing the textual taxonomy and the topological taxonomy for concept maps, 15 productions have shown up to one level differences, and five productions, two levels. One student has revealed a difference of three levels, and another student, four levels of difference. Lastly, in the comparison between the semantic and the topological taxonomy for concept maps, 16 students have shown differences up to one level in their productions, and six students, differences of two levels. As well as in the analysis related to the production of concept maps on the personal texts, similar results were observed when comparing the different taxonomies applied to the production of concept maps on the colleagues' texts.

5 Conclusions

The results point to a reciprocal development when considering levels related to the linear writing and the construction of concept maps, driven by the cycles of thought. When the conceptualization process is extended from the conventional written language to the connections in the concept map, new abstractions take place, which may be still empirical, if centered in direct observables, as well as reflective, with the construction of inferential coordinations. Both have shown the improvement of the unit of meaning in the productions investigated, which is reflected in the rewriting of the text.

The encouragement of the procedure of revision, carried out by the large majority of students in groups 1 and 2, shows the possibility of application of the method described for the age group considered. A systematic review effort was observed, mostly with reflections on cohesion and coherence elements, and consequent impacts on the semantic and structural aspects of the productions. Such reflections were mainly found in the productions about personal texts. Regarding the production of concept maps on the colleagues' texts, the method has not shown the same impacts. It was also observed the importance of the opportunity of constructing a second version of the concept map on the personal text: from the first to the second version of productions on personal texts of group 2, progress was identified in relation to the recognition of the structure of concepts and propositions in most connections, as well as the performance of inferential coordinations and improvement of linear writing.

Finally, it is pointed the relevance of performing an integrated approach, including interventions based on the students' productions and on a rich context for exploration. The news production network has allowed the raising of questions of learners' interest, as well as the socialization of discoveries with real audiences (instead of only with a teacher). So that, the construction of concept maps, the interlocution based on them and the interventions focused on semantic and structural aspects of texts have provided the background for assessing and encouraging conceptualization processes on written language.

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[i] LEC/UFRGS was responsible for guiding the pre-pilot experience of PROUCA program in Rio Grande do Sul State and, in the second phase of the project trial, is one of the coordinating centers of formation of teachers.

[ii] The hypothetical-deductive method presented by the author aims the free expression of the subject so as to encourage him to communicate basic aspects of his thought, in order to investigate processes of reasoning underlying the responses, reactions caused by questions, perturbations and regulatory activities.

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IMPROVING THE ODDS: USING CONCEPT MAPPING STRATEGIES AND INFORMATIONAL BOOKS TO BUILD CHILDREN'S AND EDUCATORS' BACKGROUND KNOWLEDGE

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Abstract The purpose of this paper is to describe a research center's initiatives that move the use of concept mapping from learning theory to action. We use concept mapping in the context of designing professional development and instructional materials that support the use of informational texts to increase students' concept knowledge. Our work additionally includes the use of concept mapping for assessment. These applications include use in community, professional development, classroom, and after-school program settings.

1 Introduction

In *The Knowledge Deficit*, E. D. Hirsch (2006) documented the achievement gap in reading proficiency between Hispanic and Black children and between both minority groups and white children. Many economically disadvantaged children enroll in kindergarten as 5-year olds with a knowledge gap (Neuman & Celano, 2006). Neuman (2006) and others (Stanovich, 1980; Hamre & Pianta, 2005) point out that this gap grows in a *Matthew effect* as children with reading proficiency gain from reading while children with inadequate proficiency fall farther and farther behind.

Neuman (2006) emphasized the connection between children's background knowledge and their reading comprehension, but noted discussion about children's content knowledge and reading achievement has been minimal. Focus on skill development in isolation from content has been countered by Siegler (2001) who emphasized learning as the central connection between instruction and cognition, i.e., the more one knows about a topic, the better one understands, learns, and remembers information.

Pavio (1990) and Novak & Cañas (2008) emphasized the need to use visual representations (e.g., dual coding and concept maps) to help children understand and make connections about information they are learning. Visible thinking by definition means "any kind of observable representation that documents and supports the development of an individual's or group's ongoing thoughts, questions, reasons, and reflections" (Tishman & Palmer, 2005, p. 2). Recent research conducted by neuroscientists at Georgetown University Medical Center (2012) revealed that skilled readers rely on their *visual dictionary* rather than sounds (decoding) for word retrieval. For young children these visual connections are essential in moving them from being decoders to proficient readers.

Teachers' use of instructional strategies that scaffold children's acquisition of knowledge is a key to closing the knowledge gap. Teachers need ongoing support including targeted professional development opportunities and in-class coaching to improve the quality of instruction taking place in their classrooms (U. S. Department of Education, 2010). If teachers' expertise in scaffolding children's vocabulary and concept development is to increase, professional learning experiences should target instructional strategies designed to enhance children's concept development. Concept mapping is a strategy that teachers can use to plan lessons in ways that help students' make connections between their existing and new knowledge.

2 Theory to Action

Guided by the theoretical framework, staff at a university-based research center developed professional development experiences and instructional materials depicted in Figure 1. Emphasis included creating and using informational texts to build children's concept development and background knowledge. Partners include a large, urban school district with 177 schools serving 125,000 students; community advocates seeking to improve outcomes for children especially those who live in poverty; and community-based early childcare providers.

The professional development experiences and instructional materials incorporated the use of concept mapping because concept map creation forces the mapper to make explicit the relationships among concepts, thus, making thinking visible. Concept mapping is used to scaffold children's learning encourages concept development in ways that call upon children to use language to express what they know and relate new information to existing knowledge. For children, concept maps provide a visual image that help makes explicit what they know, connect existing and new knowledge, and spark future inquiry.

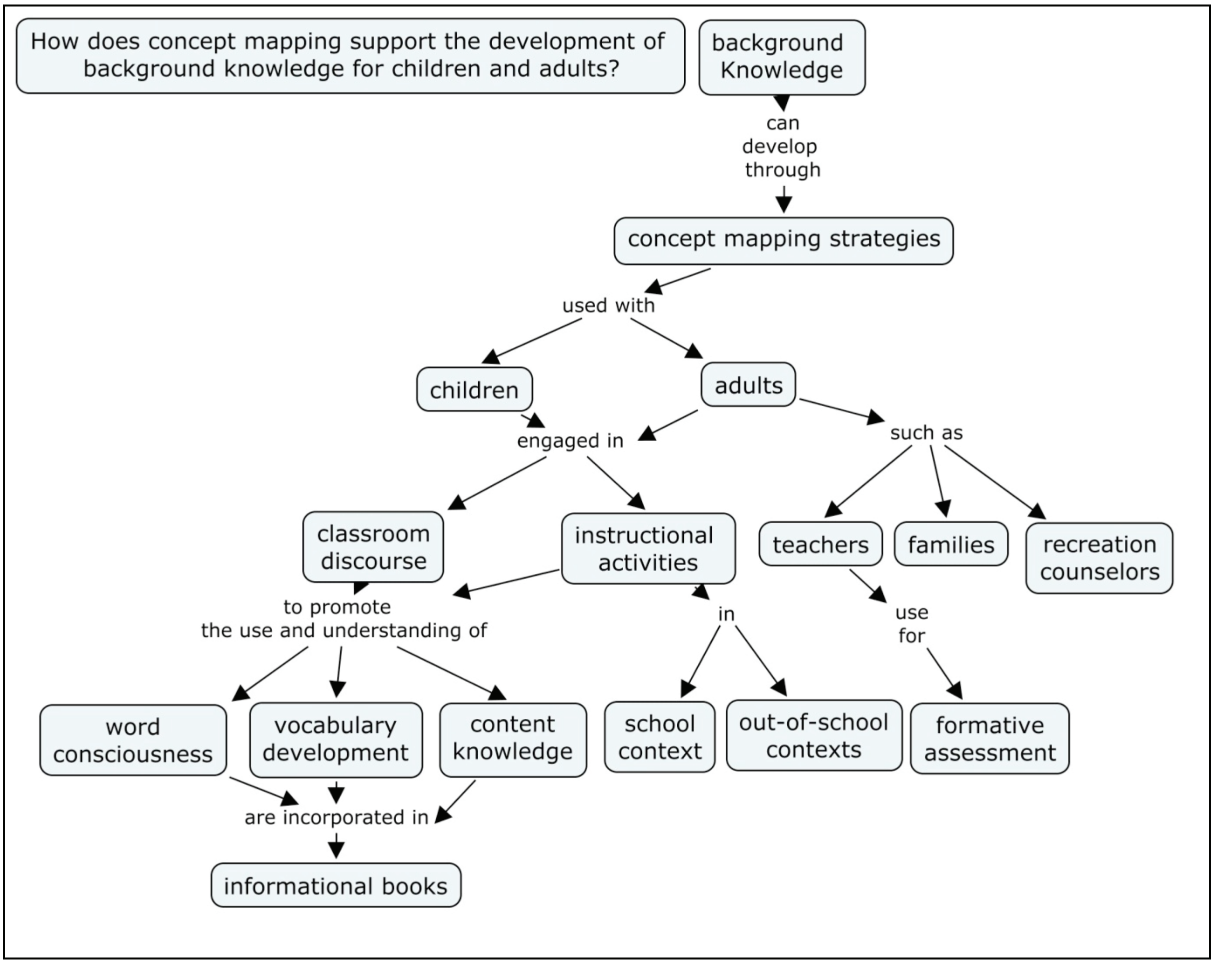

Figure 1: FIE concept mapping applications from theory to action.

2.1 Purpose

The purpose of this paper is to describe the evolution of our use of concept mapping in the context of designing professional development and instructional materials that support the use of informational texts to increase concept knowledge. Our work also includes the use of concept maps as advance organizers and for assessment. These applications have been used in classroom settings, after-school programs, in summer learning settings, and in professional development settings.

3 Concept Mapping Used in Multiple Learning Contexts

Our vision for expanding the use of concept mapping includes published center-authored informational texts for young children and adults working in both traditional classrooms and out-of-school learning environments. This strategy is based upon theories of knowledge acquisition and concept mapping. Current applications of this process are detailed in the project descriptions below and represented in Figure 2.

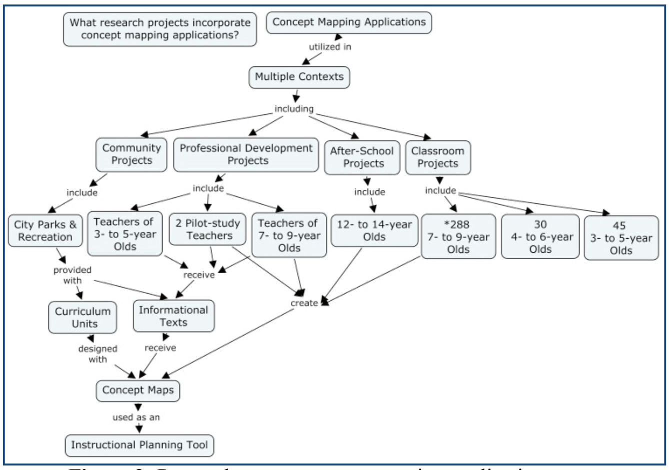

Figure 2: Research center concept mapping applications.

3.1 Community Projects

Working in collaboration with the city's parks and recreation department, center researchers developed curriculum units and informational texts for use by 5- to 10-year olds in summer camp programs in 2010, 2011, and 2012. Summer camp counselors received lesson plans and instructional materials aligned with science content. (See concept map in Figure 3.) Researchers incorporated concept maps in curriculum units using two methods: They created maps to connect science concepts in meaningful ways for camp counselors to use to plan lessons and to use in lesson activities to support children's understandings of the science concepts presented in books, discussions, and camp activities. More than 1,500 children participated in summer camp programs each year. The partnership between the research center and the city parks and recreation department supports a city-wide goal of improving literacy outcomes for all citizens.

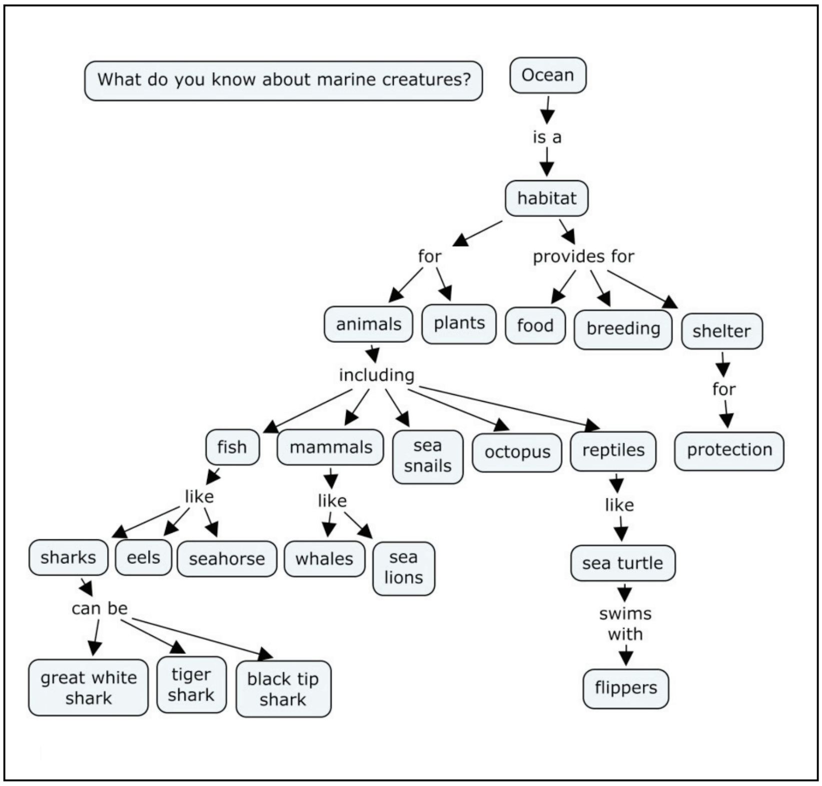

Figure 3: Concept map used to develop background knowledge for science literacy lessons.

3.2 Concept Mapping with Teachers——Professional Development Projects

Whenever possible, research center staff incorporate concept mapping strategies in a variety of settings. This was accomplished by creating concept maps for informational books used in professional development initiatives that impact teachers and children. Figure 4 depicts a book cover and embedded concept map of a research center-authored informational book.

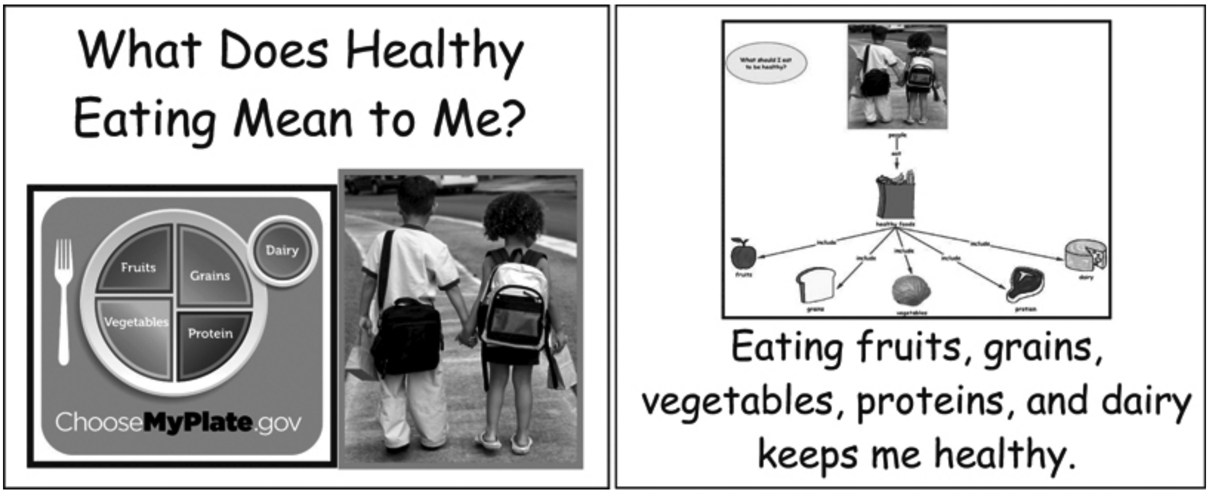

Figure 4: An example of a book cover and embedded concept map from a center-authored informational book.

In 2010-2012, center researchers designed and implemented three professional development projects using concept mapping. One project focused on teacher professional development, called HUBS, using informational books and concept mapping activities presented using a technology-focused delivery system. The second project focused on a professional development series for teachers of 7- to 9-year olds designed to improve children's concept development by focusing on background knowledge related to science informational books. The third professional development project involved two teachers of 4- to 6-year olds and their use of concept mapping to plan and deliver instruction. Concept mapping was a primary strategy used in the delivery of the professional development sessions for all three projects.

The HUBS project was developed to improve children's phonological awareness, emergent writing, and language skills. The design of the series, based in part on findings that teachers were more likely to use concept mapping strategies in their instruction when concept mapping was presented in a variety of ways during training sessions, incorporated different approaches to the presentation and implementation of concept maps (McLemore, England, & Hunter, 2010). To that end, center staff authored and published informational books (Figure 4) based on the curriculum in use by the teachers. Each book incorporated the background knowledge from the curriculum and rich language designed to support the development of children's phonological awareness, emergent writing, and language skills. Examples of rich language include alliteration, rhyming words, and word repetition. The books also include a concept map that summarizes the background knowledge. One teacher said of the books, "I like the books that you have given us to use in the classroom. We have used them for writing lessons and for the class library. The books are simple to read and many of our students like to "read" the books. I would like to receive more of the books that support our themes."

The professional development series developed for teachers of 7- to 9-year olds involved teachers creating, using, and analyzing concept maps with Kidspiration© software. One goal of the professional development was to demonstrate for teachers how to use concept mapping to plan meaningful instruction by identifying key concepts in informational books and textbooks. This kind of planning helps teachers make explicit, in instruction, the connections between the identified concepts. Figure 5 shows a concept map produced by one teacher to plan instruction for functional writing.

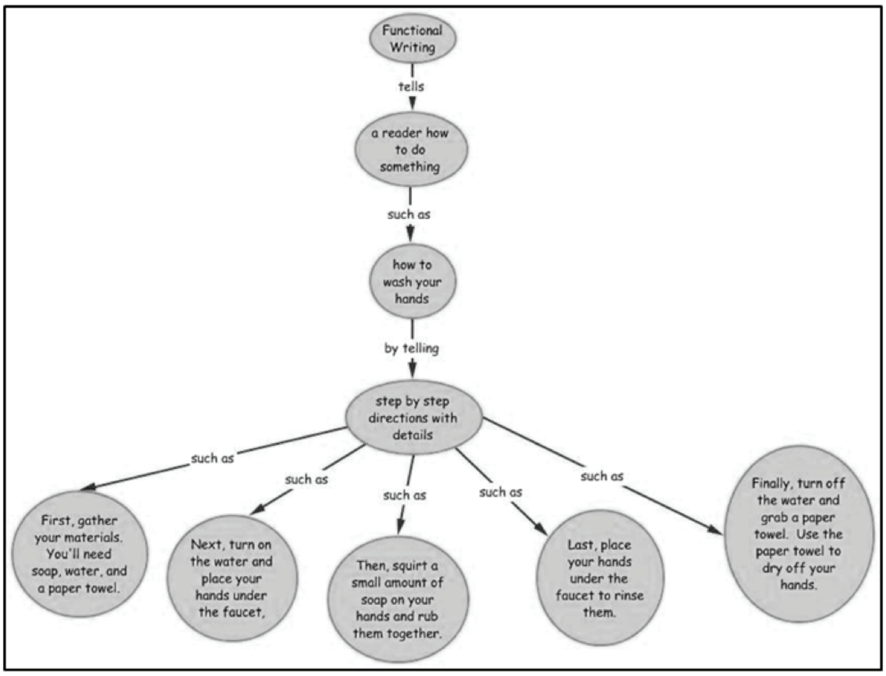

Figure 5: Concept map created by a teacher to plan instruction.

Finally, a pilot study involving two early childhood educators was implemented in the 2010-2011 and 2011-2012 school years. Each teacher received on-site coaching support from a center researcher, informational books with concept maps, and lesson plans. The use of concept maps helped make children's thinking visible. Visual representations reflect the children's progressive understanding of the presented knowledge. The researcher modeled strategies for using concept maps with young children to generate ideas, and connect previous knowledge with new knowledge. The researcher and teachers met regularly to discuss successes, identify barriers, and ideas for further concept mapping uses in their classroom instruction. The planning map developed jointly by the teachers is shown in Figure 6.

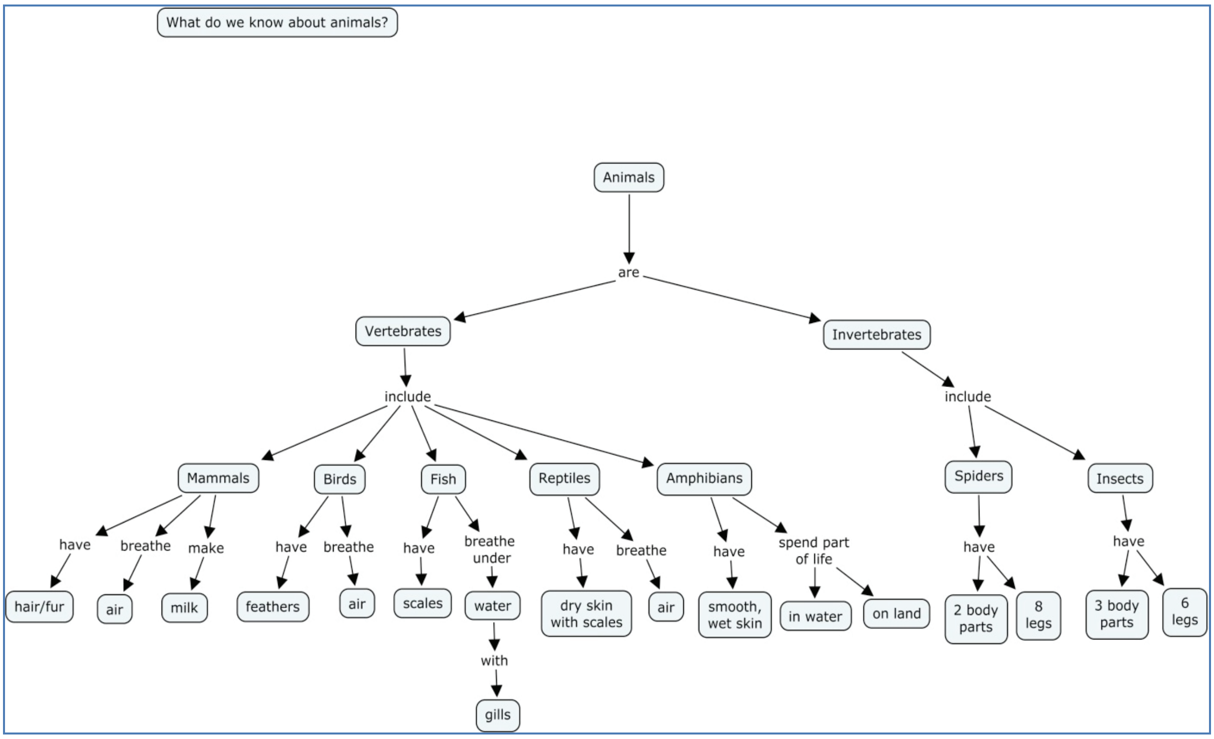

Figure 6: Concept map used as a planning tool.

3.3 Concept Mapping with Children –Classroom Projects 2011-2012

Because 3- to 5-year olds are developing as readers and writers, researchers working with children in the HUBS project collected language samples and created concept maps using transcribed interviews. This approach was based upon the work of Figueiredo, Lopes, Firmino, & deSousa (2004) and has been used to help children make connections among the concepts being taught and to assess their understandings. Figure 7 shows a concept map created from a 5-year-old child's transcribed language sample. Audio recorded language samples and written work samples were collected from approximately 60 children in 12 classrooms.

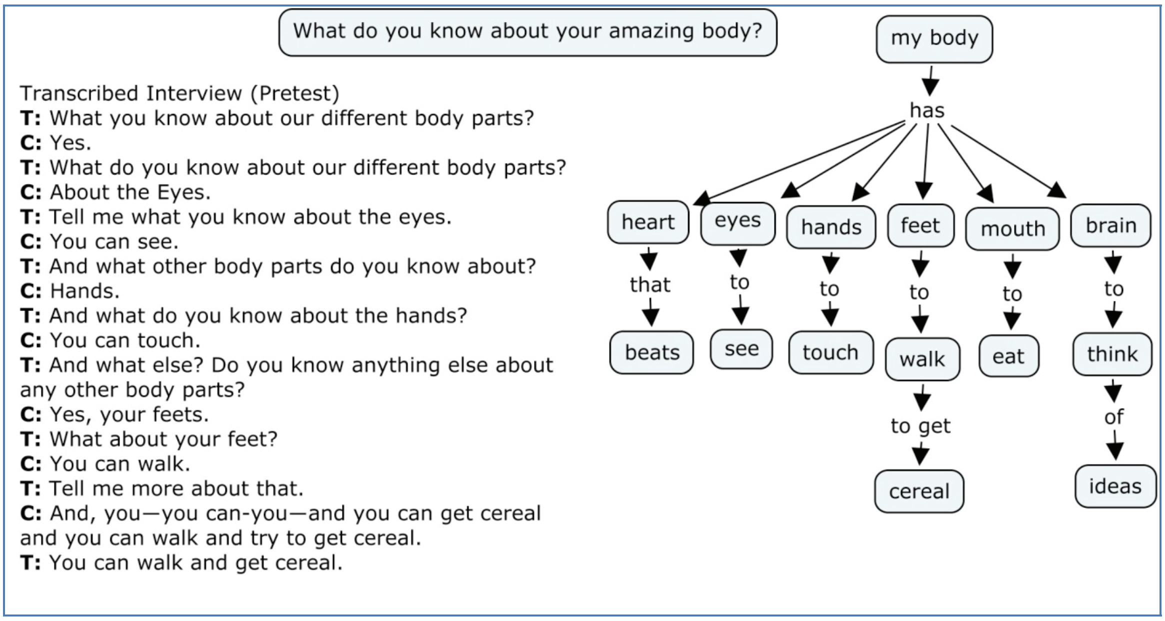

Figure 7. Transcribed language sample and derived concept map. Both receive scores in the embedded empirical study.

Using Kidspiration© software, 7- to 9-year-old children created concept maps. As teachers became more experienced concept mappers, the opportunities for children to create individual concept maps increased. End-of-unit projects related to science concepts such as habitats, mammals, and motion were topics for child-generated maps. (See Figure 8 for an example of a child-generated concept map.) Approximately 288 children in 16 classrooms participated in the project.

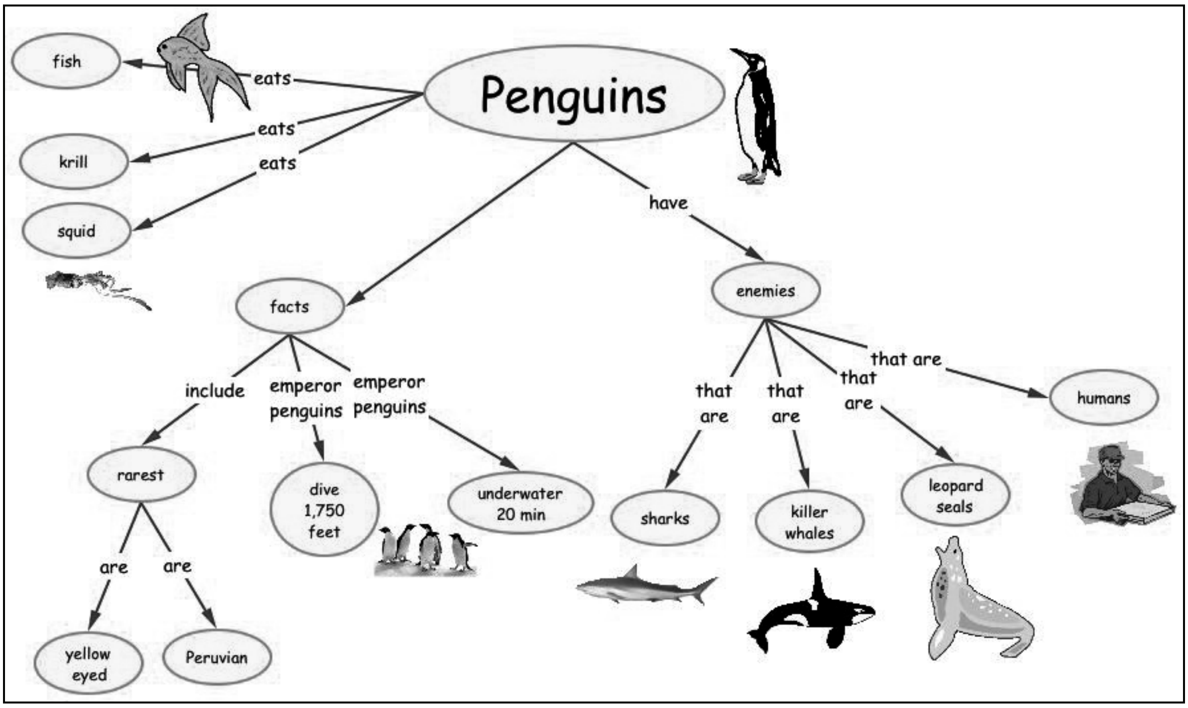

Figure 8: Child-generated concept map of his knowledge of penguins.

3.4 After-school Projects

Beginning in 2007 and continuing to present, middle school students' who participated in the research center's after-school program have created concept maps to represent their understanding of content related to human geography (Monroe-Ossi, Wehry, & Fountain, 2010; Wehry, Monroe-Ossi, Cobb, & Fountain, 2012; Wehry, Monroe-Ossi, & Fountain, 2010). Figure 9 shows a child-created concept map related to self-concept. The map was created after 18 weeks of program sessions. Approximately 120 students participate in this after school program each year.

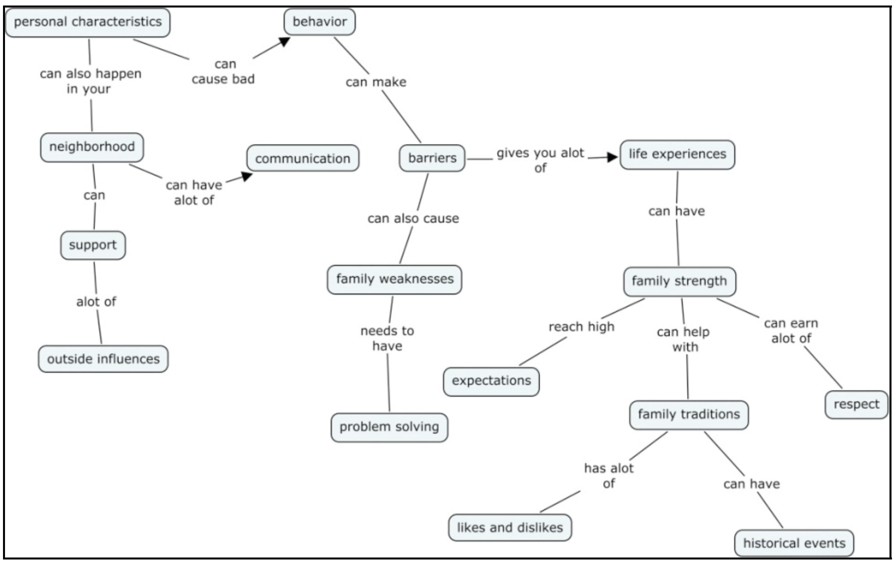

Figure 9: Student-generated concept map depicting her knowledge structure of *self-concept*.

4 Significance

We enumerated concept mapping projects spanning multiple years and contexts, involving state and community agencies and advocates, and multiple age groups. Our projects, sponsored by the state, the school district, the city, and the university show promise. Satisfaction with the projects is demonstrated at the policy level by on-going sponsorship. The state and university have supported the after-school project since 2007 and support will continue at least through the 2012-13 academic year. The center is just completing the first year of a school district 3-year commitment requesting that center staff create and deliver professional development for teachers of children with special needs, from low-income families, or both. The city's parks and recreation project began as a single summer project; however, parks and recreation staff has requested center staff to continue this project every summer. Teachers in the HUBS project use web 2.0 applications to provide feedback to center researchers. The teachers are requesting more center-authored informational books with embedded concept maps. In fact, one teacher suggested the center provide a complete set for each child in her class. While she may think she is reaching for the stars, center staff will work hard to expand the collection of books and provide more copies for class libraries. The penguins map shown in Figure 8 reinforces our commitment to help students engage in meaningful learning.

These projects demonstrate that, at all levels, concept mapping strategies are embraced by teachers if presented in the context of well-planned professional development along with in-class coaching and support. Concept mapping is working in these projects and teachers are implementing concept mapping strategies. Pairing concept mapping with professional development helps teachers make explicit their own thinking while also developing strategies they can use to scaffold children's concept development.

We have growing documentation that supports teachers' satisfaction and increases in children's concept knowledge. As our understandings deepen, our concept mapping applications expand. In every project, we have gained insight into what we are doing that is working, where and how to revise projects to incorporate teachers' suggestions, and how and where to scale-up our work.

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ITINERARIOS DE APRENDIZAJE CON MAPAS CONCEPTUALES COMO RECURSO PARA EL APRENDIZAJE AUTÓNOMO

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Abstract. Se presenta una experiencia de utilización de itinerarios de aprendizaje basados en mapas conceptuales como recurso para el estudio de una asignatura sin docencia. Se parte de la idea de que un itinerario de aprendizaje potencia las posibilidades de los mapas conceptuales en una secuenciación que atiende a las características del alumno y que se adapta mejor al modelo flexible de enseñanza-aprendizaje, dado que el alumno participa en dicho proceso trasladándose el énfasis de la enseñanza al aprendizaje. En este contexto se considera que los itinerarios de aprendizaje suponen una potente herramienta para la organización y secuenciación de los aprendizajes en los entornos virtuales de formación y constituye una herramienta útil para aquellos alumnos que tienen que estudiar una materia de forma independiente.

1 Introducción

Un itinerario de aprendizaje viene a ser un mapa conceptual que nos guía en el aprendizaje sobre un tema. Presenta una serie de competencias que deben comprenderse, dominarse y demostrarse para entenderlo. A diferencia del mapa conceptual convencional que explica el tema (los conceptos y sus relaciones, el qué de un tema) un itinerario de aprendizaje se ocupa del cómo aprender el tema. Supone, por tanto, una forma de organizar la secuencia de aprendizaje.

En el contexto de una materia donde los alumnos no tienen docencia y tienen que trabajarla de forma independiente, se ha considerado el itinerario de aprendizaje como una solución adecuada de organización y presentación de recursos para esta situación. Se trata de un grupo de 20 alumnos matriculados en la asignatura de Tecnología Educativa II, perteneciente al tercer curso de los estudios de Pedagogía, y que debido a la implementación de los estudios de Grado (EEES) y la finalización de los estudios de primer y segundo ciclo del plan de 1997, los alumnos de éste último plan deben realizar los créditos sin docencia.

El estudio que se presenta es una continuación de dos proyectos de innovación docente realizados durante los cursos 2009-2010 y 2010-2011 en los que se ha utilizado un itinerario de aprendizaje en un contexto de enseñanza semipresencial. En el primer caso el itinerario fue diseñado y validado por expertos y utilizado por los alumnos (de Benito et al, 2010). A partir de los resultados obtenidos se rediseñó dicho itinerario, introduciendo modificaciones sobre todo a nivel metodológico, evaluación y orientaciones y pautas de estudio (de Benito et al, 2011).

Estos estudios parten de los mapas conceptuales como organizadores gráficos de los materiales u objetos de aprendizaje, evidenciando que los mapas conceptuales pueden ser una potente herramienta para estructurar y presentar información y recursos de aprendizaje; que proporcionan flexibilidad y estructura no lineal a la hora de organizar y secuenciar los contenidos y objetos de aprendizaje (de Benito, Darder y Salinas, 2012).

Los resultados obtenidos en una modalidad semipresencial (o mixta) nos llevaron a aplicarlos al aprendizaje autónomo, rediseñando el itinerario previo e introduciendo las modificaciones y los recursos adecuados para este nuevo contexto de enseñanza.

2 Marco conceptual

Los itinerarios de aprendizaje son una aplicación más de los mapas conceptuales desde el momento en que nos guía en el aprendizaje sobre un tema, presentando una serie de competencias que deben comprenderse, dominarse y demostrarse para entenderlo, y que a diferencia del mapa conceptual convencional que explica el tema (los conceptos y sus relaciones, el qué de un tema), en este caso se ocupa del cómo aprenderlo (Cañas y Novak, 2010; de Benito et al, 2010).

Supone, por tanto, una forma de organizar la secuencia de aprendizaje y responde a la necesidad de guía de los alumnos por los contenidos, procesos y actividades, proporcionando, al mismo tiempo, suficiente flexibilidad para que ejerza cierta autonomía en el proceso de aprendizaje (de Benito, Darder y Salinas, 2012).

Apoyándonos en aspectos de la teoría de la elaboración en cuanto a la importancia de fortalecer la iniciativa y responsabilidad de los alumnos para la construcción de su aprendizaje (Reigeluth, 1999) y del aprendizaje significativo (Ausubel, Novak y Hanesian, 1983; Novak, 1998) un itinerario de aprendizaje podríamos caracterizarlo por (de Benito et al, 2010; Cañas y Novak , 2010):

- Constituir un potente organizador tanto de los conceptos y temas a aprender, como de los objetos y recursos de aprendizaje a utilizar.
- Dar una visión completa de lo que debe hacerse para comprender el tema en cuestión.
- Ofrecer un sistema de navegación flexible:
  - Presenta opciones o alternativas a seguir en la construcción de la propia secuencia de aprendizaje. El estudiante ajusta la navegación a sus características individuales (necesidades, estilo de aprendizaje, etc.).
  - Proporciona control al alumno sobre la secuencia de aprendizaje.
  - Constituye lo que se conoce como un mapa de experto.
- Son reutilizables. Un itinerario puede ser fácilmente modificado para ser utilizado en diferentes situaciones.
- Organización modular. Los itinerarios pueden ser organizados por bloques de tal forma que facilitan su integración con otros itinerarios o su reutilización.
- Los itinerarios pueden ser utilizados como organizadores de cursos completos.

Un itinerario de aprendizaje potencia las posibilidades de los mapas conceptuales en una secuenciación que atiende a las características del alumno y que se adapta mejor al modelo flexible de enseñanza-aprendizaje, dado que el alumno participa en dicho proceso trasladándose el énfasis de la enseñanza al aprendizaje. En este caso, las estrategias didácticas son adaptables a las características del usuario, ampliando su conocimiento y estimulando la investigación y la autonomía del estudiante.

Tal como establece la teoría de Ausubel, para que el aprendizaje sea significativo, eficiente y eficaz, requiere (Ausubel, Novak y Hanesian, 1983): una estructura cognitiva apropiada del alumno, materiales de aprendizaje conceptualmente transparentes y una disposición favorable por parte del alumno hacia este tipo de aprendizaje. Presentar la información en forma de mapa conceptual supone una potente herramienta para organizar, representar y almacenar el conocimiento. Se basan en un esquema de conceptos y relaciones entre ellos, unidas por proposiciones o palabras y organizadas jerárquicamente, y constituyen una de las principales aplicaciones prácticas de la teoría de Novak sobre el aprendizaje significativo frente al aprendizaje memorístico (Novak, 1998). Los contenidos se organizan en conceptos, y tienen asociados recursos con información ampliada sobre ese concepto. El control sobre la navegación lo tiene totalmente el alumno, pues en este tipo de materiales no se puede determinar la manera en que navega.

Por su parte, Reigeluth (1999) en la teoría de la elaboración justifica la importancia de secuenciar los contenidos y actividades de enseñanza-aprendizaje sobre dos análisis fundamentales: la reflexión sobre el contenido organizador y los diferentes niveles de elaboración en que se debe vertebrar la secuencia de aprendizaje. De esta manera, más que una secuencia lineal, es importante proveer de una guía para fortalecer la iniciativa y responsabilidad de los alumnos para la construcción de su aprendizaje.

En un entorno virtual de enseñanza-aprendizaje, como es el caso, el papel de mediación del profesor entendemos que se puede trasladar a un itinerario desde el momento en que la mediación guía y estructura el aprendizaje del alumno -sólo en la medida de lo necesario- y se ofrezca al alumno un material significativo en forma de mapa conceptual. Tal como señalan Novak y Gowin (1988) el profesor es un mediador entre la estructura conceptual de las disciplinas y la estructura cognitiva del alumno. El resultado de tal mediación sería la actualización de la estructura cognitiva que se da en el aprendizaje, en este caso en un entorno virtual y mediado por itinerarios de aprendizaje.

3 El estudio

En este estudio se ha utilizado el itinerario de aprendizaje en una asignatura sin docencia, es decir el estudiante trabaja de forma autónoma sin intervención del docente/tutor. Para ello reutilizó un itinerario validado por expertos y utilizado en cursos anteriores en modalidad de enseñanza presencial. En esta ocasión, se adaptó el itinerario utilizado en ediciones anteriores, que contaban con la presencia del tutor, incorporando nuevos recursos para completar los contenidos, elaborando guías de estudio y proponiendo actividades de carácter individual y autónoma que no requieran corrección por parte del docente.

3.1 Objetivos

El objetivo de esta experiencia es averiguar si este tipo de materiales supone un recurso válido para los alumnos que deben cursar una asignatura de forma autónoma. Y en este sentido se pretende dar respuesta a los siguientes interrogantes:

- ¿Sirven los itinerarios de aprendizaje para cursar asignaturas universitarias sin docencia?
- ¿Son adecuados los mapas conceptuales para organizar los recursos de aprendizaje?
- ¿Qué impacto tiene en los resultados académicos de los estudiantes cursar una asignatura mediante itinerarios de aprendizaje de forma autónoma?

3.2 Metodología de investigación

Se trata de una investigación que intenta resolver problemas reales en su contexto mediante la reconstrucción y creación de nuevos diseños y formas organizativas, por lo que se opta por una investigación de Diseño y Desarrollo (Reeves, 2000) con un enfoque metodológico mixto (cualitativo y cuantitativo).

Al tratarse del rediseño de itinerarios existentes (de Benito, Darder y Salinas, 2012) aplicándolos a situaciones nuevas, el énfasis está en enfrentarse a problemas complejos en contextos reales, en colaboración con los profesionales y al mismo tiempo en la producción del conocimiento con el objetivo último de mejorar los procesos del diseño (Richey y Klein, 2007).

Los procedimientos de recogida de la información se apoyan en un cuestionario (aplicado en dos momentos: después del primer mes del inicio del curso y al finalizar el mismo) y en la observación de la secuencia de navegación de los estudiantes.

3.3 Procedimiento de la experiencia

La experiencia se ha realizado en la asignatura de Tecnología Educativa II (tercer curso de los estudios de Pedagogía), y que debido a la extinción de planes de estudio generada por la implementación de los estudios de Grado (EEES), los alumnos pertenecientes a dichos planes deben cursar las asignaturas sin docencia. Por este motivo, y con la finalidad de que el alumnado alcance los objetivos y asimile los contenidos de la asignatura, se ha realizado un material auto-instructivo en forma de itinerario de aprendizaje a través de mapas conceptuales.

Se ha contado con el software CmapTools, creado en el Institute for Human & Machine Cognition, al permitir desarrollar el proceso en un entorno virtual, ya que apoya la colaboración y el intercambio y puede ser utilizada tanto en actividades presenciales, como en situaciones de distancia (Novak y Cañas, 2006).

Se trata de una asignatura teórico-práctica, estructurada en tres módulos o bloques temáticos:

- Módulo I. Las Tecnologías de la Información y la Comunicación (TIC) en la educación
- Módulo II. Investigación en Tecnología Educativa.
- Módulo III. Diseño y producción de medios interactivos

El alumno accede en primer lugar a un mapa de navegación de la asignatura, integrado en la plataforma de e-learning utilizada en la universidad (Fig. 1), que recoge toda la información sobre:

- Programa de la asignatura.
- Sistema de evaluación.
- Acceso al listado de programas e itinerario para la adquisición de habilidades prácticas.
- Orientaciones para el desarrollo del trabajo final.
- Objetivos de cada uno de los temas.
- Enlace a los itinerarios de aprendizaje de cada uno de los módulos.

Junto a este mapa de navegación se da acceso a un documento-guía sobre el uso del material, los contenidos de la asignatura y las recomendaciones de estudio. Se utilizan las herramientas de comunicación de la plataforma para habilitar un foro de debate donde los alumnos puedan intercambiar información, recursos, dudas, etc. entre ellos.

En los itinerarios que se han diseñado para cada uno de los módulos, se presentan las competencias a lograr y se enlazan diferentes recursos para la comprensión de los contenidos y el estudio de los temas. También incluyen actividades con el objetivo de que el alumno consolide los contenidos de cada tema. Son actividades de carácter autónomo y no evaluables por parte del docente (Fig. 2).

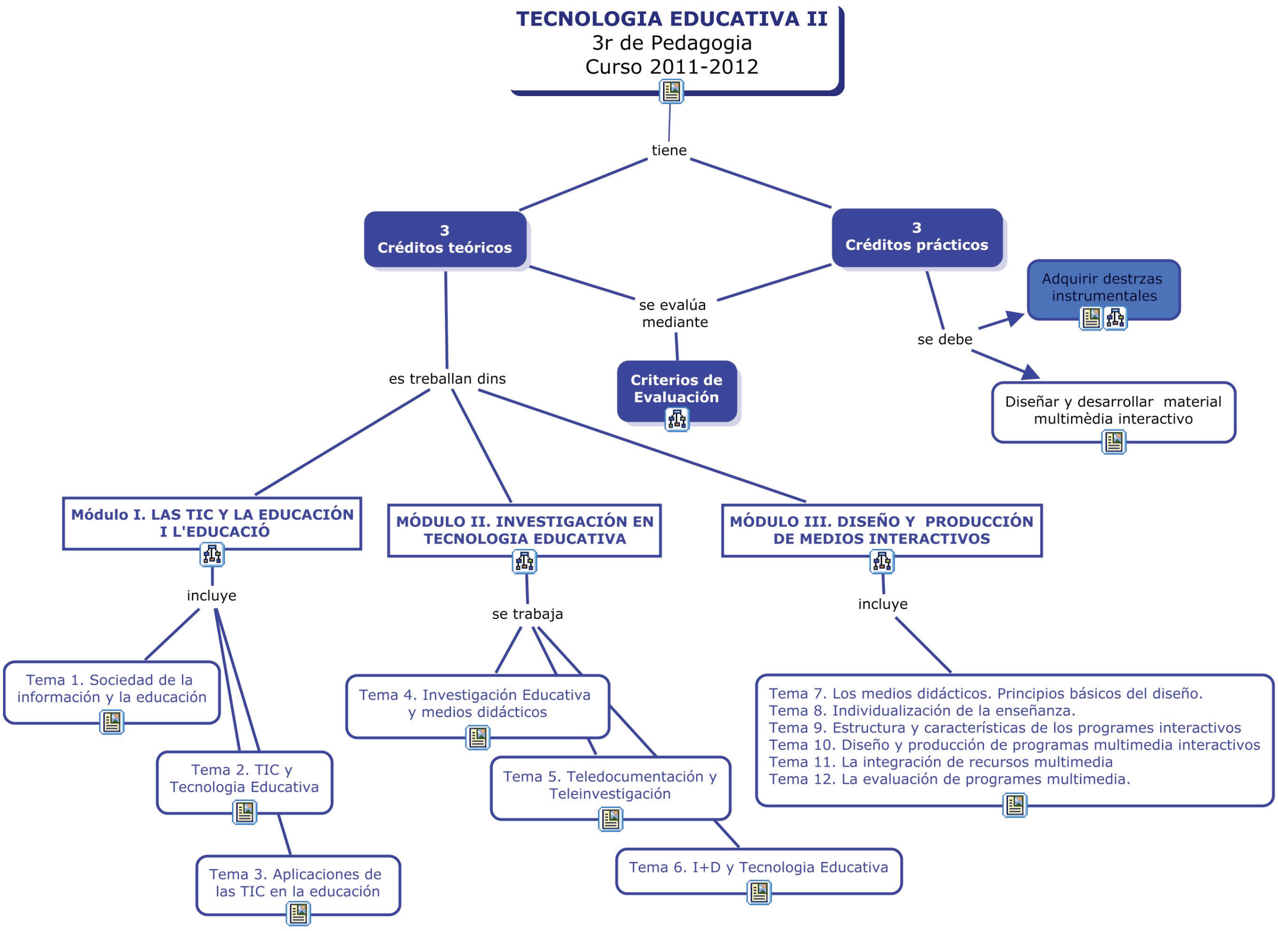

Figura 1. Mapa de navegación de la asignatura

4 Resultados

Se presentan aquí los resultados a partir de la aplicación del cuestionario (al inicio y al final del cuatrimestre) y de la observación de la secuencia de navegación de los estudiantes. No se han podido contrastar estos resultados con los resultados académicos de los estudiantes dado que bastante se ellos han optado por la segunda oportunidad de evaluación (septiembre, 2012) y de los datos parciales de que se disponen en este momento no pueden obtenerse resultados concluyentes.

4.1 Cuestionario inicial y final

Los resultados obtenidos de la aplicación del cuestionario (al inicio y al final del cuatrimestre) se han organizado en torno a los siguientes ejes:

- La navegación y control de navegación del usuario
- El proceso de aprendizaje
- La interacción/comunicación con el grupo
- El apoyo/tutoría

De los 20 alumnos matriculados y por lo tanto potencialmente participantes en el curso vía los itinerarios de aprendizaje, fueron 15 los que aceptaron y han accedido al itinerario de aprendizaje. De éstos 8 han respondido al cuestionario inicial y final del curso (aunque no corresponden siempre a las mismas personas). La aplicación del cuestionario en los dos momentos del curso ha permitido observar cómo en algunos aspectos la valoración fue más positiva al principio y en otros al finalizar el estudio.

- La navegación y control de navegación del usuario.

Por lo que respecta a la presentación y estructuración de la asignatura en forma de itinerario de aprendizaje, la valoración ha sido por lo general positiva. Así, sobre la forma como se ha presentado la asignatura fue mejor valorada en el primer cuestionario ya que el 75% lo valoró positivamente (fig. 3 y 4). En cuanto a si el itinerario presenta una estructura clara y adecuada, mientras que en el cuestionario inicial se observa más disparidad de opinión, después del estudio de la asignatura el 88% opina que sí (fig. 5 y 6).

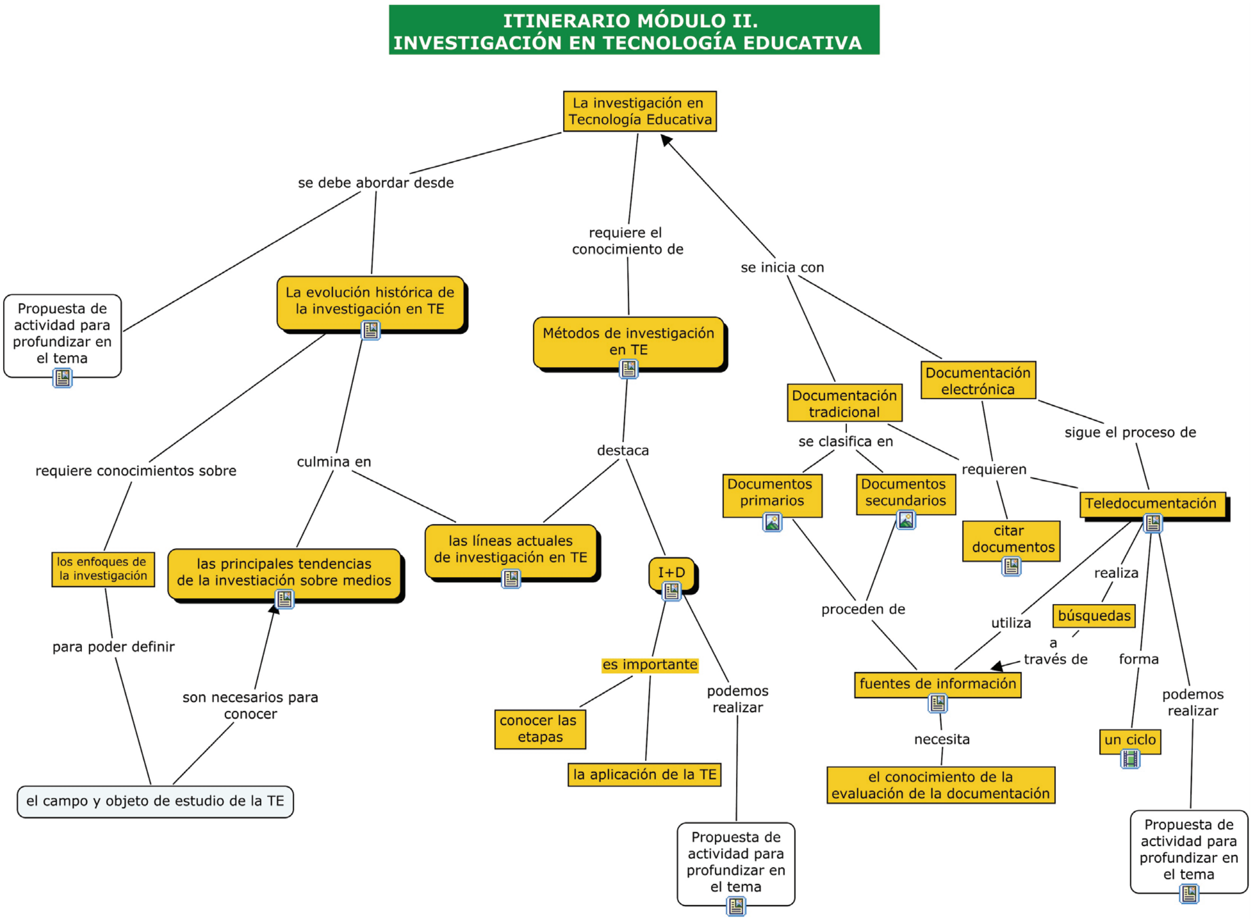

Figura 2. Ejemplo del itinerario Módulo II

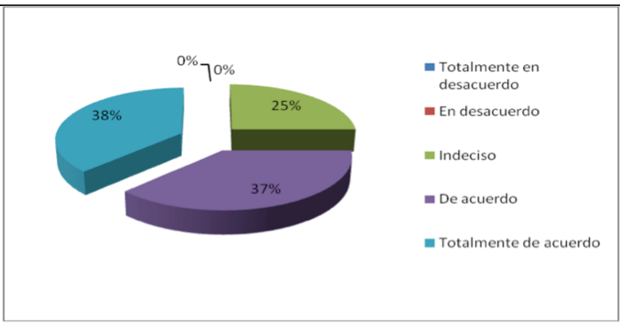

Figura 3. Valoración sobre la forma de presentar la asignatura (cuestionario inicial)

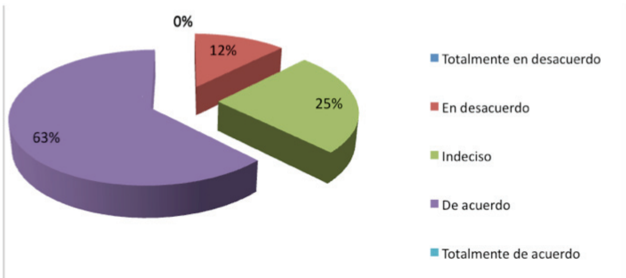

Figura 4. Valoración sobre la forma de presentar la asignatura (cuestionario final)

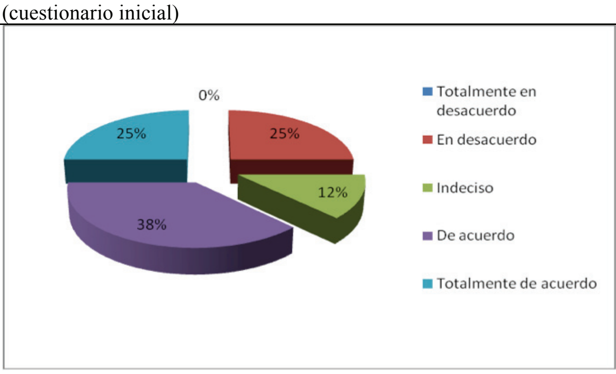

Figura 5. La estructuración de la asignatura es clara y adecuada (cuestionario inicial)

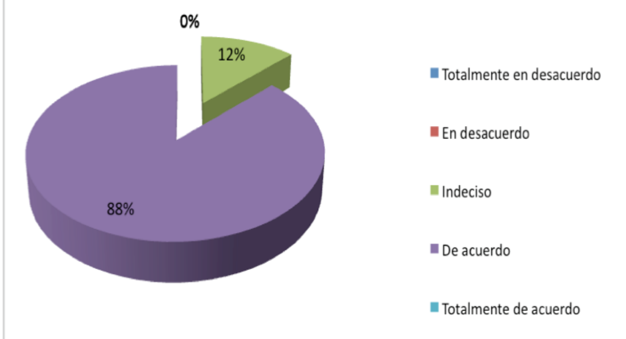

Figura 6. La estructuración de la asignatura es clara y adecuada (cuestionario final)

A la pregunta sobre si el material les ha resultado motivador las respuestas fueron más positivas en el cuestionario realizado al finalizar el curso (fig. 7 y 8). En este sentido manifiestan que los recursos asociados a los conceptos deberían ser más simples y visuales.

- El proceso de aprendizaje

En cuanto al proceso de aprendizaje el 50% de los participantes en el primer cuestionario consideran que el itinerario ayuda a estructurar los contenidos de la asignatura y que favorece el aprendizaje significativo frente al 75% del cuestionario final. El 62% de los alumnos consideran al inicio de curso que el material es un buen recurso para el autoaprendizaje mientras que al finalizar son el 100%.

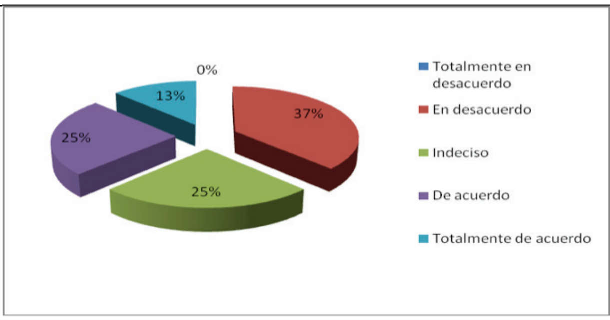

Figura 7. El material resulta motivador (cuestionario inicial)

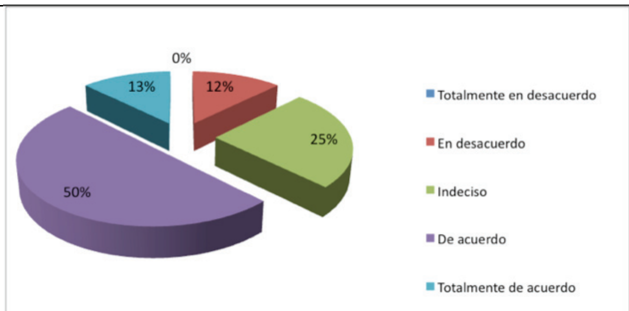

Figura 8. El material resulta motivador (cuestionario final)

Los itinerarios de aprendizaje incluyen una propuesta de actividades para fortalecer los contenidos expuestos y favorecer el aprendizaje. En este sentido valoran positivamente la presencia de dichas actividades, sin embargo en el cuestionario final se observa que sólo uno de ellos ha realizado todas las actividades propuestas (fig 9).

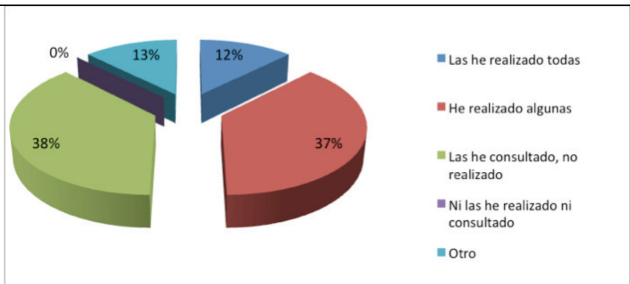

Figura 9. Realización de las actividades propuestas (cuestionario final)

- La interacción/comunicación con el grupo

Por lo que respecta a la interacción y comunicación con los otros alumnos, todos los encuestados consideran útil tener un foro de debate para comunicarse con el resto de compañeros, si fuera necesario. Sin embargo la mayoría no está de acuerdo con que se planteen actividades para realizar en grupo. Sobre si el material debería incluir actividades de autoevaluación el 75% manifiesta que sí.

- El apoyo/tutoría

En cuanto a aspectos relacionados con el apoyo y la tutoría, el 50% de los que contestaron el cuestionario al inicio manifiesta que le ha resultado útil la guía de estudio del itinerario mientras que al final son el 75%. En el cuestionario final la mayoría manifiestan que no han necesitado acudir a tutorías para plantear dudas sobre el contenido.

4.2 Observación de la secuencia de navegación de los estudiantes

Para analizar la secuencia de navegación del usuario por el itinerario se solicitó en el cuestionario inicial que enumerasen el orden en el que habían accedido a los conceptos incluidos en el mapa de presentación, así como el recorrido dentro de cada uno de los itinerarios. En la Fig. 10 se muestran los distintos itinerarios individuales seguidos en este caso en el mapa de presentación de la asignatura por los estudiantes (8) que cumplimentaron el cuestionario inicial.

Las valoraciones hechas por los estudiantes en el cuestionario final sobre la navegación en el itinerario corroboran la importancia atribuida a la posibilidad de navegar de forma autónoma en los itinerarios de aprendizaje, ya que se valora de forma positiva que la navegación por los contenidos no se presente de forma lineal (88%) y que sea el alumno quien tenga el control sobre esta (76%).

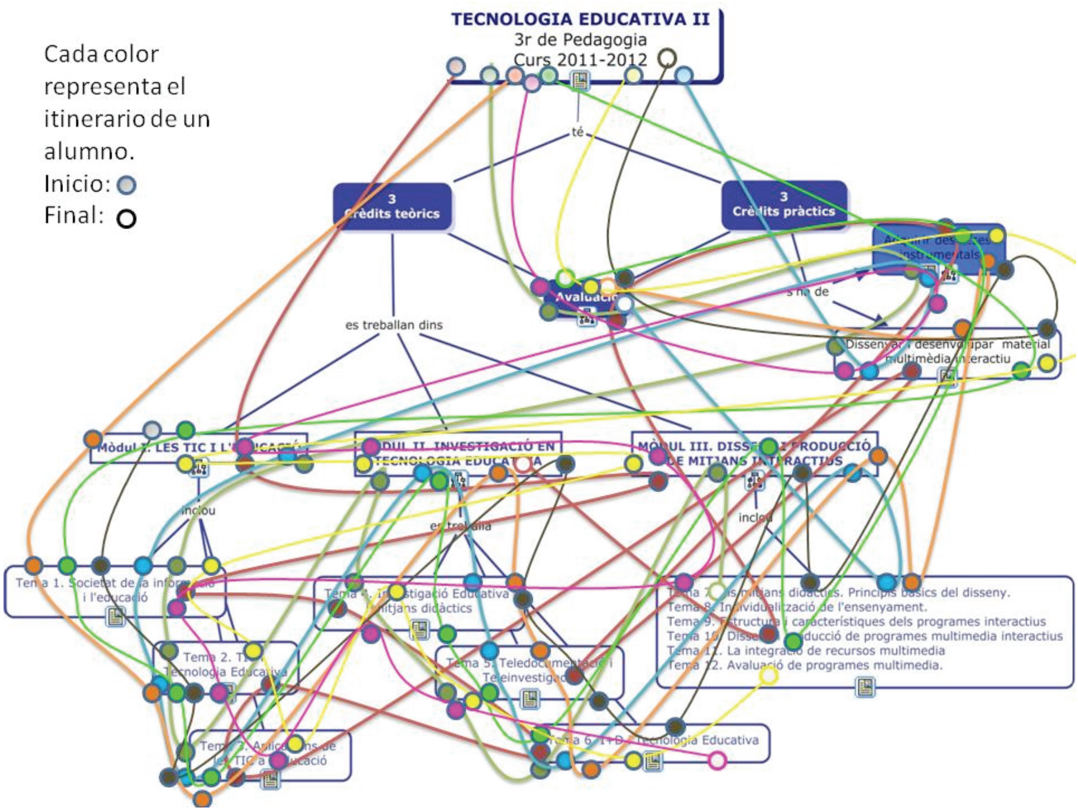

Figura 10. Secuencia seguida por cada uno de los estudiantes

5 Conclusiones

Tal como se ha expuesto en los resultados, la aplicación de un cuestionario de valoración en dos momentos del estudio de la asignatura ha permitido ver la evolución de la opinión sobre el itinerarios de aprendizaje propuesto, mientras que la observación de la secuencia de navegación de los estudiantes ha proporcionado información relevante sobre la adecuación de la navegación, la estructura del itinerario y la organización de los recursos.

Considerando que el número de alumnos que han utilizado el itinerario ha sido inferior al esperado (8 de 15) las respuestas aportadas sugieren diferentes reflexiones:

- El itinerario de aprendizaje puede resultar un buen recurso para el aprendizaje autónomo en niveles universitarios ya que posibilita el control sobre el propio proceso de aprendizaje, ayuda a estructurar los contenidos y favorece el aprendizaje.
- El seguimiento de las secuencias y recorridos, así como de los recursos más utilizados, nos permite identificar algunos elementos donde incorporar mejoras en el diseño de estos itinerarios de aprendizaje, sobre todo en relación con el diseño de los recursos asociados a los conceptos. Al mismo tiempo confirma que la propuesta es pertinente al contexto de utilización y a las características concretas de este grupo de alumnos.
- Los mapas conceptuales se configuran como mapas expertos ya que el alumno puede reconstruir su propio itinerario de aprendizaje a partir del mapa proporcionado en la asignatura, enlazando conceptos, añadiendo recursos,…
- Los itinerarios de aprendizaje basados en mapas conceptuales resultan útiles como organizadores de contenidos fácilmente adaptables y actualizables.
- En este tipo de asignaturas –materias sin docencia y que pertenecen a planes de estudios a extinguir- la interacción y comunicación entre docente y compañeros de curso no resulta un elemento clave y por lo tanto no requiere un sistema de comunicación complejo.

En definitiva, los resultados corroboran algunos de los conseguidos en los anteriores estudios (de Benito, Darder y Salinas, 2012) en cuanto a la idoneidad de los itinerarios de aprendizaje como organizador de contenidos y recursos de aprendizaje, y también se señalan debilidades ya detectadas, también, en la aplicación del itinerario en modalidad semipresencial (p.e. el carácter poco motivador del recurso de acuerdo con la percepción de los estudiantes). La autonomía en la navegación a través de los contenidos y el control sobre le proceso de aprendizaje vienen a ser los aspectos mejor valorados. Al mismo tiempo, deben considerarse mejoras dirigidas a la incorporación de actividades para la autoevaluación como forma de guiar y orientar a los estudiantes en los procesos de toma de decisiones referidas a qué y cómo estudiar, aspectos que se relacionan con la forma de acceder a la información que, en su mayoría, se realiza de forma lineal. Identificar distintos perfiles de navegación y proponer estrategias de acceso adaptadas a conocimientos y experiencias previas, permitirá personalizar la navegación por el itinerario y éste resultará más motivador para el estudiante.

En conclusión, los resultados obtenidos y la incorporación de las mejoras propuestas permitirán poner a disposición de los estudiantes itinerarios con mapas conceptuales que faciliten el aprendizaje autónomo en aquellas asignaturas sin docencia o con un alto contenido de trabajo autónomo.

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KNOWLEDGE MODEL VIEWERS FOR THE IPAD AND THE WEB

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Abstract. Knowledge Models are used extensively by the concept mapping community for a variety of purposes, including education, organizing content, and depicting expert knowledge. The CmapTools software suite automatically generates Web-based (HTML) versions of Knowledge Models when they are stored in a CmapServer. As a result, Web browsers are often the tools used to browse Knowledge Models. However, the HTML generated by CmapTools does not take advantage of new technologies, such as large high-resolution screens and tablets like the iPad. In this paper we present new Knowledge Model Viewer programs for the iPad and the Web that provide an improved navigation experience.

1 Introduction

Within the concept mapping community, and in particular among the CmapTools software (Cañas, Hill, et al., 2004) users, a *Knowledge Model* is considered to be an organized collection of concept maps and associated linked resources about a particular domain of knowledge. Knowledge Models are often built as part of a knowledge elicitation and documentation project (Coffey et al., 2003; Ford et al., 1992; Hoffman et al., 2001), but are also used as a tool to organize and navigate through collections of resources. Research has shown that a Knowledge Model is an effective tool to navigate and search through large collections of resources (Carnot et al., 2001). Large Knowledge Models often consist of hundreds of concept maps and thousands of linked resources, as is the case of the *Return to Mars* project (Briggs et al., 2004). Knowledge Models have been proposed and used for course content creation and delivery (Cañas & Novak, 2010; Coffey, 2008; Coffey & Cañas, 2003) and for curriculum development (Heinze-Fry & Ludwig, 2006). In addition, the construction of Knowledge Models by students is part of the concept map-centered learning environment proposed by Novak & Cañas (2004) in their New Model of Education.

2 Knowledge Models in CmapTools

Support for the construction and maintenance of large and small Knowledge Models was one of the main objectives in the design of CmapTools (Cañas, Hill, & Lott, 2003). Figure 1, part of the CmapTools website, summarizes the tools and features that CmapTools provides for the construction of Knowledge Models. In particular, CmapTools encourages the collaborative building of Knowledge Models, whether they are a knowledge engineer and an expert, students learning in teams, or other collaborative efforts. As a result, CmapTools has been used to develop Knowledge Models by users of all ages.

3 HTML Version of Cmaps

A popular feature of the CmapTools suite is the automatic generation of an HTML (Web) version of Cmaps[1] that are stored in a CmapServer, which can then be viewer and navigated using a Web-browser (Cañas, Carvajal, et al., 2004). Links from concept maps to other maps or to other linked resources (e.g. Web pages, videos, images, PDFs, etc.) can be opened when browsing the Web version of Knowledge Models. The CmapTools architecture allows the Knowledge Model to span beyond a single CmapServer, with Cmaps and resources located anywhere on Internet (Cañas, Hill, Granados, et al., 2003). The CmapTools (http://cmap.ihmc.us) and the International Conference on Concept Mapping (http://cmc.ihmc.us) Websites are examples of Web-based Knowledge Models that are familiar to the Cmappers community.

The Web versions of the Cmaps generated by CmapTools have limitations that can be classified into two types. First, there are features of the Cmaps themselves that are available in CmapTools that don't work on the Web version, including Annotations, Discussion Threads, Knowledge Soups, Nested Nodes, and the Info box that is displayed when the mouse is left over a concept. The purpose of generating a Web version was to provide a 'browsable' version of the Cmap, not an editable or collaborative version, and so the Annotations, Discussion Threads and Knowledge Soups don't fit within the stated purpose. The Nested Nodes and Info box do belong within intended objectives, but are not implemented.

[1] We use the term Cmap to refer to a digital concept map created with CmapTools.

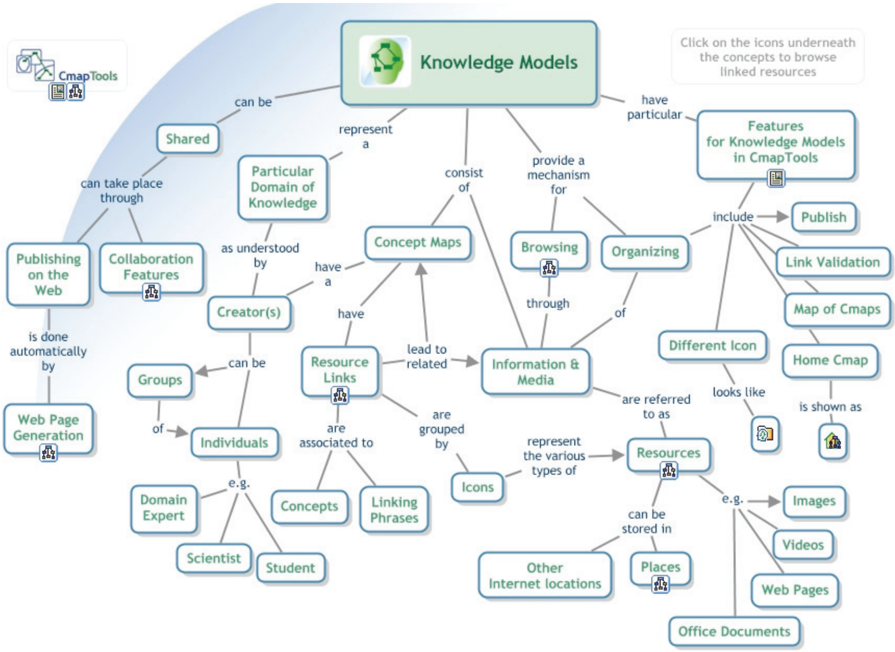

Figure 1. Support for Knowledge Models in CmapTools (from http://cmapskm.ihmc.us/rid=1064009710027_1421983319_27104/).

The second limitation is due to the way the Web version of the Cmap is implemented, which consists of a static image of the Cmap together with javascript code to implement the links on the icons under the concepts. The static image implies that the size and resolution of the Web version of the Cmap is determined at the time the Web-version of the Cmap is generated and does not take into account the size or resolution of the screen where the Cmap is viewed. For example, a Cmap may display very small on a large 27” screen, not taking advantage of the size and high resolution of new screens, or will display larger than the size of the screen on a small netbook. The limitations in the implementation are more obvious, and critical, when browsing a Knowledge Model using a tablet such as an iPad or a smartphone: the icons underneath the concepts that are ‘clicked’ to display the list of linked resources are most of the time displayed too small to be ‘tapped’ on a tablet. In this paper we report on an effort to overcome this second limitation.

4 Objectives of the New Viewers

To provide a better experience while navigating through Knowledge Models on an iPad and on the Web we developed a Viewer program for each platform. The development of these two Viewers followed the following objectives:

4.1 Scalable Viewer

The Viewer should scale the Cmap to the size of the window or screen instead of displaying a static image. To achieve this, the Viewer renders the CXL (Cañas et al., 2006) version of the Cmap as an SVG image. Since the Viewer renders the image at the time its displayed, it is presented at the highest resolution and taking advantage of the size of the screen or window. In addition, if the Cmap is resized the image is re-rendered without any loss in quality.

4.2 Presentation Mode

To better present the Cmaps, the Viewer should provide the possibility of displaying the image scaled to the size of the display. On the iPad the Cmap takes over the whole screen. On the Web, the Viewer scales the image to fill the browser’s windows. If the browser provides the feature of displaying full-screen, it will then allow the display of the Cmap full screen. The Viewer will scale and re-render the Cmap to fill the screen as the user resizes the window or enter/exits the Presentation Mode.

4.3 Lists of Resources

Briggs (2004) -- who has built some of the largest Knowledge Models we are aware of -- reports on the need to provide alternative ways to reach Cmaps and resources in addition to navigating from an single Root Cmap. His Return to Mars project (http://cmex.ihmc.us) provides a categorized list of Cmaps that provides users a means to open a Cmap directly. The Viewers should provide categorized lists of resources in addition to Cmaps, such as videos, images, documents, Web pages, etc. Through these lists the user should be able to select these resources directly.

4.4 Configurable

The Knowledge Model support on the CmapServer does not provide all the information needed by the Viewers, as will be explained when each Viewer is discussed in detail below. Therefore, the Viewers should read the lists of resources to display and other configuration information from a configuration file. The knowledge modeler sets up the configuration file providing the Viewer all the information it needs to display the browse-able Model.

5 The Viewer Architecture

For each Knowledge Model separate Apps are generated: an iPad Viewer App and a Web Viewer App. A suite of programs, as shown in Figure 1, generates these Apps. As described above, the knowledge modeler specifies a configuration file. This file consists of two sections. The first section contains basic configuration information such as the name of the App, icons for the App, Help videos, and other basic configuration information. The second section consists of a list of Cmaps and other resources to be included in or referenced by each App, and the categories for the classification of the resources. For each of the resources the configuration file will indicate information indicating whether the resource will be included in the iPad App as a local resource or a remote source, the URL to the resource in a CmapServer, the type of resource, etc.

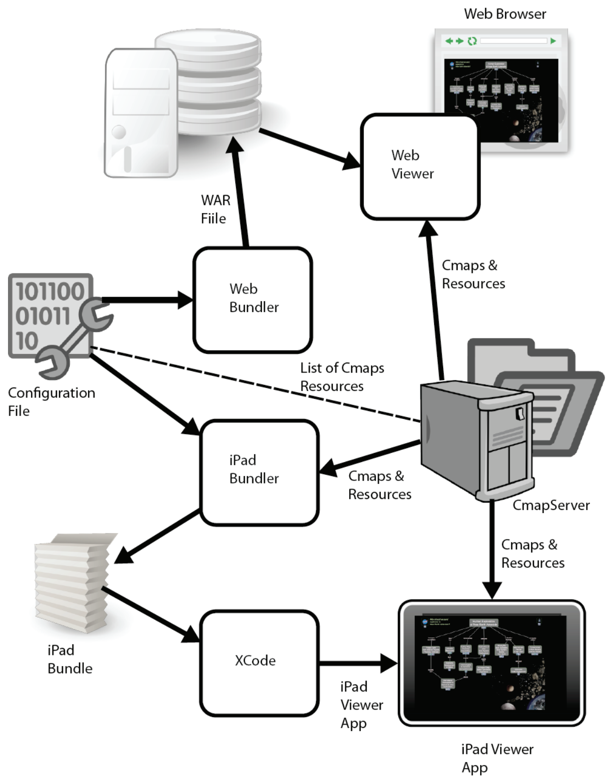

Figure 2. Architecture of the environment used to generate the iPad and Web Viewer Apps.

For the iPad Viewer, a separate iPad App is generated for each Knowledge Model. An iPad Bundler program obtains configuration information from the configuration file, retrieves from the CmapServer(s) the resources that are to be stored locally in the iPad in CXL format, and generates an iPad Bundle (set of files). Using Apple's Xcode Development Environment, the information in the iPad Bundle is used to generate an App that contains the iPad Viewer and all the local resources. This App is then transferred to the iPad, where it can be used to browse through the Knowledge Model.

In the case of the Web Viewer, a Web Bundler program obtains configuration information from the same configuration file and generates a WAR file that is then transferred to a server machine to run under the Tomcat Web server. In the case of the Web Viewer, there are no "local" resources to be retrieved at this stage. That is, all resources accessed by the Web Viewer are from the CmapServer or other Internet locations. The Web Viewer app is then launched from a Web Browser program to navigate through the Knowledge Model.

6 Sample Apps: Rationale for Human Space Exploration & Cmappers.Learn

We present two examples of Knowledge Models for which Viewer Apps have been generated.

6.1 SpaceExp: Rationale for Human Space Exploration

As part of a research project at IHMC sponsored by NASA, we developed a large-scale Knowledge Model on the *Rationale for Human Space Exploration*. The purpose of the effort was to construct collection of concept maps and associated resources that explained why humans should continue to explore space. The target user was any 'intelligent, interested' user. The project covers the human exploration of the Moon, Mars, Mars' Moons, and Near Earth Asteroids. It also incorporates a large number of maps and resources from the Return to Mars project developed by Briggs (2004) mentioned above.

The Knowledge Model consists of 130 Cmaps. After confirming that short video clips from expert scientists and astronauts from NASA were a fitting complement to the Cmaps, 227 interview video clips were prepared and linked to the Cmaps. Several hundred other video clips, and over a thousand images and Web pages were included in the Knowledge Model. The Web Viewer for the SpaceExp Knowledge Model can be reached at http://spaceexp.ihmc.us.

6.2 Cmappers.Learn

The second Knowledge Model for which Viewers were generated corresponds to the Cmappers.Learn site for learning how to do concept mapping through the navigation of Itineraries (Cañas & Novak, 2010). This is a much smaller Knowledge Model, which is under development and currently consists of less that 10 concept maps. It provided a good contrast to the large scale SpaceExp Knowledge Model.

7 iPad Viewer

Figure 3 shows a screenshot of the full screen display of a Cmap/Itinerary from the Cmappers.Learn iPad App. Tapping on a concept that has resource icon(s)s displays a list of all resources that are linked to that concept, as shown in the figure. In Figure 4, a Cmap from the SpaceExp Knowledge Model is not displayed full screen, allowing the list of categories to display at the left (in this case "Human Space Exploration", "Moon", "Mars", "Asteroids", "Videos"). If a category is tapped, the list of local resources for that category is displayed, from which a resource can be tapped to display it. Above the list a search box allows the user to search for Cmaps and resources that match a term.

The configuration file determines which resources are copied onto the iPad and which ones remain in the CmapServer(s), allowing the knowledge modeler to decide the desired size of the App (storing videos on the iPad consume a lot of memory). Figure 4 shows a user tapping on a concept to display the list of linked resources.

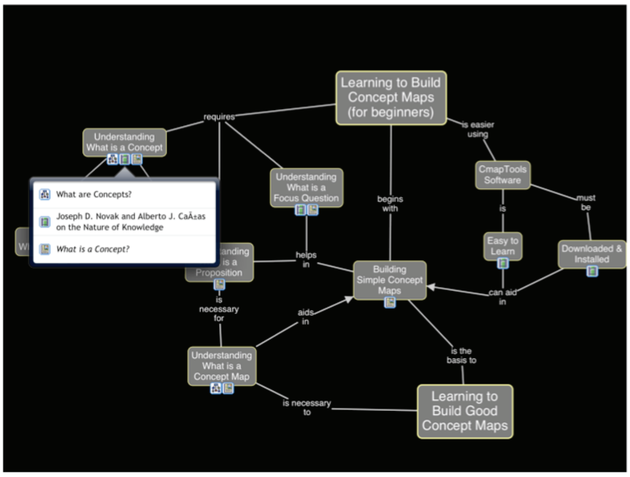

Figure 3. A full screen screenshot of the Cmappers.Learn iPad App showing a list of resources linked to a concept.

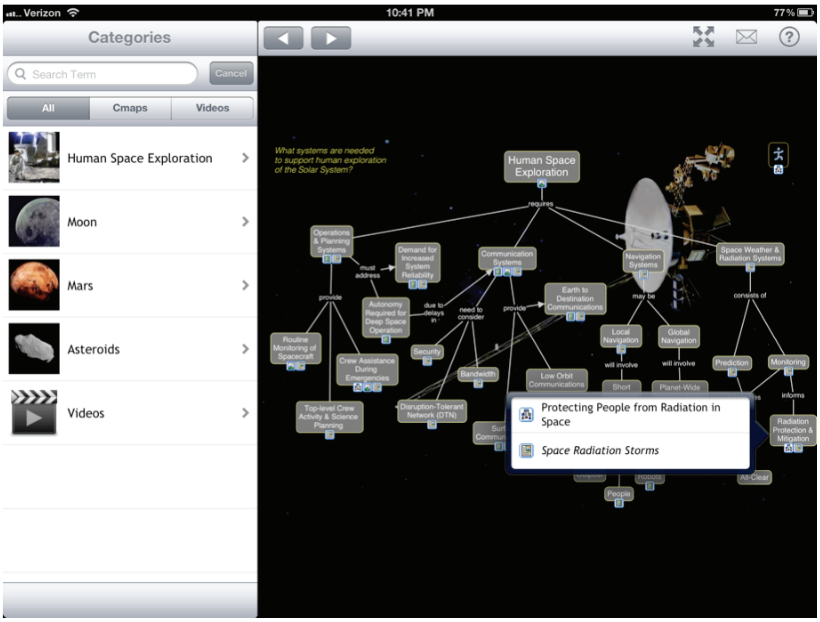

Figure 4. The SpaceExp iPad App with the list of categories on the left which provide access to the lists of resources stored locally on the iPad. The App also allows users to search for Cmaps and resources that match a term.

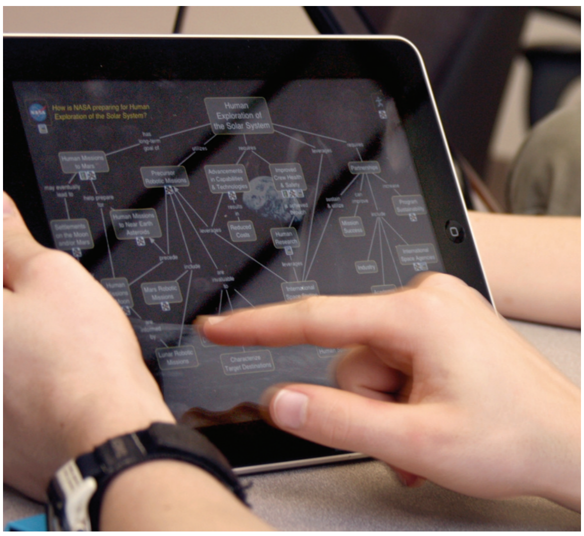

Figure 5. User tapping on a concept to navigate through the SpaceExp iPad App.

8 Web Viewer

The Web Viewer provides a much better navigation experience than the Web version of the Cmaps. Figure 6 shows the Root Cmap for the SpaceExp Knowledge Model. Menu entries above the Cmap provide options to "Enter Presentation Mode" and to display the list of "Cmaps and Videos" (see Figure 7). The Cmap displayed is scaled to fill the available space in the browser's window. The Web Viewer retrieves the Cmaps in CXL format from the CmapServer and renders the Cmap in SVG. Figure 7 shows a partial view of the list of Cmaps available under the selected Asteroids category, displayed after selecting the "Cmaps and Videos" category in Figure 6. To display the rest of the list of Cmaps the user must scroll window in the Web Browser. Figure 8 shows the result of clicking on the "Presentation Mode" option. The Web Viewer rescaled the Cmap to the size of the window. Some Web Browsers have the option to remove the top tab or menu and display the Cmap full screen.

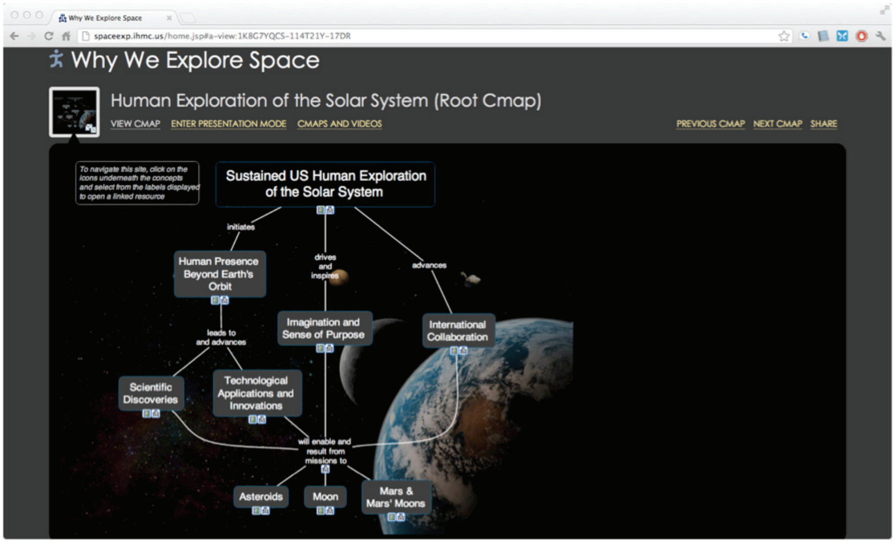

Figure 6. The Root Cmap for the Web Viewer version of the SpaceExp Knowledge Model.

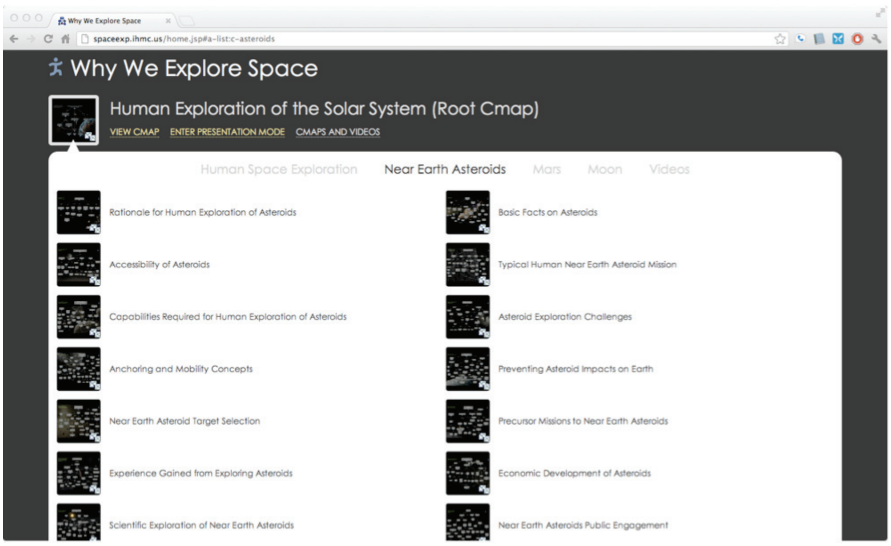

Figure 7. The List of Categories and a partial view of the list of Cmaps on Asteroids as displayed by the Web Viewer of the SpaceExp Knowledge Model.

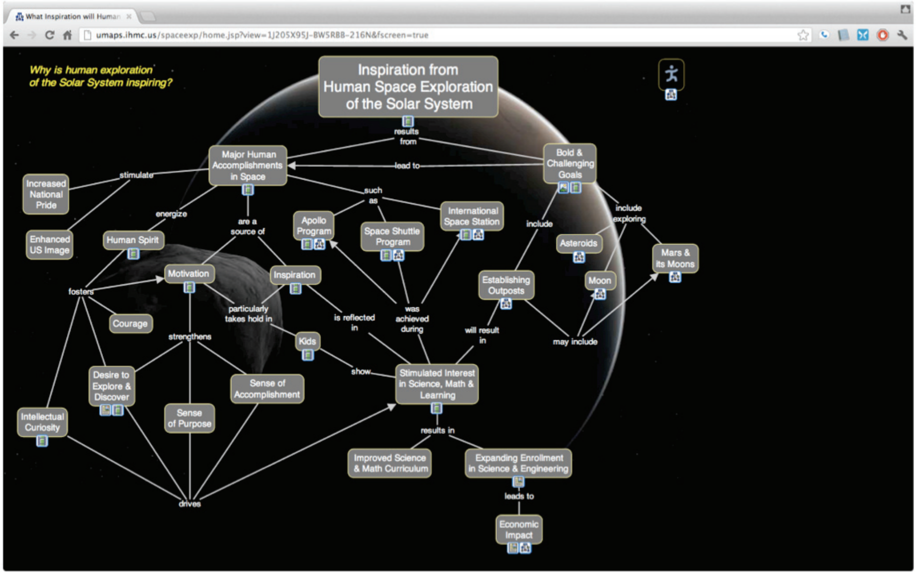

Figure 8. The Web Browser window after the Presentation Mode option is selected in the Web Viewer for the SpaceExp Knowledge Model.

9 Conclusions

New Knowledge Model Viewers for the iPad and the Web have been developed that improve on the navigation experience of the HTML-based Cmaps generated by CmapTools. A software environment utilizes user-prepared configuration file to refer to or retrieve Cmaps and other resources stored in a CmapServer to generate Viewer Apps (a WAR file and an iPad App) for each particular Knowledge Model that are then stored on a Web server and moved to iPads.

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LA SUPERVISION DE ADULTOS: USO DE MAPAS CONCEPTUALES DE RUTA COMO HERRAMIENTA PARA AUMENTAR LA COHESION, MOTIVACION Y MEMORIZACION

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Abstract. El presente artículo aborda la utilización de mapas conceptuales de ruta como herramienta en el marco de las supervisiones de adultos (coaching). Este estudio empírico, basado en una larga experiencia laboral con grupos de empleados de asociaciones y de funcionarios en Bélgica francófona, muestra como la creación de mapas conceptuales se constituye en el eje, en torno del cual, el grupo logra mejorar sus capacidades de memorización y desarrolla mejores niveles de motivación y de cohesión. En efecto, la elaboración de los mapas conceptuales durante las sesiones de trabajo de una supervisión -ya sea una misión de proyecto, de equipo u organizacional-, permite ir más allá del simple intercambio de información. En este caso, el mapa conceptual de ruta sirve a la vez como documento colectivo que sintetiza la labor llevada a cabo, como instrumento de presentación de resultados a personas externas al grupo y como soporte para la toma de decisiones. En el marco de la supervisión el mapa conceptual de ruta es el objeto de un aprendizaje colectivo y permite al supervisor el buen desempeño de las funciones de una reunión (facilitación, producción, regulación y elucidación). En el artículo se describe la manera en la que el mapa conceptual de ruta es propuesto y elaborado por el supervisor, así como algunos ejemplos de mapas realizados en el marco de dicho trabajo.

1 Introducción

La supervisión de adultos, actividad que permite a las personas implicadas trabajar en torno a un objetivo común, requiere las competencias del supervisor para el diseño y la aplicación tanto de una metodología como de la escogencia y el uso de herramientas pedagógicas convenientes en la realización de los objetivos del trabajo en grupo. Las herramientas pedagógicas desempeñan un papel fundamental en la supervisión y merecen una atención especial en su selección y aplicación, ya que son utilizadas por el supervisor a la vez para la animación de las sesiones de trabajo y para la recolección de información que emerge a lo largo de los debates. De igual manera, de su adecuada presentación y manejo depende la motivación del grupo, su cohesión, y la capacidad de memorizar a corto y a largo plazo, la información gestionada durante las sesiones de trabajo.

Nuestra experiencia de terreno, de varios años de supervisión de adultos a nivel individual y grupal en el medio asociativo y administrativo de Bélgica francófona, ha hecho que nos cuestionemos acerca de las herramientas pedagógicas utilizadas durante dichas sesiones de trabajo. Sesiones en las que se requiere del registro de la información principal, procedente de las interacciones grupales, de tal manera que sea tanto de fácil acceso como de buena comprensión para las personas que pertenecen al grupo –y/o que son externas a él-. Durante nuestro trabajo, hemos observado que se requiere de alternativas modernas que permitan un desarrollo exitoso de la supervisón, es decir, que permita al supervisor desempeñarse de manera eficiente, asegurando la obtención y una optima trasmisión de la información, e igualmente el registro de la misma de manera rápida y precisa; todo esto, manteniendo al grupo motivado y unido en torno a su problemática particular.

Según nuestra experiencia, los soportes pedagógicos "tradicionales" tales como la elaboración de carteles se muestran dispendiosos, difíciles e implican tiempo extra de trabajo para el supervisor. En cuanto a las herramientas informáticas en pedagogía utilizadas actualmente en la supervisión de adultos en el medio asociativo y administrativo, son raras y no constituyen un verdadero apoyo para aumentar el índice de cohesión, motivación y memorización en los grupos supervisados. También hemos constatado que una gran mayoría de supervisores continúan utilizando herramientas tradicionales y que, en cierta medida, se muestran temerosos y dubitativos en cuanto a la utilización del ordenador y de programas informáticos durante las sesiones de supervisión.

Buscamos entonces responder a las preguntas: *¿Es posible utilizar herramientas informáticas pedagógicas en supervisión?,* si la respuesta es positiva *¿Cuál(es) es (son) la(s) más adecuada(s)? y ¿Cómo aplicarla(s)?* En caso de utilización de una herramienta informática pedagógica *¿Es posible adaptarla de tal manera que el grupo de supervisión tenga una reacción positiva?, ¿Cuáles son los beneficios para el grupo?, ¿La herramienta permite al grupo mejorar la memorización a corto y largo plazo sobre los distintos aspectos analizados colectivamente? si la respuesta es afirmativa ¿Cómo probarlo?...* Experimentamos varias herramientas informáticas pedagógicas, tales como "Imind Map 5", "Freeplane", "Xmind" y "CmapTools", entre otros. Finalmente encontramos una solución en los "mapas conceptuales de ruta" (Cañas y Novak 2010) elaborados específicamente con el programa CmapTools.

En el proceso de elaboración, por ejemplo, observamos que los mapas conceptuales de ruta permiten la evolución del grupo no solamente en el plano cognitivo, sino también en la motivación, la cohesión, la creatividad y la memoria a corto y largo plazo. Observamos también que con el tiempo, los "supervisados", son capaces de leer los mapas conceptuales de ruta realizados meses antes sin ambigüedades, lo que no ocurre con el producto de los otros programas y técnicas aplicadas. Nuestra experiencia ha demostrado también que no solamente la motivación, la cohesión y la memorización de los grupos de supervisados se fortalecen gracias a la utilización de dichos mapas, sino que el trabajo de post-intervención, con frecuencia dispendioso para el supervisor (retranscripción de afiches, redacción de una síntesis, etc.), se reduce a "cero" gracias a su elaboración durante la sesión. El programa CmapsTools permite libertad de desplazamiento de los componentes del mapa e indica la dirección de los enlaces que presentan relaciones complejas y permite tener una visión sistémica con respecto a cualquier tema.

De esta manera, proponemos los mapas conceptuales y la utilización del programa CmapTools como una novedosa herramienta informática en pedagogía que ofrece la posibilidad de cumplir con las exigencias de los supervisores. Según nuestras informaciones, provenientes de la observación y análisis empírico de la supervisión de grupos, es la primera vez que en el medio de supervisión de adultos en Bélgica francófona se aborda esta inquietud, lo que confiere a nuestro tema de investigación, y sujeto de esta publicación, un carácter innovador. Este artículo constituye un primer aporte de elementos críticos y analíticos referentes al uso de esta herramienta informática en pedagogía aplicada a la supervisón.

Puesto que desde hace algunos años hemos estado utilizando regularmente los mapas conceptuales y el programa informático CmapTools como herramienta informática en pedagogía, las informaciones que abordaremos en el presente artículo son el resultado de este trabajo, concretamente en los años 2011 y 2012. Llamamos la atención del lector sobre el hecho que este trabajo esta básicamente fundado en nuestro conocimiento empírico y nuestras "notas de investigación", ya que hasta el momento no hemos realizado un estudio científico ni conocemos uno publicado acerca del tema.

Para desarrollar nuestra reflexión, trataremos de probar la hipótesis que "*la creación y uso de mapas conceptuales de ruta permite al grupo de supervisión mejorar sus competencias de aprendizaje, cohesión, motivación y memorización a corto y largo plazo*".

Nuestra reflexión inicia con una explicación sobre los mapas conceptuales de ruta en la gestión del conocimiento. Enseguida exploraremos el concepto de supervisión de equipos de adultos y sus características, lo que nos permitirá abordar la metodología y las herramientas utilizadas para este trabajo, entre ellas los mapas conceptuales de ruta. Presentaremos algunos ejemplos de mapas aplicados a la gestión del conocimiento en el marco de la supervisión de equipos y finalizaremos nuestro artículo con una reflexión sobre la contribución de los mapas en el incremento de las competencias citadas anteriormente.

2 Los mapas conceptuales de ruta en la gestión del conocimiento

Si bien, el mapa conceptual fue desarrollado como herramienta para representar la comprensión conceptual de los niños y para ser capaz de registrar cambios explícitos en las estructuras conceptuales y proposicionales de los mismos (Novak y Cañas, 2006), con el tiempo se ha convertido en un útil importante para representar diferentes dominios del conocimiento humano: en educación para comprender, mejorar y evaluar el proceso de enseñanza-aprendizaje; en la gestión del conocimiento, para capturar y archivar la información del experto de manera que sea fácil de utilizarlo por otras personas; finalmente se sabe que son utilizados en negocios por empresas y asociaciones en actividades de las que se tiene oficialmente poca información (Novak y Cañas, 2010).

Conservando la idea general del mapa conceptual, la de representar en forma gráfica el conocimiento a través de proposiciones, actualmente nos confrontamos a diferentes tipos de "mapas conceptuales". En efecto, de la idea original de Novak surgen derivaciones a las que se han nombrado "itinerarios", definidos como "los mapas conceptuales que guían al alumno a través de un conjunto de objetos de aprendizaje en el estudio de un tema" (Cañas y Novak 2010, p.268), y "mapas de ruta" definidos como un "itinerario formativo" (Sierra-Orrantia, 2010, p.313).

En nuestro trabajo de supervisión, los mapas conceptuales son requeridos en la captura y archivo del conocimiento del individuo o del grupo de manera que la información sea representativa y accesible tanto al grupo como a otras personas. Usaremos el término “mapa conceptual de ruta” para identificar nuestros mapas, y lo definimos como: un mapa conceptual que condensa el conjunto de información procedente de las sesiones de supervisión.

3 La supervisión de equipos o grupos

Se trata de una actividad que permite a las personas relacionadas y/o con afinidades profesionales trabajar en torno a un objetivo común. Las características de la supervisión son comparables a las de la intervención psicosociológica organizacional en el sentido que el análisis de la demanda o la creación de un contexto favorable de intervención se lleva a cabo, generalmente con el grupo de supervisión (Salamanca-Ávila, 2003). Basados en Dubost (1987), resumimos esta actividad en los siguientes pasos:

- *Creación de la relación entre el supervisor y los supervisados*: en esta etapa es importante responder a las preguntas siguientes: ¿Quién pide la intervención?, ¿Cómo define el problema cada una de las personas del futuro grupo de supervisión?, ¿En qué consiste este problema?, ¿Cuáles factores influyen en él? ¿A qué fenómenos o situaciones está ligado?, ¿A qué personas? ¿Cuál es el proceso que los interlocutores imaginan poner en práctica para resolver el problema?
- *Análisis detallado y determinación del nivel de análisis de la demanda*. El supervisor determina las hipótesis sobre el porqué de la situación del grupo, los actores implicados y la pertinencia de una supervisión de grupo, como respuesta adecuada a los problemas por los cuales fue llamado.
- *La restitución de la información*. Se comunica al grupo la manera en que el supervisor analiza la situación, el nivel de análisis y el tipo de acción que convendría aplicar para resolver el problema así como la fijación de los objetivos esperados de la intervención. En función del análisis, el supervisor puede plantear varios escenarios de intervención que pueden ir más allá de la supervisión, como por ejemplo, una auditoría organizacional o una formación en un tema específico.
- *Ayuda concerniente la toma de decisión*. El supervisor explica su análisis, hipótesis y su propuesta. Si la supervisión es la solución adecuada, entonces presenta la tipología con el fin de validar el nivel de análisis, de obtener el acuerdo del grupo y pasar a la planificación de las sesiones de trabajo.

En cuanto al nivel de análisis, podemos clasificar la supervisión en cuatro tipos principales:

<table>
<tr><th>Tipo</th><th>Objetivo</th><th>Metodología</th><th>Herramientas pedagógicas</th></tr>
<tr><td>**Clínica**</td><td>Restablecer la comunicación
Encontrar pistas de solución del problema</td><td>Debate
Mediación
Lluvia de ideas, etc.</td><td>Ninguna
Carteles</td></tr>
<tr><td>**De equipo o de grupo**</td><td>Analizar y/o producir procesos, posturas deontológica, metodologías de trabajo, etc.</td><td>Debate
Lluvia de ideas
Análisis de discursos
Análisis de practicas, etc.</td><td rowspan="3">Afiches elaborados a mano
Programas informáticos:
Power Point
Imind Map 5
Freeplane
Xmind
CmapsTools</td></tr>
<tr><td>**De proyecto**</td><td>Elaboración de proyecto
Evaluación de proyecto</td><td>Análisis de situaciones, de casos, gestión y evaluación de proyecto, etc.</td></tr>
<tr><td>**Organizacional**</td><td>Definir estrategias organizacionales, los valores, la descripción de funciones, el organigrama, etc.</td><td>Definir estrategias organizacionales, los valores, la descripción de funciones, el organigrama, etc.</td></tr>
</table>

Tabla 1. Tipología de la supervisión de grupos

La supervisión de equipos se realiza en un marco ético que permite al supervisor y al grupo guardar la confidencialidad de las charlas - y/o de los resultados- durante y después de la sesiones de supervisión. El contrato es, algunas veces, la única referencia de los compromisos de que disponen las dos partes. Por lo tanto, e independiente del objetivo, el equipo es libre de decidir el momento de la transmisión de la información, la forma que ésta puede tomar y los interlocutores apropiados.

El supervisor propone la confidencialidad de la supervisión con respecto a su entorno -a otros colegas, amigos, y a cualquier persona externa al grupo- y, a veces, el secreto profesional, que consiste en el compromiso de no hablar de lo ocurrido durante las sesiones con las personas que asistieron a la misma.

El marco de la supervisión está así determinado por su contrato, en el que el intercambio y/o la producción de información es importante. A veces, éste suele estipular la lista de documentos que hay que producir con el objetivo de presentarlos a personas externas al grupo. Es en este marco que el supervisor se centrará en la elección de las herramientas y/o de los programas informáticos más relevantes.

En cuanto al supervisor, puede tratarse de un psicólogo, sociólogo, experto en recursos humanos, en educación de adultos o de otras áreas relacionadas con el manejo de la dinámica de grupo, proporcionando experiencia en materia de supervisión. El papel del supervisor es doble. Por un lado, crear un contexto favorable -nivel de análisis, condiciones de confidencialidad, restitución de la información, etc.-, acompañando al grupo durante un proceso de intercambio y producción de información. Por otro, está llamado a regular el grupo, a facilitar el debate y a acompañar los procesos de metacomunicación.

Independientemente de su trabajo, el supervisor es un experto de la facilitación y el manejo de los aspectos de facilitación y control de contenido digital y analógico de la relación (Watzlawick, 1972). También es un especialista en mediación en el sentido básico del término: su misión es la de permitir y mantener la comunicación. Gracias a su papel de "tercero", garantiza su posicionamiento externo al grupo y, con base en sus competencias, es capaz de que cuestionar, de hacer emerger, de hacer compartir informaciones y visiones de la realidad en torno a objetivos comunes. El supervisor garantiza así las cuatro funciones de animación de una reunión (Anzieu, 1973): la *regulación* (vehicula las interacciones), la *facilitación* (toma iniciativas para facilitar la producción del grupo), la *producción* (ayuda al grupo a cumplir su objetivo) y la *elucidación* o la *metacomunicación* (toma de conciencia de la dimensión afectiva o emocional así como la explicitación de conflictos relacionales en el grupo). El desarrollo del mapa conceptual de ruta es, en este sentido, una herramienta que nos permite llevar a cabo estas funciones.

El supervisor es en este sentido un moderador de la dinámica de grupo, tal como Bonner (citado por Bany y Johnson, 1971) la describe: "la naturaleza dinámica del grupo evoluciona porque sus miembros alteran constantemente sus relaciones entre sí. Los cambios se producen porque los individuos que interactúan están influidos por diversas tensiones que tratan de resolver para recuperar su equilibrio".

4 Metodología. Los mapas conceptuales de ruta en la supervisión de equipos

El público de la supervisión de adultos en el medio asociativo y administrativo en Bélgica francófona, está constituido por personas adultas con un nivel académico técnico o universitario con base en una clasificación estipulada por el ministerio del trabajo y la Federación Bruselas-Walonia. Las sesiones de supervisón tienen lugar durante las horas de trabajo y son remuneradas por la institución. En general las sesiones duran tres horas. A menudo, el tiempo entre una sesión y otra varía entre seis y diez semanas y cada grupo puede planificar entre tres y diez encuentros por año en función de los objetivos y del presupuesto.

Los mapas conceptúales son elaborados por el supervisor, siguiendo el siguiente esquema:

- Al inicio de la sesión de supervisión se recuerda a los participantes los detalles del contrato y se fijan los objetivos.
- Enseguida, al abrir el programa CmapsTools, se anuncia al grupo que el debate será resumido utilizando esta herramienta.
- La hora siguiente es dedicada a la discusión en grupo. De manera simultánea, se va elaborando el mapa de ruta y su construcción se proyecta sobre una pantalla, sin hacer referencia a la misma.
- Durante la segunda parte, el mapa comienza a ser 'alimentado' por el grupo que propone nuevos enlaces o conceptos.
- La última parte de la supervisión se dedica a perfeccionar el mapa.
- Los últimos minutos (al menos 15) de la sesión se dedican a la lectura del mapa por parte de los miembros el grupo.
- El mapa es impreso y cada persona recibe una copia.
- El mapa puede ser modificado y/o completado al inicio de la siguiente sesión de supervisión.

4.1 Los mapas conceptuales y el aprendizaje colectivo

Consideramos que el grupo de supervisión es un conjunto de personas en proceso de aprendizaje, de hecho, e independientemente de la finalidad, cada miembro se encuentra en medio de un proceso de adquisición y/o de transformación de las representaciones. El grupo constituye, en este marco un sistema de interacciones simétricas o igualitarias (Watzlawick, 1972) lo cual facilita la metacomunicación. El efecto de esta perspectiva relacional según nuestra experiencia, consiste en aumentar la posibilidad de emitir críticas constructivas lo cual induce un aprendizaje a corto y largo plazo así como una motivación importante.

De hecho, este proceso de aprendizaje está vinculado por lo menos con tres actividades cognitivas (Stordeur, 2009):

1. *Comprensión de conocimientos y de fenómenos complejos*: es la capacidad de un grupo de intercambiar puntos de vista diferentes sobre un tema y construir poco a poco nuevas informaciones y una síntesis de las mismas. En este sentido, la elaboración de los mapas conceptuales de ruta permite llegar a las representaciones comunes o nuevas de situaciones complejas. Por lo tanto, este proceso está íntimamente relacionado con la emergencia de conocimientos tácitos que se constatan casi cada vez que se finaliza con un mapa conceptual: "¡Es genial, no sabíamos que conocíamos tantas cosas tan complejas!"
2. *Desarrollo de nuevas técnicas, enfoques, soluciones, etc. :* a través de la construcción del primer mapa de base los grupos son capaces de recordar más fácilmente los conocimientos, las informaciones y las cuestiones ya discutidas y, con base en un primer mapa, el grupo puede ir más allá en la elucidación y/o en la producción de nuevas representaciones.
3. *La memorización de la información a corto y largo plazo:* en efecto, constatamos que después de la primera supervisión, los participantes son capaces de leer de nuevo el mapa conceptual de ruta de la supervisión anterior, de la misma manera que se hizo el día de su creación. En algunos grupos, se encontró que incluso después de un año, los miembros se refieren a los elementos de los mapas, a las palabras clave, a las proposiciones, a los colores y/o a las formas de los mismos. Por consiguiente, son capaces de mantener y utilizar un conjunto de información o conocimiento a largo plazo.

Para concluir esta parte, creemos que los mapas conceptuales de ruta permiten al grupo desarrollar nuevos mecanismos de memorización. Según Stordeur (2009) cinco condiciones de memorización deben estar presentes en todo proceso cognitivo: buenas condiciones materiales, la capacidad de evocar, la capacidad de asociar las informaciones entre ellas, y entre las antiguas y las nuevas, la capacidad de priorizar la información y de organizarla, y finalmente la posibilidad de poder consultar repetidamente la información para almacenar su contenido. Hemos constatado que los mapas realmente permiten garantizar estas condiciones.

4.2 La gestión del conocimiento y la cohesión de grupo

La cohesión de grupo es un fenómeno complejo, ya que no es observable ni medible (Bany y Johnson, 1971; Parlebas, 2002). Esta implica el desarrollo del espíritu de equipo, la solidaridad entre los miembros del grupo y la capacidad de identificarse con los demás. Así, según sus autores, la cantidad y calidad de las interacciones dentro de un grupo están estrechamente relacionadas con el desarrollo de la cohesión. Sin cohesión, el rendimiento del trabajo se vería comprometido.

Creemos que la cohesión de los grupos de supervisión es estimulada por la supervisión, ya que es un “espacio-tiempo” privilegiado y protegido por un acuerdo en el cual la confidencialidad es una parte importante. El desarrollo del mapa conceptual de ruta es en este sentido, una herramienta para fomentar el espíritu de equipo porque al ser una producción colectiva con muchas posibilidades de ser presentada, el mapa es el objeto en torno al cual el grupo se reúne y se identifica. El resultado (el mapa) es a menudo objeto de orgullo: “¡No pensábamos que éramos capaces de hacer un mapa tan complejo y que sabíamos tantas cosas!”

La solidaridad está estrechamente relacionada con el desarrollo de competencias interpersonales, descritas por Andreetta di Blassio (2009) como el conjunto de habilidades que un individuo desarrolla para manejar sus relaciones con los demás, hacer frente a la presión del grupo, para ayudarlos y para mostrar su solidaridad. En este marco, la metacomunicación facilitada por el supervisor juega un papel importante: la presencia de una tercera persona en el desarrollo del mapa es fundamental, ya que el grupo puede centrarse en la elucidación y en el intercambio sin sentirse "obligado" a elaborar el mapa.

Quisiéramos explicitar que la elaboración de mapas de ruta no ha sido aplicada en el marco de las supervisiones clínicas, porque éstas se justifican por la presencia de un conflicto relacional en el grupo ligado a niveles de motivación y de cohesión muy bajos, e incuso en ocasiones, inexistentes.

4.3 Los mapas conceptuales de ruta y la motivación

Según la teoría de la dinámica motivacional de Viau (2009), no hay aprendizaje posible sin la motivación, pues esta es, en sí misma la fuente del aprendizaje. Creemos, en efecto, que la elaboración de los mapas conceptuales de ruta puede mejorar la motivación del grupo, en particular con respecto a la percepción - una de las variables de la dinámica motivacional-.

Basándonos en uno de los principios de la supervisión – ésta se lleva a cabo si el grupo es quien la solicita y la negocia directamente con el supervisor- podemos constatar la presencia del primer nivel de la motivación. El grupo acuerda alto valor a esta actividad que a veces se vive como un reconocimiento institucional. Este fenómeno es llamado la *percepción de valor*. El contrato de supervisión garantiza al grupo la capacidad de control de una serie de factores sobre su desarrollo, tales como la delimitación de los objetivos, el nivel de análisis, el tipo de supervisión a realizar, la confidencialidad, etc. – A este fenómeno se le conoce como la *percepción de controlabilidad*. Así, un último fenómeno llamado *la percepción de la competencia* está presente desde el inicio: "Somos capaces de hacerlo, sólo necesitamos una guía externa." Estas tres percepciones o fenómenos se encuentran en la base de todo tipo de supervisión, lo cual implica, la presencia de un alto nivel de motivación desde el principio del proceso.

En cuanto a la percepción de la competencia (Viau, 2009), ésta consiste en la valoración que la persona da a su capacidad de lograr de forma adecuada la actividad que se le propone. Puesto que la competencia en el control del programa informático CmapTools, así como de los criterios para el desarrollo el mapa de ruta pertenece al supervisor, la elaboración del mapa representa un "valor agregado" para el grupo, quien cuenta con la capacidad del supervisor en la elaboración del mapa. El grupo no está sometido al estrés relacionado con el desarrollo del mismo, por el contrario, en la mayoría de los casos está agradecido con el supervisor y motivado para usar el programa CmapsTools en el trabajo o en la vida privada.

El compromiso cognitivo de los miembros del grupo es completado por el supervisor, capaz de garantizar la elaboración del mapa, y por ende, la explicitación del debate. En este sentido, y en términos puramente pragmáticos (Watzlawick, 1972) la elaboración del mapa confirma la presencia de una relación simétrica o igualitaria –en la relación- y de una relación complementaria en términos de la realización del objetivo -el contenido-. Esta relación facilita el papel de metacomunicador del supervisor, así como la ejecución de las cuatro funciones de la reunión citadas anteriormente.

En cuanto a la perseverancia, es decir, al hecho de dedicar el tiempo necesario para elaborar un mapa conceptual de ruta de calidad, ésta está a cargo del supervisor que al final de la sesión, logra terminar el mapa basado en la ayuda del grupo.

4.4 Algunos ejemplos

El primero que elegimos es un mapa conceptual de ruta que representa el conjunto de valores éticos, deontológicos y profesionales de una asociación que trabaja con personas drogadictas en una región del sur de Bélgica. El trabajo fue realizado con un grupo de cinco personas en junio de 2011. El nivel académico de las mismas es universitario y superior.

Características: El mapa fue impreso en tamaño póster y se exhibe en la oficina principal de la institución. Este mapa representa el fruto de dos sesiones (seis horas). El grupo expresó su admiración ante la complejidad de su trabajo y la presencia de cuestiones éticas y deontológicas que no había relacionado anteriormente. La motivación y la cohesión del grupo fueron altas.

El segundo mapa corresponde al "proyecto de acogida" de un centro médico. Fue realizado por grupo con bajo nivel de motivación inicial. El mapa se realizo en abril 2012 con un grupo de seis personas cuyo nivel académico es superior y universitario.

Características: Al final de la sesión el grupo expresó su orgullo por los resultados de la reflexión y manifestó haber comprendido mejor el objetivo, así como la manera en que el proyecto se realizará y el papel que cada uno desempeñará en el mismo. Los miembros del grupo expresaron su compromiso personal con el proyecto. El mapa será presentado a los miembros de sus respectivos equipos para buscar su adhesión.

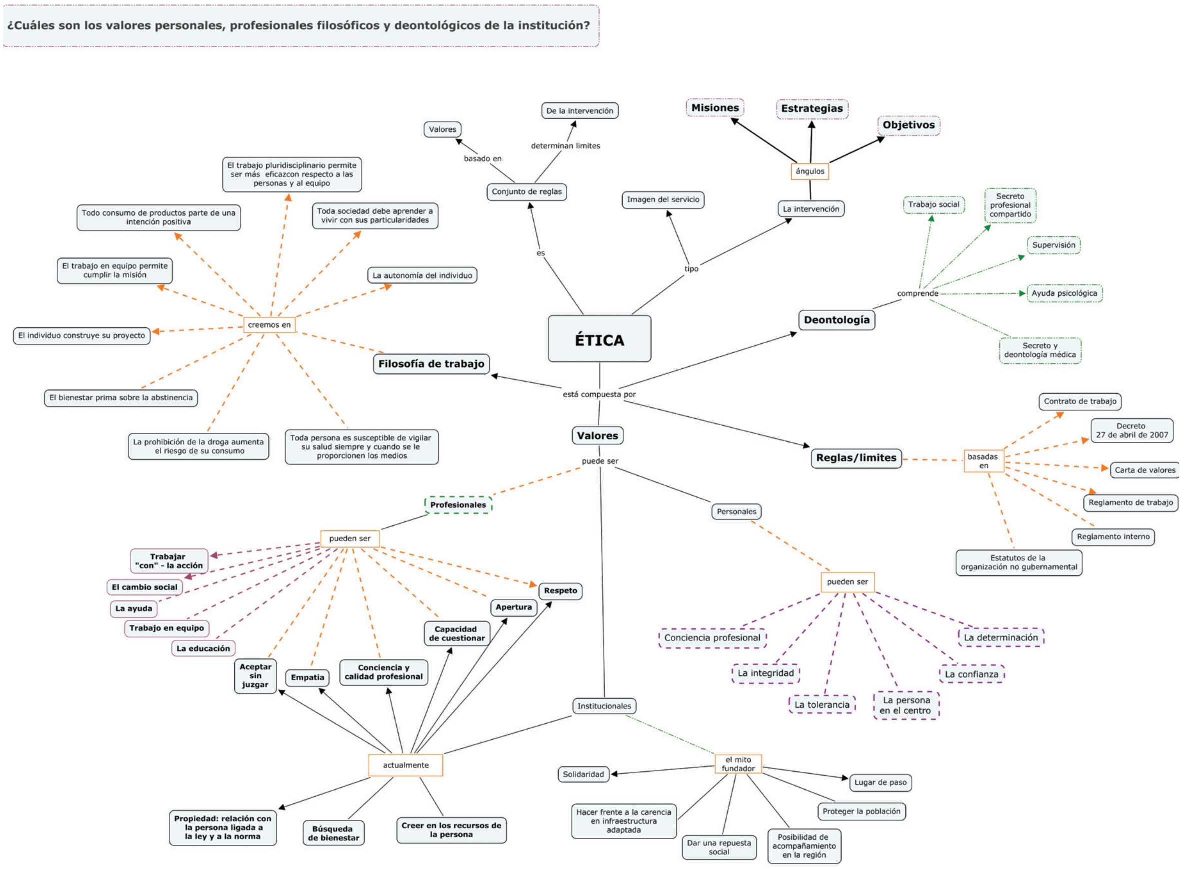

Figura 1. Mapa conceptual de ruta de los valores, deontología, ética y filosofía de una asociación que acompaña personas drogadictas

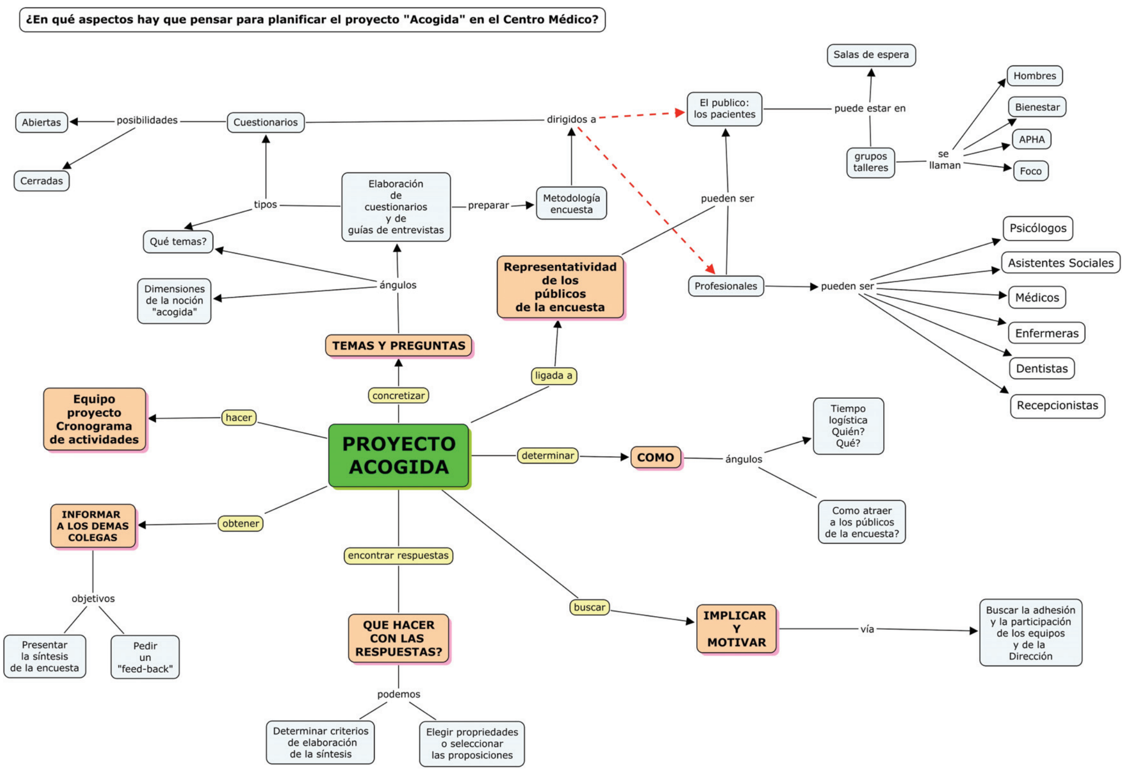

Figura 2. Mapa conceptual de ruta del proyecto de acogida de un centro médico

5 Conclusión

Los mapas conceptuales de ruta pueden ser utilizados como herramientas informáticas en pedagogía ideales para el desarrollo de nuevas estrategias cognitivas en supervisión de adultos, pues sirven para adquirir, integrar y recordar las informaciones integradas en algún momento.

Esta reflexión se basa en nuestra propia experiencia y por lo tanto, debe ser relativizada. Queda por ver si, convencidos de la importancia de la elaboración de los mapas en el mejoramiento de la motivación, la cohesión, y la memorización del miembros del grupo de supervisión, sería posible ampliar las experiencias y lograr una tipología de los mapas de ruta en la supervisión de adultos.

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LAS LÓGICAS FILOSÓFICAS EN LOS MAPAS CONCEPTUALES

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Abstract. Este artículo tiene como propósito demostrar que las lógicas filosóficas fundamentan los mapas conceptuales y dan claridad a los conceptos expuestos en ellos. Específicamente, se pretende demostrar la presencia de la lógica hermenéutica del pensador alemán Martin Heidegger en la teoría de los mapas conceptuales propuesta por Josef Novak. Por lo tanto, se expondrá cómo el círculo hermenéutico, por su carácter multidimensional y circular, se aplica en el diseño de los mapas conceptuales explicativos y cíclicos, que exponen un sistema de conocimiento, mientras la lógica formal aristotélica, por su carácter bidimensional, no logra cubrir todos sus aspectos y movimientos. Por esta razón, el mapa adquiere sentido cuando está fundamentado filosóficamente; la exposición se hace más coherente, precisa y clara.

1 Introducción

La lógica hermenéutica, o de sentido, aporta a los mapas conceptuales con su misma estructura. Es ésta, precisamente, la que da sentido a lo expuesto en el mapa. En adelante, explicaré la lógica hermenéutica y mostraré su aplicación en la estructura del mapa conceptual, no como un factor externo, ni posterior a su misma construcción, sino, como algo inherente a su construcción y de-construcción.

El artículo está dividido en dos partes: la primera presentará la lógica hermenéutica o de sentido creada por el pensador alemán Martin Heidegger, el filósofo más citado en el siglo XX, y su influencia en los mapas conceptuales. En la segunda, se indicará la relación existente entre la propuesta de Heidegger con la de Novak, especialmente en los mapas explicativos y cíclicos, que parten de una pregunta enfoque. En ambas partes se argumentará la importancia, influencia y aplicación de la lógica de sentido en los mapas conceptuales, mientras la lógica formal no alcanza a abastecer las dimensiones ni la estructura de los mapas conceptuales explicativos.

2 Lógica hermenéutica o lógica de sentido

La lógica hermenéutica o de sentido surge del pensador alemán Martin Heidegger, la cual rompe con el paradigma de Occidente de la lógica formal. Para poder conocer su lógica hay que conocer su fenomenología, pues ésta la constituye. La fenomenología heideggeriana está basada en el *lógos*, el cual captura el mostrar del ser en el comprender *(Verstehen)* y en la interpretación (*Auslegung*), partiendo de que el fenómeno es aquello que se muestra por sí mismo. Cabe mencionar que el *lógos* concebido por Heidegger, tiene más significados que el de *ratio* (razón) o lógica, concebida por la lógica formal. *Lógos* también es habla, decir mostrativo, lenguaje, interpretación, lectura y percepción. Aquello que se muestra, comprende e interpreta es el ser, el ser del hombre y no la mera aparición de lo ente. Heidegger afirma que la fenomenología es hermenéutica. "Fenomenología del Dasein es hermenéutica, en el significado originario de la palabra, en la que se designa la labor de la interpretación." (1993, § 7, p. 37).[1]

Generalmente, la hermenéutica se concibe como la interpretación de un texto, pero es mucho más que eso, pues comprende un fenómeno en el mundo y no sólo de un texto. Con la hermenéutica se intenta comprender un problema filosófico, el cual se interpreta con el *lógos* para dar un concepto. En la hermenéutica se trabaja con el *cómo* y no con el *qué*, ésta busca el sentido del ser del ser humano y de los entes en el mundo. El *cómo* es muy importante porque nos guía para poder divisar y escuchar las diferentes dimensiones del ser; no se queda en la simple presencia del fenómeno, sino busca comprenderlo e interpretarlo en sus dimensiones más densas, que no se capturan a primera vista. En la hermenéutica heideggeriana el comprender y el interpretar están unidos; no son conceptos separados que se relacionen, sino forman parte un sistema de conocimiento circular dotado de unidad:

> El proyectar del comprender tiene la posibilidad propia de formarse. La formación del comprender la llamamos Interpretación (*Auslegung*). En ella el comprender se apropia comprendiendo lo comprendido. En la Interpretación el comprender no es otra cosa sino él mismo. La interpretación funda lo existencial en el comprender y éste no emerge de aquella. (1993, § 32, p. 148).

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[1] Las citas de Heidegger las he traducido directamente del original en alemán.

El *Dasein* le da sentido a lo comprendido, pues solamente puede tener sentido algo ya comprendido; aquello que se interpreta es lo comprendido con sentido: "La interpretación no es tener entendimiento de lo comprendido, sino el desarrollo de las posibilidades proyectadas en el comprender." (Heidegger, 1993, § 32, p. 148).

En relación con el mapa conceptual, esta lógica contiene y conlleva el fenómeno al concepto expresado en el mapa; se ha tenido la experiencia con el fenómeno, pues el *lógos* ha capturado su mostrarse. Por consiguiente, el concepto, el fenómeno y su interpretación, quedan plasmados en el mapa. En esta lógica no hay una abstracción del fenómeno, sino que contiene al fenómeno en su concepto, gracias a su interpretación, que no es abstracción sino una experiencia hecha con el fenómeno condensada en la comprensión del mismo; sin comprensión no puede haber interpretación. Por ejemplo, cuando en el mapa conceptual escribimos "consumidor" o "cliente", aquí no aludimos a la abstracción de un concepto separado de la realidad, nuestro referente es el ser humano que vive en una sociedad de consumo y por ello, cobra el carácter de consumidor o cliente. De esta manera, el mapa nos remite al ser humano, en el contexto del mundo capitalista, que consume por necesidad y/o por gusto.

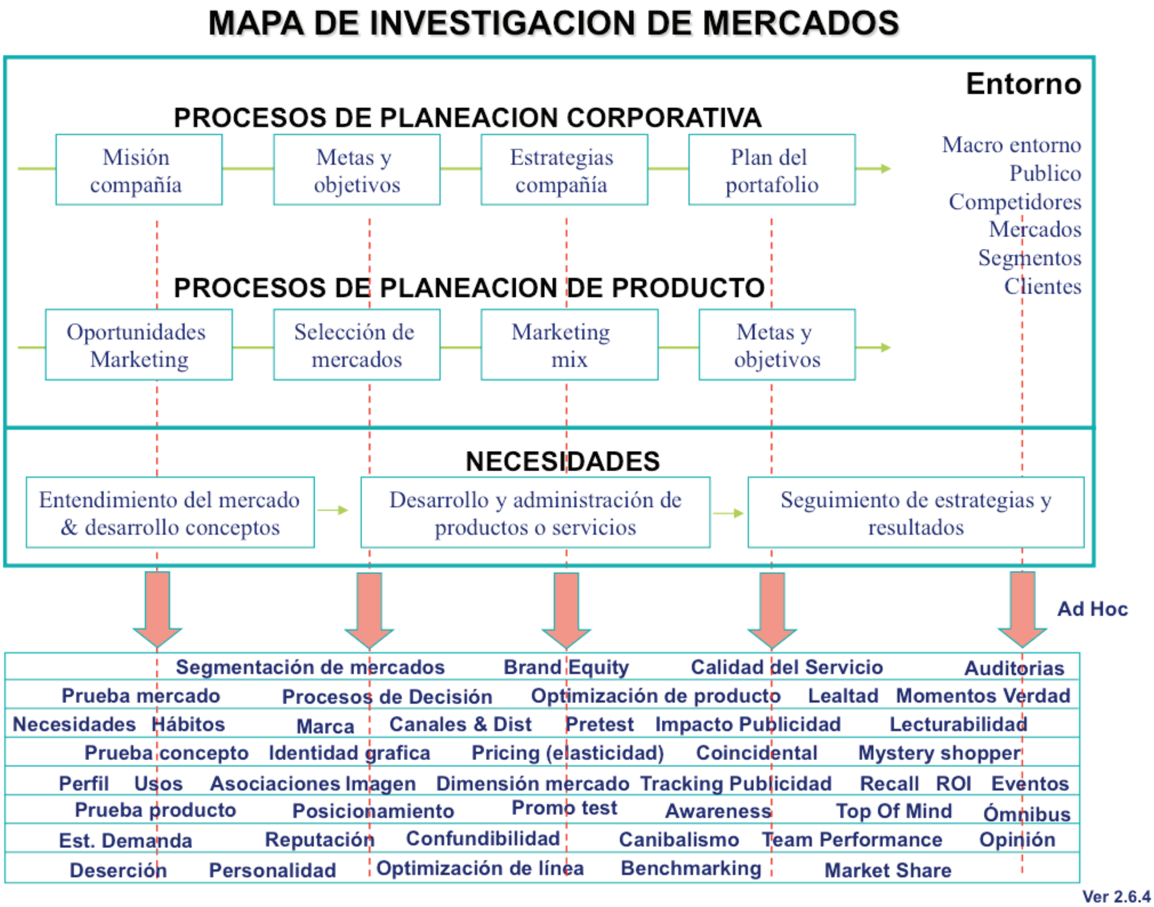

Figura 1: Mapa conceptual investigación de mercado.

Veamos la interpretación del mapa del consumidor desde la hermenéutica:

Figura 2: Círculo hermenéutico aplicado al tema del consumo.

En la anterior gráfica se observa que la relación-compresión de los conceptos es circular, los cuales nos remiten directamente al mundo; aquí no hay separación entre concepto y mundo, están íntimamente ligados en la referencia que el mismo mapa proyecta en la interpretación. "En el mundo actual de las nuevas tecnologías el sentido se da en el fenómeno de las redes establecidas por los *mass media,* en las cuales el ser humano está en constante referencia." (Cortés-Boussac, 2009, p. 71). Heidegger nos expone cómo el comprender se da en el mundo, pues al comprenderlo lo haremos con nosotros mismos. "El comprender como el estar abierto del Ahí, siempre halla el todo del ser-en-el-mundo. En cada comprender al mundo es comprendida la existencia, y viceversa" (Heidegger, 1993, p. 152). Al comprender un mapa conceptual no solo estamos comprendiendo como tal en su misma estructura; comprendemos esa parte o aspecto del mundo al que nos remite. "En el círculo sobresale el sentido, pues pertenece a su estructura. Es más, el sentido es lo que dibuja el círculo y el interpretar es lo que da la posibilidad de no quedarse en un círculo vicioso, porque se basa en la proyección hacia la comprensión." (Cortés-Boussac, 2009, p. 71).

El mapa conceptual está en referencia-en-el-mundo; no es un dinamismo aislado ni un poster externo que nos remite al mundo. Precisamente por ser conceptual abarca más dimensiones y tiene más referencias que las que aparecen solamente en un poster. La propuesta heideggeriana de *In-der-Welt-sein* (estar-siendo-en-el-mundo), que rompe con la lógica formal, nos muestra la unión teoría-praxis, la cual se condensa en los mapas conceptuales. La *In-der-Welt-sein* (estar-siendo-en-el-mundo) es una unidad entre *Dasein,* que en primera instancia sería ser humano, y mundo, que no corresponde a la concepción clásica epistemológica de sujeto-objeto: "La expresión compuesta "*In-der-Welt-sein*" (ser o estar-en-el-mundo) muestra ya en su emisión un fenómeno dotado de unidad. Hay que ver este primer estado en su integridad. Sujeto y objeto no coinciden con "*Dasein*" y mundo" (Heidegger, 1994, p. 53). "*In-der-Welt-sein*" puede traducirse como estar-siendo-en-el-mundo; un existir dotado de continuidad, que no se detiene en el momento de la simple presencia, sino que va más allá. El entorno (*Umwelt*) está presente en lo multidimensional y no sigue un movimiento lineal, sino circular. Mundo es un contexto de referencias, por ello los mapas conceptuales ayudan a exponer mejor el mundo porque nos remiten al mismo; no se quedan plasmados en la pantalla del computador, pues nos remiten a nuestro entorno. En el caso de los mapas conceptuales explicativos nos exponen un fenómeno de mundo, y en el caso de los descriptivos, nos lo describen. Por consiguiente, siempre se refieren al mundo.

En el siguiente mapa podemos ver el movimiento del círculo hermenéutico guiado por el sentido. También se puede apreciar que en Heidegger no existe la diferenciación epistemológica sujeto-objeto, pues ésta separa la comprensión entre teoría y praxis, y se lleva a cabo estrictamente en un plano bidimensional, en el que obviamente no hay cabida para lo circular, ni para la participación de la teoría en lo práctico ni viceversa. En cuanto al giro hermenéutico Heidegger escribe: "Este círculo del comprender no es un círculo en el que gire un género cualquiera de conocimientos, sino que es la expresión de la estructura existencial de prioridad del *Dasein* mismo" (1993, p.153).

El círculo hermenéutico tiene tres momentos-contextos: el anticipativo-proyectivo; el analítico-hermenéutico y el práctico-operativo. Estos se condensan en la hermenéutica heideggeriana, en la cual ocurren simultáneamente la teoría y la praxis en el comprender, pues el contexto práctico-operativo no está separado del contexto teórico. El anticipativo-proyectivo es el contexto en el que se proyecta hacia el fenómeno, del cual se debe tener cierta noción para realizar dicha proyección. El "cómo" hermenéutico (*als*) articula los contextos de

forma circular en el comprender “algo como”, en el interpretar “algo como algo” y en el enunciado “algo como algo para”. Se podría decir, que el movimiento sucede en el sentido de “algo como algo”, es decir, “algo como tal”, y de “algo como algo para algo” en el que se presta el servicio:
Vigo nos explica este movimiento en la nota de pie de página 22 –
La asociación entre ‘comprender’ (*Verstehen*) e ‘interpretación’ (*Auslegung*) es tan estrecha, que pueden verse, en rigor, ambos aspectos como las dos caras de un mismo fenómeno, a saber: como el aspecto anticipativo-proyectivo y como el aspecto analítico-hermenéutico, respectivamente, de la comprensión práctico-operativa, tal como ésta ilumina inmediatamente el trato con el ente ‘a la mano’. (2008, p. 32). De acuerdo con esto, puede afirmarse que el mapa conceptual contiene los 3 momentos de la compresión hermenéutica:

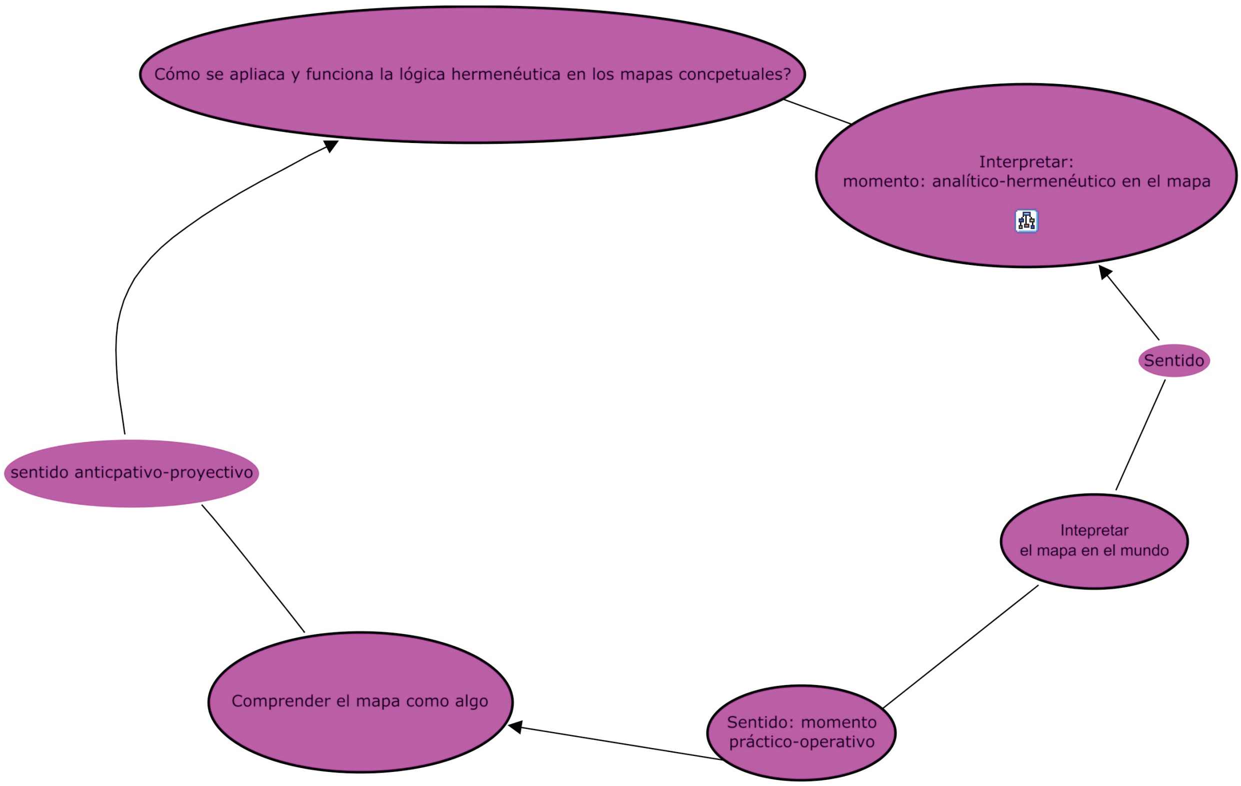

Figura 3: Mapa conceptual del círculo hermenéutico

En este mapa podemos ver el “movimiento” circular propuesto por Heidegger, pues el interpretar no va en secuencia, linealmente, sino que va más allá de la lógica formal, que se constituye en la unión lineal de los puntos de pasado, presente y futuro y no admite la contradicción, precisamente porque solo va en un sentido lineal: “Los contrarios. Lo contrario de lo bueno es lo malo; esto es evidente mediante la comprobación en los casos singulares, v.g.: de la salud, la enfermedad, y de la justicia, la injusticia…Además, en los contrarios no es necesario que si existe uno de los dos, exista también el restante: en efecto, estando todos sanos, existirá la salud y la enfermedad no.” (Aristóteles, Órganon, 14ª). De hecho, en los mapas conceptuales se muestra la lógica hermenéutica porque no va de manera lineal. Sus dimensiones tienen diferentes direcciones; se irriadian y proyectan en red; aquí simplemente se maneja otro orden. La interpretación nos remite a las posibilidades del comprender: “La interpretación no es tener entendimiento de lo comprendido, sino el desarrollo de las posibilidades proyectadas en el comprender.” (Heidegger, 1993, § 32, p. 148). Por tanto, el mapa recoge las posibilidades proyectadas en el comprender.

El “cómo” recobra el sentido captado por la interpretación, ya que un mapa conceptual no termina en la gráfica, sino que se remite a la compresión e interpretación que se hace de él mismo. Por eso, una de las características de los mapas conceptuales es explicar, mostrar conceptos y conectarlos con la realidad, es decir, se parte de la realidad y se vuelve a ella, cuando se accede a él y se interpreta. El “cómo” es aquello que nos guía la pregunta y hacia aquello que intentamos comprender. Las flechas encarnan el sentido y le otorgan el significado de redes.

3 Aplicación de la hermenéutica a los mapas conceptuales de Novak

En esta parte veremos cómo se relaciona la lógica hermenéutica y el mapa conceptual. En la construcción de los mapas conceptuales se produce la lógica del sentido, pues se crea conocimiento, se explica y se describe.

Novak y Gowin (1984, Capítulo 2) han descrito el acto de construir mapas como una actividad creativa, en la cual el estudiante debe hacer un esfuerzo para aclarar significados por medio de identificar los conceptos importantes, relaciones, y estructura dentro de un dominio específico de conocimiento. La creación de conocimiento requiere un nivel alto de *aprendizaje significativo*, y los mapas conceptuales facilitan el proceso de creación de conocimiento para los individuos y estudiantes en una disciplina (Novak, 1993). Los educadores han reconocido que lo importante es el *proceso de construcción* de un mapa conceptual, no solamente el resultado (mapa) final. (Cañas & Novak, 2004, p.3).

En esta cita se destaca la importancia de la construcción del mapa conceptual, esta afirmación empalma con la lógica de sentido, pues en la comprensión, sentido e interpretación del círculo hermenéutico se hace evidente la construcción de conocimiento. La lógica de sentido valora el proceso de compresión y de interpretación que ocurre en círculo, por eso no se juega con una lógica de la causalidad, cuyo objetivo es la finalidad. Aquí se valora todo el proceso, en términos hermenéuticos, el círculo de comprensión-interpretación.

Novak y Cañas reflexionan sobre el sentido que han tomado los mapas conceptuales desde su creación por Novak en 1972.

> Aunque los mapas conceptuales son utilizados hoy día en formas y campos que no se hubieran predicho hace años, el propósito principal de los mapas conceptuales continua siendo el mismo: es una herramienta que le permite a una o más personas representar explícitamente su entendimiento sobre un campo del conocimiento, y los fundamentos teóricos de la construcción de mapas conceptuales no han cambiado.
>
> Sin embargo, a medida que observamos el uso de la herramienta en diferentes lugares, algunas dificultades parecen ser recurrentes.
>
> 1- La construcción y la estructura de las proposiciones parecen ser un problema que muchos constructores de mapas conceptuales tienen.
> 2- La falta de una (buena) pregunta de enfoque que 'enfoque' la construcción del mapa conceptual;
> 3- Los mapas conceptuales tienden a ser mayormente descriptivos en lugar de explicativos, siendo muchos de ellos clasificatorios. (2006, p. 1).

Aquí podemos apreciar que uno de los propósitos de los mapas conceptuales es explicar los conceptos y no solo, como se hace en la actualidad, describir fenómenos sin ninguna explicación y aplicación de una teoría. El punto 2 de la cita coincide en el fundamento de la lógica hermenéutica que es el preguntar: "Todo preguntar es un buscar. Cada buscar tiene su guía previa de lo buscado. Preguntar es un buscar conocido de lo ente en su qué hacer y modo de ser" (Heidegger, 1993, § 2, p. 5). Por tanto, la pregunta enfoque orienta la búsqueda, lo que nos permite construir los mapas conceptuales explicativos.

Tal como lo observamos en la Figura 3. Mapa del círculo hermenéutico, aplicada a los mapas conceptuales cíclicos-explicativos que parten de una pregunta con un fin educativo y no solo demostrativo. El artículo de Cañas y Novak sobre la aplicación de mapas conceptuales en la educación señala que los mapas cíclicos logran este fin:

> Esto se muestra en dos mapas conceptuales sobre el tema "Calidad de la Educación" construidos por maestros durante talleres, donde el mapa conceptual en la Figura 3 fue construido desde la pregunta de enfoque "¿Qué es Calidad de la Educación?" y no se le dio un concepto raíz, resultando en un mapa de tipo declarativo, y en la Figura 4 fue construido desde la Pregunta de Enfoque "¿Cuáles son los Efectos de un Aumento en la Calidad de la Educación?" y un concepto raíz de "Aumento en la Calidad de la Educación" (un evento), lo que resultó en un interesante mapa conceptual cíclico basado en proposiciones dinámicas. (Cañas & Novak, 2006, p.7).

La cita anterior nos indica que el mapa cíclico parte de una pregunta enfoque y de un concepto raíz, se acomoda más al propósito de educar, mientras que el mapa declarativo no alcanza a cubrir estas dimensiones y por carecer del concepto raíz, carece, en cierta forma, de argumentación. Con los mapas, el niño o joven aprende sintetizar y, lo más importante, se familiariza con los conceptos de una forma activa y no pasiva, pues el círculo de comprensión, interpretativo-compresor, le da la oportunidad experimentar con el fenómeno referido en el mapa. Así mismo, los mapas conceptuales explicativos y cíclicos le facilitan al niño o joven entrar en los tres momentos-contextos de la lógica hermenéutica: el anticipativo-proyectivo; el analítico-hermenéutico y el práctico-operativo, ampliando la posibilidad de construir y deconstruir.

Veamos un mapa conceptual de Novak, que nos expone la estructura de conceptualizar el mapa:

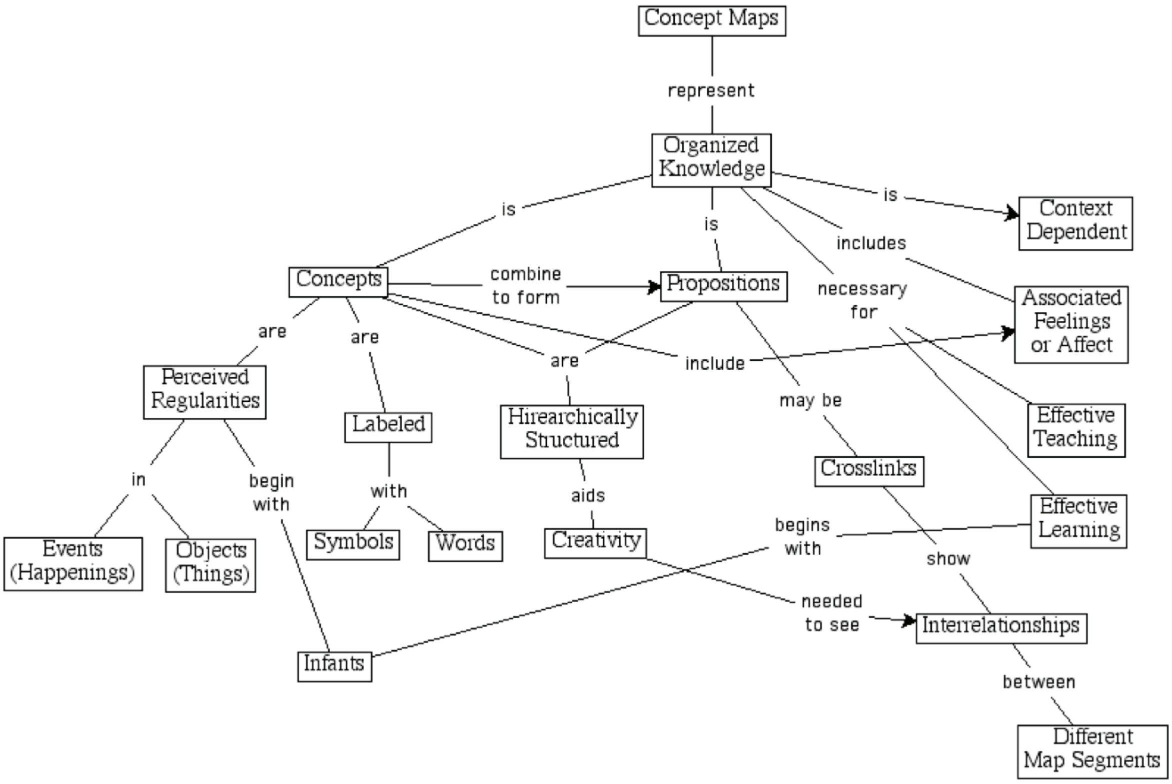

Figura 4: A concept map about concept mapping. Excerpted, rearranged (and annotated) from an online manuscript by Joseph D. Novak, Cornell University.

> El mapa conceptual es una representación gráfica de un conjunto de conceptos y sus relaciones sobre un dominio específico de conocimiento, construida de tal forma que las interrelaciones entre los conceptos son evidentes. En este esquema, los conceptos se representan como nodos rotulados y las relaciones entre conceptos como arcos rotulados conectándolos. De esta forma, los mapas conceptuales representan las relaciones significativas entre conceptos en forma de proposiciones o frases simplificadas: dos o más conceptos ligados por palabras para formar una unidad semántica. (Cañas, 2000, p. 3).

¿Qué sucedería si el mapa conceptual no solo representara, sino que encarnara el concepto? De concebirse así aportaría más a su propósito de educar. Puesto que el mapa conceptual es un sistema de aprendizaje, que expone y explica conceptos; facilita le aprendizaje porque el concepto ya está en él. Bajo esta perspectiva puede afirmarse que los mapas conceptuales no solo representan, sino también son, pues con la lógica hermenéutica el concepto queda encarnado en el mapa y, en cierta forma, se hace experiencia con el concepto al comprenderlo e interpretarlo. El mapa conceptual no se puede basar solamente en la teoría de representación, pues un modo de conocimiento se da a través de ellos, también se perdería su riqueza de referenciar. Tal como afirma Novak: "es creación de nuevo conocimiento". Si los mapas conceptuales únicamente representaran, seguiríamos en una metafísica, y los mapas son reales, existen en la red, son producto de las nuevas tecnologías. Por ello, no podemos concebir los mapas conceptuales como una simple representación del conocimiento. Al elaborarlos se lleva el conocimiento (*episteme)* a la praxis. Como su nombre lo indica ellos conceptúan y no solo describen.

Las nuevas tecnologías juegan un papel fundamental en la construcción de los mapas, pues producen una conexión real y no solo representacional. Veamos cómo se construyen los mapas con un programa diseñado para ello:

La construcción de los mapas es fácil. Mediante un editor de uso sencillo, el usuario relaciona los medios (vídeo, imágenes, sonido, mapas, etc.) y sus iconos con los nodos (conceptos). La arquitectura distribuida del sistema permite que los diversos medios y mapas se almacenen en diferentes servidores en una red, y que puedan accederse desde cualquier nodo en la red. Aprovechando la extensión y omnipresencia de Internet, se puede entonces construir sistemas de multimedia accesibles desde cualquier lugar del mundo. El programa está escrito en Java, lo cual implica que puede ser ejecutado en cualquier plataforma computacional (Windows, Macintosh). (Cañas, 2000, p. 3).

Los mapas conceptuales están en la red; son un fenómeno que no solo marca la estadística o el plano gráfico del concepto, sino que contienen y exponen un concepto en un contexto de referencias. Este fenómeno de interrelación de los conceptos queda condensado en los mapas conceptuales, en ellos se hace evidente el fenómeno del mundo en redes. La construcción de los mapas conceptuales se puede realizar con CmapTools, del IHMC: "Uno de los usos de CmapTools que está creciendo en importancia es la captura y el archivo de conocimiento experto." (Cañas, 2006, p. 5). El círculo hermenéutico permite visualizar mejor el movimiento de las redes.

La creación de los mapas conceptuales es un fenómeno de la actualidad, propio de las redes de las nuevas tecnologías, aporta al saber de esta era humana, cuyo enfoque se centra en el área de la educación. Los mapas conceptuales son más accesibles para los niños y jóvenes, precisamente por ser un fenómeno tecnológico de fácil acceso, en el computador. Los mapas son interactivos, didácticos y, por esta razón, abren posibilidades de aprendizaje alternativas a las tradicionales, de modo que el campo educativo está cubriendo las redes y la realidad. Queda abierta la propuesta de argumentar, construir y de-construir los mapas conceptuales explicativos y cíclicos con la lógica hermenéutica.

4 Conclusiones

Las nuevas tecnologías nos brindan oportunidades de crear nuevo conocimiento mediante los mapas conceptuales explicativos y circulares. La lógica hermenéutica, o de sentido, podría considerarse como el fundamento lógico de estos mapas, ya que es circular, parte de una pregunta enfoque y de un concepto, que se muestra en su explicación, compresión e interpretación.

La lógica hermenéutica ayuda a fundamentar el mapa conceptual y resalta su característica explicativa, conceptual y cíclica. De esta manera, el mapa puede aplicarse de una manera más clara, didáctica y demostrativa en la educación.

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LESSONS LEARNED ACROSS A DECADE OF KNOWLEDGE MODELING

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Abstract. I review lessons learned in the creation of knowledge models composed of Concept Maps. The models were developed in studies of expertise in a variety of domains including weather forecasting, clinical oncology, and terrain analysis. Lessons learned pertain to a number of methodological issues, such as the measurement of the effectiveness of knowledge elicitation methods, issues in organizing, resourcing and navigating large sets of Concept Maps, and issues in comparing computer performance to that of humans.

1 Introduction

"Knowledge models" are integrated sets of Concept Maps of expert knowledge. NUCES modeled the knowledge of an expert at nuclear magnetic resonance imaging for ventricular function (Ford et al., 1991). The "Return to Mars" project integrated knowledge for the NASA Center for Mars Exploration (Briggs et al., 2004). El-Tech was a knowledge model for debugging and repair of a particular kind of electronic data recorder (Coffey et al., 2003). The Launch Vehicle Systems Integration Model was of the knowledge of a NASA specialist in the Centaur launch vehicle (Coffey, Moreman, & Dyer, 1999). A variety of additional topics have been the subject for modeling: the field of social network analysis, processes in organic chemistry, event logic and causation, engineering in the electric utilities, and the psychophysiology of balance. In this paper, I briefly describe a few projects that highlight some heuristics for model development that emerged during the research.

2 System To Organize Representations in Meteorology

At the Naval Training Meteorology and Oceanographic Facility (Pensacola Naval Air Station) there were a number of senior civilian forecasters who were expert at predicting severe weather. Hundreds of Cmaps were made, providing detail on such topics as the use of weather radar, forecasting for thunderstorms, hurricanes, fog and turbulence. (See http://hcs-metoc.apl.washington.edu/hsmetoc_library/pdfs/hoffman_paper.pdf).

The knowledge model STORM included the Cmaps that referred to weather of significance for aviation in the Gulf Coast (i.e., turbulence, thunderstorms, etc). The Cmaps were resourced with the material in the *Local Forecasting Handbook*. Trainee forecasters studied the model to prepare to qualify as forecasters. Shortly after STORM was finalized, the facility was downgraded to a detachment and the senior civilian forecasters took that opportunity to retire. Were it not for the Concept Maps we had made, all of the experts' knowledge and heuristics would have been lost.

The project involved comparing methods of knowledge elicitation for their effectiveness (see Hoffman et al., 1995; Shadbolt & Burton, 1990). Methods used in the STORM project included protocol analysis, workspace observations, the Critical Decision Method (CDM), the Knowledge Audit, Cmapping, and the Cognitive Modeling Procedure. The methods were compared in terms of efficiency, gauged in terms of Total Task Minute (TTM; time to prepare to run a procedure, plus time to run the procedure, plus time to analyze the data) relative to the yield (number of propositions for use in a knowledge model). The methods also identified dozens of leverage points and also yielded behaviorally validated models of the reasoning of expert forecasters (see Hoffman, 2008). Knowledge modeling using Cmapping resulted in thousands of propositions covering domain knowledge. The Critical Decision Method yielded a number of richly populated case studies with associated Decision Requirements Tables. Along with short video clips in which expert forecasters discussed forecasting procedures, all of these results from cognitive task analysis were hyperlinked into the knowledge model.

We conducted over 60 hours of Cmapping interviews. Full protocol analysis of a single knowledge modeling session took a total of 18 hours to collect and analyze the data. The results confirmed a finding from previous studies (Burton et al., 1990) that protocol analysis (i.e., transcription and functional coding of audiotaped protocol statements, with independent coders) is too time consuming and effortful to have an effective yield. Rather than doing a protocol analysis it would be far more efficient to simply go back and do more Cmapping. The total effort taken to develop, refine, and validate knowledge models can vary by orders of magnitude depending on the knowledge elicitation method employed. A rule of thumb we developed is that Cmapping can have a yield of 2.0 informative propositions per TTM. Any method having a yield of less than one proposition 1.0 TTM is arguably inefficient.

Another lesson learned was that Cmapping mates very well with the CDM. This structured interview method is highly effective as a method for generating rich case studies (Hoffman, Crandall, & Shadbolt, 1998). Previous studies had suggested that the CDM procedure takes about two hours, but those evaluations looked only at session time. The present study involved a more inclusive measure of effort, TTM. We found that for interviewing expert weather forecasters the CDM took about 10 hours per case. The cases are rich because weather phenomena can span days and usually involve dozens of data types and scores of data fields. More importantly, expert forecasters' memories of cases can be remarkably detailed.

3 Thailand National Knowledge Base Demonstration Project

This project demonstrated how the model development process might be conducted at a large scale. Thailand's long-term economic potential depends, in part, on its traditional crafts including silk manufacture. A slide set about Thai silk had been created by Thai field researchers who had interviewed village elders and photographed their activities. We relied on this resource set to create a small knowledge model. This had a Cmap for each of a number of silk patterns. The Cmaps were resourced with photographs (e.g., of the of weaving, dyeing and other processes) and with text pieces that had been created from the textual material in the original slide set.

A lesson learned in this project had to do with the use of color and backgrounds. Our previous heuristic had been that backgrounds should not contain any high-frequency graphical elements or textures, since the Cmap itself (nodes and linking lines) consists of high-frequency graphical elements. Furthermore, it was felt that background images could be distracting. In the Thai silk model, a photo of each silk pattern served as the background for the Cmap that described it. The images were adapted graphically to make it look as if one were viewing bolts of cloth in a store display. Next, the concept nodes, text, and linking lines were set in highly contrasting colors.

The effect of these graphical manipulations was that the Cmap seemed to stand out from its silk pattern background. Furthermore, our use of contrast suited the Thai aesthetic, which includes the use of multiple contrasting patterns and sharply contrasting colors. A screen shot is presented in Figure 2.

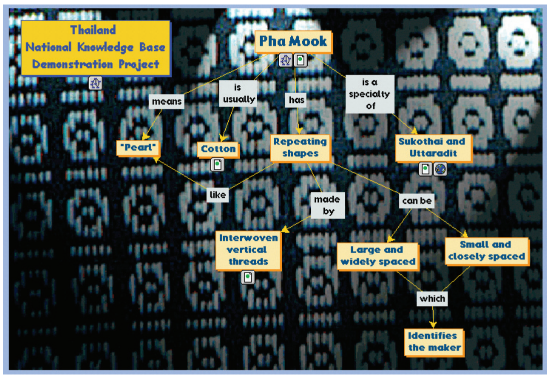

Figure 2. A screen shot from the Thailand National Knowledge Base Demonstration Project.

We still acknowledge the heuristic that such flourishes as background and use of color (in nodes, text, linking lines, etc.) should be used with caution. It is tempting for individuals to use color, for instance, to code nodes according to certain categories. In our experience, once a person begins using color to represent categories, the encodings get too complex and a legend becomes necessary.

4 Representation of Conceptual Knowledge (ROCK) in Terrain Analysis

Difficulty in coping with terrain is a major challenge for military planning and operations. Expert-level knowledge about terrain is presented in documents discussing landforms, soils, rock types, etc. (i.e., Hoffman, 1983; Mintzer & Messmore, 1984). These documents contain photo interpretation keys for landforms of all types, topographic maps, aerial photographs, and text that describes terrain and discusses implications (e.g., trafficability). As traditional documents, the material is neither useable nor useful to the warfighter. We dubbed the process of creating a knowledge model from archived material the process of "knowledge recovery." The Terrain Analysis Data Base (TADB; Hoffman, 1983) is a corpus of about 1500 proposition-like statements about terrain. These had been derived from documentation analysis and structured interviews with expert terrain analysts at the US Army Corps of Engineers. For example, some high-level information about Dunes was represented in the TADB as: *Deserts: Sand and gravel soils; Usually arid climate; Desert varnish tones; Occasional silt soils; Usually with dunes.*

The knowledge model consisted of 150 Cmaps, containing of 3,341 concepts, 1,634 linking phrases, and 3,352 propositions (e.g., “deserts usually include dunes”). The Cmaps contained an average of about 22 propositions. ROCK was the largest knowledge we had made up to that time. There were multiple Cmaps about dunes, terrain over different types of bedrock, effects of climate, and so on. The model's sheer size raised issues about it usefulness. We applied a known principle in the field of psychology, that in information search and perception redundancy is helpful for (understanding, memory encoding). This idea was manifested in our adoption of redundant methods for navigating among the ROCK Cmaps.

We created a number of "Top Maps" that organized all the Cmaps within terrain categories (e.g., climates, drainage patterns, soil types, rock types, etc.). We also created a number of "Maps of Maps" in which the nodes were all the top nodes in all the Concept Maps. In these Top Maps and Maps of Maps, all nodes that represented top nodes in other Concept Maps were colorized. A highest level Cmap was created, called "The Representation of Concept Knowledge in Terrain Analysis." This provided high-level explanatory concepts and served as the user's gateway into the knowledge model. The top concept node in each Concept Map (i.e., its main topic) was hyperlinked to the "Representation of Knowledge" Cmap and also to the Map of Maps and the Map of Top Maps. Finally, we created a "piece" of a Concept Map that we called a Navigator. This was added into every Concept Map in the upper left-hand side. This showed how the given Concept Map fit into its subordinating hierarchy of Top Maps. Using the Navigator Cmap Piece, users can navigate up to super-ordinate Top Maps.

While this may all sound confusing, it approximated our goal, which was to enable the user to get from anywhere in the knowledge model to anywhere else in a maximum of two clicks, and never "get lost in hyperspace." An example ROCK Concept Map, bearing its Navigator, is shown in Figure 3.

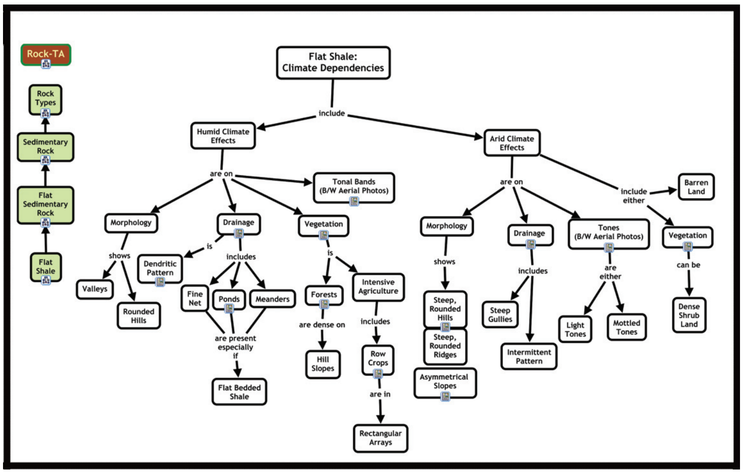

Figure 3. A representative Concept Map from the terrain analysis knowledge model "Representation of Conceptual Knowledge."

The Concept Maps were fully resourced with aerial photos, interpretation keys, text, all of the propositions from the Terrain Analysis Data Base, all of the declarative (versus procedural) knowledge from the Army Field Manual for Terrain Analysis, and all of the data elements tables and photos from the Procedural Guide for Surface Configuration. This process made it clear how resourcing is a non-trivial exercise (for some process recommendations, see Coffey & Hoffman, 2003). It is not solely a matter of combinatorics, because one needs to use each resource in more than one place, and for more than one reason, so each resource might exist under multiple labels or names. The purpose of the resourcing was to enhance the functionality of the model. Our vision for this was that the knowledge model could be used in two ways:
1). “Here is where I am going (e.g., as seen in topographic maps)—what will I see and find when I get there?” In one use context, the unit of action has been issued orders, and can use the model to get expert information about the terrain.

2). "Here is what I see from where I am—what are the implications of this terrain?" In this use context, the model is used to search and discover the rock type, soil type, and other terrain elements that would affect the operation.

What makes it possible to use the knowledge model in these two ways is the Navigator and search feature in *CmapTools* that relies on the propositional structure of the Cmaps. Thus, for instance, if one searches the knowledge model for "dune and steep slope" the search engine will find and open the Cmap about star dunes (which are a kind of dune that has steep slopes), permitting a comparison of the current view with example terrestrial and aerial photos.

The ROCK Concept Maps were produced at a rate of between 0.25 and 0.22 propositions per TTM. This number falls considerably short of the benchmark for effective knowledge elicitation. Indeed, the yield of 0.2 propositions per task minute is roughly equivalent to that for protocol analysis. The meaning of this calculation should be considered in light of the fact that the participating local terrain analysis "expert" in the Concept Map Refinement stage happened to also be a proficient Cmapper. No doubt, the refining a set of Concept Maps would have taken even longer had this not been the case, and the yield of propositions even lower than 0.2 per minute. In light of these considerations, the moral of our results is clear for any organization that in confronting issues involving the loss of expertise (see Hoffman & Hanes, 2003): *Knowledge recovery is costly.* One is better off capturing knowledge in a usable and useful form as a part of the organization's on-going knowledge management program, rather than finding oneself in a position of losing expertise because of retirement, and "wasting" knowledge because it is represented in older forms of media (i.e., hardcopy text) that are not easily compatible with newer hypermedia forms and formats.

5 The TNO Business Model

A number of people who apply Concept Mapping in business contexts have noted that group Concept Mapping often sets the stage for situations where people realize that they have been using the same words but not the same concepts (see Cañas & Novak, 2011). Insights invariably follow, at least in the cases that have been cited. Our experience in the TNO project fit this general description.

TNO, the Netherlands Organization for Applied Scientific Research, conducts research in the public interest in areas including defense, security and safety, environmental and geosciences, and information technology. One of its business units is TNO Human Factors. Its staff includes about 150 researchers. In their periodic Technology Position Audit (TPA). personnel review their progress since the previous evaluation, taking into consideration such things as changes in funding mechanisms and priorities. They re-evaluate the unit's capabilities, competencies, ambitions, and goals. As the time for the 2009 TPA approached, an opportunity arose for conducting a process of knowledge elicitation to support the preparation of the self-evaluation report. Participants were seven senior researchers representing the Departments within the Human Factors business unit.

Total time spent in Concept Mapping was 450 min. The Concept Maps included a total of 420 concepts formed into 440 propositions. Thus, the yield was 440/450 = 0.98 propositions per task minute. Much of the session time had been devoted to describing Cmapping and the *CmapTools*, explaining the process of hyperlinking Concept Maps and resources, and explaining the strategies used by the facilitator and the Cmapper to manage the sessions. Ordinarily, these activities are conducted in a workshop-like context and not in the knowledge elicitation sessions themselves. With this in mind, a yield of 0.98 is considered to be a reasonable yield. This determination should be taken in light of the fact that it was not the purpose of this activity to result in a complete set of refined Concept Maps. The intent was to deliberately leave some work unfinished so that TNO personnel might gain experience and practice at the process.

In the opinion of TNO, the Concept Maps proved useful in the preparation for the TPA. Cmapping forced the departments to be explicit about their ambitions, plans, and product portfolio. Knowledge that had been tacit was made explicit. Differences among the departments could be harmonized by using a common framework provided by the Concept Maps. The Concept Mapping process allowed all of the departments, for the first time, to capture and share their understandings of their business models to achieve a common purpose.

For example, the participants engaged in discussion of such concepts as "adaptation," "societal impact," and "short-term market potential." Pointers to a need for improved shared understanding of a business model included disagreements about what is important, subtle differences in the interpretations of key concepts, and even disagreement about what the key concepts are. A striking emergent was the lack of shared understanding of the meanings of such basic terms as “goal” and “ambition.” Considerable time was spent getting the Cmaps right about these notions.

This Cmapping activity was suggestive of how this can be conducted to describe business models, and how those can be used as templates to support integration across business units. The use of Cmaps to represent the business model of an organization is an application that has claimed success (Novak, 1998), and the emergence of disconnects in the understanding of fundamental concepts is a phenomenon that has been noted.

6 Developing Information Infrastructure for Cancer Treatment

This project was a collaboration with the H. Lee Moffitt Cancer Center and Research Institute, to develop a information repository that would support data extraction and meta-analysis for knowledge discovery in the treatment of cancer. Part of the activity would be to integrate clinical notes made by attending physicians, oncology specialists, and others involved in patient care. A capability for automated language processing was necessary because conversion to digital format of 30,000+ clinical notes would be very time consuming. The language understanding capability would have to be adapted to the terminology and telegraphic style that is utilized (e.g., *Patient is status post liver biopsy, Patient recurred with liver metastasis, Patient was staged as an early T1 N0 squamous cell carcinoma, Patient presents with pain*). How well would the language understanding system compare to the human in terms of identifying the propositions that are in a clinical note? To address this question, a set of clinical notes were turned into propositional diagrams. The question of how well Cmaps represent the ideas expressed in text has been researched within the Concept Mapping community (e.g., Villalon, Calvo, & Montenegro, 2010). Helfgott and Novak (2010) demonstrated how Concept Maps and Concept Map-like diagrams can be used to represent medical clinical information, to describe such things as blood pressure and its measurement, the medical decision making processes, and anatomical structures and their clinical indicators.

Some clinical notes we analyzed were brief—100 or so words. Some were comparatively long (500 or more words). Text pieces of that size will contain many dozens of propositions, far too many to be included in a single Cmap. Our heuristic from the STORM project was that once a Concept Map grows to having more than about 35 concepts (or about 35-40 propositions) it becomes too large to be viewed without scrolling. Most clinical notes had "Patient" as either the explicit or implicit topic of the concept, so many of the propositions would be like the examples above. This would mean large numbers of propositions all linking out from the concept node "Patient," and this too would make for a very ungainly Concept Map.

Most assertions in the clinical notes include temporal references. This sequence had to be included in the analysis, but this meant that we would be making process diagrams. We had developed a heuristic for making process diagrams in the STORM project, in which we made diagrams describing the formation of storms. The heuristic was to embed the process inside a Novakian Cmap that uses propositions to provide the "explanatory glue" that is often left implicit in process diagrams. But this heuristic would not work for the clinical notes. An example of, the format we finally settled upon is presented in Figure 4, and Figure 5 shows a close view of a portion of this diagram.

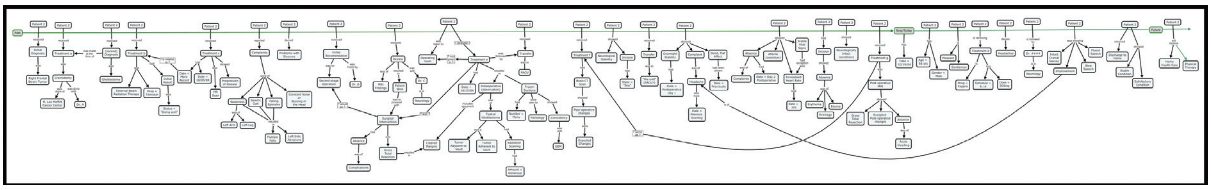

Figure 4. A representative diagram created to capture all of the propositions in a clinical note.

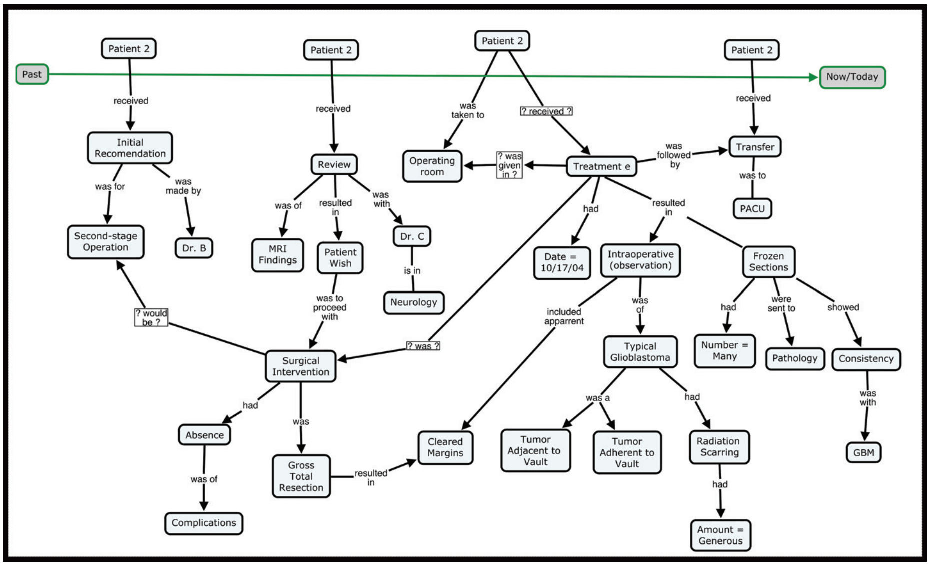

Figure 5. A closer view of a portion of the Figure 4 diagram.

We analyzed 46 clinical notes for 10 patients. The resulting 59 diagrams had over 3,000 propositions. It took a total of 48.5 hours to draft, verify and finalize all the Concept Maps, for an efficiency of 1.04. We felt that this was reasonable given the unusual nature of the diagrams we had to create.

The natural language understanding system used in this project was called TRIPS (UzZaman & Allen, 2010). How well would this make the sorts of bridging inferences that a human makes when reading text (e.g., "Patient x is male. He is 63 years of age.")? TRIPS identified 93% of the keywords (concept-terms) and 59% (range of 40% to 93%) of the propositions in the human-generated Cmap versions of the clinical notes. This latter figure requires some explication. TRIPS does not generate propositions, in the sense of ordered triples, it generates tree structure representations of sentences using its specialized syntax and grammar (e.g., for the representation of temporal relations). Consequently, concepts in a meaningful diagram (made by a human) that would be in a proposition can be distanced from one another in the tree structure generated by TRIPS. Perhaps the easiest way of understanding this is that a TRIPS representation always has "sentence" as the top node in a tree, and everything branches downward from that. An example is presented in Figure 6. Reading upwards from "her" (the patient), this says that <her, has, breathing>, <breathing, is, stable>. The patient "her" is linked to both stable and breathing, with no intervening nodes. Thus, we could not simply count propositions identified by TRIPS. We had to have a criterion, which was that the two concept-terms in a proposition were linked (meaningfully connected) and were close to one another in the TRIPS downward-branching representation. Propositions were considered to be properly output if there were zero to three nodes separating the keywords. The clinical notes that resulted in the poorest TRIPS performance were ones that were composed of run-on sentences, incomplete sentences, syntactic deviants, etc. that caused problems for the TRIPS system.

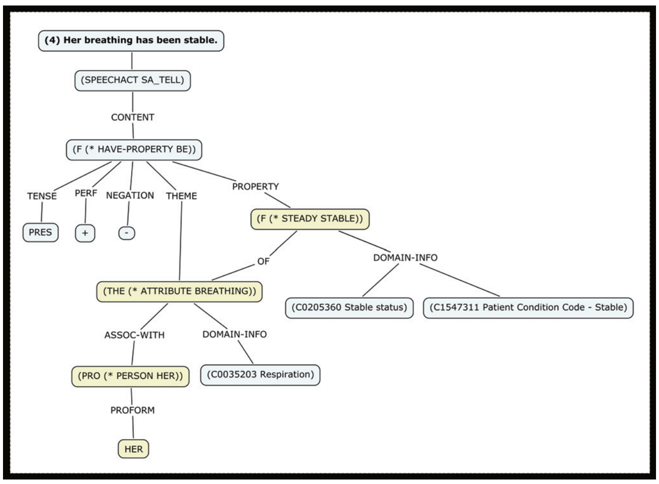

Figure 6. A portion of a TRIPS analysis of a clinical note. The two concepts that appeared as a proposition in the Concept Map are highlighted.

The lesson learned is that comparing human-generated Concept Maps to computer analyses can be anything but straight-forward. Calls for software systems that can automatically generate good Concept Maps from free text have been raised many times in the past, and we still see such calls occasionally. The issue is not how can such computer systems be created, but how far can such systems go in making half-way decent Concept Maps, that a human can then refine?

Another lesson learned is that diagramming of processes, procedures, cycles, event structures, etc. is possible and *CmapTools* is very useful, though resulting diagrams can to deviate from the Novakian form. That being said, our heuristic is to remain vigilant that process descriptions are faithful to certain cardinal aspects of Concept Maps. Our initial heuristic—about embedding the process description inside a Concept Map—is still viable. But as diagrams become more dependent on the representation of temporality (e.g., to describe unfolding events, as in our clinical notes Cmaps), there can be "Novakian pieces" within the larger diagram.

7 Conclusions

Some of our heuristics have remained stable over these decades of knowledge modeling, such as the caution about the use of graphical flourishes and color, the size of good Cmaps, and ways in which Cmaps should use space and meaning (see Crandall, Klein, & Hofman, 2006). Our ideas about knowledge elicitation have matured significantly. We have an empirical base for making claims about the effectiveness and efficiency of Cmapping relative to other knowledge elicitation methods. We have an understanding of how Concept Mapping marries well with other knowledge elicitation methods, to enable researchers to paint a complete picture of expert reasoning and knowledge. Our appreciation for the scale and scope of expert knowledge and the scale and scope for knowledge models has grown. For even the most critical or tacit knowledge of an expert, one can expect a knowledge model to need over of 100 Concept Maps. Therefore, modeling efforts need to have a clear focus. Our ideas about how to use *CmapTools* have been challenged and our heuristics have been refined, especially regarding the diagramming of processes and events.

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LOS MAPAS CONCEPTUALES COMO HERRAMIENTAS DE DIAGNÓSTICO Y TRATAMIENTO DE ERRORES CONCEPTUALES

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Abstract. El siguiente trabajo resulta de una investigación realizada para acceder al doctorado en la Upna (Navarra- España), en el cual se propone una forma de abordar y tratar los errores conceptuales (EECC) para lograr el Aprendizaje Significativo (AS). El modelo conductista en los ámbitos educativos no responde a las demandas de un aprendizaje significativo en integrar el pensamiento, el sentimiento y la acción conduciendo a la capacitación humana para el compromiso y responsabilidad. Responder a los desafíos actuales de la Sociedad del Conocimiento y la Información requiere cambiar la forma de enseñar y aprender (pasar de un Modelo Conductista- Positivista a otro Cognitivo-Constructivista), en este contexto aprender significativamente y crear conocimiento son claves para el desarrollo del pensamiento divergente, creativo y crítico. Los llamados errores conceptuales suponen auténticas barreras, para ello, esta investigación trata de eliminar y/ o paliar este problema. Un requisito clave para conseguir el AS es la elaboración de un material curricular e instruccional conceptualmente transparente, el Módulo Instruccional (MI); el tratamiento de los EECC que contribuye a modificar las estructuras cognitivas y un docente responsable que cambie la dinámica de trabajo en el aula. Se diagnosticaron los EECC y con ellos se realizó el MI, el que se implementó en escuelas secundarias de Argentina en las provincias de Tucumán (3 instituciones) y Jujuy (1 institución) a un grupo de clase (6º grado o 1º año). Se evalúa las actividades, dinámica propuesta y resultados de la implementación del MI con un mapa conceptual evaluador. Los resultados obtenidos evidencian un cambio en los grupos experimentales en las actitudes y en el rendimiento académico, En el pensamiento divergente se manifiesta el aprendizaje significativo, al aparecer en las producciones de los alumnos la creatividad en expresiones, producciones, y aplicaciones a la vida real.

1 Introducción

Las razones para innovar en educación son las exigencias de la sociedad del conocimiento y de la información, así como la necesidad de nuevas competencias cognitivas y una personalidad equilibrada emocionalmente. Para esto es fundamental un aprendizaje significativo frente al memorístico, reconocer los errores conceptuales y alcanzar una inteligencia emocional necesaria para el metaprendizaje. En general los sistemas educativos no cubren estas demandas ya que los planes de estudio apenas contemplan esta situación (González García, 2008).

En el aprendizaje significativo los errores conceptuales son un obstáculo y el docente debe ser consciente de los mismos y hacerlos conscientes a sus alumnos para avanzar en el aprendizaje. El alumno es un receptor activo, utiliza los conceptos y significados que ya internalizó para captar los nuevos e incluirlos en su estructura cognitiva (esquema conceptual). Si existen errores conceptuales (EECC) se dificulta la reorganización de su propio conocimiento, no elabora nuevas proposiciones ni logra su integración a la estructura cognitiva. El aprendizaje no es progresivo, los significados no son captados e internalizados, aprende de memoria (memoria a corto plazo) los EECC no se reconocen y no generan inconvenientes.

El aprendizaje significativo permite "SABER" ser, hacer, y sentir, lo que implica aprender a aprender. Al saber hacer se resuelven las situaciones problemáticas manejando el conocimiento para accionar en el mundo con creatividad. El "ser" ayuda a vivir rodeado de personas diferentes, actuar en una interacción social, y el "sentir" es ser plenamente responsable de uno mismo, actuando con voluntad y esfuerzo para el bien personal y colectivo. La complejidad de la vida cotidiana necesita del aprendizaje significativo, para Moreira (2000) debe ser crítico y subversivo. El pensamiento subversivo es poder cuestionarse, al plantear diferentes líneas de razonamiento y generar discursos distintos (es poder desestructurar su razonamiento y el de otros). El cambio conceptual tan necesario para lograr el aprendizaje significativo llevó a transformar los enfoques y las concepciones del aprendizaje de la ciencia. Los epistemólogos hablan de conceptos erróneos, concepciones alternativas, nociones ingenuas, nociones pre científicas pero Novak propuso adoptar la sigla *LIPH* (Limited or Inappropriate Proposicional Hierarchies) como la más apropiada para esas concepciones erróneas. (Novak, 1983 y 1993).

En el aprendizaje significativo el alumno se involucra, establece relaciones significativas y no arbitrarias. La incapacidad de trasladar ideas y el uso de conocimientos adquiridos en contextos diferentes, generan dificultades propias del aprendizaje, necesitando el cambio conceptual (González García, 2001). En general en las clases no se trabaja para lograr el aprendizaje reflexivo ni la argumentación, es necesario enseñar a pensar. El docente debe trabajar con las inteligencias múltiples (Gardner, 1995) desarrollando en sus alumnos la capacidad de resolver problemas o elaborar productos que puedan ser valorados dentro de su cultura. Las inteligencias múltiples generan en el aula nuevas oportunidades de actuar (desde las diferentes disciplinas) potenciando la autoestima y autovaloración, brindando la libertad de pensamiento, acción, creación y autogestión Para lograr este cambio es necesario considerar estas variables en un constructo (MI, módulo Instruccional) o recurso didáctico que permita su implementación. Como antecedentes sobre la aplicación de un módulo instruccional (*MI*) para lograr el aprendizaje significativo al detectar y corregir errores conceptuales se pueden citar el Proyecto Gonca (2003), Albisu y cols (2006) y González García (2008). Los objetivos de este trabajo fueron: 1) Aplicar nuevos criterios en el desarrollo y evaluación del AS, mediante el uso de los EECC. 2) Organizar la planificación en un marco general con los criterios propuestos para el MI. 3) Emplear las nuevas tecnologías para ayudar al alumno en el aprendizaje, 4) Planificar las actividades y recursos para aprender a aprender.

2 Metodología

La hipótesis asume que es posible encontrar diferencias en el rendimiento académico final (hay AS) entre los estudiantes que utilizan MMCC, trabajan con EECC y *MI* como estrategia de enseñanza con los que no lo hacen. La variable independiente es la metodología utilizada con sus dos niveles, en un curso utilizar errores conceptuales y en el otro no. La muestra estuvo integrada por alumnos de 6º grado o 1º año (12 a14 años de edad) de escuelas públicas, tres de la provincia de Tucumán (de zonas diferentes)y una de la provincia de Jujuy (escuela en zona muy pobre). Para la recolección de datos se utiliza un diseño cuasi experimental, con pretest y postest, y dos grupos de experimentación no aleatorizados.

Provincia	Muestra		Establecimiento	Curso	Tipo	Nº alumnos
Tucumán	A	1	Esc. Com. Nº 3	7º 3	Experim	38
	B			7º 4	Testigo	38
Tucumán	C	2	Liceo Nacional	1º E	Experim	38
	D			1º A	Testigo	36
Tucumán	E	3	Esc. y Liceo V. Sarmiento	6º A	Experim	36
	F			6º B	Testigo	36
Jujuy	G	4	Escuela Nueva La Salle	7º1	Experim	32
	H			7º2	Testigo	31

Tabla 1: Características de la muestra.

El estudio se extendió durante cuatro meses (Período lectivo 2010) en sesiones de tres horas cátedras semanales (40 minutos cada una) en un módulo de 80 minutos y otro de 40 minutos. La muestra se dividió en el grupo testigo y el experimental, en espacio (aulas) distintos y con docentes diferentes. El curriculum de cada escuela está adaptado a los lineamientos del curriculum oficial. Este estudio se realizó en 4 etapas

1º etapa) Diagnóstico y detección de EECC (mediante encuestas a docentes y alumnos) para elaborar el MI. Elaboración y aplicación del 1er mapa conceptual evaluador (MC evaluador 1º), elaborado por un docente y transmitido a los demás docentes de la experiencia. Consta de 25 conceptos inclusivos, necesarios para el trabajo del tema durante el año. Se incluyen conceptos que generalmente son erróneos. Se realiza en el período de diagnóstico durante 2 semanas. En el grupo experimental la organización de las actividades sigue lo propuesto en el MI utilizando el software específico cmaptools, y en el testigo la realiza el profesor siguiendo su criterio.

2º etapa) Elaboración y aplicación del MI para la detección y corrección de errores durante la aplicación del mismo. Este permite organizar de manera diferente los contenidos para el logro del AS y por otro ayudar a cambiar el esquema mental del alumno, corregir sus errores conceptuales o por lo menos aprender a pensar en ellos. Permitió al docente actuar en la zona de desarrollo próximo (González García, 2008), se enfatizan los procesos cognitivos, el desarrollo de habilidades metacognitivas, y afectivas del alumno. En el MI se organizan actividades y será a través de ellas y como ellas son asimiladas por cada uno de los estudiantes donde se puede analizar el concepto de tarea la que comprende variables fundamentales que permiten el logro de habilidades cognitivas. Los contenidos a trabajar en el MI se organizan en una serie de actividades relacionadas, en una secuencia temporal y de complejidad creciente considerando los errores detectados. Los diferentes temas se organizan en introducción, focalización y resumen, adaptado de Project LEAP (Learning about Ecology, Animals and Plants, Cornell University, 1995). El MI está inserto en un marco general que presenta siete ejes verticales (sicológico, didáctico, epistemológico, procedimental, social, comunicacional y conceptual) y un eje transversal que integra y relaciona los anteriores) la evolución del pensamiento del alumno manifestado en el

AS. Los ejes verticales surgen en la complejidad del aula e intervienen la experiencia del docente y las características del grupo de alumnos.

Para el diseño y aplicación del MI se tiene en cuenta los siguientes criterios: Manejar el conflicto cognitivo para generar cambio conceptual, aprender a aprender, considerar las inteligencias múltiples, trabajar la comunicación biunívoca, el docente como mediador en la zona de desarrollo próximo, actitud positiva del alumno y del docente, vigilancia epistemológica del docente, trabajar con TIC (Nuevas Tecnologías de la información y de la comunicación), hipertexto como creación, el docente confía y valora el trabajo individual y grupal del alumno, los contenidos curriculares se trabajan como vehículo de las estrategias cognitivas, trabaja con herramientas heurísticas, mapas conceptuales, V de Gowin, valorar positivamente el error conceptual por permitir el cambio de la estructura cognitiva, valorar lo que el alumno sabe, las ideas previas, errores conceptuales, concepciones alternativas, fomentar el diálogo intrapersonal e interpersonal para conocer las estructuras cognitivas propias y las de los otros. Estos criterios, aunque no son trabajados todos a la vez, deben ser considerados durante el trabajo en clase ya que permiten de alguna forma asegurar el logro del AS.

Es fundamental en el desarrollo de este proceso enseñar la argumentación que favorece el dialogo interpersonal e intrapersonal tan necesario para el logro del AS. Con el diálogo o comunicación en el aula se puede acceder a las estructuras mentales propias y ajenas y lograr generar la circulación de información tan necesaria para romper las barreras de la timidez, desconfianza u otras. Estas pueden impedir que afloren los errores conceptuales que obstaculizan la restructuración de los esquemas mentales. La autodisciplina y el trabajo consciente de ellas permiten ejercitar el autocontrol y el autoaprendizaje para llegar a aprender a aprender.

Otros aspectos de la tarea en el aula considerados importantes de observar y analizar son: el afectivo (como actitudes, las características propias de la personalidad, la actitud, motivación, o interés) y la evolución cognitiva continua (proceso profundo, invisible que aparece en la mente de los alumnos al responder, reaccionar o realizar las tareas en el aula o en la casa) y controlada. Es importante crear un clima de trabajo, de confianza y seguridad, donde los errores no son descalificados, sino reconocidos y reelaborados. Todo esto relacionado con el grado de dificultad que la tarea exige, y en un feedback adecuado entre la calidad de realización, permite oportunidades para lograr el final de un producto exitoso.

Se pone énfasis en los errores detectados por los propios alumnos y se trabaja con la argumentación en el aula. En esta etapa la evaluación del alumno se hace en forma permanente, analizando su evolución cognitiva.

3º etapa) Aplicación del 2º mapa evaluador (MC evaluador 2º), el alumno debe repetir el mapa evaluador de referencia.

4º etapa) Análisis comparativo MC evaluador 1º y 2º. La Valoración de Mapas y Errores Conceptuales en el grupo experimental y testigo se realiza mediante un análisis cualitativo (desde la topografía y la semántica) y cuantitativo, para lo cual se realizó el seguimiento del rendimiento académico de los alumnos, previo, durante y posterior a la aplicación del *MI.* Se aplicaron pruebas multivariadas a los indicadores de Bartels, Novak (1988), y a un nuevo índice propuesto que incluye los índices anteriores y agrega la presencia y número de los EECC. Para determinar si se da el AS se utilizaron por un lado los índices de González García y Guruzega (2004) y por otro lado se realizó la comparación del promedio de notas obtenidas durante la aplicación del MI con el obtenido en los dos cursos anteriores (4º y 5º grados).

Los datos obtenidos mediante la aplicación de los índices, fueron analizados utilizando un análisis de varianza longitudinal multivariado para comparar el rendimiento de los grupos control y experimental. El método multivariado permite estudiar simultáneamente varias respuestas. Este tipo de modelo permite cuantificar la evolución del aprendizaje de los alumnos expresado como la diferencia de los puntajes obtenidos en los MMCC inicial y final, de cada uno. A partir de los promedios de las diferencias individuales dentro de cada curso, se puede comparar el comportamiento promedio del grupo control y el experimental y establecer si existen diferencias significativas entre ellos. El test de Tukey fue utilizado cuando se obtuvieron diferencias significativas en el ANOVA.

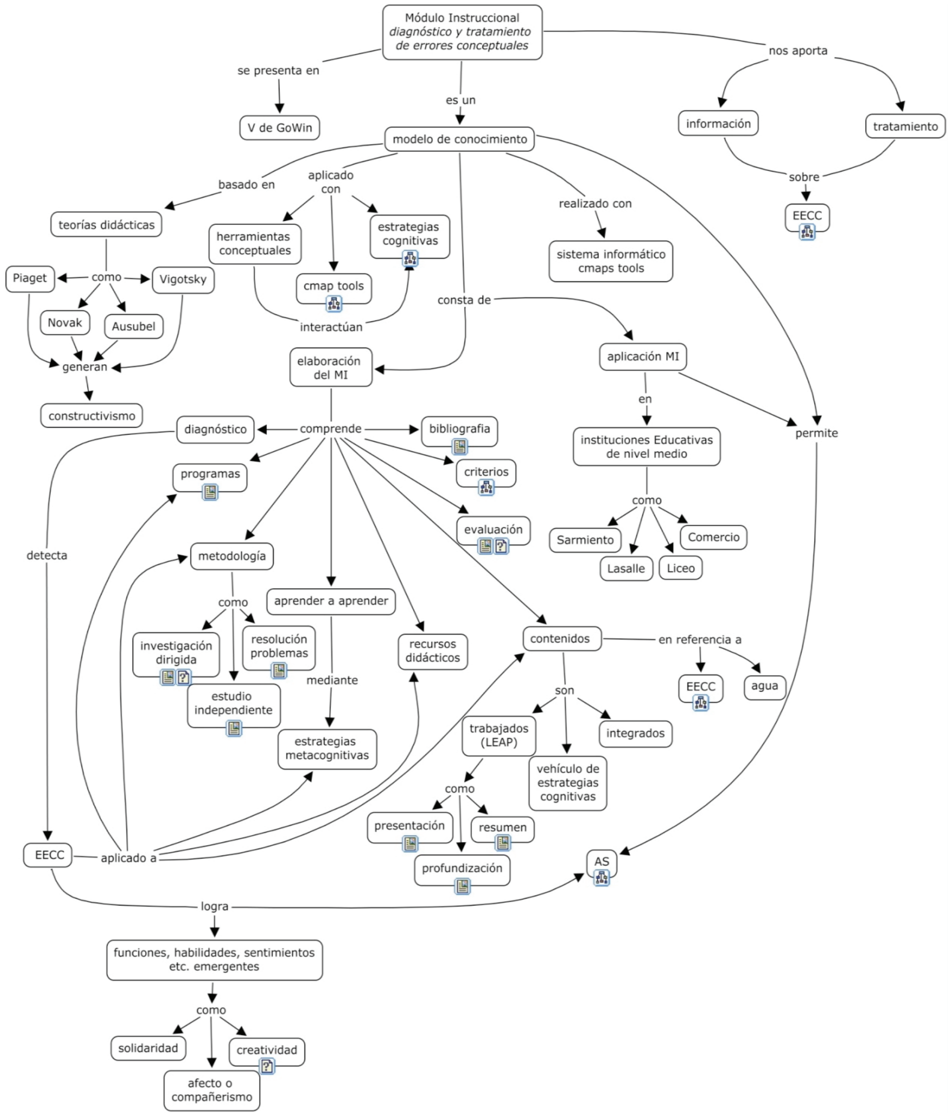

Figura 1. Mapa conceptual que describe el *MI*

3 Resultados

La encuesta para conocer los EECC se realizó a docentes (30 entre expertos y noveles) la que curiosamente no se devuelve quedando solamente por informar los resultados de la encuesta a los alumnos.

De las Instituciones Educativas en las que se realizó la experiencia solo en una de ellas (Escuela y Liceo Vocacional Sarmiento) se logran datos estadísticamente significativos. En las otras instituciones debido a situaciones de huelgas, ausencia y renuncia de profesores entre otros motivos se producen irregularidades que afectaron el normal desempeño del dictado de clases, pero si se pudieron obtener datos cualitativos. En todas las instituciones y en todos los grupos experimentales se aprecian cambios actitudinales como ser: clima afectivo positivo, mayor contención de alumnos problemáticos, mejora en las relaciones interpersonales, el trabajo con CmapTools en el laboratorio de informática permite la integración de los alumnos avanzados al colaborar con los menos diestros, además mejoran las relaciones interpersonales, y el tratamiento óptimo de alumnos con dificultades cognitivas manifiestas (Jujuy, Síndrome de Sutton).

Cuando se comparan los resultados en la Escuela 3, entre el 1º periodo (MC 1) y 2º Periodo (MC2) se observa que hay diferencia significativa entre medias solamente en el grupo experimental (indicado por letras diferentes) ($p < 0,05$), cuando se aplica el índice de Bartels.

Escuela 3	Experimental		Testigo	
	Mc 1	Mc 2	Mc 1	Mc 2
Bartels A	1.30[a]	2.00[b]	1.21[a]	1.13[a]
Bartels B	1.25[a]	1.86[b]	0.70[a]	0.92[a]
Bartels C	1.05[a]	1.61[b]	0.59[a]	0.75[a]

Tabla 2. Promedios de cada ítem del índice de Bartels, dentro de los grupos experimental y testigo. Superíndices diferentes, en cada fila, indican diferencias significativas entre medias ($p<0.05$) obtenidas con test Tukey. Categoría A) Conceptos y terminología; B) Conocimiento de las relaciones entre conceptos; C) Habilidad para comunicar conceptos a través del mapa conceptual.

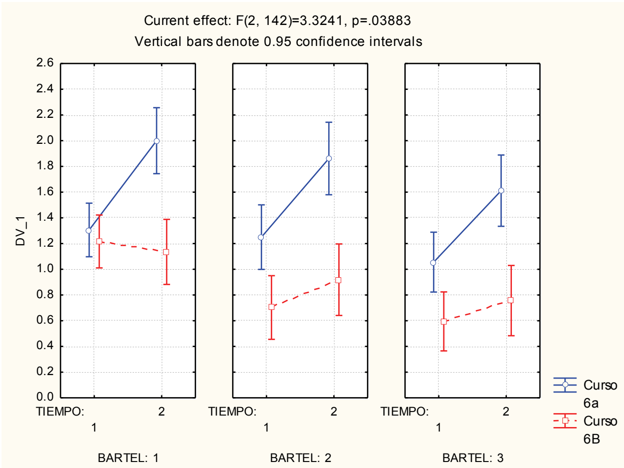

Figura 2. Gráfico de los resultados indicados en la tabla 1. Grupo experimental en azul (línea continua) (6a) y en rojo (línea de puntos) el grupo testigo (6B)

Resultados de aplicación del índice de Novak, en la siguiente tabla Nº 3:

Escuela 3	Experimental		Testigo	
	Mc 1	Mc 2	Mc 1	Mc 2
Jerarquía	**0.6[a]**	**1.2[b]**	0.5[a]	0.6[a]
Relaciones	0.3[a]	0.7[b]	0.2[a]	0.4[b]

Tabla 3. Promedios de dos ítems del índice de Novak

Al comparar los resultados obtenidos para la categoría "Jerarquías", entre el 1º y 2º Periodo hay diferencia significativa entre medias solamente en el grupo experimental (indicado por letras diferentes) ($p< 0,05$). En cambio, en "Relaciones" se observa diferencias significativas en los dos grupos. Se consideran los puntajes obtenidos en las jerarquías y relaciones ya que prácticamente no existen relaciones cruzadas y ejemplos.

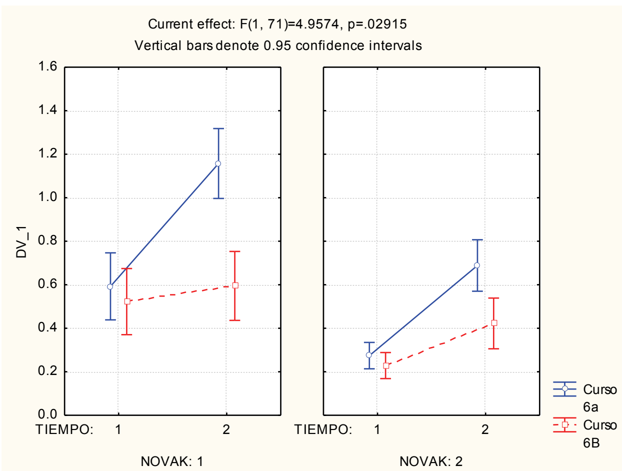

Figura 3. Gráfico de los resultados indicados en la tabla 2.

Los resultados obtenidos con el análisis de los índices de Bartels, Novak y el nuevo índice midiendo los EECC coinciden en sus resultados.

A continuación se muestran dos figuras de mapas conceptuales evaluadores (escaneados) realizados por una alumna antes (figura 4) y después de la aplicación del MI (figura 5). En la figura 4 se aprecia la falta de conectores y jerarquías, no usó todos los conceptos y las proposiciones son incorrectas. En la figura 5 se aprecia el uso correcto de conectores, de diferentes jerarquías, usa todos los conceptos y las proposiciones son correctas.

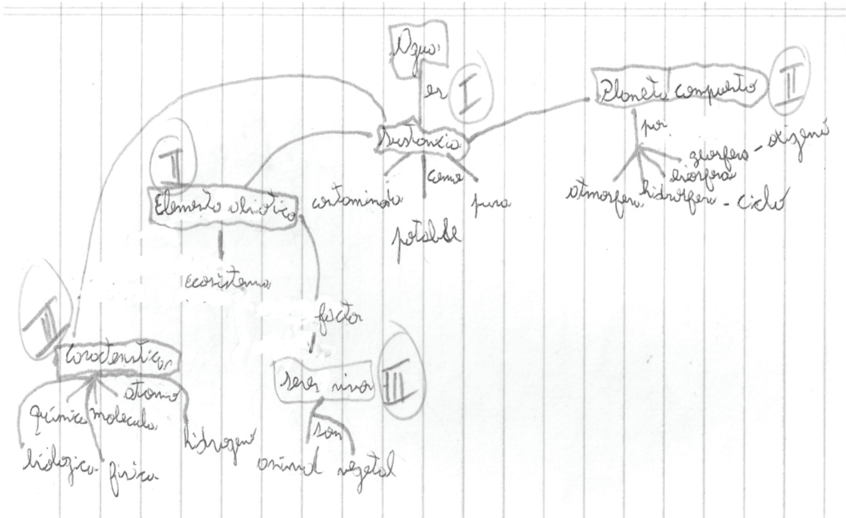

Figura 4 . Mapa conceptual evaluador 1 (previo a la aplicación MI)

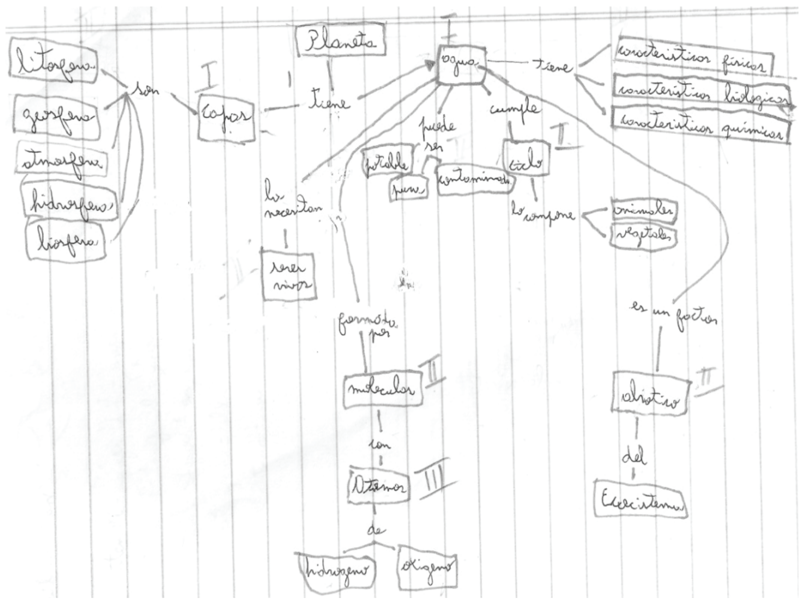

Figura 5 . Mapa conceptual evaluador 2 (posterior a la aplicación MI)

Los resultados de comparar las calificaciones finales de dos curso previos y las calificaciones trimestrales del curso correspondiente al período de aplicación del *MI* se observa en la figura 6. En la misma se grafica los resultados de la comparación de los grupos experimental y testigo donde se observa una marcada diferencia a partir del 1º trimestre (diferencia significativa). Cabe recordar que se inicia la aplicación del *MI* al comenzar el período lectivo y el dato del 1º trimestre corresponde a las primeras pruebas evaluadoras del año.

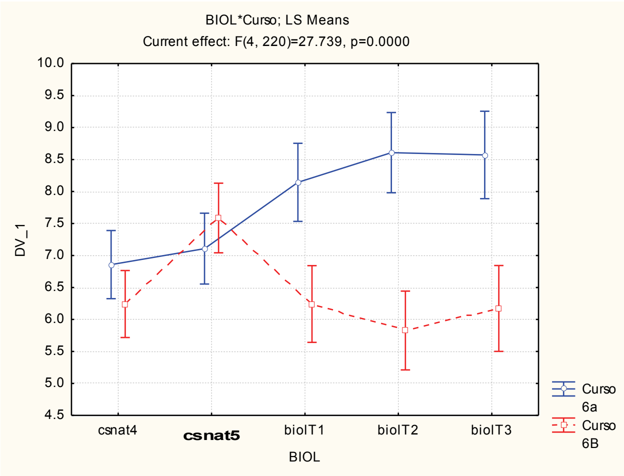

Figura 6. Resultados de la comparación de las calificaciones finales (asignatura biología).

Los alumnos del grupo experimental valoraron positivamente sus resultados y resolvieron aplicarlos voluntariamente en asignatura Historia. En la figura 7 se grafica los resultados de esta experiencia donde se observa una tendencia a la mejora en el grupo experimental hacia el 3º trimestre.

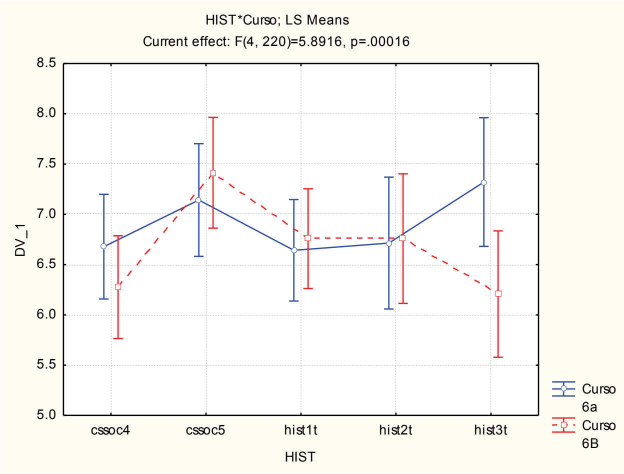

Figura 7. Resultados de la comparación de las calificaciones finales (asignatura historia).

Cuando se evaluó el Aprendizaje Significativo utilizando los indicadores descriptos por González García & Guruceaga se puede decir que en ambos grupos se logra el mismo pero de manera diferente.

4 Conclusiones

Las notas registradas en la escuela Nº 3 en 4º y 5º grado en ambos grupos al ser comparadas con los resultados de 6º, muestra que si se da una mejora en el grupo experimental. La mejora puede ser explicada por causas que tienen que ver con la organización institucional, por ejemplo: las alumnas empiezan su escolaridad en esta institución, lo que permite el logro de una gran pertenencia y les da seguridad emocional (se sienten seguras); se promueve la autodisciplina; la autogestión de actividades extra programáticas por las alumnas; un sistema de evaluación continua (exámenes parciales y finales en todas las asignatura y todos los curso); se procura la inclusión de todas las aspirantes a jardín (1º año inicial de escolaridad) y se favorece la recuperación (la no expulsión) de las alumnas con problemas de aprendizaje. Esto permite disminuir las diferencias sociales con las que ingresan las alumnas. Pudo detectarse en todo momento en el grupo experimental muy buen estado de ánimo, disposición para el trabajo y colaboración.

Este tipo de metodología permite un trabajo integrado e interdisciplinario con otros espacios curriculares y los alumnos entusiasmados con el trabajo con mapas y por sus resultados positivos utilizaron voluntariamente los mapas conceptuales en la asignatura de ciencias sociales.

La construcción de significados es un hecho individual, solo el estudiante puede decidir hacer el esfuerzo, así el debe empeñarse en modificar y reestructurar consciente y deliberadamente sus esquemas mentales. Los maestros deberían ayudar a sus alumnos a que realicen y reconstruyan sus esquemas personales en el plano conceptual, de manera que formen su competencia cognoscitiva.

Los criterios seleccionados y empleados para diseñar el *MI* se consideran adecuados y en cierta forma novedosos por su interrelación. Estos mismos criterios pueden aplicarse perfectamente en otras disciplinas en el trabajo del aula.

Se pudo organizar la planificación en un marco general que abarque los criterios propuestos para el *MI*, con diferentes núcleos temáticos fundamentales y criterios para el AS mediante el tratamiento de los EECC. Esto fue aplicado por las docentes involucradas en la experiencia. Tanto los alumnos como los docentes implicados en la experiencia reconocen la existencia y persistencia de los errores conceptuales.

La aplicación del *MI* facilita detectar y trabajar los EECC, permite la autocorrección por parte de las alumnas, que aprendan a aprender, tendiendo al aprendizaje significativo. Se detectan cambios actitudinales en la tarea en el aula, mejor rendimiento general, mayor creatividad en las producciones, más participación en el aula con mejor nivel de argumentación.

Se aplicó el software específico para el trabajo con mapas conceptuales (cmaptools) cumpliendo así el objetivo de emplear las nuevas tecnologías para ayudar al alumno en el aprendizaje.

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LOS MAPAS CONCEPTUALES PROGRESIVOS: UN ESTUDIO DE LOS ESTUDIANTES DE LA ESCUELA PRIMARIA

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Abstract: Este artículo muestra los resultados parciales de una investigación fundamentada en los principios de la Teoría de Aprendizaje Significativo de Ausubel y colaboradores. Su objetivo es analizar la potencialidad del Mapa Conceptual en el progreso de adquisición conceptual de temas en Ciencias. Como fundamentación teórica nos apoyamos en el Mapa Conceptual propuesto por Novak y Gowin que afirma: que al proporcionar aprendizaje significativo se ayuda al alumno a expresar los conceptos aprendidos. Esta fue la base da la investigación desarrollada con alumnos de quinta, sexta y séptimo grado de la Enseñanza Primaria. Para la colecta de los datos fueron utilizados Mapas Conceptuales Progresivos, elaborados en tres momentos diferentes: antes, durante y después del desarrollo de los temas: Suelo, Mamíferos y Sistema Respiratorio. El análisis parcial de los datos obtenidos nos permite afirmar que el Mapa Conceptual utilizado en forma progresiva es un importante instrumento pedagógico, a través del cual se puede evidenciar la evolución en términos estructurales, jerárquicos y conceptuales y demostrándose más eficientes "durante" el proceso de intervención.

1 Introducción

La Enseñanza de las Ciencias Naturales en Brasil en los primeros años de la educación básica ha sido fundamentada y dirigida por los Párametros Curriculares Nacionales, (Secretaría de Educación Fundamental - SEF, 1998). Esta orientación detaca la importancia, en el contexto escolar, de aprendizaje significativo y propone la construcción de una estructura general de esta área del conocimiento que "fomenta el aprendizaje significativo del conocimiento científico" (p. 31). Sin embargo, al analizar las directrizes pedagógicas establecidas por el plan de estudios nacional, no se encontraron pruebas de cómo fomentar el aprendizaje significativo de los conceptos en la sala de clases para que los estudiantes puedan aprender de manera significativa.

Por lo tanto, levantamos la hipótesis que para enseñar conceptos científicos en las ciencias naturales es necesario crear un entorno propicio para el aprendizaje significativo de los conocimientos poco a poco, ya que los estudiantes tienen un repertorio de representaciones, el conocimiento intuitivo, adquirido por la experiencia, la cultura y el sentido común, acerca de los conceptos que se enseñan en lo que respecta a la educación, lo que constituye el conocimiento previo. Además, el grado de madurez intelectual y emocional del estudiante durante su educación son también importantes en el desarrollo de los conocimientos previos que sirvieron de base para la adquisición de nuevos conceptos científicos.

Con base en esta hipótesis, se argumenta que la creación de un entorno que favorezca el aprendizaje en un enfoque de sentido ausubeliana sólo es posible mediante el uso del mapa conceptual progresivo. Esta herramienta educativa, potencialmente importante, puede ayudar al aprendizaje, así como evaluar la progresividad del mismo en términos de evolución conceptual. Por esta razón, la investigación es dirigida al aprendizaje de conceptos con el uso de la evaluación del mapa conceptual del aprendizaje progresivo de los temas de Ciencias Naturales para los estudiantes de primaria. Con el fin de lograr el objetivo, se elaboraron situaciones de aprendizaje para los temas "Suelo, los Mamíferos y el Sistema Respiratorio", los contenidos curriculares de estas disciplinas.

Las metodología de enseñanza, el aprendizaje y la investigación incluyó: pretest y postest, la prueba de evaluación final, después del desarrollo de contenidos, cuestionario de evaluación de los mapas, entrevistas semiestructuradas y los registros realizados durante la clase. Los datos se sometieron a análisis cualitativo y cuantitativo. En el análisis cualitativo, los mapas conceptuales fueron clasificados como buenos, regulares y deficientes y cuantitativa buscó el número de conceptos, las jerarquías, las relaciones y ejemplos. Consideramos como un hecho relevante, que los estudiantes tenían mejores resultados en la etapa intermedia del proceso, es decir, fueron capaces de construir buenos mapas, en mayores cantidades y mejor calidad, durante el proceso de intervención.

Este artículo presenta resultados parciales de investigación y ejemplos de mapas construidos durante el proceso, los estudiantes de tres niveles (5 º, 6 º e 7º) de una Escuela Primaria, antes, durante y después del estudio de sus súbditos. Es un recorte de una investigación mayor sobre la utilización de mapas conceptuales en la evaluación del aprendizaje de temas en Ciencias Naturales y Biología. El estudio ayuda a fortalecer los datos sobre el uso de mapas conceptuales progresivos en los diferentes niveles educativos y en diferentes contextos.

2 Marco teórico

La investigación se basa en la teoría del aprendizaje significativo de Ausubel. La atención se centra en el aprendizaje de lo que el alumno ya sabe. Acerca de eso dice: "Si tuviera que reducir toda la psicología educativa a un solo principio, yo diría que el factor más importante que influye en el aprendizaje es lo que el alumno ya sabe. Descubra eso y enseñe de acuerdo a eso". (Ausubel et al., 1980, p. 137). Para Ausubel (2002), una adquisición significativa de nuevos conocimientos depende en gran medida de las ideas que ya forman parte de la estructura cognitiva del alumno. El almacenamiento de información en el cerebro humano está organizado, formando una jerarquía de conceptos, en el que los elementos más específicos del conocimiento están vinculados y tratados como conceptos más generales. Los nuevos conocimientos que constan de los conceptos más específicos y menos inclusivos, interactúan con los conceptos más generales e inclusivos y proposiciones que ya forman parte de la estructura cognitiva del estudiante, un proceso que Ausubel llama a la subsunción. Hacer un Plan de instrucción en los principios ausubeliano requiere que el profesor utilice material potencialmente significativo y cuya organización de los contenidos a ser estudiados esten en conformidad con los principios de diferenciación progresiva y reconciliación integradora (Moreira, 2006).

Basado en las ideas de Ausubel, Novak y Gowin (1999) desarrollaron los mapas conceptuales en los años 70, como proyecciones de las prácticas de teoría del aprendizaje significativo. Estas ideas se han ido perfeccionando, Novak desde su visión humanista. El concepto humanista ve al alumno sobre todo como persona y centra su atención en el crecimiento personal y en la autorrealización. Por lo tanto, en su propuesta, Novak (2000) enfoca la educación como un conjunto de experiencias cognitivas, afectivas y psicomotoras que contribuyen para el aprimoramiento del individuo. Para el autor no tiene ningún sentido hablar de la conducta o la cognición sin tener en cuenta los sentimientos, pensamientos y acciones que se integran para promover el aprendizaje significativo.

Desde esta perspectiva, el mapa conceptual se consolidó y admite varias formas de enseñanza e investigación. Entre las investigaciones encontramos aquellos que utilizan los mapas de concepto progresivo. En el mapa conceptual se muestra el desarrollo progresivo de los conocimientos de los estudiantes en serie, o la progresión. Este modelo fue utilizado por Pearsall, Skipper y Mintzes (1997), en un estudio longitudinal con estudiantes de Biología. Al final, se consiguió una serie de mapas conceptuales para cada estudiante que permitió reconstruir el proceso de cambio conceptual y las tendencias de los mapas conceptuales. En el trabajo más reciente, Conceição y Valladares (2002) utilizaron el mapa conceptual como un apoyo progresivo de una estrategia de aprendizaje de los conceptos de la mecánica, con los estudiantes de 9 º grado en una escuela en Portugal.

Las encuestas también muestran que los mapas conceptuales se pueden utilizar en cualquier área de conocimiento y pueden ayudar al estudiante a construir y compartir significados, aprender significativamente contextualizar el aprendizaje, aprender a aprender, enseñar a pensar. Estas posibilidades son desafíos a ser enfrentados mediante la enseñanza y la investigación en el aula con la ayuda de este instrumento. De acuerdo con Novak y Gowin, es una herramienta de instrucción, potencialmente importante, cuando se utiliza como herramienta de evaluación del aprendizaje, para eso es importante analizar los conceptos apropiados y las relaciones entre ellos, es decir, información acerca de cómo la estructura de los estudiantes, filas y diferenciado, se refiere, discrimina e integra conceptos de una unidad de estudio en particular, el tema, la disciplina, entre otros. Además de proporcionar información sobre el tipo de estructura que el estudiante ve para un determinado conjunto de conceptos. Por lo tanto, hay que tener en cuenta el mapa como una herramienta de evaluación, lo que implica una postura que, para muchos, difiere de la habitual, ya que la idea principal es evaluar lo qué saben los estudiantes en términos conceptuales y no asignar una calificación numérica.

3 Desarrollo Metodológico

Esta investigación fue realizada en una escuela de la red pública municipal de enseñanza de Pernambuco, queda ubicada en la ciudad de Garanhuns, región Nordeste de Brasil. Hemos seleccionado tres clases: 16 estudiantes de quinto grado, tema Suelo, 16 encuentros (estudio 1), con 16 alumnos de sexto grado, Mamíferos, 33 encuentros (estudio 2) y séptimo grado con 24 alumnos, tema Sistema Respiratorio, 20 encuentros (estudio 3) con edades comprendidas entre 9 y 14 años. La herramienta principal de la investigación fueron los mapas conceptuales progresivos, cuyo propósito fue examinar la evolución de los conocimientos sobre los contenidos específicos relacionados con los temas mencionados. El proceso de intervención se realiza a través de situaciones de aprendizaje previstos para sus reuniones de 50 minutos cada uno. La preparación de mapas se hizo de forma individual y en parejas: antes, durante y después de la enseñanza de los contenidos. Para el análisis cualitativo de los mapas en tres momentos se establecieron los criterios de clasificación en relación con el grado de jerarquía. Los criterios de análisis adoptadas se basan en nuevas estrategias para la evaluación de los mapas conceptuales propuestos por Novak (2000). Los mapas fueron analizados en base a tres categorías de clasificación: i) Mapa de Bueno (MB) - Indica una mayor aceptación del tema; ii) Mapa Regular (MR) - Indica baja aceptación del tema, y iii) Mapa Deficiente (MD) - Indica la falta de comprensión del tema en cuestión (tabla 1). Con el fin de identificar evidencias de aprendizaje significativo en los mapas de los estudiantes, se tuvo en cuenta: el número de conceptos válidos y su relación con el tema, el número de enlaces correctos (simple cruz) la adecuación de las palabras de enlace que utilizan; las jerarquías y una indicación de ejemplos válidos que se encuentran en los mapas aprobados como representante de los conocimientos de los estudiantes antes, durante y después del estudio de los sujetos (tabla 2). En la tabla 2, se decidió trabajar sólo con números enteros. El símbolo (-) indica que los datos no existe. Cuando los datos existe pero es menor o igual a 0,5, se registró el "0" (esto ocurrió en el caso de las medias aritméticas). A modo de ejemplo presentamos algunos mapas conceptuales elaborados por los estudiantes progresivamente. La idea principal era entender qué saben los estudiantes en términos conceptuales.

4 Resultados y Discusión

Se presenta en la Tabla 1, para todos los estudiantes de cada nivel de la escuela y el número total de estudiantes que participaron en la investigación, la evolución de la calidad de los mapas conceptuales producidos en las tres etapas del estudio de los respectivos temas. Se observa que al principio sólo quince del total de los estudiantes fueron capaces de producir buenos mapas, un porcentaje que se elevó a treinta y dos en el momento intermedio y llegó a treinta y ocho en el último momento. El porcentaje de los mapas clasificados como deficiente fue pequeño, antes y durante. Después del estudio hubo una reducción en el porcentaje de 5 a 4 mapas deficientes.

De acuerdo con los datos mostrados en la tabla 1 hay diferencias significativas observadas entre los tres conjuntos. Al inicio del estudio, dos estudiantes de quinto grado y de sexto grado lograron hacer un buen mapa. En el séptimo grado, la participación de los mapas clasificados como "bueno", en un primer momento, fueron los de once estudiantes. Cuando se suman los porcentajes de buenos mapas y mapas regulares en el momento inicial, tenemos una idea de la proporción de estudiantes que han demostrado los conocimientos previos que podrían anclar los nuevos conceptos que se estudiarían en cada grupo. Estos porcentajes son bastante altos en el 7 º grado y más bajos en el quinto y en el sexto grado.

Hacemos una observación en relación con los estudiantes que construyeron los mapas finales clasificados como deficiente, y con aquellos que no demostraron una mejora en la calidad de sus mapas, que elaboraron mapas regulares antes, durante y después del estudio del tema. En el contexto de la educación, eso era esperado, ya que, según Ausubel (2002), para que el aprendizaje significativo ocurra, es necesario tanto la presentación, a los estudiantes, de un material potencialmente significativo, como la disposición para el aprendizaje por parte de los estudiantes. Además, como afirma el autor, el estudiante debe poseer conceptos relevantes integrados en su estructura cognitiva, es decir, inclusores que pueden servir como ancla para los nuevos conocimientos. La ausencia de tal condición es un problema común en el contexto de las escuelas públicas, ya que muchos estudiantes no tienen el contenido cognitivo estructurado de acuerdo a su nivel escolar, lo que constituye una dificultad en el aprendizaje de conceptos científicos cada vez más elaborado.

En la Tabla 2, están dispuestos la media global de los tres mapas en diferentes momentos de los estudios 1, 2 y 3. Su análisis se basó en el número de conceptos válidos y su relación con el tema. Al comienzo era posible asignar un gran número de conceptos. Esta posibilidad encuentra apoyo en la recomendación de Novak y Gowin (1999) que en el inicio del trabajo con mapas, el número de conceptos puede situarse entre 6 y 10. En los estudios 1 y 2 el número de conceptos se mantuvo alto en los tres momentos por lo tanto difiere del estudio 3. El número de enlaces correctos (simple cruz) representa la existencia de relaciones entre conceptos pertenecientes a diferentes segmentos del mapa, ya que el mapa ideal es aquel que tiene muchos vínculos directos, el número de filas debe ser mayor que los conceptos, de esta forma al mostrar las relaciones entre los conceptos, nos permite una mejor representación del conocimiento.

Observamos en los estudios 2 y 3 que el número de filas que contienen palabras de enlace fue alta y en el estudio 1 coincidió con el número de conceptos. Estos datos representan la idoneidad de las palabras de conexión, que se utilizaron para explicar la naturaleza de las relaciones entre los conceptos, de esta manera, cuanto más cerca esté el número de palabras de enlace al número de líneas de conexión, mejor será el mapa. En este sentido, Moreira (2006 p. 94) señala que no es fácil encontrar una palabra clave que expresa una relación significativa entre los dos conceptos. Así que la tendencia es caer en el uso de los verbos y las preposiciones que, en el mejor de los casos, surgen relaciones muy pobres que descartan el gran potencial ofrecido allí para una negociación de significados.

Nos pareció que en los tres momentos en los que los estudiantes llevaron a cabo los mapas, las mismas expresiones han prevalecido y las mismas frases utilizadas en los estudios 1, 2 y 3. Enlaces cruzados representan la existencia de relaciones entre conceptos pertenecientes a diferentes segmentos del mapa, por lo que la presencia de dos enlaces cruzados pueden indicar la capacidad creativa de los estudiantes. Pensando así, podemos concluir que en los estudios 2 y 3, este número es directamente proporcional a la cantidad de conceptos, los estudiantes demostraron capacidad creativa para hacer las conexiones.

Tabla 1 - Evolución de la calidad del los mapas conceptuales en los tres estudios

Nº e %	Calidad de los Mapas Conceptuales								
	Antes			Durante			Después		
	MB	MR	MD	MB	MR	MD	MB	MR	MD
	Estudio 1 – 5º grado, 16 alumnos								
Número	2	13	1	5	10	1	8	6	2
%	12	81	6	31	63	6	50	38	12
	Estudio 2 – 6º grado, 16 alumnos								
Número	2	10	4	8	4	4	12	2	2
%	12	63	25	50	25	25	75	12	12
	Estudio 3 – 7º grado, 24 alumnos								
Número	11	13	-	19	5	-	18	6	-
%	46	54	-	79	21	-	75	25	-
	Total de los tres estudios, 56 alumnos								
Número	15	36	5	32	19	5	38	14	4
%	27	64	9	57	34	9	68	25	7

El número de niveles jerárquicos, de acuerdo con Novak y Gowin (1999), puede ser analizada con el tipo de estructura del mapa, ya que ambos enfocan la jerarquía entre los conceptos. Cuanto mayor respeto a la jerarquía, será mejor organizado el mapa de conceptos. Así, entre los estudios de 1, 2 y 3, este último fue el más cercano a la jerarquía defendida por los autores y en el que los estudiantes presentaron conceptos básicos y generales del tema. En otros dos estudios, hubo una variación en el número de conceptos e ideas demostradas por los estudiantes, algunos conceptos centrales de la materia de enseñanza y otros relevantes. También mostró algunas de las características puntuales a cada tema. Podemos considerar a partir de los tipos de estructuras mostradas en los mapas, que prevalecieron en los tres estudios la estructura de tipo la jerárquica.

Tabla 2 - Promedio de las estructuras generales de los tres mapas (antes, durante y después) en los tres estudios

Estructuras				Estudios		
				Antes	**Durante**	**Después**
Total de Conceptos				16	15	10
Ligaciones	Total de Línea(fila)			16	16	12
	Línea Ausentes			0	0	-
	Conectores	ÚNICO	Verbo	2	2	1
			Artículo	1	0	0
			Conjunção	0	-	-
			Pronombre	-	0	0
			Adverbio	1	-	0
			Preposición	1	0	0
			Ejemplo	0	1	0
		Expresión		8	7	5
		Frase		4	4	6
Niveles Jerárquicos	Vertical			7	6	5
	Horizontal			5	6	5
Relaciones entre Conceptos[a] (Um concepto conectado a ...)	1			8	7	3
	2			5	5	4
	3			1	1	1
	4			1	1	1
	5			0	0	0
	6			0	0	0
	7			0	0	0
	8			0	0	0
	9			0	0	0
	10			0	0	0
	12			0	-	-
	13			-	0	-
	15			-	0	-
Conexiones Cruzadas				1	2	2
Estructura Jerárquica				1	1	1

[a] No hubo relaciones a uno y 1 X 11 14 X conceptos.

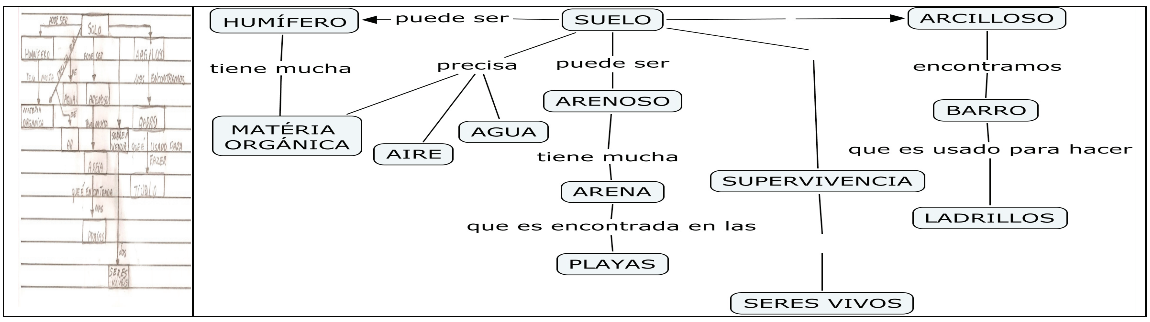

Figura 1: Mapa Conceptual - S9

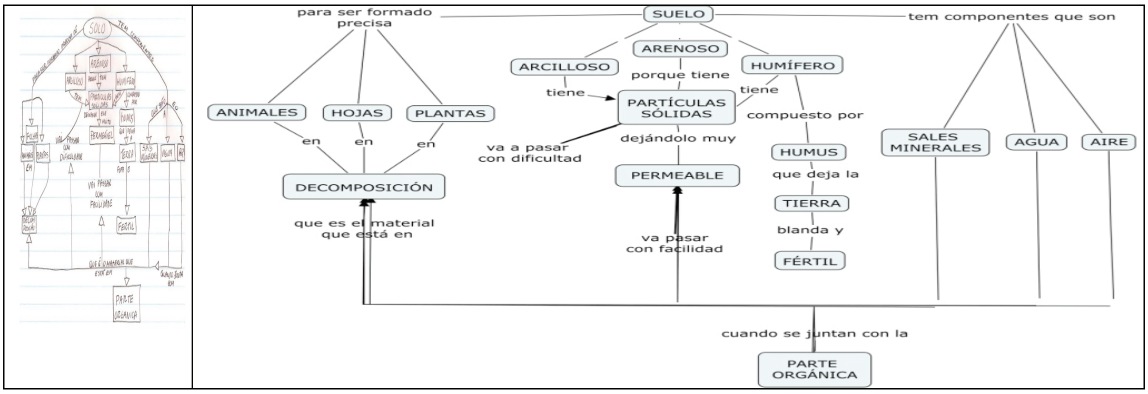

Figura 2: Mapa Conceptual - S9

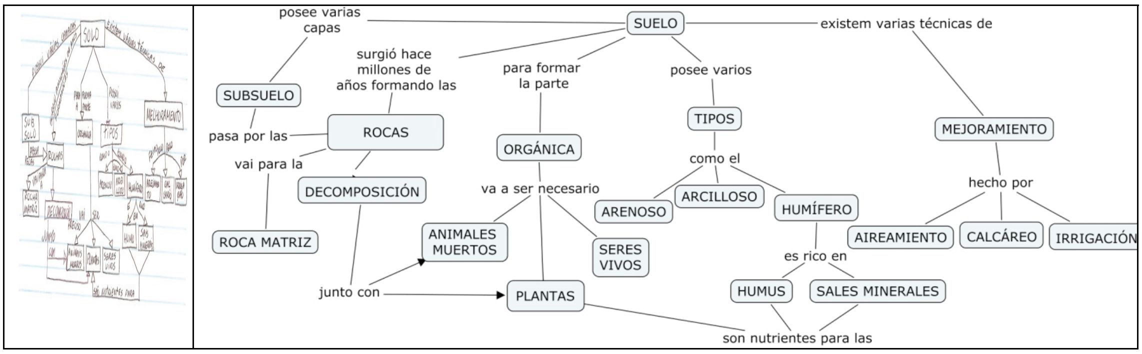

Figura 3: Mapa Conceptual - S9

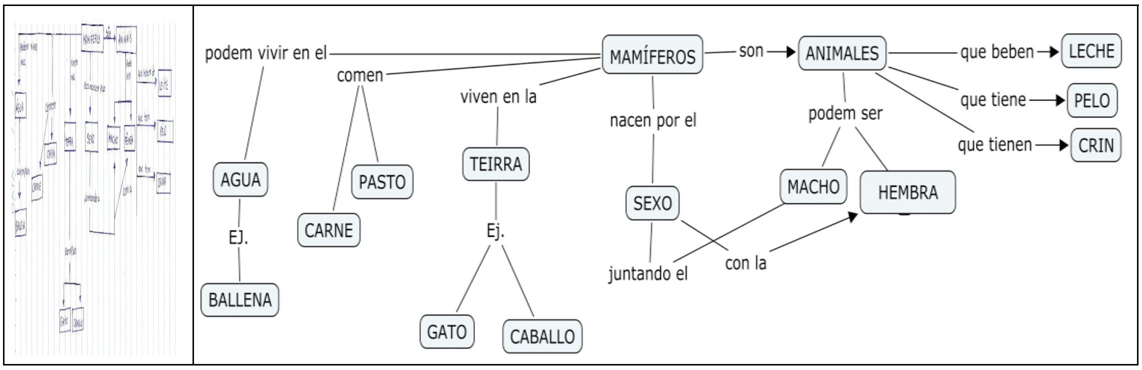

Figura 4: Mapa Conceptual pareja (M7, M8)

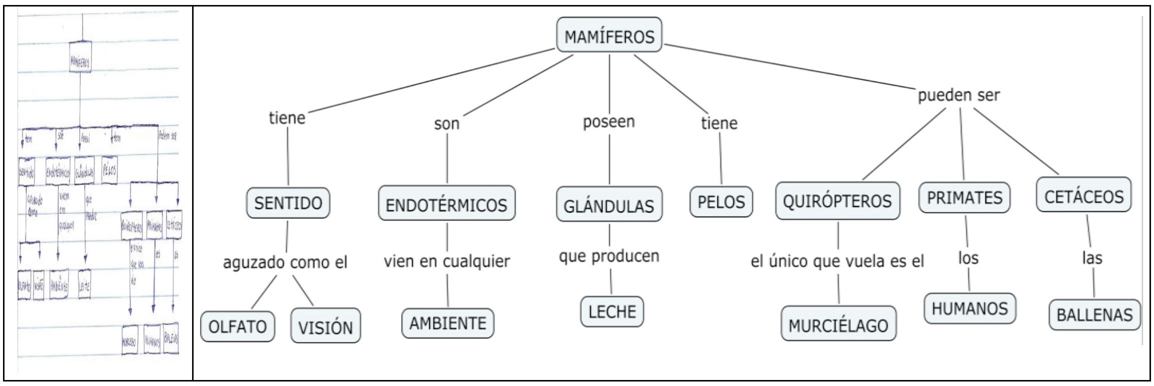

Figura 5: Mapa Conceptual pareja (M7, M8)

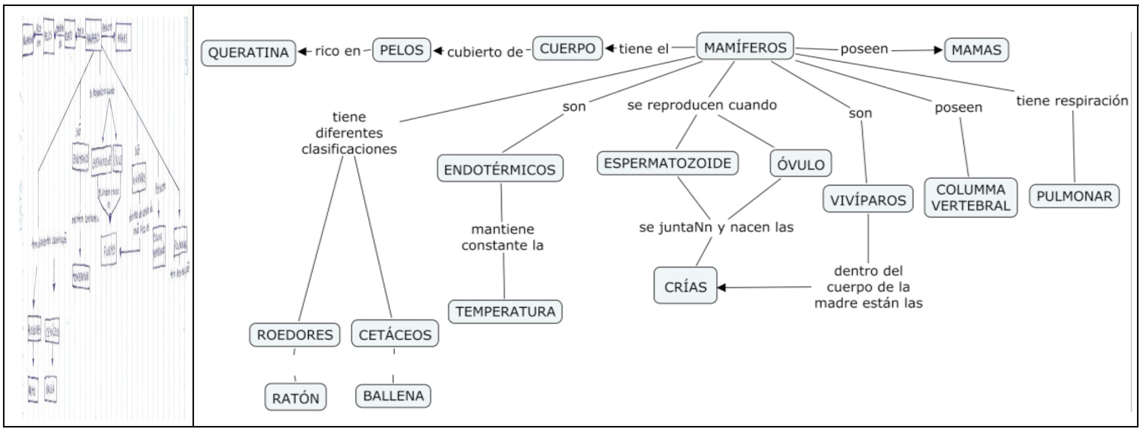

Figura 6: Mapa Conceptual pareja (M7, M8)

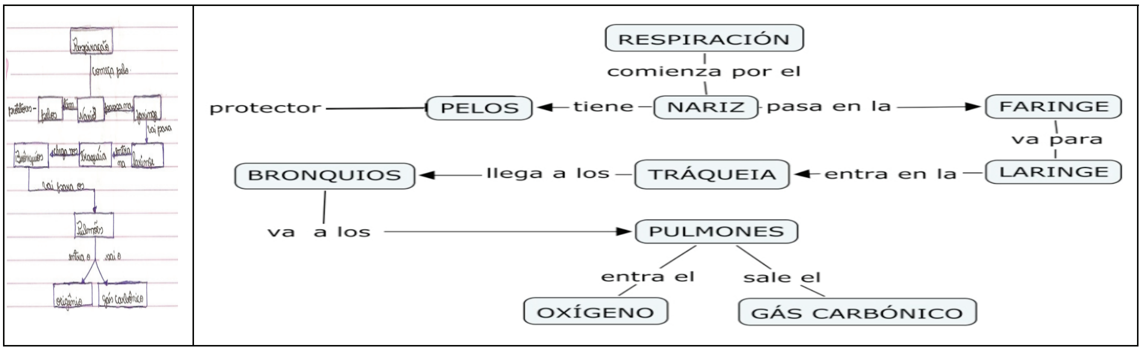

Figura 7: Mapa Conceptual - R32

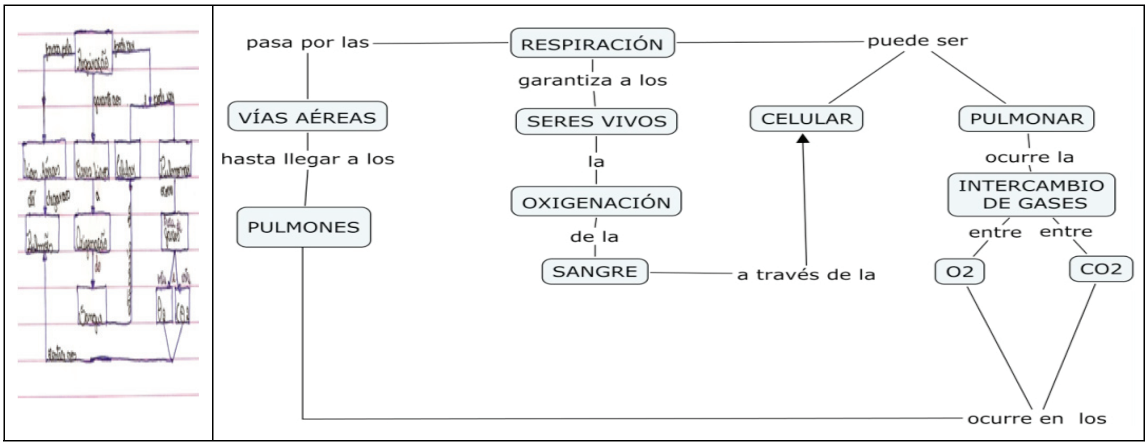

Figura 8: Mapa Conceptual - R32

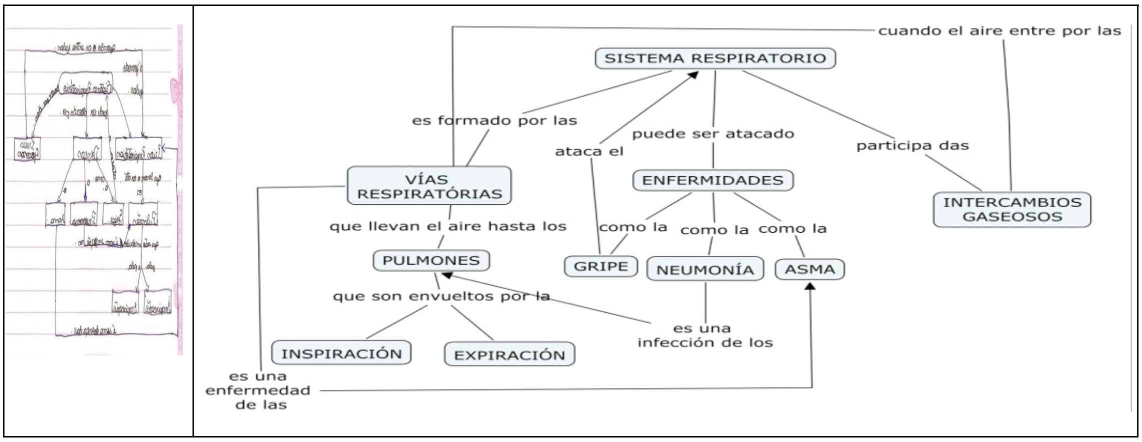

Figura 9: Mapa Conceptual - R32

5 Consideraciones finales

El análisis de los mapas conceptuales elaborados por los estudiantes de cada nivel, antes, durante y después del estudio de sus temas, permite entender los significados que são atribuidos a los conceptos estudiados, así como las relaciones conceptuales creadas por ellos. Creemos que, al utilizar los mapas conceptuales progresivos como un recurso para la enseñanza, aprendizaje y evaluación, los objetivos fueron alcanzados, porque los estudiantes demostraron evolución conceptual al final y por sobre todo, por la aceptación del nuevo instrumento, que hasta entonces era desconocido para ellos. Nos dimos cuenta de que la construcción de los mapas de forma individual y en parejas requiere una especial atención y dedicación por parte del profesor con respecto a la asistencia prestada a cada estudiante. La participación activa, el interrogatorio, la disposición de él en la elaboración de los mapas, la discusión con los colegas, refuerza la importancia de la investigación sobre el potencial educativo de los mapas conceptuales. Creemos que, con base en el análisis que los mapas conceptuales de los tres estudios- antes, durante y después - dejó claro que los estudiantes pueden incorporar nuevos conceptos y son capaces de establecer jerarquías y relaciones conceptuales. En general, podemos decir que la elaboración de los mapas ha mejorado progresivamente "durante" el proceso de intervención. Llegamos a la conclusión del análisis de los mapas conceptuales pueden mostrar evidencia de un aprendizaje significativo en la construcción de significados de la materia cuando se comparan con los mapas originales preparadas durante y después del proceso.

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MAKING INTERDISCIPLINARITY VISIBLE USING CONCEPT MAPPING

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Abstract. Interdisciplinarity can be considered an alternative way to reorganize the content taught during courses to recover the loss of meaning caused by the exponential growth of knowledge. Despite its importance, interdisciplinary activities in classrooms are still rare because of difficulties faced by instructors involving curriculum design and teaching method selection. The literature does not present a reliable procedure to help instructors identify possible connections between courses. The aim of this paper is to propose a procedure using Cmaps to make visible the concepts that can foster interdisciplinarity, as well as the productive dialogue involving instructors. The interdisciplinary propositional interface (IPI) highlights the core concepts responsible for merging course content and helping instructors focus attempts to connect their courses. A case study involving the courses Natural Sciences (NS) and Psychology, Education and Contemporary Issues (PECI) is presented. These courses represent the two-culture isolation, considering NS and PECI courses are from the scientific and humanities fields, respectively. Despite a seemingly difficult task, the collaborative efforts involving the instructors confirmed that the conceptual frameworks of courses can be connected. The more promising concepts to overcome the two-culture barriers are "complexity", "religion", and "technology". The concepts and propositions presented in the IPI offer an excellent starting point for instructors to collaborate on concrete actions to promote interdisciplinarity in their classrooms, such as teaching methods and instructional materials. Making interdisciplinarity visible is only part of the way to make our courses more connected. The next step will be to explore the information obtained using Cmaps to make the interdisciplinarity visible to students.

1 The need of interdisciplinarity

The explosion of scientific knowledge and the paradigms of contemporary society have brought new challenges to formal education, which are not adequately addressed using the traditional curricular configuration. The integrated understanding of content from different disciplines is a key aspect that should be considered in higher education to prepare professionals who are capable of dealing with the complex challenges of our contemporary society (Ford & Forman, 2006; Moran, 2010; UNESCO, 2005). Therefore, interdisciplinary approach should be intentionally adopted and curriculum should facilitate an inter-relationship among disciplinary content. Despite its importance, interdisciplinary activities in classrooms are still rare because of difficulties faced by instructors that involve curriculum design and teaching method selection.

Organizing the curriculum into disciplines was a solution to account for the enormous amount of information accumulated by humanity and facilitated and standardized the transmission of expert knowledge. For this reason, disciplines play a critical role in the development and organization of the academic curriculum. Additionally, the fragmentation of knowledge into disciplines is employed to organize and systematize the knowledge necessary to educate students. Despite all attempts to organize a non-disciplinary curriculum, the disciplines are the preferred way to transmit knowledge in formal education (Klein, 1996; Lattuca, 2001; 2002).

In comparison to traditional practices, interdisciplinarity can be considered a response to the exponential growth of knowledge, which assumes the organization of content in terms of contemporary issues that require the articulation of concepts from various fields of knowledge (Klein, 1996; Weingart & Stehr, 2000; Lattuca, 2001). Moreover, interdisciplinarity also fosters innovation and creativity and breaks the paradigm of standardization; thus, better connecting scholarly contexts with new demands of our contemporary society (Sawyer, 2006).

The literature related to the organization of interdisciplinary curricula in higher education reveals a gap that hinders the establishment of links between concepts from different knowledge fields. There is no robust procedure to help instructors identify possible connections between their courses. The experience of our research group with Cmaps indicates that this technique can be used to graphically organize and represent the conceptual content of disciplines to search by interdisciplinary connections. Further, Cmaps can support the meaning negotiation among instructors through collaborative knowledge construction (Crandall, Klein & Hoffman, 2006; Fischer et al., 2002).

2 Concept mapping and collaborative knowledge construction

2.1 Historical development of concept mapping

Concept mapping was developed by Novak and colleagues in 1972 at Cornell University. At that time, Cmaps were used to represent the conceptual network established by students throughout elementary and high school, which resulted in a 12-year longitudinal study of conceptual change in science education (Novak & Musonda, 1991). Audio from taped interviews with students was the primary source of empirical data and because of difficulties in fully transcribing them, Cmaps were used to represent part of student's cognitive structure by organizing concepts into a propositional network. This graphical form of representing the concepts mentioned by students during the interviews allowed the researchers to observe, with detail and accuracy, conceptual changes that occurred over the years (Novak & Musonda, 1991; Novak and Cañas 2006, 2010).

Propositions are the remarkable feature of Cmaps and they are formed by two concepts connected by a linking phrase that states clearly the conceptual relationship. The need to include linking phrases is the main difference of Cmaps compared to other graphical organizers (Novak, 2010). The content of the Cmap is more objective and less idiosyncratic, which facilitates the communication process during collaborative activities (Torres & Marriott, 2009; Moon et al., 2011).

The historical development of Cmaps is represented by a timeline that begins in the 60s (Figure 1). The initial milestone occurred before the birth of Cmaps (1972) when David Ausubel published *Assimilation Theory of Meaningful Learning and Retention* (Ausubel, 2000). Although it is important to use Cmaps appropriately for educational purposes, this theory has been neglected by beginner users who claim the difficulties in getting the promised benefits shown in the literature.

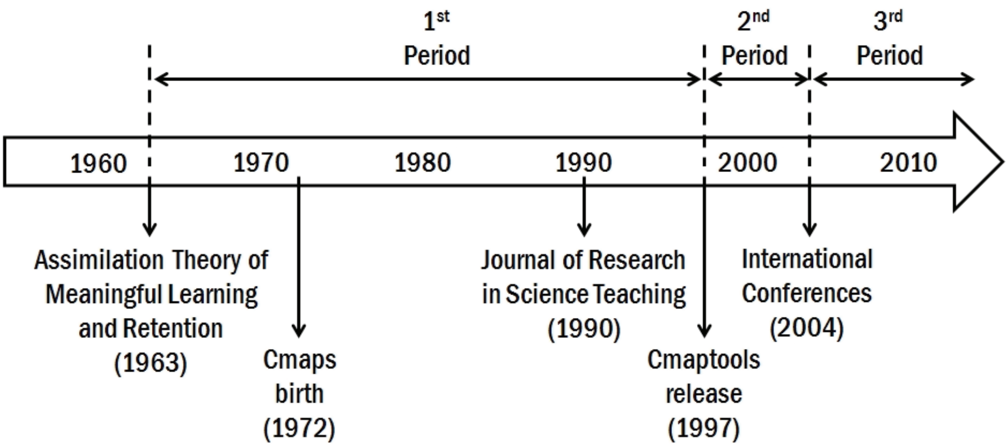

Figure 1. Historical development of the conceptual mapping from the 60s to today.

The first period was characterized by the development of Cmaps (1972) and the widespread use of manuscript Cmaps, especially for science teaching. The difficulty of revising this kind of Cmap hindered the potential of the technique because users had not yet fully explored the recursive revision. Nevertheless, the recognition of concept mapping as a valuable technique to foster conceptual changes throughout formal education was confirmed in 1990 in a publication of a special issue about Cmaps in the *Journal of Research in Science Teaching* (Beyerbach & Smith, 1990; Novak, 1990; Wandersee, 1990).

The release of CmapTools in 1997 was responsible for increasing the use of Cmaps because it made easier to revise and share digital files (.cmap). CmapTools (Cañas et al, 2004) is the result of a collaboration between Joseph Novak and Alberto Cañas and has been developed by the Institute for Human and Machine Cognition (IHMC). The increase in Internet access and the possibility to use this free software toolkit (downloadable at http://cmap.ihmc.us/download/) burgeoned the use of Cmaps for purposes that go beyond educational interests. In addition to the opportunity to review digital Cmaps, as easily as we can edit text using word processing software, synchronous and asynchronous collaboration has become a reality. Today, conceptual mapping is also used in corporations for information and knowledge management (Moon et al., 2011), expanding collaborative and lifelong learning to contexts that extrapolate formal education (Visser & Visser-Valfrey, 2008).

International conferences on concept mapping have occurred every two years since 2004. Researchers, instructors, and practitioners interested in Cmaps gather at these meetings to consolidate advances in the use of this graphical organizer, which confirm the universality and ubiquitousness of Cmaps (Novak & Cañas, 2010). This is the context, the latest research on concept mapping is discussed (Almeida & Moreira, 2008; Cicuto & Correia, 2012; Correia, 2012; Correia, da Silva & Romano Jr., 2010; Correia et al., 2010; Derbentseva, Safayeni & Cañas, 2007; Hay, Kinchin & Lygo-Baker, 2008; Hay, Wells & Kinchin, 2008; Hilbert & Renkl, 2008; Karpicke & Blunt, 2011; Kinchin, Hay & Adams, 2000; Kinchin, Lygo-Baker & Hay, 2008; Nesbit & Adesope, 2006, 2011; Novak, 2002, 2005; Romano Jr. & Correia, 2010; Safayeni, Derbentseva & Cañas, 2005; Yin et al., 2005).

2.2 Collaborative concept mapping aiming knowledge construction

The process of collaborative knowledge construction (CKC) can be understood as a succession of three steps (Fischer et al., 2002). Externalization and elicitation of task-relevant knowledge precedes consensus building, which can be achieved by conflict or integration of ideas (Table 1).

Table 1: Main steps for describing the collaborative knowledge construction and the role of concept mapping to externalize, elicit and build consensus.

Step	Itemized description	Concept mapping	
		Individual	Collaborative
1	Externalization of task-relevant knowledge	Yes	No
	• *Individuals bring individual prior knowledge into the situation* • *Different points of view can be clarified* • *Exchange of individual concepts is the starting point for negotiating common meaning* • *Diagnosis and resolution of misconceptions can take place*		
2	Elicitation of task-relevant knowledge	Yes	Yes
	• *Learning partners express their knowledge related to the task* • *Elicitation occurs frequently in the form of questions, which leads to externalizations in the form of explanations* • *Elicitation could be partly responsible for successful learning*		
3(a)	Conflict-oriented consensus building	No	Yes
	• *Individuals seek a common solution or assessment of the given facts* • *Conflict plays an important role in reaching consensus* • *Different interpretations made by learning partners can led to a modification of knowledge structure*		
3(b)	Integration-oriented consensus building	No	Yes
	• *Consensus can be reached through the integration of various individual perspectives into a common interpretation or solution for the given task* • *Superficial conflict-avoiding cooperation style may be used in this attempt to incorporate individual views in a common perspective* • *There is a tendency on the part of the learners to reach an illusionary consensus*		

Visualization tools can foster CKC. Among other options, Cmaps appear as powerful visualization tools to represent knowledge. They are useful for making idiosyncratic mental models explicit for revising (intrapersonal activity with individual Cmaps) and sharing ideas (interpersonal activity with collaborative Cmaps). Both purposes are important during CKC because all participants can visualize, interpret, and organize their own ideas (intrapersonal) before engaging in conflict-oriented or integration-oriented consensus building (interpersonal). Moreover, collaborative concept mapping can also support discursive meaning mediation and conflict negotiation, even when on-line tools are used.

Elicitation of expert knowledge is a critical issue that can be addressed using Cmaps and naturalistic studies (Crandall, Klein &Hoffman, 2006). This is a sophisticated use of concept mapping and its success depends on the skills of the interviewer (mapper facilitator) to organize and clarify the specialized knowledge by posing questions during a half-structured interview. The dialogue among instructors who aim to find interdisciplinary connections among their courses fits into this description. Therefore, concept mapping can be explored to make interdisciplinarity visible.

3 Research goals

This paper proposes a procedure using Cmaps to increase visibility of concepts that foster interdisciplinary curriculum. A case study involving the courses Natural Sciences (NS) and Psychology, Education and Contemporary Issues (PECI) is presented.

4 Procedures to increase visibility of interdisciplinarity

4.1 Preparation and revision of Cmaps before collaborative knowledge construction (CKC)

One Cmap was created to represent the conceptual framework of each course considered (NS and PECI). Table 2 shows the 4-step procedure followed to revise the Cmaps, which must be carried out before the CKC.

Table 2: Procedure to prepare and revise Cmaps.

Step	Main goal	Description	Cmap ID
1	*Student's point of view about the course*	*An undergraduate student who knows how to prepare a Cmap (G.B.C.) checks his or her notes about the course. His or her perspective drives the creation of the Cmap (draft version).*	Cmap-1
2	*Semantic clarity revision*	*Cmap-1 is revised during a meeting (90-120 min) between the student (G.B.C.) and an expert on concept mapping (P.R.M.C.). The goal is to check the semantic clarity of each proposition through a dynamic involving questions and answers.*	Cmap-2
3	*Instructor's point of view about the course*	*Cmap-2 is discussed with the course instructor during a half-structured interview (40-60 min) with the undergraduate student (G.B.C.). The goal is to include the instructor's point of view through exclusion, inclusion, and modification of concepts and propositions.*	Cmap-3
4	*Semantic clarity, hierarchy and level of detail revision*	*Cmap-3 is revised during a meeting (90-120 min) between the student (G.B.C.) and an expert on concept mapping (P.R.M.C.). The goal is to check the propositional network considering its semantic clarity, conceptual hierarchy, and level of detail (number of concepts used to describe each course).*	Cmap-4

Steps 1-4 are critical to identify interdisciplinary connections between courses. In this case study, one Cmap-4 was obtained for each course (NS and PECI). All meetings and half-structured interviews were audio recorded.

4.2 CKC and the search for interdisciplinarity

Figure 1 shows the role of preparation and revision steps (Table 1) to the CKC; a final meeting (180-240 min) involving the student (G.B.C.), the expert in concept mapping (P.R.M.C.), and the course instructors is conducted. The goal is to merge the Cmap-4 of each course by connecting the concepts from them through a dynamic involving questions and answers.

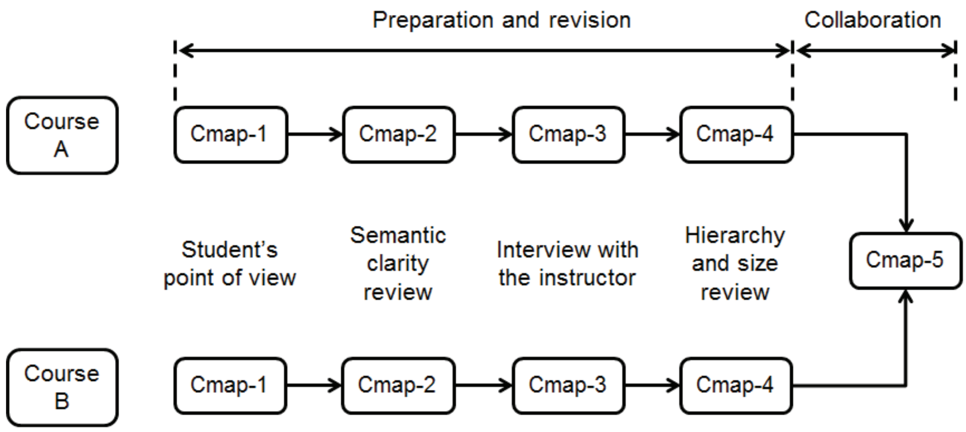

Figure 1. Mapping the conceptual framework of courses to search for interdisciplinarity connections. The CKC aims to produce Cmap-5 after the preparation and revision steps.

Cmap-5 is the most promising representation of prospective interdisciplinary connections. The interdisciplinary propositional interface (IPI) is a new concept proposed in this paper (Figure 2). Specifically, IPI highlights the core concepts that are responsible for merging courses content and helping instructors focus the attempts of interdisciplinary connections.

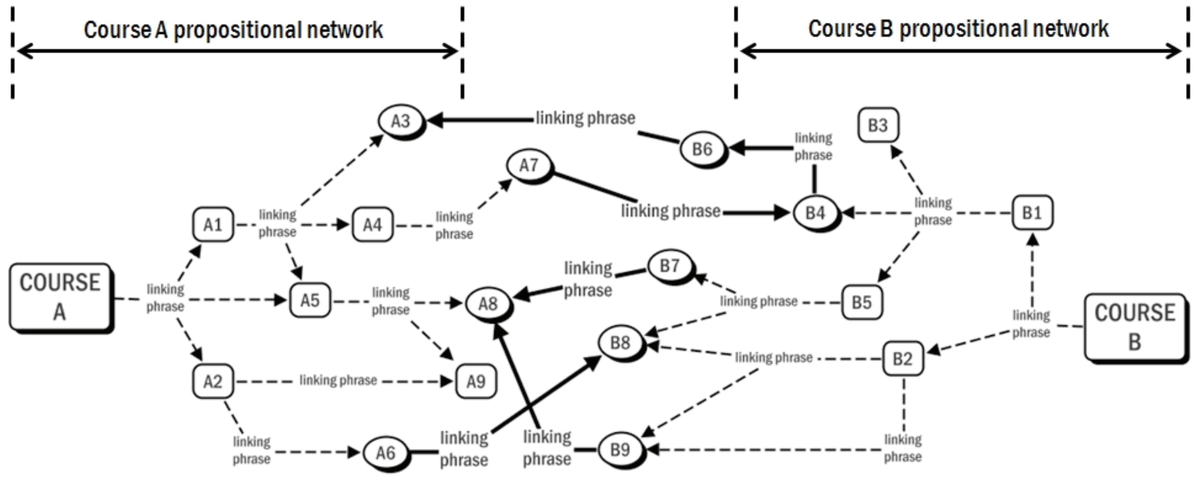

Figure 2. Schematic representation of the interdisciplinary propositional interface (IPI), which can be identified in Cmap-5. The IPI contains the core concepts (shadowed circles linked with thicker lines) from each course that is responsible for prospective interdisciplinary connections. Concepts A and B describe the conceptual framework of courses A and B, respectively.

5 Prospective interdisciplinary connections between the two cultures

C. P. Snow's (1998) thoughts about the British educational system were first revealed in the 60s; however, they are still recalled because they highlight the barriers that isolate scientists and literary intellectuals from each other. The desire to pursue interdisciplinarity can be understood as a movement to bring together these two cultures. The courses chosen for this case study represent this two-culture isolation; considering the Natural Sciences (NS) course and the Psychology, Education and Contemporary Issue (PECI) course are from the scientific and humanity academic cultures, respectively.

Figure 3 shows the Cmap-5 obtained after following the procedures described in the previous section. Despite seeming a difficult task, the discussion during the CKC confirmed that the conceptual frameworks of these courses can be connected. The more promising concepts to overcome the two-culture barrier are "complexity", "religion", and "technology", as shown in the IPI (see shadowed circles and the thicker lines in Figure 3). This insight was the most important result after a 3-hour discussion among the student (G.B.C.), the instructors, and the expert on concept mapping (P.R.M.C.).

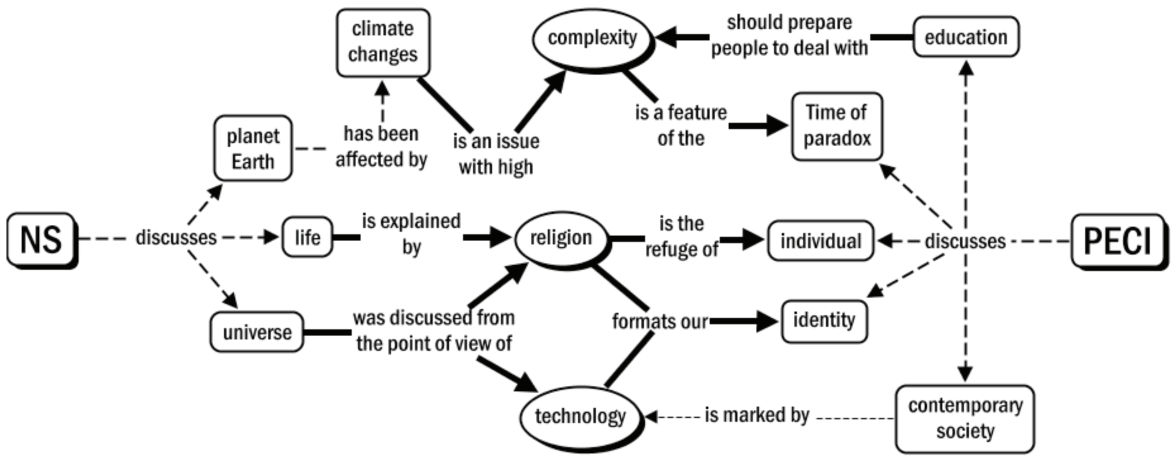

Figure 3. Cmap-5 obtained for our case study, involving two courses that express the apparent isolation of the two cultures. The interdisciplinary propositional interface (IPI) shows that "complexity", "religion", and "technology" (shadowed circles) are promising concepts to prospective interdisciplinary connections. Instructors can visualize interdisciplinarity in this Cmap and start a discussion about teaching methods and conceptual approaches to let students visualize these connections in the classroom.

Latent information that was not considered by the instructor was made visible by using concept mapping as a graphical organizer to manage knowledge and information. The concepts and propositions presented in the IPI offer an excellent starting point to instructors think about concrete actions in terms of teaching methods and instructional materials. Making interdisciplinarity visible is just part of the way to better connect courses. The next step is to explore the information obtained using Cmaps to make the interdisciplinarity in the classroom visible to the students. The ultimate goal is to let students note the relevance of connecting disciplinary knowledge to understand the high-complexity problems of the 21st century. We agree with the literature that suggests the interdisciplinary approach can encourage students to choose meaningful rather than rote learning (Lattuca, Voigt & Fath, 2004).

6 Summary

The summary of this paper is presented using a Cmap (Figure 4).

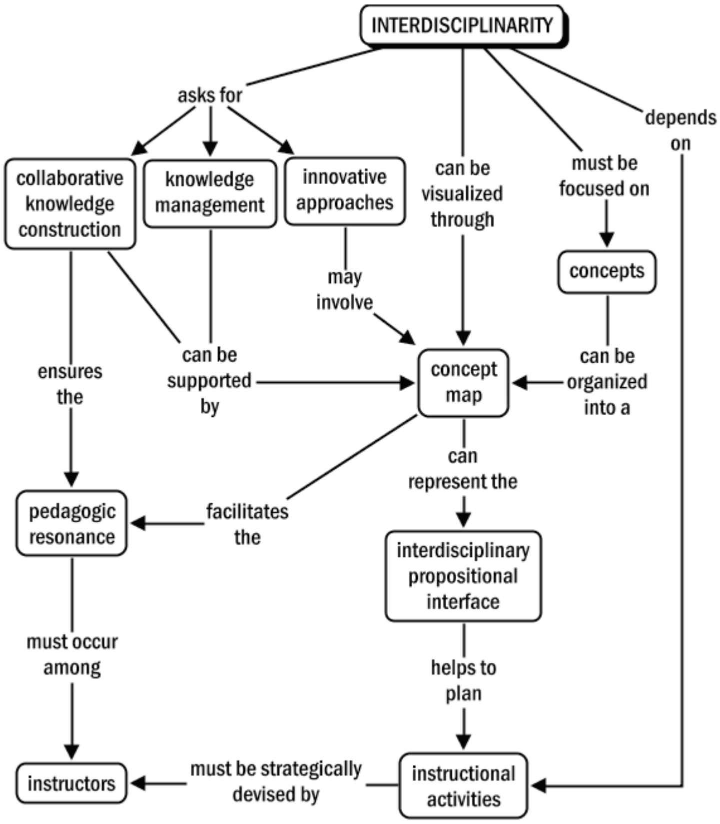

Figure 4. Cmap to summarize this study. Focal question: What are the key ideas related to our study? The root concept is highlighted in a shadowed box and serves at starting point to read the propositional network.

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MAPAS CONCEPTUALES COMO HERRAMIENTA PARA MEJORAR LA INTEGRACIÓN DEL CONOCIMIENTO EN LA FORMACIÓN INICIAL DEL PROFESORADO

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Abstract. This piece of research has been accomplished in Higher education, in particular with students of 3 rd Grade in Early years School Teacher Training Degree Course. It was found that concept mapping supports the identification of the essential concepts of the subject, establishing levels of hierarchy among these concepts and relationships among them. Significant differences have been found in these respects. During one semester, every student has made concept maps of the themes covered bay the subject. These were reviewed in group and improved with input from others. It was used a control group at the end of the evaluation period.

1 Introducción

El siglo XX ha supuesto muchos cambios en los ámbitos cultural, social, económico e industrial. Estos cambios se han producido a partir de revoluciones que han ido modificando toda la actividad humana. Sus ciclos, hasta el siglo XIX eran amplios, aproximadamente de 75 años, se fueron acelerando y acortando durante el S.XX y el siglo actual. Si todo sigue por la senda marcada, dichos cambios serán mucho más vertiginosos. Obligándonos, como ciudadanos a ir asimilando aquellos que nos afecten a nuestro conocimiento de la vida y de nuestro área de especialización, a nuestra organización y funcionamiento social, a la forma en la que se establecen las transacciones económicas y cómo estás nos afectan como país y luego redundan en nosotros como ciudadanos y finalmente, asimilar los nuevos descubrimientos que afecten a la industria, ávida de aplicar los avances científicos para producir herramientas tecnológicas que satisfagan nuevas necesidades del mercado.

La sabiduría popular tiene un refrán que dice “vales lo que tienes”. Sin embargo, ha dejado de ser válido. Sería mejor decir “vales lo que sabes y descubres”, pues los países más desarrollados no son aquellos que más producen, sino aquellos que tienen el desarrollo tecnológico adecuado que les permita seguir descubriendo nuevas aplicaciones industriales.

En este contexto ¿qué sentido tiene la educación? ¿de qué manera podemos contribuir a que la nueva sociedad, marcada por la sociedad del conocimiento, siga desarrollándose?

Según González García (2008) son varias las razones por las que es necesario innovar en el sistema educativo. Una de ellas tiene que ver con las exigencias de la sociedad del conocimiento y de la información. Drucker (1993, cit. González García, 2008) describió certeramente la sociedad actual: *Una sociedad del conocimiento y de la información donde, fundamentalmente, van a primar la inteligencia y el conocimiento como los factores más importantes del progreso social y económico. Una sociedad donde la ética de la responsabilidad sustituirá a la ética de la obligación. En donde los profesionales serán trabajadores del conocimiento, es decir, personas cuyo trabajo no dependerá de lo que les diga otro, sino de sí mismos.* (p.18)

En este sentido, el uso de los mapas conceptuales nos asegura que la persona que lo construye demuestra haber organizado la información en un formato distinto. Normalmente los conocimientos los va a adquirir a través de la lectura de textos o de escuchar información. Sin embargo, el mapa conceptual tiene un formato gráfico que permite ver de forma global los conceptos principales, secundarios y sus relaciones acerca de un tema. En definitiva, permite ver cómo la persona ha procesado la información asimilándola y reelaborándola como propia.

Los mapas conceptuales son herramientas para organizar, representar y compartir el conocimiento. Se diseñaron para representar la estructura cognitiva de una persona y expresar conceptos y proposiciones (Novak & Gowin, 1984). Supone una representación bidimiensional en la que el eje vertical representa la jerarquía de los conceptos estando los más generales e inclusivos en la parte superior (González García, 2008). Existen tres tipos de mapas conceptuales: el modelo de araña, el mapa de cadena, y el mapa jerárquico (Ali & Ismail, 2004).
Ausubel indicó que el aprendizaje significativo implicaba la asimilación de nuevos conceptos y proposiciones en las estructuras cognitivas ya existentes. El aprendizaje significativo se producía cuando los alumnos hacían un esfuerzo consciente para relacionar el conocimiento que se va a aprender con el que ya se poseía. En este sentido, el mapa conceptual es una herramienta para desarrollar un aprendizaje significativo, enmarcado dentro

de un modelo constructivista (Cañas, Carvalho, Arguedas, & Leake, 2004). Relacionándolo con los mapas, el aprendizaje significativo se manifiesta (incluso se cuantifica) a través de la suma de los conceptos relevantes más las proposiciones relevantes (Ahlberg & Ahoranta, 2004).

Así, el mapa conceptual elaborado para aprender permite al profesor y al estudiante estructurar el conocimiento:

- Pone de relieve la complejidad de las relaciones entre conceptos.
- Proporciona una visión global del conocimiento y particular de la posición de cada concepto en relación con los demás y en su posición en el conjunto.
- Además ofrece la posibilidad de añadir y representar información estructurada (textos, características, palabras claves) y no estructurada (texto e imágenes) (Durand Alegría, Fernández Hernando, Gallego Picó, Garcinuño Martínez, García Mayor, & Sánchez Muñoz, 2008).

Es decir, permite diferenciar entre lo fundamental y lo accesorio, y poner de relieve la complejidad de las relaciones.

La construcción de un mapa obliga, por un lado, a seleccionar los conceptos por orden jerárquico y por otro a identificar los conectores que los unen, es decir las palabras que indican su relación. Según Novak y Gowin (1984) es de gran importancia colocar dichos conectores, pues son ellos los que permitir leer el mapa (que es gráfico y global) como un texto (secuencial con múltiples apartados entrelazados).

Hay diversos modelos y programas de realización de los mapas (Conception software; EDraw MIndmap; Mindomo; Visual Understanding Environment…), pero uno de los que permite establecer precisamente los conectores es el CmapTools de IHMC, por esta razón se ha usado en esta investigación.

Al revisar la bibliografía se han visto diferentes sistemas de evaluación de los resultados producidos por los mapas conceptuales, desde cuestionarios sobre la satisfacción en el uso de los mapas conceptuales con mayor o menor precisión en sus categorías, listas de control sobre cantidad de mapas realizados/ corregidos, mejoras realizadas en los mismos… (Chacón, 2004), análisis de contenidos de los diarios de los alumnos (Daley, 2004), análisis de los componentes implicados (Ali & Ismail, 2004), hasta sistemas de cuantificación y análisis de los conceptos empleados y sus relaciones (Afamasaga-Fuata'i, 2004a) (Afamasaga-Fuata'i & K., 2004b). En este estudio se ha optado por emplear estos últimos métodos por ser los que, desde una perspectiva del procesamiento de la información, indican mejor cómo es de significativo el aprendizaje del alumno.

Algunos de los programas tienen incluso un sistema automático de corrección de los mapas conceptuales (Conception software (www.parlog.com)) que permite que los alumnos vuelvan a rehacerlos en función de las sugerencias que aporta el sistema RFA (Conlon, 2004). El RFA es el sistema de evaluación. El profesor introduce un mapa experto del tema y con ese modelo el programa corrige el resto de los mapas elaborados por los alumnos. Este programa contabiliza los tipos de cambios realizados por los alumnos y les proporciona feedback para que los mejoren. A los alumnos se les entregó una hoja sobre el manejo del programa.

Se han incluido más abajo, algunas de las preguntas del cuestionario que utilizaron para evaluar todo el proceso de elaboración de los mapas y la opinión de los alumnos acerca de su interés. Sólo están aquellas relacionadas directamente con el funcionamiento del Analizador RFA, pues evidencian cómo funciona.

Tabla 1. Selección de ítems del cuestionario sobre el funcionamiento del Analizador RFA (Conlon, 2004)

RFA COMO ESTÍMULO PARA LA REVISIÓN DE LOS MAPAS CONCEPTUALES
7. El uso del Analizador RFA hizo que quisiera rehacer partes de mi mapa.
8. En un futuro haría un mayor esfuerzo si supiera que mi mapa conceptual va a ser analizado por el Analizador.
9. Utilizando el Analizador me hizo darme cuenta que necesito aprender más acerca del tema del mapa.
ACTITUDES HACIA LA FUNCIÓN DE ARGUMENTACIÓN
10. Fue divertido usar el botón "Argumentar" del Analizador.
11. La puntuación que recibió mi mapa por parte del Analizador fue justa, incluso antes de usar el botón "argumentar".
12. Fue frustrante discutir/argumentar con el Analizador.
13. Está bien que se pueda mejorar la puntuación del mapa al argumentar con el Analizador.
14. Cuando argumentaba con el Analizador, estuve tentado de hacer trampas

diciendo que diferentes palabras significaban lo mismo.
15. Si intentara hacer trampas mientras argumento con el Analizador, seguro que me descubriría.
16. Al discutir/argumento con el Analizador, siempre respondí sus preguntas de forma honesta.

PERCEPCIÓN DE LAS PUNTUACIONES Y DE LAS SUGERENCIAS
17. El Analizador explica bien cómo obtiene las puntuaciones del mapa conceptual.
18. Las sugerencias proporcionadas por el Analizador fueron adecuadas.
19. Si tuviera la oportunidad, usaría el Analizador cada vez que hiciera un mapa.

En general, la elaboración de mapas permite al profesor constatar el grado de comprensión del tema por parte de los estudiantes comparando sus diferentes mapas lo que:

- Permite determinar globalmente el aprendizaje de la materia, perfilando los puntos débiles.
- Determina el aprendizaje de la materia, evaluando las estructuras cognitivas de los estudiantes, haciéndolo visualmente en su estructura y su proposición.
- Hace que el aprendizaje sea más comprensible. (Durand Alegría, Fernández Hernando, Gallego Picó, Garcinuño Martínez, García Mayor, & Sánchez Muñoz, 2008)

El propósito de este trabajo fue dar respuesta a las siguientes preguntas de investigación:
¿En qué medida influye el entrenamiento sistemático de mapas conceptuales para la elaboración de los mismos? y
¿En qué medida influye la elaboración de los mapas conceptuales en la adquisición de conceptos lógicos de la materia "Observación y Evaluación en Educación Infantil" y sus niveles de relación y estructura?

La **hipótesis** principal es que los alumnos/as con entrenamiento en mapas conceptuales tendrán un aprendizaje significativo mayor, entendido éste por las proposiciones que establezcan los alumnos (suma de los conceptos relevantes más las proposiciones relevantes) (Ahlberg & Ahoranta, 2004). Es decir, *el uso de los mapas conceptuales favorece la adquisición de los conceptos de la asignatura y la relación entre los mismos.*

Las hipótesis secundarias son:

Los alumnos del grupo experimental obtendrán mejores puntuaciones al final del tratamiento que al inicio.

Los alumnos del grupo experimental obtendrán mejores puntuaciones al final del tratamiento que los alumnos del grupo control.

2 Método

La **muestra** está formada por 36 estudiantes de 3º de Magisterio de Educación Infantil de una universidad privada todas ellas mujeres y de edades comprendidas entre 20 y 35 años. De los cuales, el grupo experimental está formado por 15 alumnas (entre los 20 y 25 años), y otro grupo no experimental formado por 21 alumnas (con edades comprendidas entre los 25 y 35 años).

Se respetó el sistema de aulas intactas de los grupos participantes. Se procedió a la asignación al azar de los grupos como experimental y control. Ambos grupos (experimental y control) fueron evaluados en dos momentos diferentes del desarrollo de la asignatura, antes (pre test) y después (post test) de la finalización del programa de clases. El diseño es pre-experimental estático de dos grupos.

	pre	x	post
GE	-	x	O_2
GC	-	-	O_2

La **variable** *independiente* de la investigación es el entrenamiento recibido en la elaboración de mapas conceptuales. Mientras que las *variables dependientes* están definidas por el nivel de aprendizaje significativo y por la calidad de los mapas realizados. Para la variable "nivel de aprendizaje significativo" se han tomado los siguientes indicadores: nivel de asimilación de los contenidos de la asignatura, y grado de relación de los contenidos de la asignatura. Y para la variable "calidad de los mapas realizados" se han tenido en cuenta las categorías y subcategorías establecidas entre los conceptos clave y los no esenciales. El **instrumento** usado en la recogida de datos fue una hoja donde se identificaba a cada uno de los alumnos de cada grupo de la fase pre y post.

Durante la fase de entrenamiento, los alumnos podían usar el programa IHMC CmapTools v4.16 para facilitarles la realización de los mapas. Cada alumno debía realizar un mapa conceptual de cada uno de los bloques temáticos del programa de la asignatura.

El **procedimiento** seguido fue que se pidió a los alumnos la elaboración de un mapa conceptual basándose en los conocimientos previos que tuvieran sobre la asignatura de Observación y Evaluación en Educación Infantil y con el conocimiento que tuvieran de la elaboración de mapas conceptuales. Al finalizar la asignatura se volvió a pedir otro mapa conceptual sobre los mismos contenidos para medir el grado de los conocimientos adquiridos. Esta evaluación final se realizó tanto a los alumnos del grupo inicial como del final.
Se dedicó la primera sesión de clase, a explicar que dentro de los objetivos de la asignatura estaba el analizar los conocimientos previos sobre evaluación que tenían. Esta evaluación previa se iba a realizar mediante el uso de los mapas conceptuales con el fin de que experimentaran otras técnicas de evaluación que pudieran aplicar con sus futuros alumnos, incrementando así sus recursos en evaluación.

Durante el estudio de cada uno de los 6 bloques temáticos que componen la asignatura, se pidió a los alumnos que cada uno de ellos presentara, un mapa conceptual. En cada bloque se expusieron y corrigieron los mapas de 4 alumnos, y éstos agregaron las aportaciones de la profesora y el grupo. Después de esto, los alumnos fueron entregando a la profesora los mapas de cada uno de los temas para su corrección y calificación. Todos los mapas conceptuales elaborados a lo largo del año forman parte de un dossier realizado en la asignatura de Observación y Evaluación en Educación Infantil. Se puede apreciar la evolución que han tenido desde el primero al último realizado.

Al final de la asignatura y fase de entrenamiento se pidió que elaboraran un mapa general de la misma, recogiéndose los datos de igual manera que al inicio.

2.1 Análisis de datos

El procedimiento empleado para el análisis e interpretación de los datos a partir de los mapas conceptuales elaborados por los alumnos ha consistido en cuantificar por un lado, una serie de criterios referidos a los contenidos como son los conceptos empleados, las entradas inapropiadas, entradas referidas a definiciones, ejemplos, por otro lado, criterios referidos a las proposiciones, si estas serán válidas o no y finalmente, criterios referidos a la estructura, incluyendo las ramas principales, ramas secundarias, media de niveles jerárquicos en cada rama secundaria y ramas múltiples y nivel en el que se encuentran (Novak & Gowin, 1984). En concreto, se ha seguido el sistema de evaluación adoptado por Afamasaga, pues nos ha parecido el más exhaustivo a la hora de medir los criterios directamente relacionados con la definición de un aprendizaje significativo, es decir, los conceptos y sus relaciones (Afamasaga-Fuata'i, 2004a)

	CRITERIOS DE PUNTUACIÓN	PESOS
	NATURALEZA DE LOS CONTENIDOS Y PROPOSICIONES VÁLIDAS	
	Evaluación del Mapa	
A	Conceptos	1
B	Ejemplos	0,5
C	Definiciones	1
D	Entradas inapropiadas Proposiciones inválidas	-1
	Procedimientos	1
	Palabras conectoras incluidas en los cuadros de conceptos	1
	Entradas redundantes	Cuando hay una entrada redundante sólo se contabiliza una vez ese concepto. El resto de veces se contabiliza como redundante.
	COMPLEJIDAD DE LA ESTRUCTURA	
	Ramas	
	Niveles de jerarquía	1
	Número de Ramas en cada nivel	
	• nivel 1	1

	• nivel 2	1
	• nivel 3	1
	• nivel 4	1
	• nivel 5	1
	Mal establecimiento de ramas	-1
	Número total de Ramas	
	Uniones entre subramas de un mismo nivel	1
	Uniones entre subramas de distinto nivel	1

Tabla 2. Criterios y pesos de puntuación de mapas conceptuales

3 Resultados

Se han empleado las pruebas T para muestras relacionadas para evaluar el grado de mejora en el grupo experimental comparando los datos iniciales y finales al entrenamiento. Y se han usado las pruebas T para muestras independientes para comparar los resultados de significación del aprendizaje entre el grupo experimental y control. El programa estadístico empleado ha sido SPSS v17 y se ha tenido en cuenta un nivel de significación = 0,05.

Los datos presentados en la tabla siguiente nos muestran los resultados iniciales y finales del grupo experimental. Como podemos ver, los alumnos han mejorado significativamente en la cantidad de conceptos que incluyen (,000) los niveles de jerarquía establecidos (,000), la cantidad de ramas incluidas en los niveles 2 (,009), nivel 3 (,001), nivel 4 (,002) y finalmente, en el número de ramas totales incluidos (,001). Esto quiere decir que los alumnos son capaces de identificar los conceptos esenciales y otros conceptos, definiciones o ejemplos que acotan más a los generales. Por tanto, son capaces de precisar más la información.

Tabla 3. Pruebas T de muestras relacionadas del grupo experimental (inicial y final)

Prueba de muestras relacionadas				
		t	gl	Sig. (bilateral)
Par 1	Conceptos Grupo Experimental Inicial - Conceptos Grupo Experimental Final	-5,545	11	,000*
Par 2	Ejemplos explicaciones Experimental Inicial - Ejemplos explicaciones Experimental Final	1,262	7	,248
Par 8	Niveles de jerarquía Experimental Inicial - Niveles de jerarquía Experimental Final	-5,064	11	,000*
Par 9	nivel 1 Experimental Inicial - nivel 1 Experimental Final	-1,542	11	,151
Par 10	nivel 2 Experimental Inicial - nivel 2 Experimental Final	-3,183	11	,009*
Par 11	nivel 3 Experimental Inicial - nivel 3 Experimental Final	-5,006	8	,001*
Par 12	nivel 4 Experimental Inicial - nivel 4 Experimental Final	-5,951	5	,002*
Par 13	nivel 5 Experimental Inicial - nivel 5 Experimental Final	-2,041	2	,178
Par 14	nivel 6 Experimental Inicial - nivel 6 Experimental Final	-1,143	1	,458
Par 23	Enlaces+palabras conectoras Experimental Inicial - Enlaces+palabras conectoras Experimental Final	-1,809	5	,130
Par 24	número total de Ramas Experimental Inicial - número total de Ramas Experimental Final	-4,739	11	,001*

Sin embargo, en la siguiente tabla podemos observar los resultados de la prueba T de diferencia de medias entre los grupos experimental y el grupo control al finalizar la experiencia, es decir, son el fruto del análisis de los mapas conceptuales elaborados después de todo el periodo de entrenamiento del grupo experimental. Se aprecian diferencias significativas ($\propto$= 0,05), a favor del grupo experimental, en que éstos incluyen mayor número de ejemplos explicativos de los conceptos incluidos (,006). Los alumnos del grupo experimental categorizan la información en un mayor número de ramas en cada nivel, de ahí que haya diferencias significativas a favor del grupo experimental en el nivel 1 (,002), nivel 2 (,013) y 5 (,007). En los niveles 7 y 8 los alumnos del grupo control ni siquiera llegaron a establecer un nivel de jerarquía, de ahí que no se hayan hecho cálculos. Por tanto, también se encuentran diferencias significativas en el número total de ramas, a favor del grupo experimental (,010).

Tabla 4. Pruebas T de muestras independientes de los grupos experimental y control (final)

Prueba de muestras independientes						
		Prueba de Levene para la igualdad de varianzas		Prueba T para la igualdad de medias	
		F	Sig.	t	gl
Conceptos Grupo Experimental Final	Se han asumido varianzas iguales	3,821	,060	1,974	31
	No se han asumido varianzas iguales			1,834	16,805
Ejemplos explicaciones Experimental Final	Se han asumido varianzas iguales	9,727	,006*	,845	17
	No se han asumido varianzas iguales			1,410	14,202
Definiciones Experimental Final	Se han asumido varianzas iguales	.	.	-1,196	14
	No se han asumido varianzas iguales			.	.
Entradas redundantes Experimental Final	Se han asumido varianzas iguales	.	.	-1,109	11
	No se han asumido varianzas iguales			.	.
nivel 1 Experimental Final	Se han asumido varianzas iguales	11,754	,002*	1,626	30
	No se han asumido varianzas iguales			1,524	14,000
nivel 2 Experimental Final	Se han asumido varianzas iguales	7,023	,013*	4,113	30
	No se han asumido varianzas iguales			3,975	21,319
nivel 3 Experimental Final	Se han asumido varianzas iguales	1,610	,214	4,148	30
	No se han asumido varianzas iguales			4,038	23,390
nivel 4 Experimental Final	Se han asumido varianzas iguales	3,679	,065	2,968	29
	No se han asumido varianzas iguales			2,918	21,891
nivel 5 Experimental Final	Se han asumido varianzas iguales	8,502	,007*	1,992	28
	No se han asumido varianzas iguales			1,992	16,357
nivel 6 Experimental Final	Se han asumido varianzas iguales	3,119	,093	1,358	20
	No se han asumido varianzas iguales			1,597	14,741
nivel 7 Experimental Final	Se han asumido varianzas iguales	.	.	,417	9
	No se han asumido varianzas iguales			.	.
nivel 8 Experimental Final	Se han asumido varianzas iguales	.	.	,440	7
	No se han asumido varianzas iguales			.	.
Enlaces+palabras conectoras Experimental Final	Se han asumido varianzas iguales	3,840	,068	1,142	16
	No se han asumido varianzas iguales			2,606	14,225
número total de Ramas Experimental Final	Se han asumido varianzas iguales	7,630	,010*	3,613	30
	No se han asumido varianzas iguales			3,403	14,953

4 Conclusiones y discusión

Hemos comprobado que los alumnos del grupo experimental, frente al control, han mejorado en la elaboración de mapas conceptuales antes y después del entrenamiento, así como sus niveles de adquisición de conceptos en la asignatura "Observación y evaluación en Educación Infantil", la relación entre los mismos y la estructura jerárquica establecida. Si partimos de la idea de que el aprendizaje significativo es la suma de los conceptos relevantes más las proposiciones relevantes (Ahlberg & Ahoranta, 2004) podríamos afirmar que su aprendizaje ha sido más significativo haciendo que éste sea también más comprensible (Durand Alegría, Fernández Hernando, Gallego Picó, Garcinuño Martínez, García Mayor, & Sánchez Muñoz, 2008).

Estos resultados están de acuerdo con los encontrados por otros autores (Afamasaga-Fuata'i K. , 2004a). De este autor tomamos el sistema de evaluación y confirma, al igual que nosotros, mejoras en la adquisición de conceptos, niveles de jerarquías, aportación de ejemplos y diferenciación de conceptos dentro de una misma rama. Este autor encontró mejoras en la realización de los mapas conceptuales desde la primera versión realizada individualmente por el alumno a la última realizada por un grupo de cuatro compañeros realizada a partir de las aportaciones de cada uno de ellos.

En futuras investigaciones sería interesante valorar los efectos del uso de esta herramienta teniendo en cuenta distintos niveles de dificultad de las materias y comprobar la consistencia de estos aprendizajes a lo largo del tiempo (Martos Montes, García Viedma, & Callejas Aguilera, 2008) (Gerstner & Bogner, 2010). Se podría ampliar el uso de otras variables como el desarrollo del aprendizaje crítico (Shiah-Lian, Tienli, & Mei-Li, 2011), o el aprendizaje cooperativo en la elaboración conjunta de mapas (Schaal, Bogner, & Girwidz, 2011). La experiencia aquí realizada se podría también mejorar añadiendo mediciones iniciales al grupo control y comparando la mejora en la elaboración de los mapas conceptuales y el aprendizaje de la asignatura usando una misma prueba objetiva de evaluación de los contenidos de la materia.

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MASTERY AND APPROPRIATION OF CONCEPT MAPPING IN HIGHER EDUCATION

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Abstract. It is the purpose of this paper to explain the difficulties that higher education students confront when constructing concept maps from academic texts readings. To this effect, interviews with 15 participants at the college level were analyzed and the resulting concept maps that they produced throughout a six-month school term were analyzed as a tool that can be used to understand textbooks. The sociocultural perspective, with conceptualizations such as mediated action which includes aspects of mastery and appropriation, resistance, and multiplicity of objectives (Wertsch, 1998), turns out to be useful to understand the functions that concept mapping performs as a cultural tool in learning mediation as well as to understand the deficiencies in constructing a concept map.

1 Introduction

The concept map is being the topic of discussion in different scientific communities these days. Its widespread use and dissemination have allowed it to reach a level of stability which, beyond merely being a technique, has become the subject of research. Analytically, it is possible to make a distinction between concept mapping theory and its technique (Aguilar Tamayo, 2004, 2006b). In other words, one can learn to construct a concept map without knowing the theory that lies behind it. This distinction allows for it to be considered a subject of research form other theoretical perspectives that will help explain in this case some difficulties that individuals are confronted with at the time of constructing them. In its *Theory of Education* (1982), Novak had already identified some concepts derived from the sociocultural theory, such as *word and language,* to highlight its importance in the formation of scientific concepts. He has more recently recognized the usefulness of other conceptualizations by Vygotski on *collaborative work* and *the Zone of Proximal Development* (ZPD) to guide his formulations on new educational facts (Aguilar Tamayo and Aguilar García, 2008).

This paper seeks to set forth elements to reflect on why higher education students find it difficult to build concept maps from a reading comprehension exercise. In order to understand how and why the different cultural artifacts are –or are not– used, one can take a look at the sociocultural perspective, from where a concept map is conceived as a mediated action, which can be understood as a dialectic action between agent and agengy (Wertsch, 1998). The concepts of mastery and appropriation inherent to mediated action might be useful to understand some difficulties present when building concept maps, particularly that one which is built from the reading of scientific texts. Some of these problems have already been reported in past works (Acuña, Aguilar Tamayo, and Manzano C., 2010; Aguilar Tamayo, García, Cuenca, and Montero, 2006; Manzano C., 2010; Manzano C., Aguilar Tamayo, Sánchez Valenzuela, and Alvarado Vázquez, 2010).

2 Difficulties in constructing a concept map

Constructing concept maps from one reading can be used both as an assessment tool (Anderson and Huang, 1989; Hay, 2007; Rice, Ryan and Samson, 1998) as well as a comprehension tool (Chang, Sung, and Chen, 2002; Hilbert and Renkl, 2008; Iraizoz Sanzol and Gonzalez García, 2006; Liu, Chen, and Chang, 2010). However, students who have just begun working on them may exhibit problems of various types; for example, cognitive overload (Chang, et al., 2002; Reader and Hammond, 1994), which prevents them from taking full advantage of semiotic mediation afforded by concept mapping. Other difficulties in its construction have to do either with the totality of previous knowledge that students may have on a specific domain of knowledge, or with their level of reading comprehension (Acuña, Aguilar Tamayo, and Manzano C., 2010). Difficulties have also been reported in the construction of a concept map when it has been utilized to interpret a text or as an ancillary tool in the presentation of a topic. For instance, a tendency has been identified to build and read conceptual maps from left to right –such as it is done in the alphabetical culture of the West– as the principle of hierarchical organization is left aside. It has also been observed that in its creation, a certain order is followed in the narrative or argumentative structure. Similarly, there are cases where no complete conceptualization is achieved, as students create their concept map from the first four or five pages of a text, or maybe there is no focus question due to the fact that some word from the title is reintroduced and placed as main concept (Aguilar Tamayo, et al., 2006).

Other studies report fruitless educational experiences in the implementation of concept maps as a didactic strategy. Moreover, a deficient construction is identified in such studies together with certain resistance strategies linked both to memoristic learning and to strategies to get credit for courses. In such experiences, while most students appear to acknowledge the fact that concept maps are a learning tool, they consider it difficult to get rid of the strategies that have worked well for them and allowed them to pass their courses. They are *used to summarizing* from 'reading, identifying fragments that look relevant and literally copying them' (Manzano C., et al., 2010, p. 257). Their rejection and resistance towards concept mapping could also be attributed to the fact that doing maps entails activities that are more complex than merely carrying out a *procedure*, and that call for the development of a *set of skills* (Moon et al., 2011).

The construction of concepts maps from a text requires the use of multiple simultaneous goals. This helps to understand why students exhibit difficulties when constructing them, as the cognitive processes involved in their learning –when associated with other objectives of the context where the activity is inserted– make their *mastery and appropriation* difficult (Wertsch, 1998). This overlapping of tasks results in a *cognitive overload* for the student (Chang, et al., 2002; Reader and Hammond, 1994); in such a case, the number of complex processes that the creation of the concept map requires undermines an ideal learning. In this work, those students who exhibited this difficulty report that the readings were 'complicated, difficult, and long.' Thus, it can be inferred that the reading comprehension was already a problem to which the task of learning to build concept maps to reflect their understanding of the text was added. That said, they found it difficult to match the contents of the assignment with the didactic tool, the aim of which was to favor reading, learning, and the representation of both.

All of the above alerts us as to how necessary and important it is to reflect on a *didactic method for concept mapping* (Aguilar Tamayo, 2006). In addition to the comprehension reading aspect, such didactic method must take into account the formative deficiencies of teachers, especially with regard to higher education; otherwise, any complex learning that might be supported by the concept map strategy will be displaced by those practices that reintroduce resistance and simulation (Manzano C., et al., 2010).

3 Mediated action and the concept map

As it was mentioned, this paper provides elements to re-conceptualize the concept map from the sociocultural perspective, that is, as a cultural tool that mediates learning within the concept of educational practices. Aguilar Tamayo (2006a; Aguilar Tamayo and Aguilar García, 2008) suggests that *ZPD* concepts and the idea of cultural *tool* or *artifact* may serve as a guide to attain said approximation. The *ZPD* concept developed by Vygotski helps to understand the construction processes of meanings as well as the mediation that is done in this zone through the *accompaniment* and the function of *expert structure* as semiotic interventions made up by human agents or artifacts that intervene as learning mediators. The concept map thus performs the function of mediator (Aguilar Tamayo, 2003).

In this order of ideas, Wertsch (1998), upon analyzing human action, resorts to Burke's Dramatistic Method (1975), also known as *pentad*, which consists of: a) act, b) scene, c) agent, d) agency, and e) purpose, to describe, interpret, or explain human action[1] somehow opposed to phenomena like conduct, attitudes, or psychic or linguistic structures. Wertsch reintroduces the *agent* and the *agency* from Burkes's model as core elements of his understanding of *mediated action* and affirms that all the other elements of the pentad are integrated in the agent-agengy dialectic on the grounds that virtually all human action involves mediated action that is always centered on the agent and its cultural tools, which are invariably situated within a historical, institutional, and cultural context. The *agent* is the one who performs the act and the *agency* the means or the instruments used by the agent in the performance of the act, in other words, the cultural tool. By the same token, the mediated action and the cultural tools exhibit certain characteristics that will eventually give form to their expression. For the purpose of this paper, we will reintroduce mainly those belonging to *mastery and appropriation*.

Mastery implies "knowing how" to utilize a form of mediation with ease. (Ryle, 1949, cited in Wertsch, 1998, p. 87). A greater *mastery* of the cultural tool would result in positive *appropriation.* However, this is not always the case. One can master a tool without appropriating it, as the *appropriation* always implies resistance in some way. This is the rule rather than the exception. Besides, the *appropriation* is directly

[1] Human action as basic analysis phenomenon has previously been studied by Vygotsky (1978, 1981,1987), Bakhtin (1981) and Mead (1934), all of them cited in Wertsch (1998, p. 32)

related to some spontaneous, creative, and free use in different spaces and scenarios, as Moon (2011, p.44) states in its metaphor "when you have a hammer, everything looks like a nail." On some occasions, the resistance may turn into rejection. In extreme cases, those where the agent is forced to use the tool, one resorts to simulation strategies.

Pursuant to the concept map, we can affirm that one has mastered the technique of concept mapping when: a) it is constructed from a focus question; b) there is hierarchization; c) no concepts are repeated, nor are there verbs serving as concepts or vice-versa; d) it has more than four arms or branches; e) there are cross links[2] and, f) it comprises 35 to 40 concepts (Moon, et al., 2011, Domínguez-Marrufo, 2009). Evidence that the student has appropriated the concept map is when she uses it in other fields and activities on her own initiative. There could be *mastery* without *appropriation*, though not *appropriation* without *mastery*.

4 Methodology

4.1 Participants and design

Fifteen college-level students participated in the study. They were enrolled in the fourth semester (core courses) of the General Didactics program leading to a Sciences of Education and Teaching degree in a public university located in southern Mexico. The concept maps collected were the product of readings (eight texts) from the course's basic bibliography. Moreover, the students were interviewed to find out more about their ideas and knowledge on concept mapping and the CmapTools (Cañas et al, 2004) program.

The didactic model that guided the implementation of the concept map was configured through five stages: a) introduction to the concept map and to the CmapTools program by the teacher; b) construction of a concept map by the student after reading the text in order to submit it and share it through CmapTools; c) review of the concept map by the teacher (as many times as was deemed necessary) and suggestions for improvement; d) correction and re-construction of the concept map by the student and; e) collection of the initial and final concept map for each reading in an evidential digital file at Cmap Tools' CmapServer. In addition to the group analysis of the readings, the activity with concept maps carried out through the school term incorporated peer review, and practices in collaborative work. In class, half the time was dedicated to the construction of concept maps in the computer classroom. This not only facilitated the use and practice of the CmapTools program – especially for those students that had no computer– but also guaranteed the constant monitoring of conceptual map creation by the teacher.

Before the school term was over, the participating students were interviewed. The interviews were semi-structured, designed to be completed in about 30 minutes, and they were intended to make a contrast between the understanding one already has of the concept map and the already-formulated concept maps. One more goal was to find out more about learning and the contents of the course.

4.2 Data analysis method:

Data were analyzed qualitatively. In order to evaluate the concept maps, the Rubric to evaluate concept maps created from reading comprehension was used (Domínguez-Marrufo, 2009).[3] In the selection of the concept maps to be evaluated through the Rubric, it was decided to choose first the most recent reconstructions of concepts maps, and second, to choose the practice of the concept map that was done throughout the semester in order to identify the different stages of the learning of the technique (See Table 1).

It must be added that the points awarded to the concepts maps through the rubric are tallied up to a score through which they can be identified as *good, average,* or *deficient*. A good concept map garners upwards of 60 points, average conceptual maps carry between 33 and 60 points and deficient maps are below 33 points.[4]

Table 1. Selection of concept maps to be evaluated through the Rubric

[2] Elements that are reintroduced from the scoring system for Novak's concept maps (Novak and Gowin, 1988)

[3] The rubric evaluates the following dimensions: a) focus question and main concept, b) subordinate questions, c) links and propositions, d) cross links and e) hierarchy. The rubric identifies three levels of performance based on significant learning, which show the learning achieved by the students in the construction of the map.

[4] According to the category outlined in the rubric (see previous footnote), the numerical values assigned to each category vary in function of its importance in relation with the construction of a concept map (Domínguez-Marrufo, 2009).

Moment when the technique is learned	Moment when the learning of the technique begins	Moment when the technique was learned (stability)	Moment when the technique is perfected and signs of creativity
Text chosen from the basic bibliography	Text 1	Text 5	Most recently read text (it could have been 6, 7 or 8)
Denomination	Initial concept map	Intermediate concept map	Final concept map
Construction	Last reconstruction	Last reconstruction	Last reconstruction

Table 1. The selection of the maps to be evaluated through the rubric is described in accordance with the moment of learning of the technique as well as with the mapped text.

The interviews were analyzed under the following categories: attitude and readiness to construct concept maps, number of reviews and concept map reconstruction, use of concept maps in other areas, ease/difficulty to construct concept maps, ease/difficulty in the reading comprehension, utilization of other techniques and learning strategies, learning of didactic and CmapTools material. This information was contrasted with the students' concept maps.

5 Results and Discussions

It must be pointed out that even though the student's discourse can be viewed as a cultural tool, for the purpose of this paper such discourse is considered merely as part of the scene. The students' discourse on the use of the concept map and the concept maps that they construct help to identify whether there is *mastery* and/or *appropriation* of the cultural tool, which helps to explain, partly, the difficulties that students encounter when constructing them. Still other aspects that may as well help us to understand why the student is unable to construct good concept maps is the one called *illusion of knowing*[5] (or of comprehension) and cognitive overload, which results from the quantity and quality of activities performed towards the construction of a concept map.

Pursuant to the interviews analyzed, although the questions were made at different times of the interview, they are shown in a continuous manner due to space constrains, and ellipsis dots (…) were used to show a break in the continuity. Finally, it must be pointed out that care was taken at all times to maintain the original sense and meaning of the student's discourse.

In terms of *mastery* and *appropriation*, the following examples illustrate the concept map:

Interview with Agustina

E: Did you like using concept maps?

R: Yes, a lot. As I was saying, I was one of those who focused just on reading, I never highlighted the concepts, concepts maps kind of helped me to get more out of it. While in the past I understood 50%, now I understand a little more, 60%, with the help of concept maps. (…)

E: What is a concept map?

R: Well, it is a tool that facilitates reading comprehension…that facilitates reading.

E: OK. Have you at some point used concept maps in other courses?

R: No. So far I haven't.

It can be posited that Agustina has somehow mastered concept mapping as her first map earned her a good score (57 points); by contrast, on her last map she obtained a rather poor score (33 points). This would indicate either that she has not reached full mastery of the technique, or that she is finding the reading difficult, in other words, that the text proved difficult for her to understand, and not necessarily that she was unable to construct a concept map. With regard to appropriation, one can say that no mastery was accomplished: although Agustina did realize that concept maps have enabled her to "understand a little bit more," she also admits not using it in other courses, in other words, she has not *made it hers*.

Interview with Brenda

E: About the General Didactics course, what can you tell me about your experience with concept maps?

[5] Illusion of knowing (Commmander and Stanwick, 1997) is associated with a deficit in monitoring reading that triggers failures in comprehension and undermines learning. It arises when the level of reading is elementary: where one can relate what the text says, but one cannot interpret, infer, or learn with and from the text.

R: Uh, for me, it is a good alternative because it is another tool you can use at work, at school, or with any other exercise in general. Using concept maps provided me with a good alternative to do things differently from what I was doing, like underlining and reflecting…and that was just about it. Concept maps have enabled me to accomplish more, some sort of a more tangible work where I can link them up and connect them, which will lead to some analysis, some reasoning, but with some basis to support me any time I want.
E: Did you like using concept maps?
R: Yes, like I said, I was already using this program. I already knew it, and that was it, I knew it superficially but not really in detail. Creating a concept map totally changes your perspective when someone tells you how to use it, to simply know that it is there for you whenever you need it. (…)

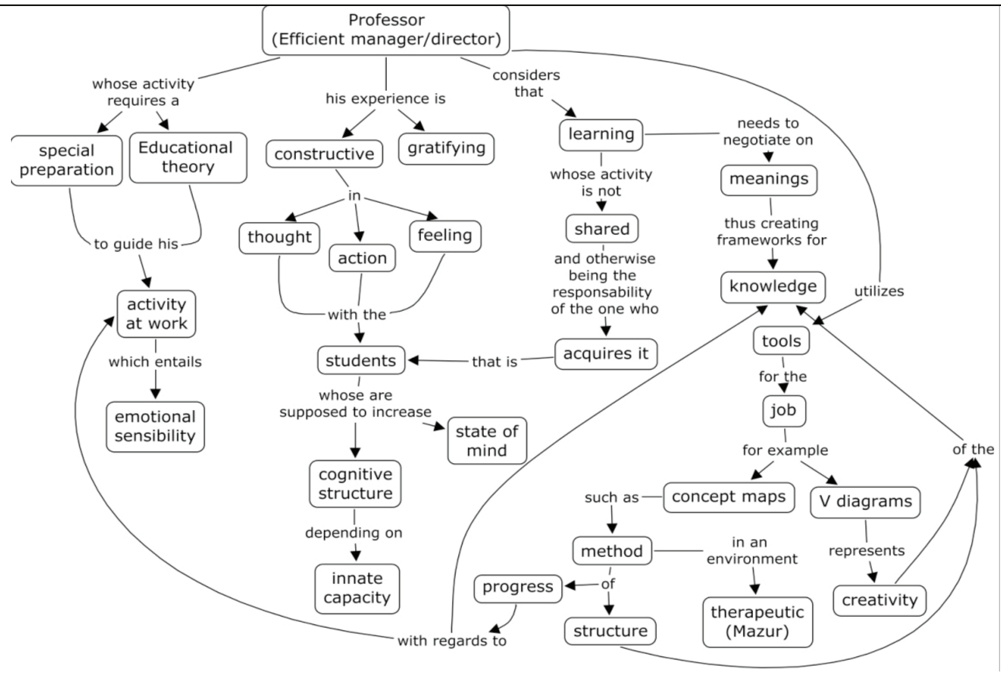

Chart 1. Most recent concept map constructed by Brenda (with a score of 54). This concept map shows that no sentences are used as concepts. A good hierarchization and cross links can be observed.

Brenda turned in good concept maps (with scores above 60), thus demonstrating good mastery of the tool and a good reading comprehension. Compared with Agustina, Brenda engages in a more elaborate discourse, understands concept mapping as a tool to understand texts, and has used it in other courses on her own initiative, proof that she has *appropriated* the map.

On the subject of the multiplicity of simultaneous goals inherent in mediated action –which also helps to explain the difficulty one encounters when constructing a concept map– it can be posited that the task of learning the contents of didactics and the use of cognitive resources needed in reading comprehension interfered with the task of learning the concept map technique and with the way it is used in guiding, understanding, and representing said reading comprehension. Following are some examples:

Interview with Alexis

E: Do you think you understood the most important aspects?
R: Well, yes. I did understand the most important aspects, but still there is this lag, like there was a *bunch* of information, yes it is the information, but for us, that is really not the idea, like cut and dried, that we have to read and read and… I mean, it is like we do not totally understand the first part; there is a *bunch* of information that maybe we don't run through all. (…)
E: What elements did you like the least?
R: That in order to reason you have to read over and over again, I mean in order to grasp the basic concepts. (…)
E: What elements did you find the most difficult?
R: The most difficult? The final parts, the key words of the diagram; as it moved from the top down; to place the least important concepts, you do one reading and it's like you find everything important right away, that is my real problem. (…)

Alexis obtained poor scores on both the intermediate and final maps (13 points on each). These scores seems to have a direct relationship with *the bunch of information to be read over and over again in order to grasp the basic concepts*. It seems that identifying the hierarchy was the greatest difficulty for Alexis as he mentions that he found it hard to assign a hierarchy to the reading concepts on the grounds that all of them seemed to have the same weight. It can be said that Alexis found himself facing the choice between understanding the reading and constructing a good concept map.

Still another type of difficulty that we encountered when doing concept maps was what we referred to above as illusion of knowing (Commander and Stanwyck, 2007). In this case, the students declared that they learned the technique involving concept maps and the contents of General Didactics, and that they are even satisfied and happy that they *learned* to use the conceptual map; however, their concept maps demonstrate the opposite, as evidenced by the following interview:

Interview with María Elena

E: Do you use any other technique or tool?
R: Not anymore. Before I would use the comparative tables, synoptic tables, mind maps…
E: What do you mean by 'not anymore'?
R: I mean we kind of lean more towards constructing concept maps, it's like the technique…I found it a little easier…easier to do maybe.
E: Regarding the General Didactics course… How did you find the experience of using conceptual maps?
R: I think it was alright because we kind of learnt more about the work that needs to be done to create a concept map, like trying to do it the right way.
E: Also, about this Didactics course, do you think that you understood the main points of the course?
R: Maybe not 100%, but I did grasp the basics of the course.
E: Did you like using concept maps? **R:** Yes, I did (…)
E: I mean, were there any other courses where you used the maps on your own initiative? (…)
R: Yes. I used them in Psycho-pedagogical Problems in Learning. (…)
E: What do you like best about concept maps?
R: That at any time that I get the chance to go back I will find a map that I have done, I can look at it again, and maybe remember, just by looking at the way I organized it, what topic it is about.
E: Are you thinking of continuing to use them? **R:** Yes.
E: Why?
R: Because it is a very easy to understand the texts that way.

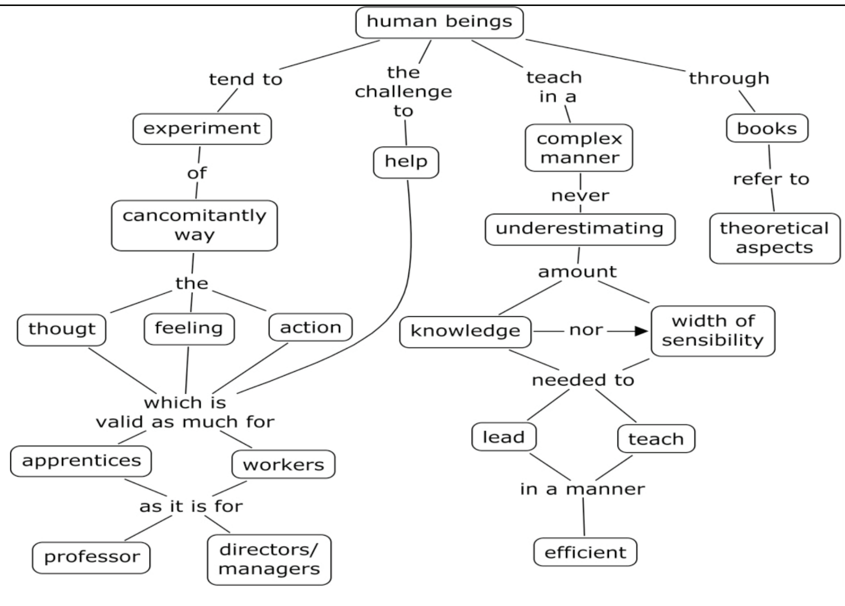

Chart 2. María Elena's last concept map, where she obtained a score of 13. This concept map illustrates the contrast between the discourse of an appropriation of the concept map and its drawing as such. It also demonstrates how the text's narrative lines follow each other: "Humans tend to experiment concomitantly…"

In Maria Elena's case, her discourse seems to demonstrate the appropriation of the concept map. She mentions that she found concept mapping easier, that she liked using them, that she learned at least the basics from the contents of Didactics and that she has used them in other courses. However, her concept maps were deficient: there were no significant changes in subsequent drawings and higher scores were reported on the first ones as compared with the final ones (35, 33 and 13 points respectively), which may indicate a lack of *mastery*. When asked what part she liked best, she answered that *when she finds a map that she has done she will perhaps remember the way she organized it*. This leads us to infer that after this course she has no intention of continuing to use concept maps, while also suggesting that there is no *appropriation.*

6 Conclusions

The cases depicted in this work –as well as several others which were not included by reason of space– are associated with difficulties in reading comprehension and with the fact that the learning of the concept map technique was not understood as a tool intended to guide reading, nor was it meant to understand or represent the acquired knowledge. Instead it was viewed as more material to be learnt during the Didactics course. At the same time, this made reading –as well as the mastery and appropriation of the technique– more difficult. A concept map that results from reading is not a tool that can be easily mastered. Building a concept map is not only a procedure, it entails the use of a set of cognitive, metacognitive, and self-regulatory skills, among them the automatization of reading, the possession of strategies for reading comprehension and for learning and, finally, the determination to learn extensively. The contents of these interviews give us elements to reflect on the students' learning practices because the decision to learn the concept map technique –and learn through it– is undermined by traditionalistic pedagogical models that still persist in higher education, such as the practice to learn through memorization and through the repetition of contents without any meaning or sense whatsoever, albeit effective to pass courses. It is necessary to reconsider the need to design a didactic of the concept map –at least in the domain of the social sciences– that takes into consideration the problems set forth.

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MODELO DE CONOCIMIENTO Y LA REPRESENTACIÓN DE IMAGINARIOS SOCIALES

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Abstract. Los modelos de conocimiento son un sistema de mapas conceptuales sobre un tema y teorías. Los mapas conceptuales permiten la representación gráfica de conceptos y proposiciones. En este trabajo se muestra el uso del modelo de conocimiento como una herramienta metodológica para averiguar y analizar las representaciones sociales en los estudiantes que cursan la licenciatura en Artes. Para la recolección de datos se realizaron tres grupos focales con alumnos de diferentes semestres escolares. En este trabajo se expone la experiencia de elaborar mapas conceptuales y un modelo de conocimiento para conocer las creencias, actitudes y conocimientos cotidianos de alumnos en torno a conceptos relacionados al Arte. Se abordan los procesos de construcción de los mapas conceptuales y modelo en CmapTools así como los resultados y conclusiones que surgieron a partir del uso de estas técnicas de representación.

1 Introducción

La finalidad de este trabajo es presentar los resultados y reflexiones sobre la construcción de un modelo de conocimiento utilizando el CmapTools (Cañas et al, 2004) (http://cmap.ihmc.us/). El modelo de conocimiento se desarrolló como herramienta metodológica para la búsqueda, análisis e interpretación de representaciones sociales, también consideradas o expresadas como creencias, ideas, pensamientos, teorías implícitas, actitudes, estereotipos e imaginarios de las personas. Las representaciones sociales son un cuerpo organizado de conocimientos caracterizados por ser transmitidos en la sociedad, ayudan a adquirir un sentido en la vida cotidiana y crear una realidad. En este estudio se procuró averiguar las representaciones sociales en estudiantes de la licenciatura de Artes en la Universidad Autónoma del Estado de Morelos en México (UAEM). Así como su descripción y representación a partir de diversos mapas conceptuales.

El mapa conceptual es un esquema formado a partir de conceptos y proposiciones que permite la representación de conocimientos y significados (Novak, 1988). Se realizaron diversos mapas conceptuales para investigar y describir las representaciones sociales de los estudiantes en torno a conceptos como: Arte, Artista, Teoría del Arte, Imagen, Obra de arte, Estereotipos en el Artista, Técnica Artística, entre otros. A partir de los mapas elaborados se estructuró un modelo de conocimiento que facilitó la interconexión entre temáticas, además de distintas imágenes de pinturas, fotografías, esculturas que los estudiantes consideraron como arte ejemplificadas mediante ligas a las páginas web que ellos recomendaron sobre destacados artistas.

La elaboración del modelo de conocimiento es parte de una investigación más amplia que se desarrolla en el posgrado *sobre Imagen, Arte, cultura y Sociedad* en la Facultad de Artes, UAEM. Es la primera vez en esta facultad que se utiliza el modelo de conocimiento como metodología para rescatar lo que los alumnos piensan, dicen, creen y hacen en torno al arte. El modelo de conocimiento ha sido evaluado y revisado por expertos en elaboración de mapas conceptuales, además del comité de posgrado. Se considera que este modelo de conocimiento debe ser publicado y de esta manera mostrar el conocimiento y pensamiento social de los alumnos de una manera ordenada y jerarquizada. Esto facilitaría a los alumnos, docentes y directivos darse cuenta de que es lo que realmente piensan sobre el arte así como ciertas concepciones y actitudes que pueden estar en conflicto con los objetivos del curriculum o con aquellos aprendizajes relevantes para la formación profesional.

2 Metodología

2.1 Participantes y procedimiento

Los participantes fueron 30 estudiantes universitarios que cursan la licenciatura en Artes Visuales. Se trabajó a partir de tres grupos focales, cada uno conformado por 10 estudiantes. El grupo focal es una técnica de recolección de datos que permite la obtención de discursos, opiniones, creencias o actitudes sobre algún tema en particular. El primer grupo fue constituido por alumnos de octavo y noveno semestre de la licenciatura, el segundo grupo fue conformado por alumnos de sexto semestre y el tercero por estudiantes de cuarto semestre. Los grupos fueron organizados de esta forma para obtener diversidad de concepciones e imaginarios sobre el arte, con la hipótesis de que su mayor conocimiento del campo se puede expresarse en el lenguaje y formas de conceptualizar el arte y al artista. De esta manera se buscó elaborar diversos mapas conceptuales para contrastar los distintos discursos de los estudiantes, desde los semestres iniciales hasta los alumnos que están a punto de egresar de la licenciatura.

Cada grupo focal se organizó en una sesión de aproximadamente 60 minutos. Se realizaron tres sesiones con los tres grupos de distintos semestres. La dinámica de cada sesión consistió en una charla en relación a ciertos conceptos. En cada grupo focal se dialogó y se discutió en base a planteamientos cómo: ¿Qué significa el arte? ¿Qué es un artista? ¿Qué sería una obra de arte? ¿Cuáles son las técnicas artísticas? ¿Qué es una imagen? ¿Qué estereotipos se le atribuye al artista? ¿Cuáles eran las obras de arte y artistas favoritos?, entre otras. Los participantes tuvieron total libertad de expresar sus diversos puntos de vista y las concepciones que ellos tenían en torno a estas preguntas. Cada charla de los grupos focales fue grabada y después fue transcrita, de esta forma se tuvo la oportunidad de realizar una lectura analítica, se seleccionó y se remarcó la información más relevante para de esta forma, identificar y definir los conceptos que se iban a mapear.

Ya terminada la recolección de datos y testimonios se realizaron mapas conceptuales por cada grupo focal, y se organizaron en tres ejes, los cuales fueron el eje teórico sobre el arte, el eje de identidad del artista y el eje cultural y social en el arte. Los mapas conceptuales ayudaron a un análisis detallado de los testimonios y a estructurar un modelo de conocimiento, el cual se formó a partir de un mapa general derivando mapas conceptuales específicos por cada grupo. El modelo de conocimiento finalizado fue estructurado con 25 mapas conceptuales los cuales fueron interconectados y con distintos recursos hipermedia como: textos digitales, páginas web, imágenes de artistas y obras de arte de acuerdo a las menciones y recomendaciones de los alumnos participantes en los grupos focales.

Para la elaboración de los mapas conceptuales se utilizó CmapTools V.5.04.02 [http://cmap.ihmc.us]. Por cada grupo se realizaron varias versiones de los mapas conceptuales, este es un proceso de integración generalización que buscó a detalle las relaciones de conceptos en distintos niveles, esto permitió decidir por elaborar tres versiones por cada concepto, por ejemplo, tres versiones de mapas para los conceptos de Arte, Obra de Arte, Artista, Técnica Artística, por mencionar los más relevantes.

3 Modelo de Conocimiento y Representaciones Sociales de estudiantes Artistas.

La representación social es un concepto que originó en el campo de la psicología social y fue desarrollado por Serge Moscovici (1961); “Las representaciones sociales son sistemas de valores, ideas y prácticas que tienen una doble función: en primer lugar, establecer un orden que permita a los individuos orientarse en un mundo social y dominarlo; y en segundo término, permitir la comunicación entre los miembros de cada comunidad, aportándoles un código para el intercambio social y un código para denominar y clasificar de manera inequívoca los aspectos de su mundo y de su historia individual y grupal” (Moscovici, 1973 p.30) (citado por Duveen 2003) Este estudio busca reconocer el sistema de prácticas e ideas de estudiantes en artes para hacer visibles aquellas representaciones que han adquirido en su formación y la presencia de otras representaciones que su experiencia cultural y social compartidas por el grupo de estudiantes de la licenciatura.

La representación social ha sido entendida de varias formas cómo imagen mental, conocimientos, conceptos, explicaciones, creencias sobre objetos y hechos, también se les ha considerado como mitos, visiones, formas de pensar, sistema de actitudes, opiniones, imaginarios, estereotipos y teorías implícitas que los sujetos crean para adquirir y reproducir conocimiento y para darle un sentido a la realidad social en la que viven. Las representaciones sociales permiten conocer el sistema lógico del pensamiento social, sus contenidos y su relación con la construcción mental de la realidad, (Banchs, 2000) dicho pensamiento social surge de los procesos de interacción social en los que el sujeto participa, el conocimiento se adquiere por medio de la escuela, trabajo, lenguaje, de los medios de comunicación (Banchs, 1990), entre otros. Algunas de las funciones de las representaciones sociales es crear un sistema de conocimiento para entender la realidad, predicción de comportamientos y desarrollo de una identidad personal y social.

Existen diversas orientaciones metodológicas para el estudio de las representaciones sociales, algunas de ellas son la aplicación y análisis de entrevistas estructuradas y semiestructuradas, cuestionarios, sondeos, diálogos recogidos en textos, redes semánticas, encuestas, entre otras. En este trabajo se introduce un elemento innovador en el método de análisis de los datos recogidos mediante grupos focales, los mapas conceptuales para “La organización y representación gráfica del conocimiento”. (Novak y Cañas 2008), Las representaciones sociales están conformadas por una serie de discursos compuestos por proposiciones y el mapa conceptual es la técnica idónea para el rastreo, representación y análisis de estas. En los mapas conceptuales se plasmaron las proposiciones más importantes que los alumnos habían expresado y se encontró que la mayoría de ellos expresaban algunas proposiciones similares y con el mismo sentido, por ejemplo: “El artista es un creador de lenguajes y realidades que expresa vivencias, pensamientos y sentimientos”, el “Arte es proceso creativo y producto artístico que surge a partir de imágenes”, “La imagen puede ser una fotografía”. La elaboración del mapa conceptual permitió hacer visibles cada una de las representaciones proposicionales de las creencias de los participantes.

Un modelo de conocimiento es una red de mapas conceptuales sobre un tema y/o dominio de conocimiento, son sistemas que permiten representar el conocimiento de una manera organizada y estructurada e integrar otros elementos a este sistema organizado, tal como fuentes de información, documentos, imágenes, videos, audios, (Cañas et al, 2000) entre otros. Los recursos integrados al modelo de conocimiento también reflejan la amplitud o variedad de la información, y su acceso además de posibilitado por el hipervínculo, es también una manera estructura para llegar a la información. (Díaz et al, 2010). Con los mapas conceptuales elaborados a partir de temáticas/preguntas clave se construyó un modelo de conocimiento para mostrar las relaciones de los conceptos de los alumnos. Hacer mapas conceptuales en un modelo de conocimiento permitió la selección, diferenciación, organización, jerarquización de los conceptos y proposiciones de los alumnos. El reto consistió en reconocer una visión general de las representaciones sociales de alumnos de diferentes semestres académicos. Los mapas conceptuales dieron cuenta de concepciones a nivel individual que expresaron, sin embargo lo que se investigaba era encontrar aquellas concepciones y creencias que a nivel social sostenían y que habían aprendido de las clases en la facultad, de algunos profesores e incluso de los mismos compañeros de la carrera.

El modelo de conocimiento se ordenó a partir de un mapa general que sirve para la navegación entre los otros mapas conceptuales de temáticas más específicas. Por ejemplo: mapa conceptual del grupo 1: correspondiente a alumnos de octavo y noveno semestre, grupo 2: relacionado a concepciones de alumnos de sexto semestre y grupo 3: correspondiente a estudiantes de cuarto semestre. De esta forma el modelo de conocimiento muestra tres perspectivas grupales diferentes sobre ciertos conceptos relacionados a su formación escolar. (Véase figura 1)

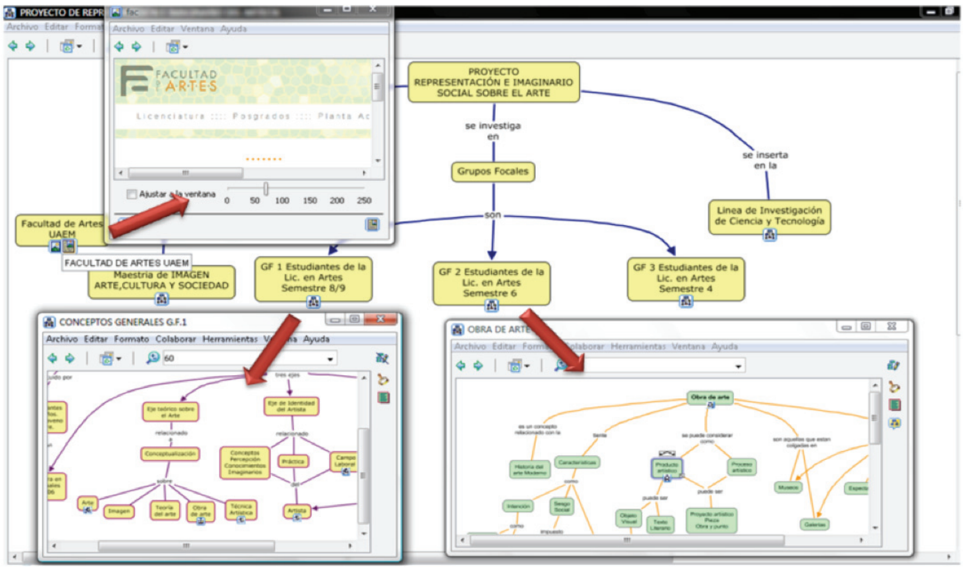

Figura 1. Mapa general del Modelo de Conocimiento que guía a la navegación de mapas específicos.

3.1 Mapas conceptuales en torno a conceptos del Campo Artístico

Al inicio de este estudio la información y testimonios recabados en los participantes mostraban cierta ambigüedad y contradicciones, la información estaba desordenada y había muchas ideas dispersas en cuanto a los conceptos. En el mapeo de la información se definieron algunas categorías ejes para tener mapas específicos de conceptos como Arte, Artista, Teoría del Arte, Técnica Artística, Estereotipos y Campo Laboral del Artista. Una de las dificultades que existieron al mapear es que algunas proposiciones de los alumnos se encontraban en un lenguaje coloquial y con palabras ambiguas que al momento de construir un mapa conceptual se tenían que especificar con otra etiqueta conceptual.

Ya que la información se recabó a partir de tres grupos focales, se realizó una carpeta de mapas conceptuales por cada grupo de tal manera que se hicieron tres versiones por cada concepto de Arte, Artista, Teoría del Arte, entre otros. El análisis que se obtuvo a partir de la revisión de mapas conceptuales se encontró que varias versiones eran parecidas, incluso se detectaron proposiciones semejantes en los alumnos. Se identificó que los grupos focales comparten diversas relaciones conceptuales. Se compararon y se analizaron las similitudes, diferencias, contradicciones en las concepciones de los grupos desde los semestres iniciales de la licenciatura hasta los estudiantes que ya están por egresar. (Ver figura 2) Los mapas conceptuales fueron organizados a partir de un mapa general que conduce a la navegación de mapas más específicos que ayudan a explicitar los conceptos. Cada mapa conceptual fue elaborado en base a una pregunta de enfoque, esta refleja un planteamiento general acerca del concepto que se está abordando. Algunas preguntas de enfoque fueron ¿Qué es el arte? ¿Qué es una obra artística? ¿Qué es ser Artista? ¿Cuáles son las técnicas Artísticas? ¿Cómo se le estereotipa al artista? La mayoría de los mapas conceptuales están interconectados con otros mapas conceptuales, propiciando redes de conceptos, algunos mapas están relacionados por ciertas temáticas, esto permite explicar ampliamente las concepciones de los alumnos y tener una mejor organización del contenido en una forma integral.

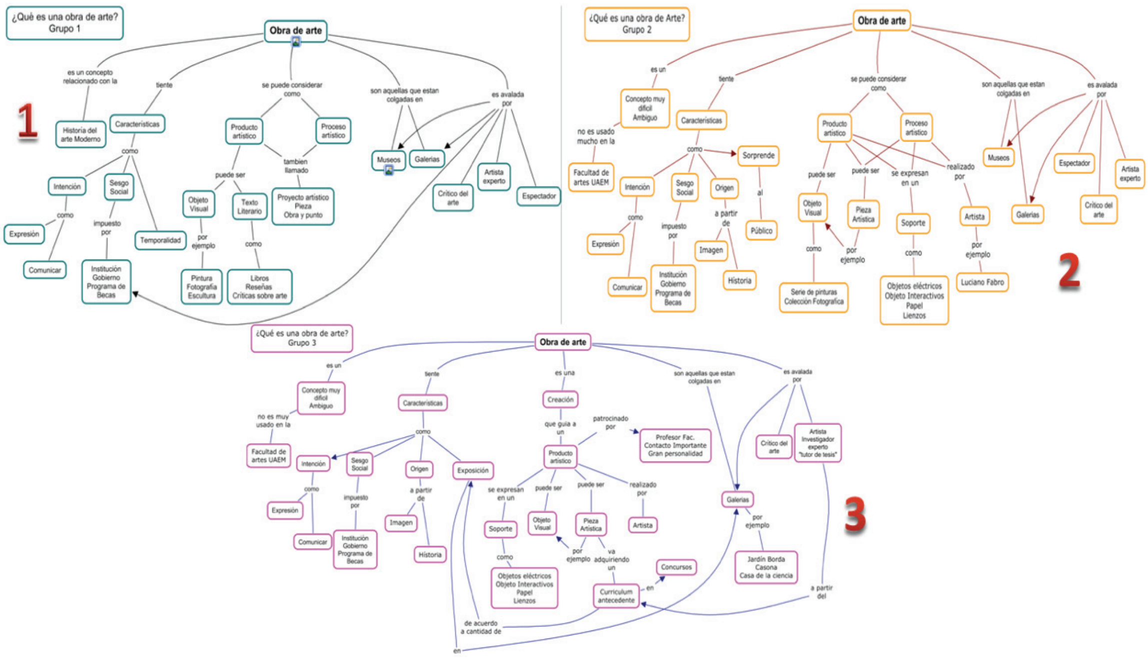

Figura 2. Mapas conceptuales sobre el concepto de obra de arte de acuerdo a la versión de cada uno de los grupos focales.

3.1.1 Uso de CmapTools

Los mapas conceptuales y el modelo de conocimiento fueron realizados a partir del software de CmapTools. Este programa permite la elaboración de mapas conceptuales de una forma más fácil y cuenta con herramientas específicas para este propósito, como es, por mencionar un ejemplo, los servidores de mapas conceptuales mediante los cuales pueden distribuirse los modelos de conocimiento mediante internet.

CmapTools es un software gratuito y fácil de descargar que permite la construcción de conocimiento a partir de mapas conceptuales y modelos de conocimiento. El programa ayuda a navegar fácilmente entre los mapas conceptuales y recursos de información como video, audio, imágenes, páginas web y más.

En el proyecto que se desarrolló los mapas conceptuales tienen distintos hipervínculos a páginas web que los alumnos recomendaron en relación a Artistas que eran destacados y que les agradaban. Además en los diversos mapas conceptuales sobre las representaciones sociales de estos alumnos se adjuntaron una variedad de imágenes acerca de lo que ellos consideraban como obras de Arte, algunas correspondientes al Arte contemporáneo y otras al arte Moderno y Renacentista. Otros hipervínculos guían a imágenes correspondientes a pinturas, esculturas y fotografías de artistas como Botticelli, Kandinsky, Velázquez, Andy Warhol, Elena Kalis, Lucas Stoffel, Flor Garduño, Tina Modotti entre otros. (Ver figura 3).

Varios de los mapas conceptuales en relación al concepto de teoría del Arte tienen un hipervínculo a archivos de texto en PDF y en Word donde se muestran algunos planteamientos y teorías acerca del arte que los alumnos consideraron interesantes. La construcción de mapas conceptuales exige una constante reelaboración y a partir de CmapTools este proceso se facilita ya que tiene todos los instrumentos para editar, diseñar un mapa conceptual.

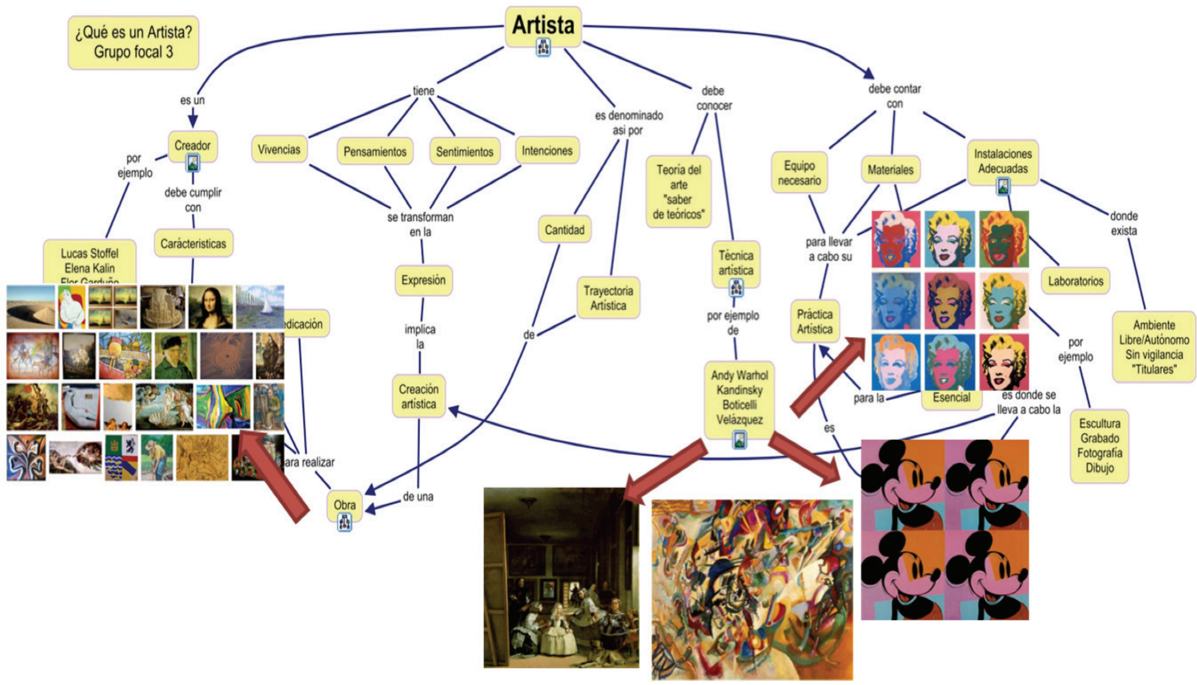

Figura 3. Mapa conceptual sobre el concepto de Artista, se muestran los hipervínculos a obras de Arte de distinguidos artistas.

CmapTools ofrece una gran gama de herramientas de formato, diseño y navegación para aplicar a los mapas conceptuales y dan como resultado una mejor presentación a los mapas. Cuenta con una variedad de funciones entre las que destaca el diseño automático de mapas conceptuales. En ocasiones pueden realizarse mapas conceptuales donde no se encuentra definida la organización y jerarquía de conceptos y esta función puede mejorar la presentación visual de esos mapas. Otra función de CmapTools es la edición de mapas conceptuales a partir del uso de diferentes estilos, con esta opción se puede dar color a las letras y a los mapas, se puede editar el tipo de líneas y la forma de los conceptos. Algunas características útiles en este proyecto fue el uso de carpetas exclusivas para organizar los mapas conceptuales además de utilizar constantemente las notas dentro del mapa conceptual ya que ayudaron en el proceso de esclarecer conceptos, recordar frases y conceptos entre los tres grupos de alumnos, para anotar los nombres de Artistas, Obras de Arte, Páginas Web y Teorías de Arte que ellos mencionaron.

Una de las funciones que más se utilizó de CmapTools es la comparación de mapas conceptuales, esta herramienta permitió comparar ciertos conceptos y proposiciones entre versiones parecidas de cmaps, es así como se encontró que los mapas conceptuales en relación al concepto de Arte, Artista, Obra de Arte y Estereotipos eran muy semejantes a pesar de que los grupos de alumnos eran de diferentes edades, semestres académicos y áreas artísticas. Esto facilitó la reflexión sobre los conocimientos que de algún modo se han ido formando como representaciones sociales.

4 Resultados

El mapeo de los conceptos y proposiciones de los estudiantes permitió la detección y análisis de algunos conocimientos y creencias que tenían en torno al arte. A partir de la comparación de las versiones de mapas conceptuales en cada grupo, se observó que hay representaciones de los conceptos de una forma generalizada, existen creencias sociales que han sido adquiridas y compartidas socialmente dentro de la Facultad de Artes.

En los mapas conceptuales relacionados al eje teórico como el concepto de Arte, Teoría del Arte, Imagen y Artista se encontró que la representación social está relacionada con la idea de que cada uno de estos conceptos es de gran complicación y que es difícil atribuirle una concepción y significado específico. Por lo tanto existe la creencia que es un concepto tan complejo e innecesario su estudio, su reflexión y teorización por lo que no se lograría una definición concreta. Sin embargo la mayoría de los alumnos consideraron que: “El arte es el producto artístico ya sea una obra así como el proceso de elaboración de la misma”. Sólo unos cuantos alumnos de los semestres intermedios reflejaron todavía una visión romántica del arte al hablar sobre cuestiones del amor y felicidad en el quehacer artístico, además de considerar que el arte es el producto que realiza el artista.

En cuanto al concepto de artista la mayoría de los mapas realizados reflejaron que la representación social está relacionada con que “El artista siempre va a tener vivencias, pensamientos, sentimientos, intenciones que debe expresar y que se materializan al producir una obra”. En los mapas conceptuales se encontró que el concepto expresión estuvo presente en los tres grupos por lo tanto el artista se debe caracterizar por siempre expresar algo. El imaginario social en cuanto al artista también tiene que ver con la idea de que es aquel que ya tiene una trayectoria artística, lo cual implica la exposición de gran cantidad de obras, el reconocimiento del público y un buen prestigio como artista.

Otras representaciones sociales que surgieron a partir del análisis de los mapas conceptuales es que el concepto de imagen es relacionado más a la fotografía, la mayoría de los ejemplos que dieron los participantes de imagen correspondían a trabajos de fotógrafos. En los mapas conceptuales respecto a la obra de arte y técnica artística se encontró que la creencia social que las “obras de arte son aquellas que están expuestas y colgadas en los museos y galerías y que son siempre avaladas por esas instituciones, por los críticos del arte, espectadores, y artistas e investigadores expertos”, jamás se mencionó que el artista puede avalar su propia obra de arte. Los alumnos mencionaban que el uso del concepto de obra de arte no es muy frecuentemente en su lenguaje académico. También que todo lo que realizaban era técnica artística, sin embargo en los mapas conceptuales no hubo una definición clara sobre esta, solo hubo algunos ejemplos. Los mapas conceptuales relacionados a los estereotipos del artista coincidieron en que a la mayoría se les ha etiquetado como “alcohólicos, drogadictos, locos, rebeldes, estrafalarios, hippies, fiesteros e inadaptados sociales, además de ser criticados porque no hay fuentes de trabajo para el arte” (ver figura 4). Algunas proposiciones sobre los estereotipos fue que “son falsas imágenes y creencias que tienen del artista y que los medios masivos de comunicación como televisión, internet etc. Generan esas falsas concepciones del arte” Se identificó que los estudiantes de nuevo ingreso a la licenciatura se ven influenciados por estos medios al querer llamar la atención y transgredir a partir de su apariencia estrafalaria, formas de vestir e imposición de modas en la facultad. Aclararon que la mayoría de los estereotipos que les atribuye la gente son falsos, ya que los artistas en realidad tienen una vida normal.

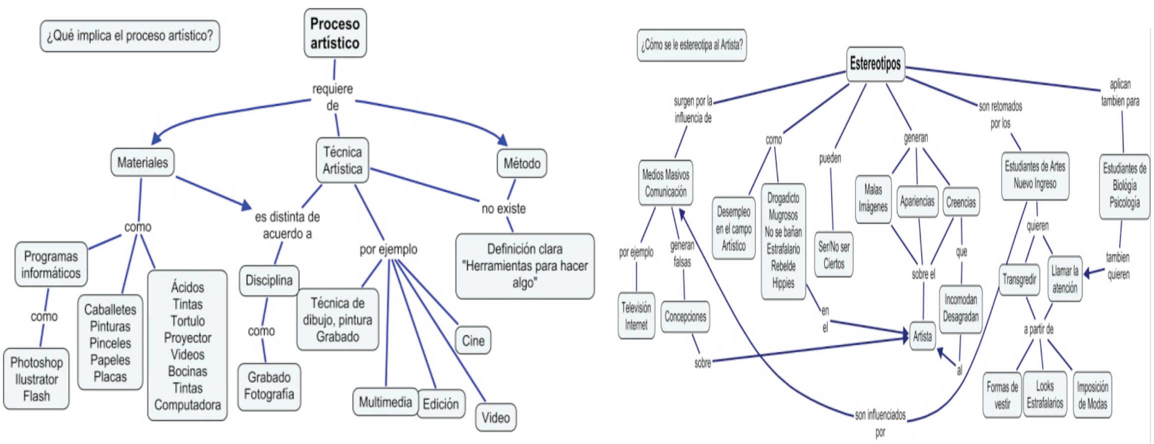

Figura 4. Mapas conceptuales sobre técnica artística y estereotipos en los Alumnos de la licenciatura en Artes.

5 Conclusiones

A pesar de que existen diversas metodologías para el análisis de las representaciones sociales se optó por utilizar el modelo de conocimiento como herramienta metodológica con el fin de averiguar, analizar y hacer un estudio profundo sobre las concepciones de las personas. Los mapas conceptuales y el modelo de conocimiento han sido muy efectivos para representar las creencias, imaginarios, formas de pensar y actitudes de los alumnos que estudian la licenciatura en Artes. El uso del modelo de conocimiento como metodología en el desarrollo de un proyecto de maestría ha causado cierto asombro por parte de algunos investigadores ya que es un instrumento desconocido y poco utilizado en la universidad, sin embargo a partir de debates y exposiciones sobre este en diversos seminarios dio apertura y aceptación para la utilización de este proyecto.

En el aspecto formativo la integración de los mapas conceptuales de los grupos en el modelo de conocimiento nos permitió tener una visión general de las representaciones y conocimientos de los estudiantes en artes, un dato interesante que se encontró es que una de las representaciones sociales está relacionada a creencias de que hay conceptos teóricos en el área artística que no tienen definición clara y por lo tanto son difíciles de conceptualizar y reflexionar sobre estos. Existe una resistencia al comentar sobre la parte teórica del arte, ya que los alumnos evadían algunos comentarios y tenían un mejor manejo de los conceptos tocante a la práctica, quehacer y producción artística. La información obtenida puede ser de gran ayuda a la facultad de Artes y así reorientar y mejorar con algunas propuestas académicas.

Para tener un panorama más amplio de las concepciones sobre arte, la siguiente etapa de este proyecto es realizar otro modelo de conocimiento donde se muestren las representaciones sociales de Artistas expertos, lo cual ayudaría a contrastar la forma de pensar que tienen los estudiantes en arte y la visión que tienen los Artistas con una trayectoria artística ya realizada.

6 Agradecimientos

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MODELOS DE PROCEDIMIENTOS CREADOS MEDIANTE MAPAS CONCEPTUALES. CONCRECIÓN A UNA PRÁCTICA DE LABORATORIO DE ÓPTICA

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Abstract. En este trabajo se presenta la utilidad de los Mapas Conceptuales elaborados con CmapTools para la creación de Modelos de Procedimientos como recurso didáctico para la realización estructurada de las prácticas de laboratorio. Para esta experiencia se ha elegido una práctica del laboratorio de óptica. La experiencia se ha llevado a cabo en el curso 2010/2011 con los alumnos de la asignatura "Técnicas experimentales en óptica" de la Facultad de Ciencias en la Universidad de Extremadura (España). El estudio ha consistido en la introducción de Mapas Conceptuales en el trabajo práctico en el Laboratorio, con el fin de ayudar a los alumnos a relacionar significativamente los contenidos teóricos con el conocimiento práctico, para aumentar la conexión teórico-práctica y mejorar el rendimiento conseguido. Los resultados obtenidos en la evaluación de la utilización de esta metodología didáctica indican una mejora del aprendizaje tras esta integración de herramientas didácticas cognitivas en las prácticas de laboratorio. Concretamente, se ha comprobado que estos mapas de procedimientos han ayudado a organizar los contenidos, objetivos y fundamentos de las prácticas, a la vez que han permitido a los alumnos alcanzar una comprensión duradera del contenido de óptica trabajado en el laboratorio, pues incluyen enlaces directos a fotografías, videos didácticos y animaciones, constituyendo un Mapa-guion de prácticas estructurado mediante dicho mapa. Los resultados obtenidos con los instrumentos de evaluación utilizados (cuestionarios y análisis de las entrevistas realizadas), sugieren que los mapas conceptuales y los mapas de procedimientos, constituyen una herramienta para "aprender a aprender" con Modelos de Conocimientos, y para "aprender a proceder" con Modelos de Procedimientos en las actividades prácticas en el laboratorio de óptica, y han permitido a los alumnos establecer conexiones entre los conceptos y procedimientos más relevantes puestos en juego en el laboratorio.

1 Introducción

1.1 Los mapas conceptuales y la enseñanza de la física

Los mapas conceptuales constituyen unas herramientas muy efectivas para promover el aprendizaje significativo, permitiendo a los alumnos construir su conocimiento a partir de una estructuración y organización de los contenidos conceptuales (Novak, Gowin & Johansen, 1983; Novak & Gowin, 1984; Novak & Musonda 1991; Chiu, Huang & Chang, 2000). La base teórica de los mapas conceptuales se encuentra en la Teoría de la Asimilación de Ausubel (Ausubel, 1968, 2000) y en la Teoría del Aprendizaje de Novak (Novak & Gowin, 1984). Estos autores afirman que para que se realice un aprendizaje significativo, la integración de los nuevos conceptos en nuestra estructura cognitiva exige vincular estos nuevos conocimientos a los conceptos previos que ya poseen los alumnos. En palabras de Novak, los mapas conceptuales son una poderosa herramienta para representar las estructuras de conocimiento del individuo y los cambios explícitos que tienen lugar en su conocimiento a lo largo del tiempo. Cañas et al. (2003), afirma que estas herramientas de representación del conocimiento deben tener una estructura básica y unas características específicas por lo que no todos los gráficos con texto en sus nodos son mapas conceptuales; sino que los Mapas conceptuales son bidimensionales, jerárquicos, de nodos enlazados, y constituyen diagramas que representan el conocimiento conceptual de una forma visual y concisa (Quinn, Mintzes & Leyes, 2004; Horton et al, 1993).

Si hacemos una revisión sobre las diferentes experiencias con el uso de mapas conceptuales, algunos autores han demostrado su utilidad como una forma de sintetizar el contenido estudiado durante una secuencia de aprendizaje (Horton et al., 1993). Sin embargo, como cualquier otra herramienta didáctica, su eficacia depende de cómo se utiliza y las condiciones en las que se usa. Concretamente, si nos centramos en la utilidad y el uso de los mapas conceptuales en la enseñanza de las ciencias, Okebukola & Jegede (1988, 1989) han presentado algunas de las principales ventajas del uso de mapas conceptuales como una estrategia para el aprendizaje de contenidos científicos, en particular, su influencia positiva en el rendimiento académico de los estudiantes. Montanero &Montanero (1995) estudiaron su utilidad como pre-organizadores, es decir, como un medio de presentar una visión general del contenido capaz de mostrar los conocimientos previos de los estudiantes. Walker (2003) utiliza los mapas conceptuales para la evaluación de los estudiantes. Otros autores (Hernández & Serio, 2004), comparan varios métodos de enseñanza en un tema de ciencias concreto, mostrando que los mapas conceptuales son especialmente útiles como pre-organizadores del conocimiento, tanto si son presentados por el profesor como si son los propios alumnos quienes los construyen , siempre y cuando el docente les ayude a conectar con lo que se ha aprendido. Broggy & McClelland (2008), han llevado a cabo una investigación para determinar el impacto de los mapas conceptuales en el aprendizaje de la física. El proceso de construcción de un mapa conceptual es una estrategia de aprendizaje de gran alcance que obliga al alumno a reflexionar activamente sobre la relación entre los términos. Esto hace que los mapas conceptuales sean especialmente adecuados para el estudio de la ciencia, sobre todo para los alumnos que perciben la ciencia como una simple memorización de datos (Dorough & Centeno, 1997).

Austin & Shore (1995), utilizan los mapas conceptuales para el aprendizaje de la física, y han puesto de manifiesto que los mapas conceptuales son útiles para evaluar la comprensión de las relaciones entre los conceptos necesarios para resolver problemas de física. Particularmente, Zieneddine & Abd-El-Khalick (2001), estudiaron la efectividad de los mapas conceptuales como herramientas de aprendizaje en el desarrollo de la comprensión conceptual de los estudiantes de primer año en un curso universitario de física, y demostraron que los estudiantes que utilizan los mapas conceptuales obtuvieron mejores puntuaciones. Por otra parte, los participantes señalaron que los mapas conceptuales les ayudaron a organizar su conocimiento y promover su comprensión de los conceptos de física.

Otros estudios señalan las ventajas de la colaboración en el uso de mapas conceptuales en física. El aprendizaje colaborativo se basa en la idea de que los estudiantes se influyen mutuamente en su aprendizaje a través de un intercambio de conocimientos y de una negociación de sus significados (Pérez et al. 2010; Baker, Hansen, Unión & Traum, 1999; Barron, 2003). Roth & Roychoudhury (1992) encontraron que cuanto más extenso fueron las explicaciones y justificaciones en la discusión, mayor era la probabilidad de que se produjese el cambio conceptual. Pérez et al. (2008) llevaron a cabo una serie de experiencias educativas en las que probaron la aplicación de los mapas conceptuales en apoyo de los procesos de colaboración en la reconstrucción entre el conocimiento y el cambio conceptual en los alumnos. Sus resultados demostraron el gran potencial de los mapas conceptuales para fomentar el cambio conceptual y la modificación de las teorías implícitas sobre los fenómenos físicos.

1.2 Los mapas conceptuales: De los modelos de conocimiento a los modelos de procedimientos

La implantación del Sistema europeo de transferencia y acumulación de créditos, (créditos ECTS) han supuesto la remodelación del sistema educativo universitario español en cuanto a las programaciones y a la metodología didáctica, centrándose ambas, cada vez más, en la actividad de los alumnos, siendo la función del profesor la de actuar como guía en el proceso de aprendizaje de los estudiantes. Esto conlleva la conveniencia de proponer algunas metodologías innovadoras para favorecer la construcción del aprendizaje en nuestros alumnos.

Desde hace muchos años, nuestro grupo de Investigación viene aplicando los mapas conceptuales como metodología didáctica en las asignaturas que tenemos asignadas en el departamento de Física de la Facultad de Ciencias, en la Universidad de Extremadura, con el objetivo de promover el aprendizaje significativo en nuestros alumnos, así como con el fin de potenciar diferentes estrategias de aprendizaje para transformar la información sobre los contenidos de una asignatura en conocimiento (Pérez, Suero, Montanero & Montanero, 2000; Pérez, Suero, Montanero & M. Pardo, 2001; Pérez, Suero, Pardo & Montanero, 2006; Pérez, Suero & Pardo, 2008; Pérez et. al., 2010). En la línea de este planteamiento, los mapas conceptuales permiten la construcción de modelos de conocimientos (Cañas et al., 2000) que proporcionen una estructura cognitiva lógica para relacionar los contenidos conceptuales de una materia. Para la construcción de estos modelos de conocimientos, se interrelacionan entre sí diferentes mapas conceptuales (y sus correspondientes recursos) en los que se organizan y clarifican los conceptos, para estructurar la información, configurando y generando conocimiento, y haciendo mucho más eficaz la comunicación de la misma (Martínez, Pérez, Suero & Pardo, 2012).

Concretamente, en investigaciones previas a la que aquí se presenta, nuestro grupo de trabajo ha mostrado el incremento de aprendizaje estadísticamente significativo que se obtiene tras la utilización de los alumnos de modelos de conocimientos basados en mapas conceptuales (Martínez, Pérez, Suero & Pardo, 2010; Pérez, et al. 2010). Quedando con ello validado que los mapas conceptuales son una herramienta didáctica muy potente para ayudar a los alumnos a "aprender a aprender" y trabajar los contenidos conceptuales que puedan ser estudiado en una materia de aprendizaje. Sin embargo, en asignaturas científicas de carácter más práctico como puede ser el Laboratorio de Óptica, el trabajo experimental forma parte de su carácter disciplinar, por lo que es necesario realizar también materiales didácticos para atender a estos objetivos de tipo procedimentales. Es por ello que en este trabajo se ha atendido también a la parte experimental de la Óptica, y se han desarrollado "Modelos Procedimentales" basados en Mapas conceptuales de las prácticas del laboratorio, que han proporcionado a los alumnos y a los profesores, nuevas herramientas didácticas que permiten llevar a cabo experiencias de laboratorio en entornos tanto presenciales como virtuales (usando la herramienta Cmaptools). Consideramos por tanto, que es posible la extrapolación al ámbito procedimental de la utilización de los mapas conceptuales. En la línea de este planteamiento, se ha llevado a cabo esta experiencia para trabajar con mapas conceptuales tanto contenidos conceptuales como procedimentales en la asignatura de óptica. Estos mapas conceptuales han servido a los alumnos de "andamiaje" para facilitarles el proceso de adquisición de los contenidos conceptuales y procedimentales de manera organizada, secuenciada, jerárquica e integradora, convirtiendo a los mapas conceptuales en una herramienta no sólo para ayudar a "aprender a aprender" a nuestros alumnos, sino también para ayudarles a "aprender a proceder".

El objetivo de este trabajo ha sido la utilización de mapas conceptuales en las prácticas de laboratorio con el fin de focalizar a través de las preguntas claves de los mapas conceptuales desarrollados, el contenido, fundamento, objetivos, materiales, procedimientos, resultados y conclusiones de las distintas experiencias del laboratorio. El objetivo de partida es valorar si los conceptos y procedimientos que adquieren los alumnos son más significativos con los Mapas-Guiones desarrollados que con los tradicionales guiones de prácticas. En la figura 1 se muestra un mapa conceptual sobre el uso de los mapas conceptuales como Modelos de Procedimientos.

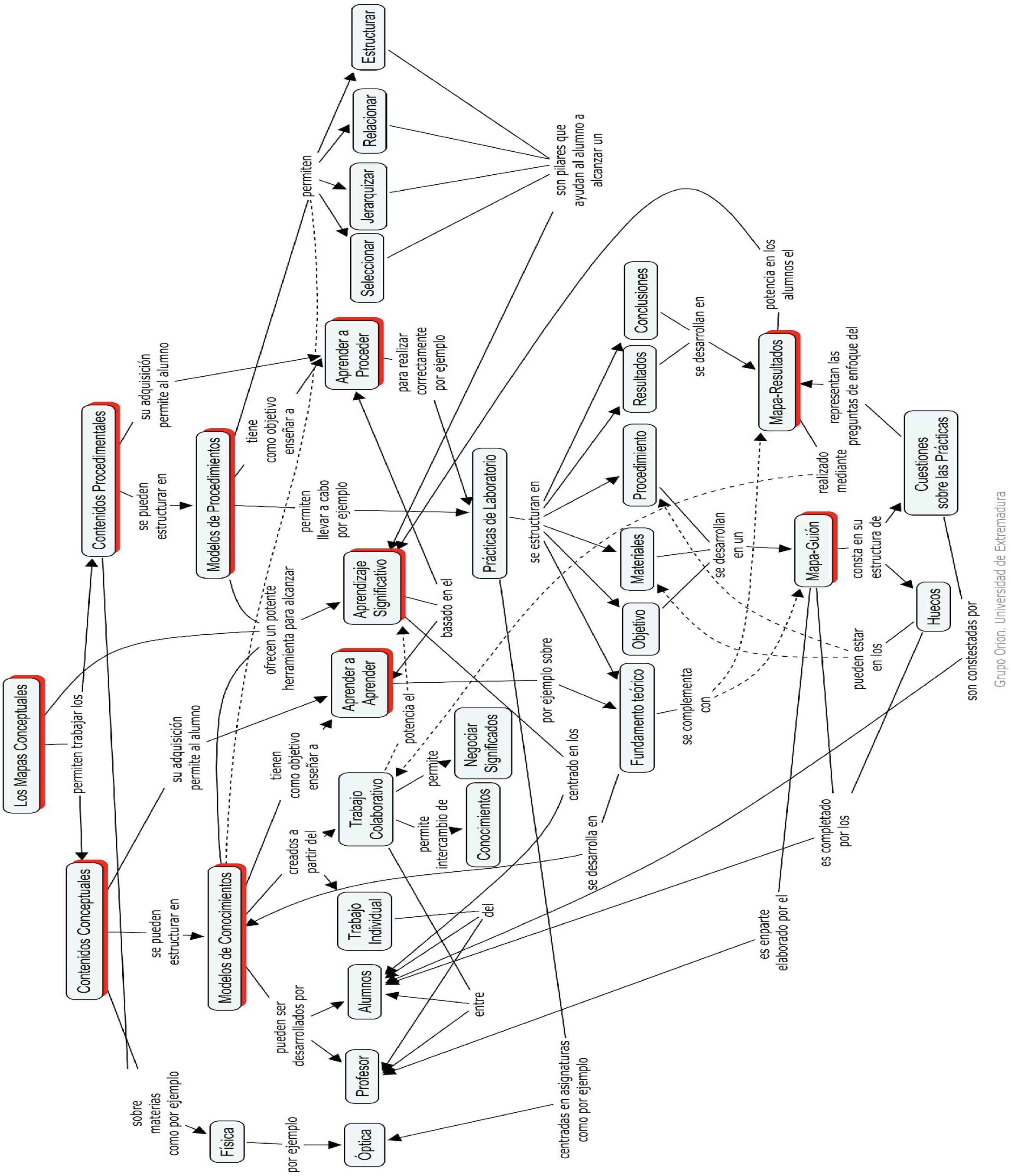


Figura 1. Mapa conceptual sobre el uso de los mapas conceptuales como Modelos de Procedimientos

2 Metodología y desarrollo de la Investigación

2.1 Diseño de la Investigación

La experiencia que se presenta se ha llevado a cabo en el curso académico 2010/2011 con los alumnos que cursaban la asignatura de "Laboratorio de Óptica" en la Facultad de Ciencias en la Universidad de Extremadura (España). El estudio experimental se ha llevado a cabo en 8 sesiones de prácticas de laboratorio de 4 horas cada una, en las que se han estudiado y realizado diferentes prácticas sobre los contenidos de Óptica: Reflexión de la luz, Refracción de la luz, Lentes, Prismas Ópticos, Fenómenos de Interferencia y Fenómenos de Difracción.

La metodología utilizada se ha dividido en las siguientes fases:

- En primer lugar, se llevó a cabo una primera sesión con los alumnos, a modo de introducción, sobre Mapas Conceptuales. En este seminario, se les introducía el concepto de mapa conceptual, sus características y ventajas y se les instruía en la realización de los mismos con el programa Cmaptools del IHMC. En esta primera sesión para facilitarles la construcción de los mapas conceptuales, se utilizaron los videotutoriales elaborados por nuestro grupo de investigación y que se encuentran disponibles en la página web: http://grupoorion.unex.es/cmaptools/cmaptools.htm (Martínez, Pérez, Suero & Pardo; 2007)**.**
- En una segunda fase, los alumnos elaboraron de manera individual Mapas Conceptuales sobre los fundamentos teóricos de las prácticas de laboratorio que se iban a llevar a cabo. De esta manera, se pudo evaluar cuales eran los conceptos y preconcepciones que presentaba cada alumno con respecto a los contenidos teóricos que se iban a trabajar en las prácticas del laboratorio.
- Se utilizaron algunos de los Mapas Conceptuales creados por los alumnos como organizadores previos para la exposición de los contenidos teóricos trabajados. Para ello, se utilizó un primer nivel de elaboración del Mapa Conceptual en el que se incluían únicamente los conceptos más generales del tema. Esto nos permitió utilizar el mapa como un "puente conceptual" entre los conocimientos previos del alumno (lo que el alumno sabe) y el nuevo contenido a aprender. Es decir, esta fase en el proceso de elaboración de los Mapas Conceptuales, nos permitió "negociar los significados" de los contenidos tratados (Novak & Gowin, 1984; Novak & Musonda, 1991; Novak & Cañas, 2006; Ausubel, 2000).
- Posteriormente, se corrigieron y se reelaboraron los Mapas Conceptuales creados inicialmente. Esta fase se llevó a cabo con los alumnos agrupados por parejas: Se obtuvieron así mapas conceptuales consensuados por cada grupo de 2 alumnos. Este proceso de reelaboración es importante, porque dio lugar al establecimiento de relaciones conceptuales no consideradas en un primer momento. Se propició así la aparición de nuevas construcciones proposicionales y nuevos conocimientos.
- Una vez puesta en común la base teórica de la práctica, las parejas de alumnos realizaron las experiencias de laboratorio correspondientes a esos contenidos conceptuales trabajados. De entre todos los mapas consensuados por parejas, se eligió por votación, en función de la puntuación obtenida en los mapas por los métodos de Bartels (1995) y/o de Novak, el mejor mapa conceptual que representase la base teórica de cada práctica. Con esta actividad se consiguió una mayor motivación por parte del alumnado, pues se les puntuaba con un 0,25 extra en la calificación final de las prácticas de la asignatura por cada mapa conceptual que hubiese sido seleccionado.
- Una vez elaborados los distintos Mapas Conceptuales de los fundamentos teóricos de las prácticas, se enlazaron entre sí a través de los conceptos que tenían en común para construir un Modelo de Conocimiento sobre la materia tratada, transformando la información sobre los contenidos de la asignatura de óptica en conocimiento.
- En una tercera fase, el profesor facilitaba al alumno un mapa conceptual de base sobre la práctica que tenían que realizar por parejas. En dicho mapa conceptual, se recogían el título y objetivo de la práctica que se iba llevar a cabo. Del mismo modo, se le facilitaba el equipo de laboratorio y la bibliografía necesaria para la correcta realización de la práctica. Los alumnos, debían completar los mapas conceptuales del guion de las prácticas añadiendo los materiales, procedimiento y los enlaces cruzados que estuvieran relacionados con el mapa conceptual de los fundamentos teóricos que se habían realizado en las otras sesiones. Para facilitar la construcción de estos mapas a los alumnos, se les facilitaba una serie de conceptos mínimos que debían de aparecer. Así como una serie de preguntas guía para focalizar la atención del alumno, y que sirviesen de preguntas de enfoque de los mapas conceptuales de resultados. Tras la realización de la práctica, el alumno debía presentar un informe final de prácticas con un mapa conceptual elaborado con Cmaptools en el que se reflejaran los resultados y conclusiones obtenidas.

En la figura 2 se muestra un ejemplo del Modelo de Procedimiento que constituye el Mapa-guion de la práctica "Reflexión de la luz. Formación de Imágenes".

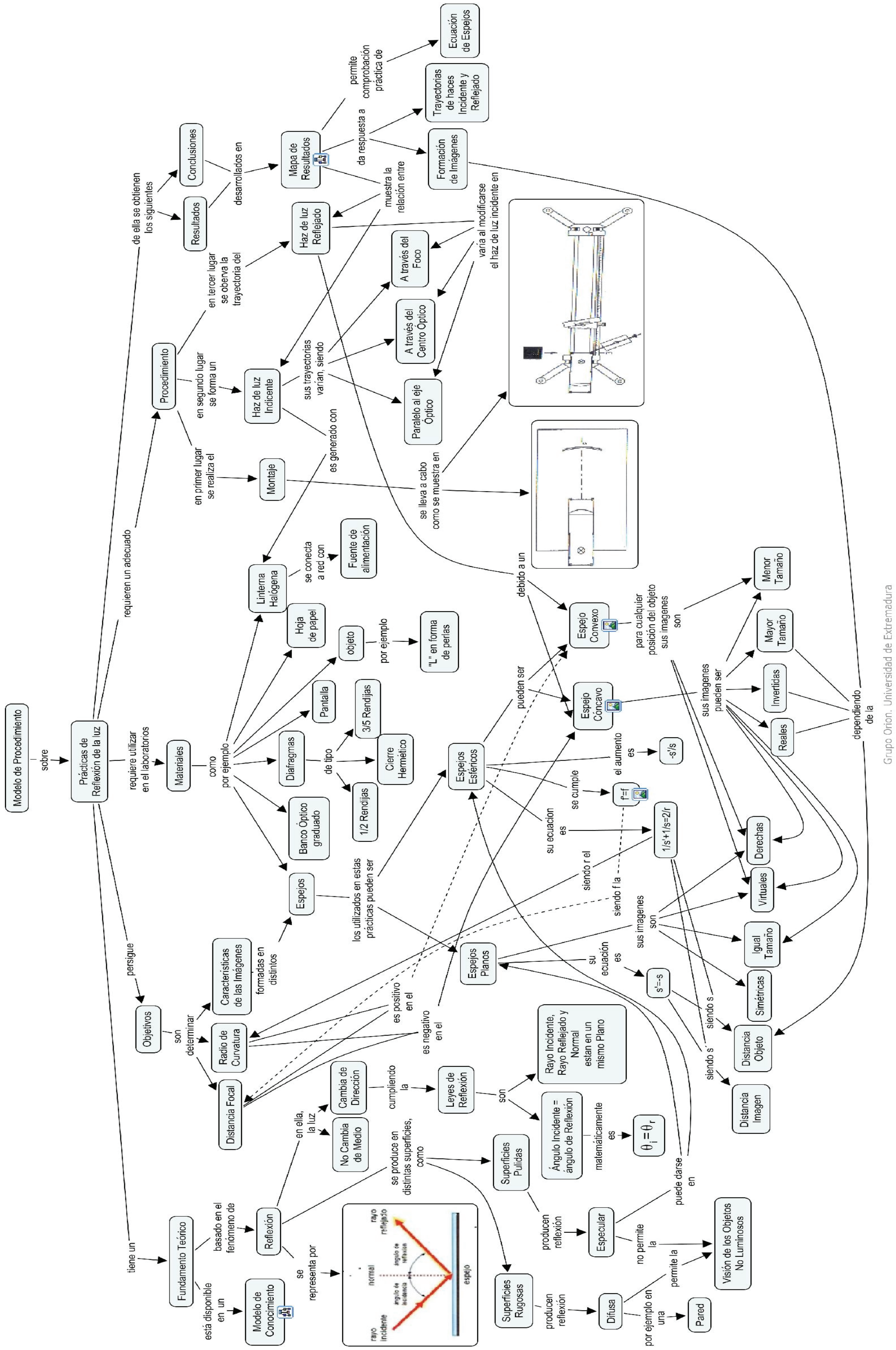
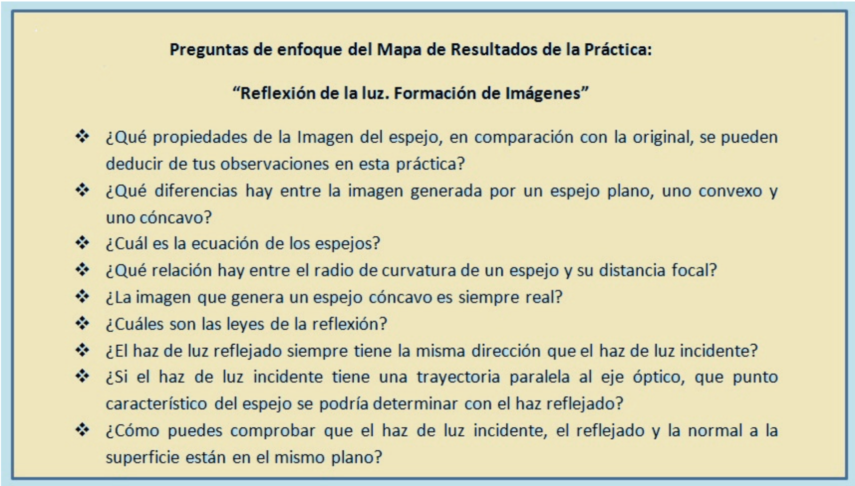


Figura 2. Modelo de Procedimiento que constituye el Mapa-guion de la práctica "Reflexión de la luz. Formación de Imágenes".

En la figura 3 se muestran a modo de ejemplo una captura de la ficha-práctica con las preguntas guía que conforman las preguntas de enfoque del Mapa de Resultados.



Preguntas de enfoque del Mapa de Resultados de la Práctica:

"Reflexión de la luz. Formación de Imágenes"

- ¿Qué propiedades de la Imagen del espejo, en comparación con la original, se pueden deducir de tus observaciones en esta práctica?
- ¿Qué diferencias hay entre la imagen generada por un espejo plano, uno convexo y uno cóncavo?
- ¿Cuál es la ecuación de los espejos?
- ¿Qué relación hay entre el radio de curvatura de un espejo y su distancia focal?
- ¿La imagen que genera un espejo cóncavo es siempre real?
- ¿Cuáles son las leyes de la reflexión?
- ¿El haz de luz reflejado siempre tiene la misma dirección que el haz de luz incidente?
- ¿Si el haz de luz incidente tiene una trayectoria paralela al eje óptico, que punto característico del espejo se podría determinar con el haz reflejado?
- ¿Cómo puedes comprobar que el haz de luz incidente, el reflejado y la normal a la superficie están en el mismo plano?

Figura 3. Captura de la ficha-práctica con las preguntas guía que conforman las preguntas de enfoque del Mapa de Resultados.

3 Resultados y Conclusiones

La evaluación de esta experiencia se ha realizado desde tres puntos de vista:

- Evaluación del aprendizaje obtenido (Con test de conocimientos y procedimientos).
- Evaluación cuantitativa de los mapas conceptuales y procedimentales (Método de Novak).
- Evaluación de la metodología (Entrevistas estructuradas y valoración en escala Likert).

Concretamente, para evaluar el grado de aprendizaje obtenido por los alumnos, una vez realizada la práctica de laboratorio, el alumno debía contestar a un cuestionario específico y a un test de conocimientos para cada una de las experiencias. Las preguntas combinaban los modelos de test de repuestas múltiples, dicotómicas y preguntas cortas para abarcar todos los contenidos conceptuales y procedimentales de las prácticas. Dichos cuestionarios podían ser descargados de la plataforma virtual en formato pdf, o ser contestados on-line a través de formularios interactivos. Una vez completados debían ser enviados al profesor para su evaluación. En la figura 4 se muestran las calificaciones medias obtenidas en las prácticas por los alumnos que formaron parte de esta experiencia. Puede observarse que el 100% de los alumnos aprobaron con éxito las prácticas de laboratorio, el 53,8% tuvo una calificación de notable y el 46,2% de sobresaliente. Este resultado nos indica que los Modelos de Procedimientos constituyen una herramienta didáctica cognitiva de gran utilidad para que el alumno aprenda a proceder significativamente.

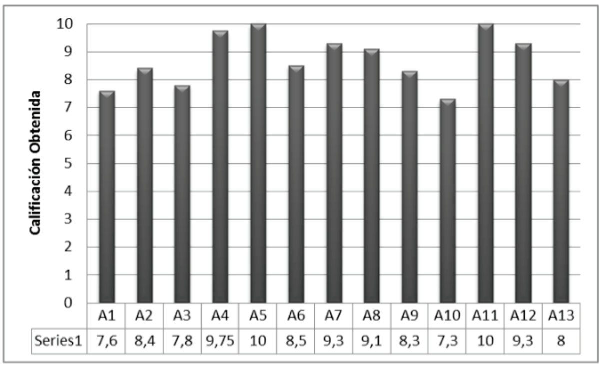


Figura 4. Calificaciones medias obtenidas por los alumnos

Por otro lado, se realizó una evaluación cuantitativa de los mapas conceptuales realizados por los alumnos, tanto los que constituyen el Modelo de Conocimiento sobre los contenidos teóricos de las prácticas, como los que constituyen los Modelos de Procedimientos de las experiencias realizadas. Para llevar a cabo esta valoración de la actividad, se utilizó el Método de Novak (Novak, 1984). Según Novak, con este método de evaluación de los mapas se puede diferenciar entre el grado de aprendizaje memorístico y aprendizaje significativo realizado por los autores de los mapas conceptuales. La puntuación obtenida (según el índice de Novak) de cada mapa consensuado por los alumnos se comparó con los valores obtenidos en el Modelo de Procedimiento guía realizado por el profesor de la asignatura. De esta manera, se pudo cuantificar el grado de aprendizaje de los alumnos a partir de las jerarquías, relaciones válidas, asociaciones cruzadas válidas y significativas y ejemplos aportados por los estudiantes en los Modelos de Procedimientos. Las altas puntuaciones obtenidas en los mapas consensuados, han revelado que la integración de herramientas didácticas cognitivas en las prácticas de laboratorio permite a los alumnos alcanzar una comprensión duradera del contenido y del procedimiento estructurado en los mapas.

Adicionalmente, se llevó a cabo una evaluación cualitativa de la metodología didáctica empleada a través de entrevistas estructuradas a los alumnos, quienes debían evaluar en una escala Likert el grado de satisfacción con la metodología utilizada. El objetivo que se pretendía con ello era obtener información del usuario final a nivel cualitativo sobre la efectividad de los Modelos de Procedimientos y de los Modelos de Conocimiento en el aprendizaje de los alumnos, con el fin de poder introducir mejoras y correcciones para su futura utilización en otros cursos académicos. En este apartado, la valoración obtenida fue muy positiva. Concretamente, los alumnos participaron activamente en la experiencia y mostraron un gran interés con la metodología didáctica empleada, considerando que gracias a ella habían superado con éxito la asignatura de prácticas.

Todos estos resultados, nos han permitido concluir que, los mapas conceptuales y los mapas de procedimientos, constituyen una herramienta para "aprender a aprender" con Modelos de Conocimientos, y para "aprender a proceder" con Modelos de Procedimientos" en las actividades prácticas en el laboratorio de óptica, y han permitido a los alumnos establecer conexiones entre los conceptos y procedimientos más relevantes puestos en juego en el laboratorio.

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MODELOS DE RAZONAMIENTOS REALIZADOS CON MAPAS CONCEPTUALES (MAPAS DE EXPERTO) EFECTUADOS CON CMAPTOOLS. EJEMPLO DE CINEMÁTICA

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Abstract. El presente estudio tiene como objetivo la elaboración de Modelos de Razonamientos a partir de mapas conceptuales realizados con el programa CmapTools en los que se captura la forma de razonar del profesor experto. La experiencia se ha llevado a cabo durante el curso académico 2011/12 en la Facultad de Ciencias en la Universidad de Extremadura (España). El trabajo se ha concretado en el desarrollo, utilización y validación de un Modelo de Razonamiento para la resolución de problemas cinemáticos en un movimiento rectilíneo uniformemente acelerado. Estos Modelos de Razonamiento están constituidos por todos los tipos de contenidos que forman parte del proceso de aprendizaje, es decir, conceptos, procedimientos y razonamientos principalmente, por lo que hemos adoptado para ellos la terminología de Mapas de Experto para poner de manifiesto que son estos los que los elaboran. Para la validación de dichos Modelos de Razonamientos se han utilizado como instrumentos de evaluación unos cuestionarios compuestos por preguntas que engloban diferentes tipos de problemas de cinemática, para comprobar si el alumno es capaz de razonar correctamente la resolución de cualquier problema referido al movimiento rectilíneo uniformemente acelerado. Los resultados obtenidos han puesto de manifiesto que, la realización y utilización de este tipo de pseudomapas conceptuales suponen una gran ayuda para "Enseñar a Pensar" a nuestros alumnos, lo que evidencia el gran interés que presenta la elaboración de los mismos, concretamente en las asignaturas de Física.

1 Introducción

Entre la multitud de utilidades que tienen los mapas conceptuales Novak & Gowin (1984) destacan su utilización para capturar el conocimiento de un experto en el tema en cuestión y elaborar de esa manera un modelo de conocimiento que puede ser ofrecido a otras personas menos expertas como ejemplo de una propuesta de seleccionar, jerarquizar, relacionar y estructurar los conceptos y las relaciones entre los mismos que componen dicho conocimiento. La elaboración del conocimiento es una tarea personal que cada cual debe llevar a cabo por sí mismo, pero que puede ser ayudada por otras personas mediante propuestas de relaciones entre conceptos que cada individuo tendrá a bien asumir o no en función de su propia estructura cognitiva y de su compatibilidad con la nueva propuesta que se le hace. En este sentido son muchos los trabajos que han visto la luz recientemente y cada vez son más los investigadores que dedican esfuerzo a la creación de modelos de conocimientos (Cañas et al., 2000; Nesbit & Olusola, 2006; Novak, 1998; Martínez, Pérez, Suero & Pardo, 2010; 2012).

Pero los contenidos de aprendizajes no son solo de tipo conceptuales, hechos, conceptos y principios con nuestra propuesta de incluir los fenómenos como un nuevo tipo de contenido de aprendizaje de tipo conceptual (Pérez, Suero, Montanero & Montanero, 1998 [I]), sino que además de los mismos existen los contenidos de tipo procedimentales y los de tipo actitudinales. La pregunta que nos planteamos es, ¿pueden ser utilizados los mapas conceptuales para trabajar con contenidos de tipo procedimentales de la misma manera que son ampliamente utilizados para trabajar con los conceptos? La respuesta a dicha pregunta creemos que depende de la respuesta a esta otra más operativa, ¿tienen los procedimientos una estructura que permita ser representada mediante mapas conceptuales?

La primera reflexión es que si se pudieran hacer estos "mapas de procedimientos" ya sería inadecuado seguir llamándolos mapas conceptuales. Puesto que ya no son solo conceptos los que aparezcan en el mismo, habría que buscarles un nombre más adecuado.

Otra cuestión inmediata que se plantea es la siguiente, ¿podrían hacerse también mapas de contenidos actitudinales (actitudes, valores y normas)?, cuya respuesta comenzaría por analizar esta otra pregunta, ¿tienen los contenidos actitudinales una estructura que permita su representación mediante pseudomapas conceptuales? Todas estas preguntas nos llevan a una situación de aprendizaje (no olvidemos que todo aprendizaje no es más que la búsqueda de nuestra respuesta personal a una pregunta, que sin pregunta no puede haber verdadero aprendizaje) siendo éste el objetivo del trabajo que se presenta en esta comunicación.

Dejaremos para otra ocasión el estudio de la respuesta a la última pregunta formulada. Solamente apuntar que efectivamente, todo parece indicar que tanto las actitudes como los valores y las normas parecerían tener una estructura, ciertas actitudes (o valores o normas) serán consideradas como procedentes en un contexto donde sean consideradas procedentes otras series de actitudes (o valores, o normas) y serían improcedentes en otros contextos donde estás otras actitudes (o valores, o normas) no fueran aceptadas. Hasta el mundo de la afectividad (tan importante en los procesos de enseñanza-aprendizaje) parece tener estructura. Ya lo dice el refrán: "los amigos de mis amigos son mis amigos"; es frecuente que instintivamente "sintamos" un afecto positivo o negativo hacia una persona que acabamos de conocer como consecuencia de "extrapolar" otros afectos en función de una serie de parámetros., lo que vendría a poner en evidencia una especie de "estructura afectiva". Pero, como decimos, dejemos este tema para otra ocasión.

Con respecto a la respuesta a la pregunta, ¿pueden ser utilizados los mapas conceptuales para trabajar con contenidos de tipo procedimentales de la misma manera que son ampliamente utilizados para trabajar con los conceptos? En la comunicación presentada a este mismo congreso titulada: "Los Mapas Conceptuales para la creación de Modelos de Procedimientos. Concreción a una Práctica de Laboratorio de Óptica" nos ocupamos ampliamente de ella y a dicha comunicación remitimos al lector.

En esta comunicación queremos dar un paso más que consideramos crucial, ¿y los razonamientos?, ¿podrían crearse "mapas de razonamientos" a modo de pseudomapas conceptuales? ¿podrían capturarse el razonamiento de experto y representarlo mediante un pseudomapa conceptual? ¿podrían crearse modelos de razonamiento para ser ofrecidos como ejemplo a otras personas menos expertas en el tema? La realización y utilización de este tipo de mapa supondría una gran ayuda para "Enseñar a Pensar", lo que evidencia el enorme interés que puede tener la elaboración de los mismos. Estos Modelos de Razonamiento contendrían todo tipo de contenidos de aprendizaje (conceptos, procedimientos y razonamientos principalmente) por lo que deberemos buscar otro nombre para referirnos a ellos. Ya que son realizados por expertos en el tema en cuestión, nuestra propuesta es llamarlos MAPAS DE EXPERTO como ya hemos hecho con anterioridad (Pérez, Suero, Montanero & Montanero, 1998 [II]). Es decir, un Mapa de Experto es una especie de mapa conceptual en el que, además de los conceptos, tiene cabida todo tipo de contenido de aprendizaje y que es realizado por un experto en el tema en cuestión, en el que se captura su conocimiento (no solo conceptual, sino también procedimental y de razonamiento) y con el que se origina un modelo de conocimiento (no solo conceptual, sino también procedimental y de razonamiento) que es ofrecido como ejemplo a personas menos experta en el tema en cuestión.

2 Antecedentes: Los Mapas de Experto Tridimensionales

Durante el desarrollo del proyecto de investigación educativa "Propuesta de un método de secuenciación de contenidos basado en la teoría de la elaboración de Reigeluth y Stein. Aplicación a contenidos de Física de diferentes niveles del Sistema Educativo", llevado a cabo por nuestro grupo de trabajo entre 1996 y 1998 y que fue reconocido con el 2º premio de investigación educativa 1998 por el Ministerio de Educación y Ciencia del estado español, nuestro grupo de trabajo introdujo el concepto de Mapa de Experto Tridimensional. Así, para operativizar la aplicación a la enseñanza de la teoría de la Elaboración de Reigeluth y Stein, en la memoria de dicho proyecto decíamos:

La herramienta fundamental que proponemos para operativizar todo este diseño didáctico, está constituida por lo que hemos denominado mapas de experto tridimensionales. El mapa conceptual, como instrumento de análisis de la estructura lógica (Novak, Gowin & Johansen, 1983), tan sólo permitía representar un contenido en función de una dimensión vertical, correspondiente a las relaciones de pertenencia semántica entre cada concepto y otros más generales a los que se subordina, y otra horizontal, donde se visualizan aquellos que se relacionan en un mismo nivel jerárquico (Cañas et al., 2003). El mapa tridimensional, por el contrario, es un instrumento didáctico que no se constriñe a un solo tipo de contenidos y que además facilita la representación en un tercer vector de "profundidad" en el que se representan los diferentes niveles de elaboración que podemos establecer en la secuencia instruccional. Para ello, utilizamos dos tipos de enlaces: en primer lugar, las tradicionales líneas (etiquetadas proposicionalmente) que unen los diferentes contenidos entre sí (enmarcados generalmente en rectángulos o elipses) y que son el soporte de la dimensión vertical y horizontal, antes mencionada; y, en segundo lugar, algunos de esos mismos contenidos (cuyos marcos aparecen sombreados), que se convierten en un enlace de "profundidad" que conecta con otros mapas.

El mapa tridimensional es en realidad un "hipermapa" que permite al usuario simular y recorrer libremente los caminos de subordinación y supraordinación a lo largo de un sistema conceptual jerarquizado. Por ello, su utilidad didáctica está claramente ligada a un soporte informático. En nuestro caso, hemos utilizado el programa Mac Flow (versión 3.7.4.), para Macintosh y el FlowCharter (versión 6.0) para los ordenadores PC compatibles.

La innovación didáctica del mapa tridimensional reside en definitiva en su doble capacidad de integración. Por un lado, permite jerarquizar varios mapas en niveles sucesivos de complejidad, integrando, como hemos explicado, las dos vías, ascendente y descendente, en una sola secuenciación en "espiral". Por otro lado, esta *versatilidad le convierte en el "mapa de experto" por antonomasia, dado que facilita la integración en un mismo soporte de diferentes herramientas que vamos a necesitar para representar los contenidos del epítome y de la secuencia elaborativa en general; es decir, mapas conceptuales, mapas de principios y, sobre todo, los mapas de fenómenos. En definitiva, los mapas tridimesionales constituyen el recurso fundamental a la hora de aplicar la teoría de la elaboración al diseño de secuencias instruccionales, no sólo de la Física, sino probablemente en otros ámbitos de la enseñanza de la Ciencia en la Educación Secundaria.*

Para llegar al concepto de Mapa de Experto Tridimensional, en primer lugar se construyeron Mapas Conceptuales Tridimensionales, que suponían una ampliación de los conocidos mapas conceptuales a un espacio informático de 3 dimensiones. Una vez trabajando con estos Mapas Conceptuales Tridimensionales se observó la posibilidad de que en estos Mapas Tridimensionales pudieran incluirse, además de los de conceptos, otros tipos de contenidos de aprendizaje (procedimientos, principios, fenómenos, etc.). Como estos mapas son conocidos como mapas de experto, de ahí el nombre final de Mapas de Experto Tridimensionales.

Estos Mapas pueden bajarse de nuestra página web: http://grupoorion.unex.es (siguiendo el enlace: Materiales para el Aula/Mapas de Experto Tridimensionales). La descarga se realiza en 2 partes: la "Introducción", un texto de 80 páginas (2 MB) con el fundamento teórico del proyecto y la "Aplicación", un archivo zip de 8 MB con el que se instala en su ordenador una versión de libre distribución de la aplicación informática utilizada y los 4 mapas de Expertos realizados por nosotros, pudiendo de esta manera ser utilizados desde el propio ordenador del usuario. De 2 de estos Mapas de Experto (los de Electricidad y Óptica) se ha elaborado una versión en CmapTools que se encuentra alojada en nuestro Sitio Cmap "Universidad de Extremadura(España)" (Pérez, Suero, Pardo &Montanero, 2004).

3 Los mapas conceptuales: Hacia los Mapas de Experto

En el trabajo que se presenta en esta ocasión, proponemos "recuperar" la denominación de Mapas de Experto para referirnos a este tipo de mapas con los que se crean modelos de conocimientos (de todo tipo de conocimientos, no solo conceptuales) mediante la captura del conocimiento creado a través de mucho tiempo y mediante muchas horas de reflexión en la estructura cognitiva de un experto en el tema en cuestión. En la figura 1 se muestra un mapa conceptual sobre los Mapas de Experto como integración de Modelos de Conocimiento, Modelos de Procedimientos y Modelos de Razonamientos.

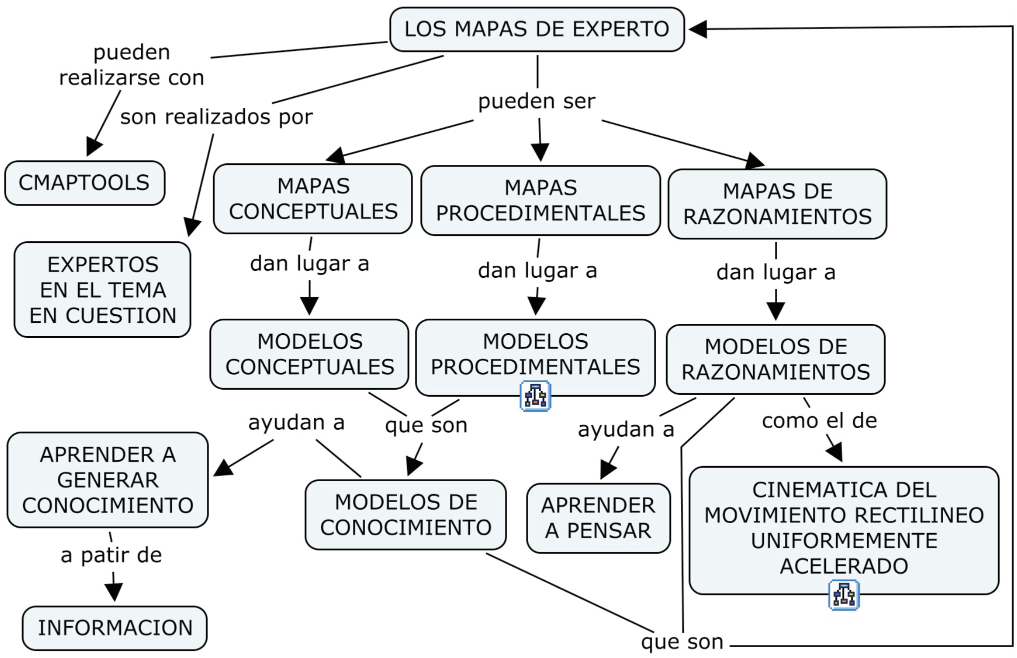

Figura 1. Mapa conceptual sobre los Mapas de Experto como integración de Modelos de Conocimiento, Modelos de Procedimientos y Modelos de Razonamiento.

4 Ejemplo de Modelo de Razonamiento. Resolución de problemas cinemáticos de un movimiento rectilíneo uniformemente acelerado

Como ejemplo de un mapa de experto hemos creado un Modelo de Razonamiento en el que se captura la forma de razonar de un profesor experto en resolver problemas de cinemática de un movimiento rectilíneo uniformemente acelerado. En la figura 2 se muestra dicho Modelo de Razonamiento realizado con el programa CmapTools.

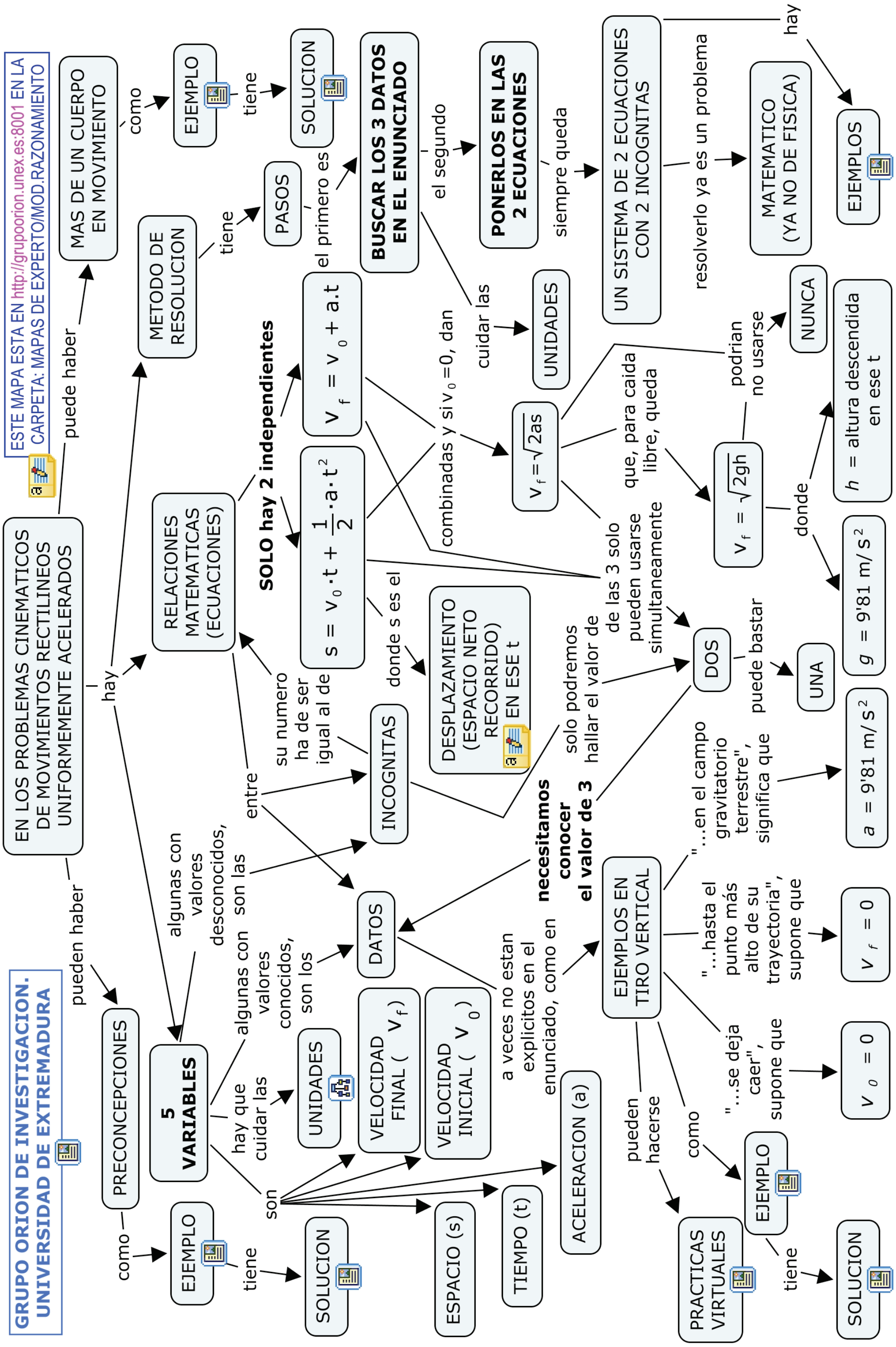

Figura 2. Modelo de Razonamiento en el que se captura la forma de razonar de un profesor experto en resolver problemas de cinemática de un movimiento rectilíneo uniformemente acelerado.

Como puede apreciarse en este mapa de razonamiento de la figura 2, después de muchos problemas resueltos sobre el tema, el experto construye una forma de razonar para resolver este tipo de problemas que puede generalizarse para la resolución de TODOS los problemas de este tipo. En dicho mapa hay zonas de tipo conceptuales y zonas de tipo procedimentales y se incluyen ejemplos que clarifican los razonamientos propuestos en el mismo. En la figura 3 se muestra un mapa conceptual sobre las unidades de medida de las magnitudes físicas, complementario al Modelo de Razonamiento para la resolución de problemas cinemáticos, cuyo hipervínculo está incluido en el Modelo de Razonamiento de la figura 2.

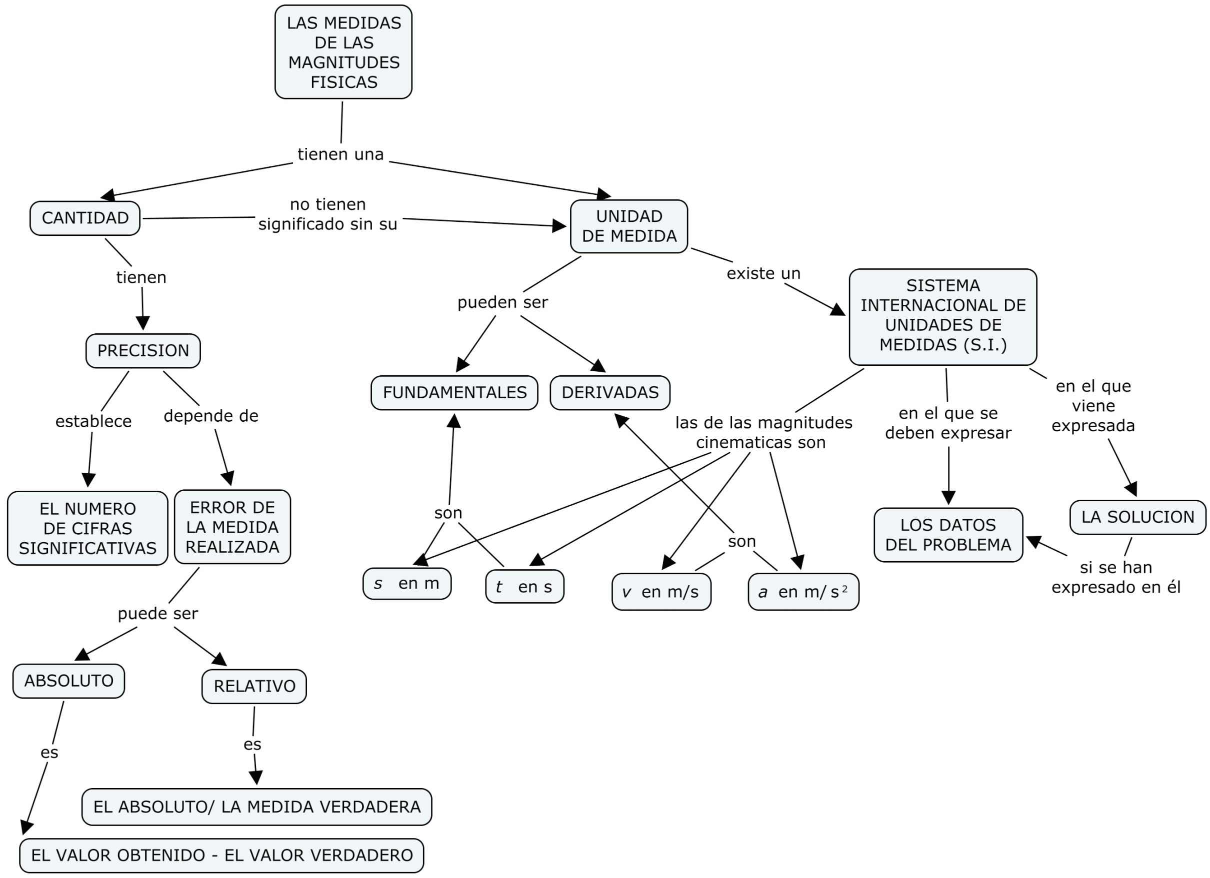

Figura 3. Mapa Conceptual de las medidas de las magnitudes físicas complementario al Modelo de Razonamiento para la resolución de problemas cinemáticos.

5 Evaluación de la experiencia

Para llevar a cabo la validación de la eficacia didáctica de los Modelos de Razonamiento desarrollados, se ha seguido un diseño cuasi-experimental con post-test y grupo de control. Se ha considerado como variable independiente la metodología didáctica empleada en el proceso de aprendizaje de los alumnos, es decir, utilizar los Modelos de Razonamiento para el estudio de la cinemática del movimiento rectilíneo uniformemente acelerado (metodología didáctica del grupo experimental) o utilizar una metodología didáctica tradicional (metodología didáctica del grupo de control). La variable dependiente ha sido la cantidad de aprendizaje conseguida por los alumnos. La investigación se ha llevado a cabo con los datos recopilados de nuestros alumnos de la Universidad de Extremadura. En concreto, con 23 alumnos en cada grupo de diversos Másteres de postgrado. El instrumento de evaluación que se ha diseñado ha sido igual para todos los alumnos de los dos grupos de trabajo, con el fin de poder realizar posteriormente un análisis comparativo entre ellos. Concretamente, se ha elaborado un cuestionario formado por 10 problemas tipo sobre cinemática. En la figura 4 se muestra el cuestionario utilizado como instrumento de evaluación, y en la figura 5 las soluciones al cuestionario de evaluación, siguiendo el Modelo de Razonamiento.

CUESTIONARIO DE EVALUACIÓN

PROBLEMAS DE CINEMÁTICA DEL MOVIMIENTO RECTILÍNEO UNIFORMEMENTE ACELERADO

ENUNCIADOS:

1) Un automóvil que va a una cierta velocidad frena y se detiene en 100 m. Si la duración de la frenada ha sido de 10 s ¿Cuál ha sido el valor de dicha aceleración?
2) Se lanza un objeto verticalmente hacia arriba y alcanza 5 m de altura, ¿con qué velocidad se hizo el lanzamiento?
3) Un coche que va a 10 m/s frena y se detiene en 20 m, ¿Cuál ha sido la aceleración de la frenada?
4) Se lanza verticalmente hacia arriba un objeto con una velocidad de 5 m/s, ¿Cuál es su velocidad cuando ha ascendido 6,25 m?
5) Un móvil que va a 10 m/s frena durante 5 s y recorre 100 m durante la frenada, ¿Cuál es la velocidad al final de la misma?
6) Un coche que va a una cierta velocidad frena durante 10 s con una aceleración de -2 m/s^2 y recorre 150 m durante dicha frenada, ¿Cuál es su nueva velocidad?
7) Un coche frena y se detiene en 10 s. Si la longitud de la frenada ha sido de 50 m, ¿Cuál era su velocidad cuando comenzó la misma?
8) ¿Cuánto tiempo tarda un cuerpo lanzado verticalmente hacia arriba en alcanzar su altura máxima de 20 m?
9) Un automóvil que va a 20 m/s frena y se detiene en 200 m, ¿Cuál ha sido su aceleración?
10) ¿Qué velocidad lleva inicialmente un objeto alzado verticalmente hacia arriba que recorre 1 m en 1 s?

Nota: En todos los enunciados se supone que las aceleraciones son constantes. Para simplificar los cálculos considerar la g = 10 m/s^2.

Figura 4. Cuestionario utilizado como instrumento de evaluación

CUESTIONARIO DE EVALUACIÓN

SOLUCIONES

Enunciado	Los 3 datos son	Las 2 ecuaciones quedan	Solución
1	e = 100 m; t = 10 s; vf = 0	$100 = v_0 t + ½ a t^2$; $0 = v_0 + a\,10$	a= -2 m/s^2
2	e = 5 m ; v_f= 0 ; a = -10 m/s^2	$5 = v_0 t + ½ (-10) t^2$; $0 = v_0 - 10 t$	v_0=10m/s
3	e = 20 m ; v_0= 10 m/s ; v_f = 0	$20 = 10 t + ½ a t^2$; $0 = 10 + a t$	a = 2.5 m/s^2
4	e = 6,25 m; v_0 = 5 m/s; a = -10 m/s^2	$6,25 = 5 t - ½\, 10 t^2$; $v_f = 5 + 10 t$	v_f = 10 m/s
5	e =100 m ; v_0= 10 m/s; t = 5s	$100 = 10 \cdot 5 + ½ a 5^2$; $v_f = 10 + a\,5$	vf = 30 m/s
6	e = 150 m ; a = -2 m/s^2; t = 10	$150 = v_0\, 10 + ½ (-2)\, 10^2$; $v_f = v_0 - 2 \cdot 10$	v_f = 5m/s
7	e = 50 m; v_f=0 ; t = 10 s	$50 = v_0\, 10 + ½ a\, 10^2$; $0 = v_0 + a\,10$	v_0= 10m/s
8	e = 20 m ; v_f=0 ; a = -10 m/s^2	$20 = v_0 t + ½ (-10) t^2$; $0 = v_0 - 10 t$	t = 2 s
9	e = 200 m ; v_0=20 m/s ; v_f = 0	$200 = 20 t + ½ a t^2$; $0 = 20 + a t$	a = -1 m/s^2
10	e = 1 m ; a = -10 m/s^2 ; t = 1s	$1 = v_0 1 + ½(-10)\, 1^2$; $v_f = v_0 - 10 \cdot 1$	v_0 = 6 m/s

Figura 5. Soluciones al cuestionario de evaluación utilizado siguiendo el Modelo de Razonamiento

Con los datos obtenidos en el cuestionario de evaluación, se ha comparado el porcentaje de aciertos de los alumnos que formaron el grupo de control frente al de los alumnos que constituyeron el grupo experimental. En la tabla 1 se muestra el promedio de aciertos, la desviación típica y el error típico de la media obtenida en cada uno de los grupos, y en la figura 6 se representan los histogramas del porcentaje de las calificaciones obtenidas y la curva gaussiana superpuesta para el grupo de control y el grupo experimental. Se puede observar que existe una diferencia entre los alumnos que utilizaron los Modelos de Razonamiento (grupo experimental) frente a los que no los utilizaron (grupo de control).

Grupos	**N**	**Media**	**Desviación típica**	**Error típico de la media**
Experimental	23	8,00	1,65	0,34
Control	23	6,44	2,31	0,48

Tabla 1: Análisis estadístico descriptivo de las calificaciones promedio obtenidas por cada grupo.

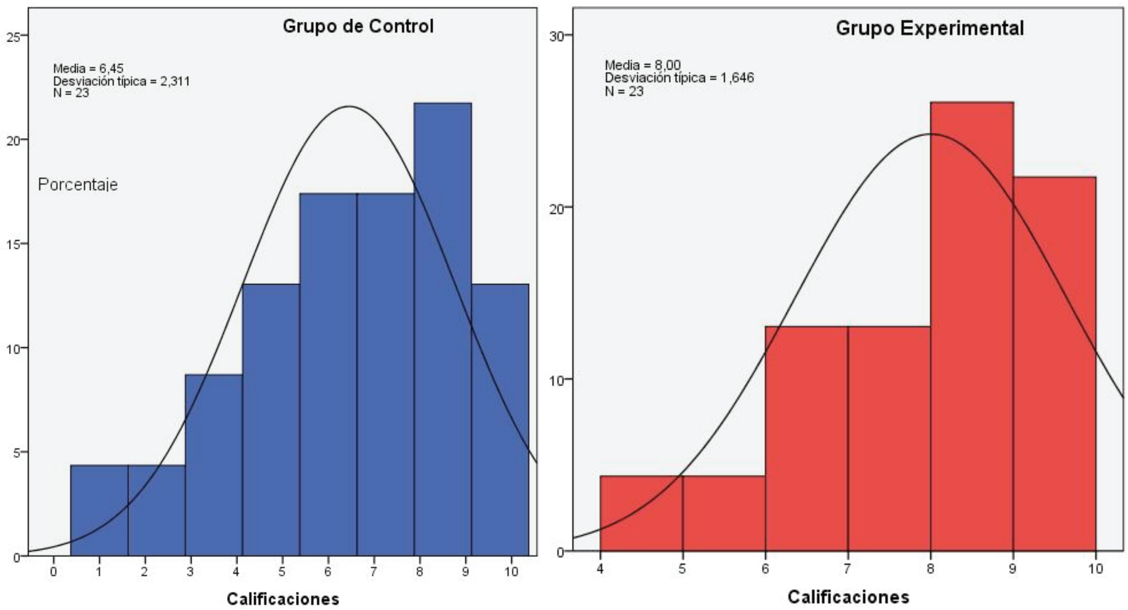

Figura 6. Histogramas del porcentaje de las calificaciones obtenidas y curva gaussiana superpuesta para el Grupo de Control (izquierda) y Grupo Experimental (derecha).

Para cuantificar cuál es la diferencia de puntuaciones entre ambos grupos, se ha realizado una prueba t de Student. El resultado obtenido en dicha prueba se muestra en la tabla 2. En primer lugar se ha comprobado la igualdad de varianzas mediante la prueba de Levene (Significatividad obtenida de 0,065 > 0,05), lo que nos ha permitido aceptar la homogeneidad de varianzas. En la tabla 2, se observa que la diferencia de medias encontrada entre los grupos de control y experimental ha sido de 1,55 puntos con un error típico de 0,59 a favor del grupo experimental. La significación bilateral de la prueba t ha sido de 0,012 < 0,05 (p-valor de referencia). Esto nos ha permitido afirmar que la diferencia encontrada entre ambos grupos es significativa. Concretamente, el grupo que utiliza los Modelos de Razonamiento, tiene un promedio de aciertos superior al grupo que no los utiliza.

Prueba de Levene		**Prueba T para la igualdad de medias**						
F	Sig.	t	g.l.	Sig. (bilateral)	Diferencia de medias	Error típ. de la diferencia	95% Intervalo de confianza para la diferencia	
							Inferior	Superior
3,478	**0,069**	2,627	44	**0,012**	1,55	0,59	0,36	2,75

Tabla 2: Prueba t para la igualdad de medias

Este resultado nos permite afirmar que existen diferencias significativas entre el aprendizaje obtenido por los alumnos a favor de utilizar el Modelo de Razonamiento realizado por un experto. Los resultados obtenidos han puesto de manifiesto que, la realización y utilización de estos Mapas de Experto suponen una gran ayuda para "Enseñar a Pensar" a nuestros alumnos, lo que evidencia el gran interés que presenta la elaboración de los mismos. Siendo posiblemente en las asignaturas de ciencias y más concretamente en las de Física donde mayor interés pueden presentar.

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PROSPECTIVE TEACHERS' KNOWLEDGE OF CONSTRUCTING CONCEPT MAPS

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Abstract. This paper presents an exploratory study that investigated prospective teachers' knowledge of concept mapping. Current research emphasizes concept mapping as an important tool in the classroom for teaching, learning and assessment of student learning. Despite the large number of studies on K-12 students' use of concept mapping, there are very few studies on prospective teachers' knowledge of concept mapping, and thus, how they plan to use concept mapping as a future teaching and learning tool in classrooms. Data included prospective teachers' concept maps on two science topics, narratives and interviews used to derive the perspectives that underscored the processes prospective teachers used to create their concept maps. Analysis of data revealed that prospective teachers possessed limited knowledge about: (1) the basic components of the structure and form of a concept map and (2) the processes involved in creating a concept map. The findings indicate that prospective teachers' knowledge of concept mapping was superficial even though they claimed that they had used or were informed about concept mapping in K-12 classrooms. Additionally, the various structural forms of concept maps constructed by prospective teachers indicated that there was no uniformity in the processes leading to the construction of concept maps. Taken together, the findings suggest that teacher educators need to derive and assess their prospective teachers' prior knowledge of concept mapping and then provide frameworks to guide their prospective teachers' proper and acceptable use of concept mapping in their future classrooms.

1 Introduction

The use of concept mapping in classrooms for teaching, learning and assessment have been empirically studied and well documented in the literature. Scholars like Novak, Kinchin and others have investigated, discussed and are continuously building the knowledge on concept maps for the past two to three decades (Borda et al., 2009; Edmondson, 2000). Concept mapping has continuously been identified as an effective tool and technique for facilitating, capturing, eliciting and representing students' conceptual understanding, cognitive structures and their meaning-making. Despite the extensive literature on concept mapping as an instructional tool, a learning tool and an assessment tool (Gouli, Gogoulou, & Grigoriadou, 2003; Hay, 2008; Kinchin, 2000; Novak & Cañas, 2006; 2008; Yin et al., 2005) there is very limited literature on prospective teachers' knowledge of constructing concept maps. Addressing this gap in the literature is important because prospective teachers themselves have been consumers of concept mapping during their K-12 experiences (Borda et al., 2009) and will become future users of concept mapping for instruction, learning and assessment. Most importantly, insights into prospective teachers' knowledge of concept mapping can provide a window into what prospective teachers know and do not know about concept mapping. These insights are pertinent in shaping prospective teachers' knowledge of concept mapping because "the structural complexity and propositional validity of concept maps is directly related to the knowledge used in creating the structure and upholding the quality of concept maps during the concept map preparation process" (Gerstner & Bogner 2009, p. 427). Additionally, teachers need to acquire this knowledge about concept mapping because both the structure and quality of concept maps reflect the credibility and validity of students' understandings and it is the quality and structure expressed through concept maps during the process of concept mapping that provide the windows into students' understanding (Mintzes, Wandersee, & Novak, 2001; Novak, 1984).

This paper details the collection and analysis of prospective teachers' concept maps for two science topics: dissolving and density. The concept maps were analyzed for quality and structure to gather perspectives on prospective teachers' knowledge of constructing concept maps. The propositional validity of the science content was not the focus of this study. Findings of the analyses and samples of concept maps drawn by prospective teachers are provided.

2 Review of Literature

A review of literature indicates that four distinct knowledge domains are necessary for constructing concept maps in classrooms. The four knowledge domains include attributes of concept maps such as concepts and linking phrases, hierarchical/graphical structure of the map, concept map quality, and the extent to which construction of the concept map was self-directed (i.e., c- map or s-map).

The first domain is the knowledge of the attributes of concept maps. The five major attributes of the traditional concept map include the concepts/nodes/terms, directional linking lines, linking phrases, labeled lines and propositions (Novak & Cañas, 2006; 2008; Yin & Shavelson, 2008). At the basic level, concept maps consist of subordinate concepts related to a superordinate concept, and connected to each other via links in a hierarchical form. At an advanced level the superordinate concept and/or subordinate concepts may be cross linked to illustrate in-depth or extensive relationships between concepts (Kinchin, 2000; Novak & Cañas, 2006; 2008; Yin & Shavelson, 2008).

The second domain is the knowledge of the structure of concept maps. Literature indicates that the structure of concept maps can be typically categorized using two approaches: hierarchical and graphical. Basically, the hierarchical approach explicates the levels of knowledge, the number of single concepts, links between concepts, and cross links among concepts in a top-down fashion while the graphical approach explicates the level of meaningful conceptual understanding by advocating different levels of understanding to each overall shape. The graphical approach to concept maps qualitatively classifies concept maps as chain/linear, circular, hub/spoke, tree and network/net. Among these structures, the network/net is categorized as complex and indicating advanced and deep understanding of the interrelationships between the superordinate concept and the subordinate concepts through labeled links and cross links while the rest of the structures suggest simple associations between concepts (Kinchin, 2000; Yin et al., 2005; Yin & Shavelson, 2008).

The third domain is the knowledge of the quality of concept maps. Literature defines the quality of concept maps in a number of ways. First, a quality map or "good" map is defined as one that contains one superordinate concept linked and/or cross-linked with appropriate linking words/phrases to at least 20 subordinate concepts forming valid, logical, and scientifically correct propositions and collectively reflecting a hierarchical structure (Novak & Cañas, 2006; 2008) or graphical structure (Kinchin, 2000; Yin et al., 2005; Yin & Shavelson, 2008). This quality of a concept map is dependent on the validity of linkages and propositions and also reflects the concept-map structure complexity (Meagher, 2009). Second, a quality map is one that takes on the form of a net structure that contains valid, logical and scientifically accepted linked and/or cross linked propositions representing meaningful learning and conceptual understanding (Kinchin, 2000; Novak & Cañas, 2006; 2008; Yin & Shavelson, 2008). In contrast, "poor" quality maps are those "those with few nodes, weak linkages and indistinct layering" (Johnstone & Otis, 2006, p. 89).

The fourth domain is the knowledge of the process of creating concept maps. Literature indicates that there are two dominant processes for creating concept maps in classrooms. One process is when students are totally responsible for creating the concept maps by themselves without the aid of subordinate concepts, and linking words/phrases: c-map (Yin et al., 2005; Yin & Shavelson, 2008). Johnstone and Otis (2006) describe this process of creating a concept map as placing "a key concept (or node) in the middle of a page" and surrounding the key concept with "closely related concepts (or nodes) linked by lines and some words to link them" and repeating the links and cross links until "a 'picture' of the knowledge and understanding" is revealed (p. 85). The other process is when students are provided with the structure of the concept map, the superordinate concept, the subordinate concepts, and linking words/phrases and are required to fill and complete the concept map to show the appropriate relational propositions: s-map (Yin et al., 2005; Yin & Shavelson, 2008).

3 Synthesis and Research Question

The review of literature indicates that the process of constructing concept maps is dependent on the teachers' knowledge of the four distinct domains that contribute to the quality and structure of the concept maps. These knowledge domains are important for teachers to know because these four domains underpin any activity where concept maps are used for instruction, learning and assessment (Wallace & Mintzes, 1990). This study is based on two suppositions First, the authors of the study argue that extensive utilization and prevalence of concept maps in K-12 classrooms (Borda et al., 2009) have provided prospective teachers with experiential knowledge on the process of creating concept maps and this knowledge will in turn become future pointers for the use of concept maps in their own classrooms. Second, the authors contend that prospective teachers' concept maps will exhibit (1) the essential attributes of concept maps (the superordinate concept, subordinate concepts, directional linking lines, linking phrases, labeled lines and propositions); and, (2) quality in terms of network structures that contain complex interactions (labeled links and cross links). The research question that underscored this study was "How do prospective teachers' concept maps reveal their knowledge of constructing concept maps?"

4 Methodology

4.1 Participants and Context

Participants for this study were 61 prospective teachers enrolled in four sections of an elementary science methods course at a large university in the southwest region of the United States. The participants were in their final semester of coursework prior to student teaching semester. All participants met requirements for admission to teacher education, which includes a minimum grade point average of 2.75. The minimum degree plan requirements for each participant includes 12 semester credits hours of science (four courses), selected from the biological sciences, chemistry, physics, geology, environmental science or astronomy.

4.2 Data Collection and Analysis

Two sets of concept maps were collected from each participant at two points in the 15 week semester. The pre- and post- concept maps on dissolving were collected on the fourth and fifth week respectively and the density concept maps were collected on the eighth and ninth week respectively. Participants were given the following instructions before they created their concept maps for dissolving and density: “Construct a concept map for dissolving” and “Construct a concept map for density”. For three sections of the methods course both pre- and post- maps were collected while for one section only pre-concept maps were collected. A total of 229 concept maps were collected while 12 constructions were rejected because they did not resemble the traditional concept map.

Each concept map was analyzed for its correlation to the attributes of a concept map, and for quality and structure. Initially, the first domain of knowledge for each concept map was analyzed for the presence and/or absence of the superordinate concept, subordinates concepts, linking lines, linking phrases, labeled lines and propositions. Next, each concept map was analyzed for the second domain of knowledge; that is the concept maps were examined for the presence of a graphical (linear, circular, hub, tree and network) or hierarchical structure; and for the presence and/or absence of cross links. The third domain of knowledge is about the quality of the concept, therefore maps were examined for net structures that contained directional links and cross links. On identification of each of these features, a quantification of these features was carried out to provide percentages for the presence of each concept map element in domain one and also for each type of graphical or hierarchical structure.

5 Findings

Analysis of data revealed that out of the 229 concept maps collected only 208 or 91% of the concept maps exhibited some of the essential attributes of concept maps. In all, these 208 concept maps only contained the superordinate concept, subordinates concepts, and linking lines but no directionality and linking phrases at all (see Figure 1 for examples). That is, these 208 concepts did not have labeled lines and thus, it was impossible to validate propositions as scientifically correct. Data also revealed that only 25 or 11% of the concept maps exhibited a network structure while 83 or 33% of concept maps had a hub structure and 80 or 35% of the concept maps had a tree structure (see Figure 1 for examples). Analysis also indicated that only 33 or 14% of the 229 concept maps exhibited cross links (Figure 2). The 12 rejected constructions took the form of pictures and Venn diagrams (Figure 3).

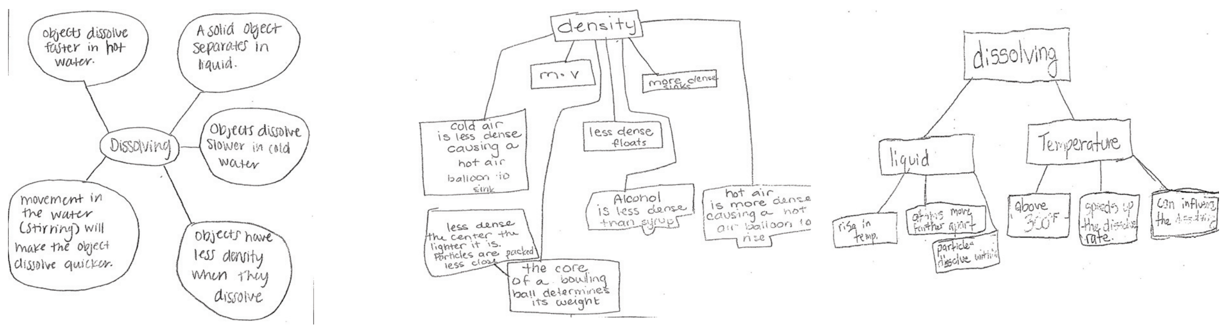

Figure 1. Samples of hub and tree concept maps

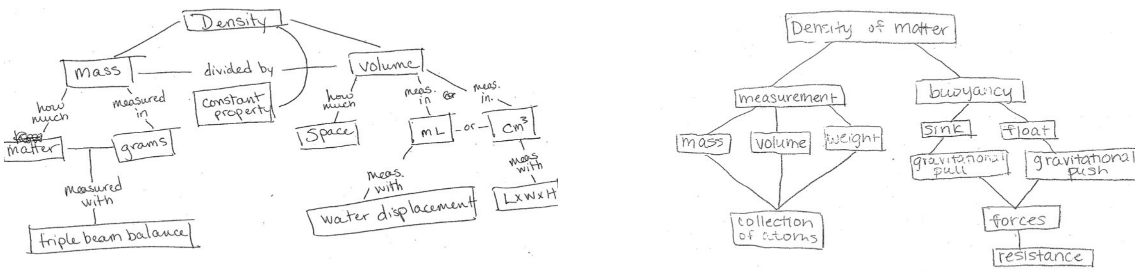

Figure 2. Samples of concept maps with cross links

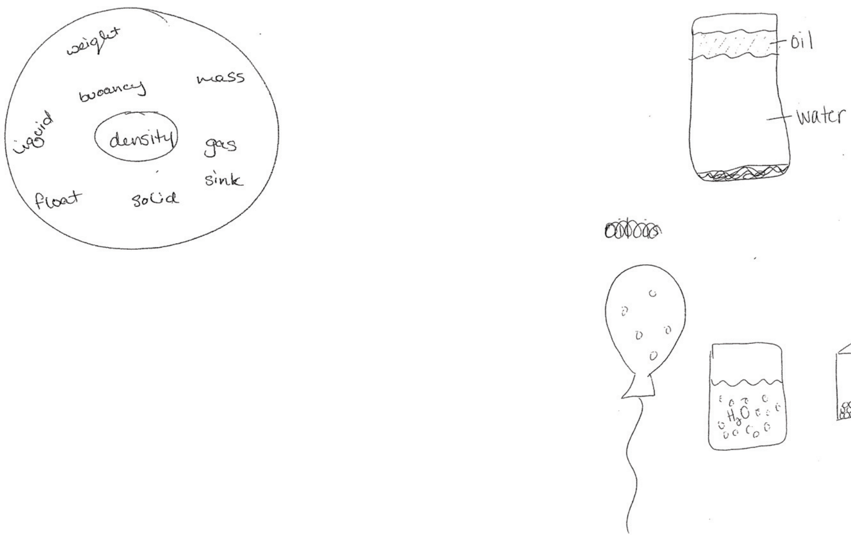

Figure 3. Samples of rejected "concept" maps

6 Summary

The findings of the study indicate that participants were aware of the basic features of concept maps. That is, participants' knowledge of the attributes of concept maps was limited to the superordinate concept, subordinate concepts, and linking lines but they were unaware of the importance of linking lines and phrases and/or directional lines in describing the relationship between the superordinate concept and the subordinate concepts (Yin & Shavelson, 2008). Even though this study did not look at the validity of propositions, it was evident that an analysis of the validity of propositions was impossible without linking lines and phrases and/or labeled lines.

Findings also indicated that participants in this study were comfortable in creating concept maps that were predominantly hub graphical and/or tree graphical structures. These graphical structures cohere with what Kinchin and Hay (2000) contend as concept maps that exhibit simple associations between concepts, lack complex interactions, lack map integrity, and exhibit limited conceptual development. The limited number of concept maps with cross links or network graphical structures suggest that participants are unaware a quality map is one that takes the form of a net structure and contains valid, logical and scientifically accepted linked and/or cross linked propositions representing meaningful learning and conceptual understanding (Johnstone & Otis, 2006; Kinchin, 2000; Novak & Cañas, 2006; 2008; Yin & Shavelson, 2008).

One important implication for teacher educators is the need to derive prospective teachers' prior knowledge of concept maps and the process of concept mapping during teacher education courses. This will help to reveal prospective teachers' knowledge or limited knowledge of creating concept maps so as to pinpoint areas of concern and thus, reshape their knowledge base of concept mapping. Finally, teacher educators, professional development instructors and teachers need to emphasize the knowledge domains that underscore the process of constructing concept maps so that the students and/or consumers to whom they introduce and use concept mapping can understand and apply the quality standards required to produce concept maps that are conducive to learning and all the potential benefits that the literature on concept maps extols.

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RESOLUCIÓN DE PROBLEMAS DE FÍSICA: AVERÍGÜESE CON MAPAS METACOGNITIVOS LO QUE EL PROFESOR YA SABE…Y QUE APRENDA EN CONSECUENCIA

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Abstract. En la Universidad Nacional Experimental del Táchira UNET en Venezuela, se reporta una investigación cualitativa que explora mediante la construcción de mapas conceptuales sucesivos depurados, la comprensión del docente del manejo de sus habilidades cognitivas y la metacognición para la resolución de problemas de Física. Se busca la construcción idiosincrásica de lo que aquí se llama el *mapa conceptual metacognitivo* (Ramírez de M. *et al.,* 2012) de cada profesor para que, al mejorar su comprensión de los procesos cognitivos y metacognitivos seguidos, pueda ayudar también al alumno a entender su accionar al resolver problemas. Bajo un enfoque cualitativo se investigaron doce profesores de Física abocados al tema de comprensión del proceso individual seguido en la solución de problemas, utilizando mapas conceptuales como instrumento auxiliar del aprendizaje y como expresión de las perspectivas individuales sobre ese tema. Cada profesor desarrolló un mapa conceptual que fue progresivamente modificando. Se utilizó el método dialógico-crítico con los profesores para revisar sus producciones, los conceptos y procesos presentados en él y los mecanismos de control aplicados durante el proceso de resolución, buscando hacer evidente la metacognición. Se hizo una evaluación cualitativa de esos mapas y de comentarios registrados durante las sesiones individuales de discusión con los investigadores, buscando variaciones en la comprensión de los procedimientos seguidos y en la metacognición que controlaba su quehacer mientras resuelve problemas. Estos resultados fueron coevaluados por cada profesor. Se evidencian cambios en el dominio de procedimientos y de su metacognición que, caracterizados por la complejidad y la psicodiversidad, fluctúan desde una *inconsciencia inconsciente* hasta una *conciencia inconsciente.* Los resultados sugieren que la construcción de mapas conceptuales metacognitivos depurados ayuda al profesor a comprender su proceso de resolución de problemas de Física para que posteriormente pueda también ayudar al alumno a conseguir su propio camino.

1 Introducción

La resolución de problemas de Física es parte fundamental del quehacer académico del alumno y está ampliamente relacionada con la forma en la que el estudiante maneja sus propias habilidades. Pero, vale la pena preguntarse ¿existe un modo de manejar esas habilidades para lograr un óptimo desempeño al resolver problemas de Física? En una continua búsqueda de respuestas a esa interrogante no parece posible conseguir una estrategia única para resolver problemas que sirva a todos. Mas bien, en un mundo multifactorial y caracterizado por la complejidad, estamos convencidos en nuestro grupo de investigación, que si se acepta la psicodiversidad y fisiodiversidad del ser humano se debe entonces propiciar la consecución individual de un procedimiento para resolver problemas (Ramírez de M., Sanabria, Téllez, Quintero y Aspeé, 2012).

En una investigación anterior en la Universidad Nacional Experimental del Táchira UNET se usaron mapas conceptuales sucesivos depurados para que el alumno comprendiera su proceso de resolución de problemas, PRP, construyendo y mejorando progresivamente su propio mapa (Ramírez de M. et al., 2012). Sin embargo, hemos detectado que cuando el profesor trata de ayudar a los alumnos a entender lo que están haciendo, enfrenta problemas parecidos. Es decir, si bien tiene un dominio adecuado de la Física y en general también de los procedimientos u operaciones involucrados en esa tarea, muchas veces no sabe explicarle al alumno como llegó hasta la solución, los procesos de pensamiento que él activa mientras resuelve el problema, ni puede aclarar el tipo de control que él mismo ejerce sobre todo lo que está haciendo. Por ello, se llevó a cabo en la UNET una investigación para lograr que el profesor comprenda mejor el uso de la metacognición y al mismo tiempo haga más efectivo su aprendizaje de las habilidades y los procesos involucrados en la resolución, con la esperanza que pueda así ayudar más efectivamente al alumno a conseguir la organización idiosincrásica de su propio PRP.

2 Los Mapas Conceptuales, y mapas metacognitivos

El mapa conceptual es una herramienta heurística diseñada por Novak (Novak y Cañas, 2006) para facilitar el aprendizaje que ayuda al estudiante en la construcción del conocimiento. Es una representación gráfica que intenta, desde la perspectiva del que lo construye, responder a una idea central o según Novak la main idea. El mapa se inicia para explicar este concepto central con un concepto inclusor y a partir de él se van construyendo las relaciones significativas con otros conceptos subordinados. El mapa muestra conceptos unidos a través de palabras enlace para formar proposiciones, es decir oraciones que tienen un valor de verdad. Así se van formando estructuras conceptuales de las uniones de diversas proposiciones (Figura 1). En la construcción de un mapa se evidencian los principios básicos del aprendizaje significativo de organización jerárquica, diferenciación progresiva y reconciliación integradora (Ramírez de M, Sanabria y Aspeé, 2006a).

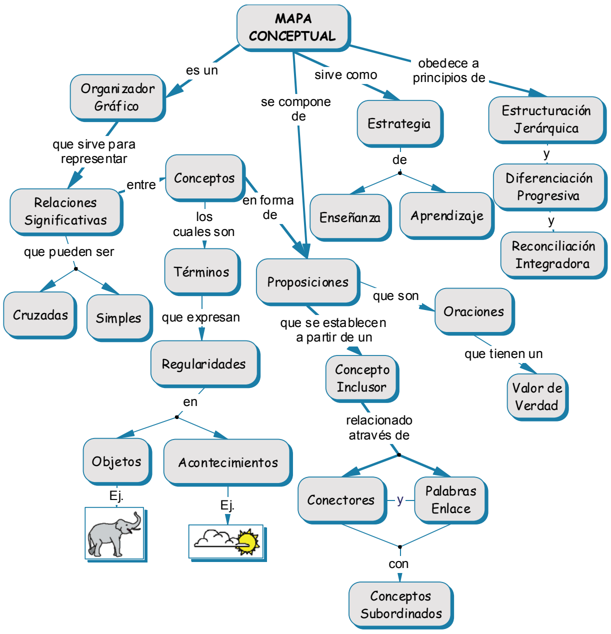

Figura 1. Mapa del Mapa Conceptual.

La importancia de los mapas conceptuales ha sido destacada en innumerables experiencias presentadas en los cuatro Congresos Internacionales CMC sobre el tema. Novak y Cañas (2006) describen posibilidades de acción con los mapas. En la UNET hemos reportado diversas estrategias para usarlos en Física I tanto en la teoría como en el laboratorio (Ramírez de M. *et al.,* 2006a; Ramírez de M., Aspee, Sanabria y Téllez, 2009).

Concretamente en cuanto a los mapas conceptuales sucesivos depurados los empleamos para que el alumno de maestría construyera gradualmente su conocimiento sobre un tema complejo, consiguiendo así lo que llamamos una borrosidad decreciente (Ramírez de M., Sanabria y Aspee, 2006b) y, por otra parte los alumnos de Física (Ramírez de M. *et al.,* 2012 los emplean para estudiar la manera como ellos mismos resuelven problemas de Física. Esos antecedentes sentaron las bases para esta investigación centrada en conseguir la construcción individual e idiosincrásica del *mapa metacognitivo del profesor para la resolución de problemas de física*, a partir de la reflexión recursiva del profesor acerca de sus acciones y procesos de pensamiento y empleando los mapas conceptuales para explicitar su pensamiento y como instrumento que facilite la borrosidad decreciente. Se entiende **el mapa conceptual metacognitivo** como un mapa que describe la estructura conceptual del proceso de resolución de problemas y también las acciones metacognitivas que la persona toma para controlar, evaluar o corregir el mismo proceso.

3 La Experiencia

Esta investigación se llevó a cabo con una muestra no probabilística intencional opinática formada por doce profesores de Física de la UNET y de institutos universitarios de la región. Estos fueron seleccionados teniendo en cuenta (a) el interés por estudiar su proceso de resolución de problemas; (b) dominio de la herramienta heurística de los mapas conceptuales; (c) disponibilidad para tres entrevistas en profundidad con los investigadores, durante un semestre académico. El propósito del trabajo acordado con los profesores fue la construcción individual de su mapa metacognitivo para la resolución de problemas de física. Nuestro interés en esta investigación era utilizar los mapas para que el profesor lograse una mayor comprensión del proceso de resolución de problemas, las fases involucradas en el y tomara conciencia de lo que hace y del manejo de su metacognición. Se procedió bajo un enfoque cualitativo basado en la fenomenología de Husserl (1979). Además se usó el método dialógico crítico, con entrevistas clínicas en profundidad en un trabajo individual con cada uno de los docentes. El trabajo se organizó de la siguiente manera:

3.1 Ubicación en el contexto

En la sesión inicial la investigadora, autora principal de este artículo, se reunió con cada uno de los profesores. Se les explicó el objetivo central de esta investigación y la presunción de que ellos pueden ayudar a sus alumnos a conseguir su propio camino para la resolución de problemas, si tienen conciencia plena de los pasos y procedimientos que utilizan. Se acordó con cada profesor la realización, a lo largo de un semestre académico, de por lo menos tres sesiones de reflexión con la investigadora, para compartir los hallazgos y también las experiencias que en este sentido iban teniendo con los alumnos. Se les explicó lo que en esta experiencia se iba a considerar como un *mapa metacognitivo para la resolución de problemas*.

3.2 Construcción de su mapa conceptual inicial

Se les pidió construyeran un mapa conceptual individual de problema y de cómo se resuelve un problema de Física (que lo llamaríamos PRP). Se les pidió no consultar ni buscar información, sino expresar su propio pensamiento en torno al tema.

3.3 Incorporando la metacognición

Se les preguntó si sabían lo que era la metacognición y como se expresaría la misma en la construcción de un mapa metacognitivo sobre el proceso de resolución de problemas. Es decir que le fueran añadiendo a su mapa las preguntas que ellos mismos se hacen para controlar su propio desempeño. Son también las preguntas que habitualmente hace el profesor en alta voz, mientras resuelve un problema en la clase, tratando de modelar su propio pensamiento.

3.4 Diálogo recursivo permanente sobre resolución de problemas. Depuración sucesiva de fases

Se utilizó el método dialógico-crítico con los profesores para revisar sus producciones, los conceptos y procesos presentados en él y los mecanismos de control que, según ellos mismos, hacían sobre el proceso de resolución buscando hacer evidente la metacognición. Se les pidió que los revisaran añadiendo al mapa los procedimientos procesos o fases que faltaran. El profesor iba añadiendo o modificando elementos que se discutían en la próxima sesión de trabajo. Algunas modificaciones obedecían a pasos no declarados en el mapa pero que sí seguía. Otras veces se referían a preguntas o medidas de control que el se hacía en cada etapa del proceso. Se les pidió que resolvieran problemas y revisaran su mapa metacognitivo para ver si efectivamente seguía los pasos indicados en el mapa.

3.5 Una mirada al espejo y una mirada desde el espejo

Se les pidió a los profesores que revisaran su mapa metacognitivo es decir "se *miraran al espejo"* y evaluaran su comprensión del PRP en cuanto a los pasos o procedimientos a seguir en cada momento y en cuanto al proceso de control y supervisión de los procedimientos. Finalmente, los profesores revisaron su mapa metacognitivo y discutieron su evaluación con los investigadores quienes "*desde el espejo"* (desde afuera), analizaron el progreso del profesor en la explicitación de sus acciones y en el dominio de su metacognición.

4 Técnicas e Instrumentos

Para hacer un análisis crítico de la experiencia se utilizaron los mapas conceptuales diseñados por los profesores, grabaciones en audio de comentarios emitidos por ellos mismos y de sus reflexiones con la investigadora, durante el proceso recursivo de discusión de su trabajo en las entrevistas en profundidad. La evaluación de los mapas para inferir si había una borrosidad decreciente se hizo considerando las categorías de análisis indicadas en la Tabla 1. Se muestran también, a manera de ejemplo, algunas de las preguntas realizadas por los investigadores en las entrevistas para propiciar la reflexión sobre los mapas.

5 Resultados

Los profesores manifestaron un progreso significativo al interesarse por descubrir su propio patrón de funcionamiento en cuanto a los procesos que siguen mientras resuelven problemas. Igualmente reportaron *toma de conciencia creciente* acerca de la forma como iba evolucionando su manera de comprender el proceso de resolución y los mecanismos de control y evaluación que ellos mismos aplicaron.

En la Tabla 1 se muestran las categorías de análisis usadas para analizar las producciones de los profesores. También se muestra ejemplos del tipo de preguntas que los investigadores hacían durante el proceso.

CATEGORÍAS DE ANÁLISIS	Ejemplo de preguntas básicas para revisar con el docente sus mapas metacognitivos de resolución de problemas
1 Ambigüedad por falta de precisión en la expresión de un procedimiento específico a seguir en la resolución de un problema.	¿Son estas las fases o etapas para resolver un problema de Física I? ¿Y es necesario añadir alguna otra? ¿Cuál? ¿Por qué? ¿Qué haces tú primero? ¿Qué haces si un alumno no hace lo mismo? ¿Cómo le haces ver que algo le faltó? ¿Cómo te das cuenta que algo te faltó? ¿Consideras importante "imaginarte la situación problemática"? ¿Cómo haces para imaginártela? ¿Cómo haces para representar la situación?
2. Ambigüedad por falta de precisión en la expresión del tipo de control seguido	¿Y cómo sabes que está bien lo que estás haciendo? ¿Qué haces para saber si es correcto lo que estás haciendo, o simplemente lo haces y después compruebas resultados? ¿Qué significa leer con cuidado? ¿Qué significa mirar bien? ¿Qué significa buscar concordancia?
3. Error o confusión de procedimientos para la resolución de problemas	¿Seleccionas las fórmulas de acuerdo a los datos? ¿Revisas los principios involucrados antes de escoger fórmulas? ¿Cuándo organizaste los procedimientos que ibas a seguir? ¿Al inicio? ¿Dónde lo declaraste? ¿Consideras importante planificar lo que vas a hacer? ¿O simplemente lo haces? ¿Qué quieres decir con procesos externos? ¿En qué fase haces eso? ¿No se ve en tu mapa conceptual? ¿Es lo mismo hacer un plan que aplicar fórmulas?
4. Error o confusión de términos para indicar medidas de control sobre el proceso o sobre alguna de las fases	¿Existen varios momentos para evaluar o corresponden a alguna fase en particular? ¿Cómo y cuándo decides cambiar de una pregunta a la otra? ¿Qué revisas para ver si está bien lo que estás haciendo? ¿Te has fijado si cuando revisas sigues algún tipo de algoritmo, heurístico o preguntas que tú mismo te haces? Por ejemplo al resolver en voz alta has dicho "*ajá, pero no, ya va, no… eso no es lo primero… antes tengo que…*" ¿A quién le estabas contestando y cuál fue la pregunta que te hizo?

Tabla 1: Protocolo de Análisis y preguntas para revisar los procesos seguidos.

5.1 Comentarios de algunos Mapas Conceptuales iniciales

Al inicio la mayoría de los profesores ofrecen versiones ambiguas del proceso de solución de problemas que muestran lo que el profesor sabe del tema sin que se perciba claridad conceptual. Les cuesta expresar su pensamiento (ver Figura 2). En otros casos es difícil comprender los planteamientos iníciales plasmados en los mapas (ver Figura 3) aunque al preguntarles logran explicitar lo que quisieron significar en el gráfico.

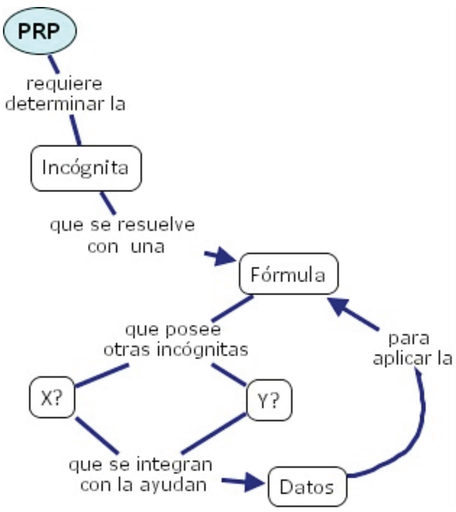

Figura 2. Mapa metacognitivo conceptual de P1 con desarrollo de la fase de aplicación

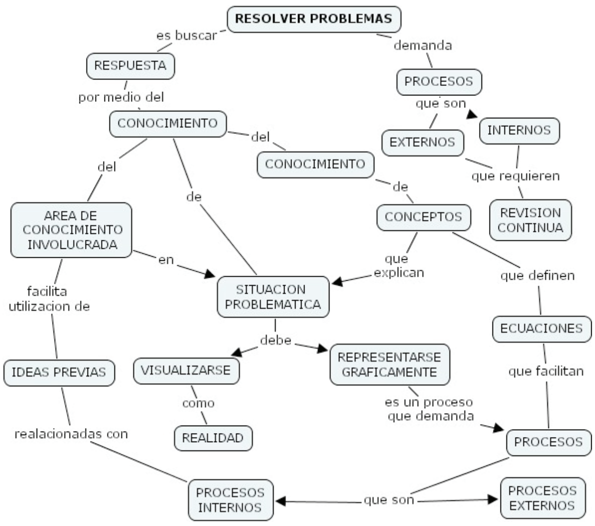

Figura 3. Mapa metacognitivo conceptual inicial de P10

Se evidencia en tres profesores un desconocimiento inicial de procesos básicos y terminología adecuada. Además se vio poca receptividad en dos de los profesores quienes terminaron evadiendo la tarea. Al pedirles que resuelvan un problema y analizar con ellos la solución, se hace evidente que no logran relacionar los pasos descritos en sus mapas con lo que realmente hacen.

5.2 *Ejemplos de Mapas Conceptuales a lo largo del Proceso y Comentarios*

Comienzan a tomar conciencia de etapas claramente definidas. Se observa que incorporan medidas de control sobre el proceso. Nueve profesores reflexionan acerca de sus propios PRP e incorporan mas acciones al mapa sobre el control del proceso y otros lo hacen en la discusión final. En la Figura 4 se resaltan en gris los conceptos escritos al inicio por el profesor P5. Los recuadros en blanco indican los planteamientos finales después de la reflexión recursiva con el investigador, que reflejan medidas de control definidas en todas las etapas.

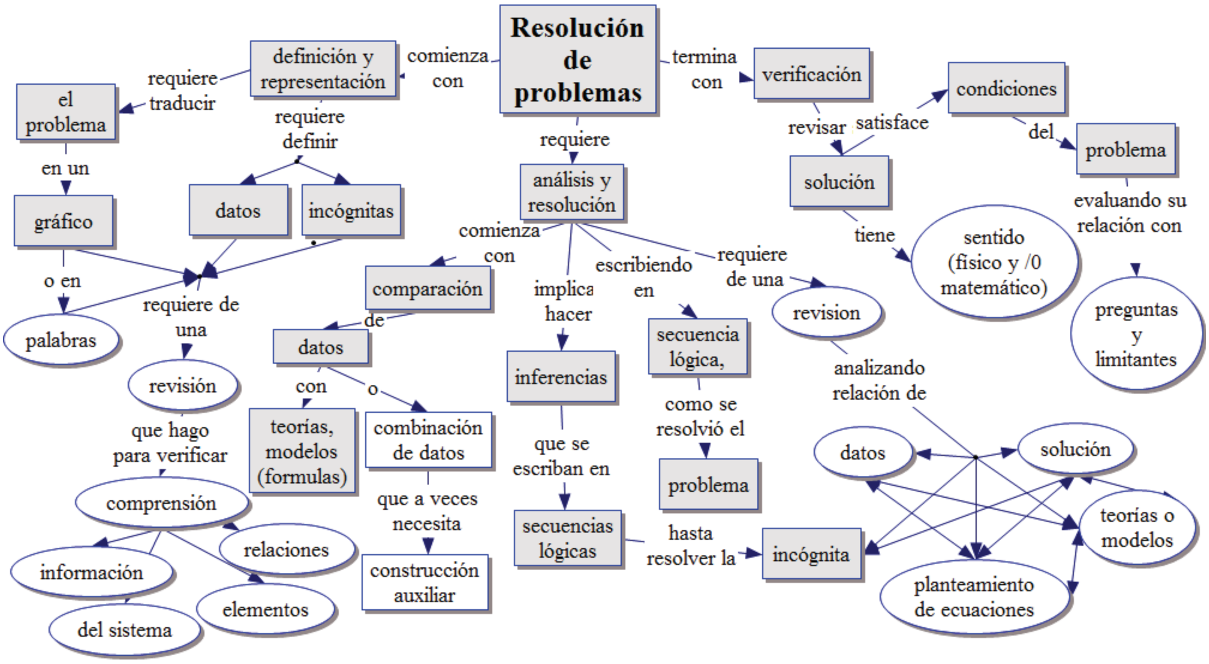

Figura 4. Mapa conceptual del profesor P5 señalando aspectos iniciales (fondo gris) y finales (fondo blanco) añadidos en su reflexión

Por otra parte hay logros diversos. La profesora identificada como P7, quien hizo el mapa mostrado en la Figura 5, señala que además de incorporar la metacognición ella mejoró mucho en la fase de comprensión.

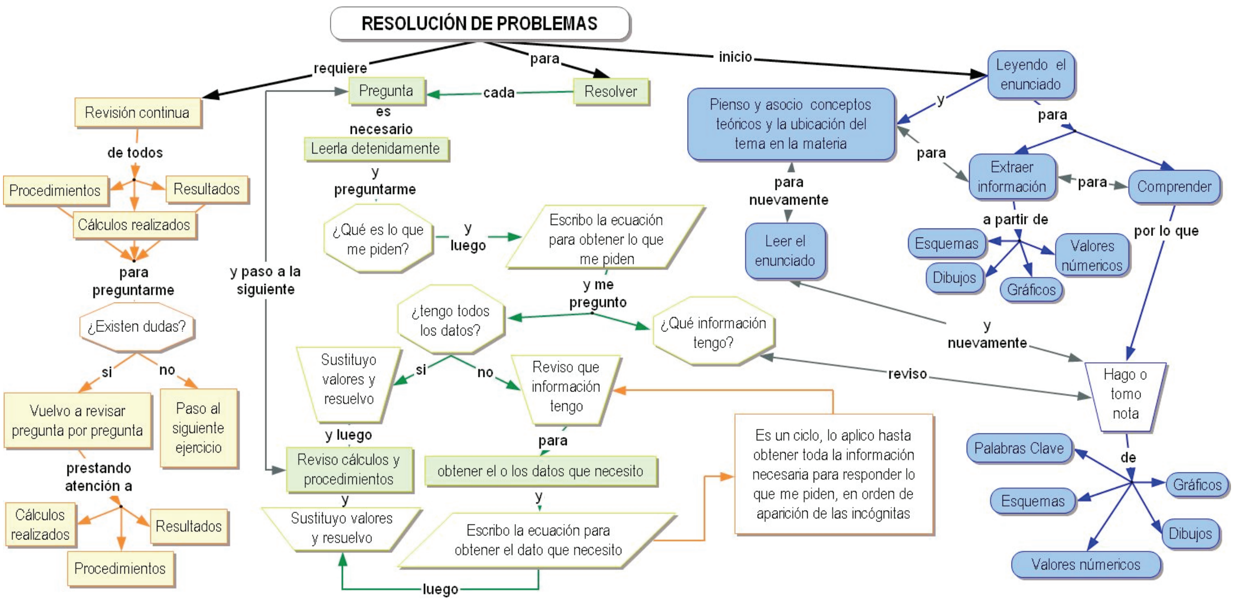

Figura 5. Mapa Metacognitivo general de una profesora (P7)

"*De esta experiencia, me he percatado que se debe tener especial cuidado al leer el enunciado así como las preguntas, en la extracción y la comprensión de la información plasmada, puesto que de nada me sirven las ecuaciones si hago un uso incorrecto de la información dada, por lo que es de vital importancia el comprender el enunciado y la información suministrada, para poder saber cómo hacer uso de la misma correctamente*"

(Entrevista final con P7).

La Figura 6 muestra el mapa de otra profesora (P4). Se observa la gran variedad de preguntas que ella se puede hacer mientras resuelve un problema. Señala como lo más importante que la metacognición o reflexión sobre su propio pensamiento está presente supervisando y revisando las acciones que toma a cada instante.

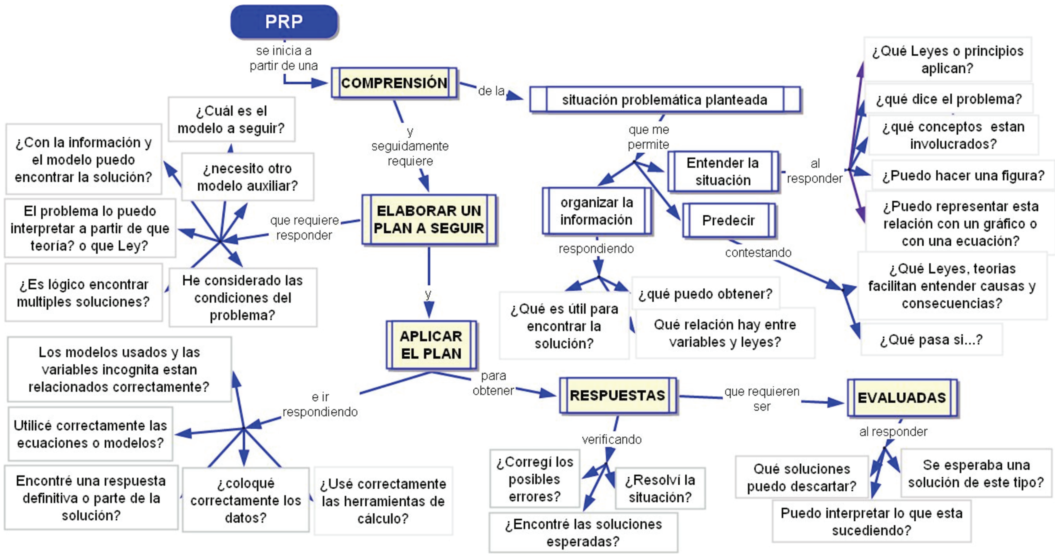

Figura 6. Mapa Metacognitivo general de una profesora (P4)

La Figura 7 muestra un mapa con un enfoque totalmente diferente de otro profesor (P6). El señala que las fases de realización y los pasos concretos a dar en cada una de ellas, dependen del problema y de su contexto.

Figura 7. Mapa en el que se insiste en la importancia de las habilidades y la metacognición

Este profesor (P6) también dice que "*el énfasis y la reflexión no debe estar en las fases a seguir sino mas bien en el desarrollo de las habilidades que se van usando, a medida que son requeridas por la metacognición para enfrentar ya sea la comprensión del problema, la planificación, la resolución o la verificación*". (Entrevista final con P6).

A lo largo del semestre se mantuvo la diversidad. Al final los profesores revisaron sus mapas y su evolución y junto con los investigadores pudieron evaluar su propio desempeño y saber si ellos habían logrado cambios en su comportamiento. Esto se hizo mediante una serie de indicadores que se resumen en la Tabla 2.

	Procedimientos	Metacognición
Incompetencia Inconsciente (no sabe que no sabe cómo lo hace)	A pesar que resuelve problemas, no tiene dominio de muchos conceptos involucrados en el proceso de solución de problemas y al igual que los alumnos solo menciona expresiones como “Leer” “analizar” “determinar que piden” “resolver” y “revisar” con evidentes muestras de confusión de términos y de reglas de operación básicas.	Desconocimiento del significado del término metacognición y de que papel juega en la resolución de problemas. Desconocimiento de los esquemas de pensamiento que el profesor sigue.
Incompetencia consciente (si sabe que no sabe cómo lo hace)	Se da cuenta que resuelve los problemas pero no sabe como definir adecuadamente las etapas, ni cómo lo hace, o por qué sigue ciertas acciones. Nota saltos en su proceso de razonamiento pero no puede explicarlos.	Se da cuenta que algo hace para controlar sus acciones, pero no tiene consciencia clara de los mecanismos que sigue y no logra explicarlos.
Competencia consciente (sabe que sabe)	Explicita su propio pensamiento en cuanto a cada acción que realiza, cada proceso que sigue.	Explicita su propio pensamiento en cuanto a las preguntas de control que se hace en cada momento.
Competencia inconsciente (No se da cuenta que sabe cómo lo hace)	Va planteando cada etapa, fase o paso a seguir sin darse cuenta que lo hace. Relaciona correctamente todos los procesos de razonamiento que sigue y las acciones que toma de manera casi automática.	Toma precauciones y evalúa cada paso que ha dado, sin darse cuenta de ello. Maneja de manera casi automática sus habilidades y la metacognición.

Tabla 2: Nivel de competencia en procedimientos y metacognición

En función de los logros de cada uno se resume en la Tabla 3 la ubicación inicial de los participantes (indicada con P1, P2, P3, etc.) y luego la ubicación final de los mismos (indicada con ***P_2***, ***P_7***, ***P_9*** , etc.)

	Manejo de la metacognición			
	Incompetencia inconsciente	Incompetencia consciente	Competencia consciente	Competencia inconsciente
Manejo de procedimientos				
Incompetencia inconsciente	P_1			
Incompetencia consciente	P_8 P_{10} P_{11}	P_{12} ***P_{12}***		
Competencia consciente	P_2 P_7 P_9		***P_2*** ***P_7*** ***P_9***	
Competencia inconsciente	P_3 P_4 P_5	***P_{11}***	***P_5*** ***P_8*** ***P_{10}***	P_6 ***P_4*** ***P_6*** ***P_3***

Tabla 3: Evaluación de los profesores

Los profesores quedaron muy satisfechos con la experiencia de reflexión y construcción de sus mapas. Tres de ellos mejoraron básicamente en cuanto al manejo de su metacognición (P2 P7 y P9), y los demás mejoraron en diversos grados su comprensión en los dos sentidos, con tendencia hacia una **competencia consciente** o **inconsciente** en procedimientos o en metacognición.

P1 abandonó la investigación, P12 entregó dos mapas y no continuó. Queda la duda si el problema fue dificultades con la herramienta de mapas conceptuales o para explicitar su propio pensamiento. Por otra parte, los demás señalan que nunca habían analizado los procedimientos que siguen (mas allá de lo “común”, que le dicen a sus alumnos) y menos aún los procesos y habilidades usados mientras resuelven problemas.

Algunos profesores, a pesar de hacer bien sus mapas metacognitivos tienen dificultades para usarlos de manera que guíen realmente el proceso de resolución de problemas. Hay diferencias entre lo que hace y lo que dice que hace. Esto sugiere una desconexión entre la teoría y la práctica que debe ser explorada con más detenimiento. P6 maneja su metacognición y habilidades de forma casi automática e insiste en la importancia de desarrollar las habilidades cognitivas básicas y sobre todo de la metacognición. El dice que: “*Cuando debo enfrentar, como se enfrenta un enemigo, a un problema de Física, entonces invoco a un duende personal mío, uno de mis súper poderes que en esta circunstancia me ayudará a triunfar y que se llama Κυβερνήτης (kubernites, que se refiere al timonel, el cual gobierna la embarcación y que Uds. conocen como la metacognición). El maneja las demás habilidades”*. (Entrevista final con P6).

Finalmente diez profesores coinciden en la importancia de mejorar sus habilidades para poder ayudar al alumno y en la necesidad de actuar de manera consciente en cuanto a procedimientos y metacognición, para que al modelar para el alumno comience éste a construir su propio camino de resolución de problemas.

6 Conclusiones

- Con énfasis en la metacognición se desarrolló una estrategia para que el profesor reflexione acerca de las acciones que sigue en el proceso de resolución de problemas de Física mientras construye su propio *mapa conceptual metacognitivo*. Esto le ayudará para orientar a los alumnos en un proceso parecido.
- A pesar de que es el profesor quien, *mirándose al espejo*, construye su propio conocimiento acerca de cómo el resuelve problemas, no deja de ser fundamental en esta estrategia el papel del investigador quien, usando el método dialógico-crítico, y *desde el espejo*, le ayuda a reflexionar.
- La psicodiversidad presente en el grupo se manifestó con los diferentes enfoques con que se abordó la tarea inicial, las diferentes formas de expresar cada fase de la resolución de problemas y las preguntas de control que se hacen. A lo largo del proceso continuaron las diferencias significativas de enfoque en cuanto a la visualización del proceso como un todo en mapas generales que incluían proceso y control (metacognición), hasta mapas por etapas y profesores que no pudieron visualizar el proceso con mapas.
- Los profesores manifestaron haber alcanzado un alto grado de dominio de su propia metacognición.
- En general mejoraron su comprensión en diversos grados en procedimientos, en metacognición o en los dos sentidos, con tendencia **hacia una competencia consciente o inconsciente.**
- Hay resistencia de algunos profesores a desarrollar su propio mapa metacognitivo. Igualmente se detectaron dificultades para usar los mapas construidos por ellos mismos para guiar el proceso de resolución de problemas. Esto debe ser objeto de futuras investigaciones pues sugiere una desconexión entre el pensar y el quehacer del profesor. Creemos que en la medida que disminuya esta diferencia se beneficiará el alumno cuando el profesor intente ayudarlo a el también.
- Existe coincidencia en cuanto a que el profesor debe desarrollar sus habilidades para poder ayudar al alumno a entender y desarrollar las suyas.
- Los profesores creen que si actúan con competencia consciente en cuanto a procedimientos y en cuanto a la metacognición podrán modelar el proceso de pensamiento de manera que el alumno comience a construir su propio camino de resolución.
- Las evaluaciones cualitativas realizadas a partir del análisis de los mapas conceptuales diseñados por los profesores y de sus opiniones, permiten afirmar que la estrategia se presenta como un elemento promisorio que contribuye a mejorar la comprensión del proceso de resolución de problemas y la importancia de la metacognición en el mismo.

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Valletta, Malta 2012

THE DEVELOPMENT OF SIXTEEN YEAR OLD STUDENTS' BIOLOGY CONCEPTS THROUGH OUT-OF- CLASSROOM ACTIVITIES

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Abstract. Classroom based teaching tends to be dominated by teacher talk and passive students are barely involved in their learning. Out of classroom activities offer students a physical context where theory learnt in class can became an authentic science experience. Meta-cognitive tools (concept maps and Vee diagrams) help students obtain a holistic science experience which focuses on feelings, emotions and attitudes together with cognitive development.

1 Introduction

The 21st century society needs to be equipped with scientifically literate citizens able to take informed decisions (Woolnough, 1998), be 'critical consumers of scientific information related to their everyday lives' and continue to learn science throughout their life (NRC, 2011, p.9). Thus, a science education that meets the needs of a minority of students who aim to be the future scientists and ignores the needs and interests of a large majority of students needs to be replaced. Millar & Osborne (1998) acknowledge the need for a paradigm shift in science education; a change in the delivery system that meets the needs and demands of a changing world and addresses and holds the interests of all the students.

Teachers are aware that the school is not any more the primary source of knowledge nor is textbook knowledge the most widely used during one's lifetime. Learning is not confined to school hours but is a continuous and lifelong process. Moreover, students come into the classroom already equipped with scientific information obtained through media, hobbies and family activities. Thus, rather than rooting our science teaching in the laboratory, which often results dull, boring and repetitive for the students (Osborne & Collins, 2001), community resources such as botanic gardens, museums and plant nurseries offer students more accurate and relevant science knowledge, making science more valid and stimulating for the students (Falk & Dierking, 2000). Site-visits offer an authentic picture of science and direct experience with scientists in contextualised settings making the contribution of science to society even more evident.

During site visits, the teacher is the mediator between the learners and the actual world. Students are driven by personal interests and by their intrinsic motivation to explore, discover new environments and ask questions that arise from their curiosities and observations on site. Through such activities, students are actively involved and responsible for their learning. On site, there is no emphasis on competition amongst students, memorization of facts and syllabus boundaries. Rather than sitting passively in class listening to the teacher dishing out information which students may be unable to link to their already existing conceptual frameworks, site visits offer a unique experience for every individual student through multiple stimuli that cater for a variety of students' interests and learning styles.

There are controversial ideas about the value of site-visits. Whereas Shortland (1987, p.213) writes that teachers' and students' clashing agendas make it difficult to reconcile entertainment, interest and motivation with science concepts, Falk, Coulson & Moussouri (1998) explain that when education and entertainment are symbiotically related, this provides significant learning gains for the students. Intrinsically motivated students are more able to judge and filter the information relevant to them and are more emotionally involved in the experience. This makes every experience worth remembering for the learner and thus admitted in their long-term memory (Salmi, 1993 as quoted in Braund & Reiss, 2006; Knapp, 2000)

2 Methodology

Though site-visits are a compulsory part of the practicals presented for the biology MatSec exam in Malta, they do not feature in the Intermediate level syllabus studied at post-secondary level. This study aimed to investigate whether site visits are an effective teaching strategy with sixteen-year old biology students.

Reading through the literature I observed that most research relied on traditional pre and post visit tests to measure the outcomes of the visit. These tests were restrictive because cognitive gains had to be defined in advance so that the measuring instrument could be constructed and measured only cognitive gains leaving little opportunity to measure affective, social and behavioural outcomes from site visits (Rennie, Feher & Dierking, 2003). Also, I did not want the students to write lengthy reports about the site visits using downloaded or copied information which they do not personalize nor understand.

It was decided that constructivist tools offered multiple and creative ways of assessing students' learning outcomes without limiting myself to the cognitive aspect only but explore also emotional and affective outcomes thus giving me a more holistic and realistic picture of the learning outcomes from each site visit. Such tools are valuable to help students think about their learning and use their prior knowledge as the basis to add new knowledge.

Data was collected through concept maps, Vee diagrams, class discussions and interviews. The original Vee presented by Gowin was judged difficult to tackle with students new to this procedure, thus a simpler version of the Vee, devised by Ahlberg & Ahoranta (2002) and used by Vanhear (2006) was used for this study. Before data collection started:

1. The students were trained to draw concept maps using information being tackled in class at the time: students' concept maps were discussed and used as examples of good practice.
2. Each site was visited and the guide was informed about the aims of the visit and the students' misconceptions.
3. The date of the site-visit was planned so as to complement the topic being covered in class and avoid any clashes with the school agenda.

The data collected was divided into three main phases:

2.1 Pre-visit activity:

Students were introduced to the focus question and were given the questions forming part of the planning phase (left-hand side) of the Vee diagram. This included drawing a pre-visit concept map. Worksheets were collected and a class discussion was carried out in order to obtain immediate feedback from the students about the activity and the topic being discussed. Four students were interviewed so as to obtain a more in-depth point of view. All interviews were transcribed.

2.2 Implementation phase:

Three visits were planned along the scholastic year. Each site chosen was related to the topic being tackled in class at the time so that the visit complemented classroom work. Each visit was planned for about two hours in the morning; short enough to avoid students getting bored but long enough to give time to the guide to provide us with all the necessary detail.

2.3 Post-visit activity:

After the visit, students were given the questions forming part of the evaluation phase (right-hand side) of the Vee diagram. This included drawing a post-visit concept map. Another class discussion was carried out to obtain immediate feedback of the students' feelings and attitudes after the visit and the same four students were interviewed. Pre and post visit concept maps were compared and analyzed to check if after the site visit:

- New biological information was added
- Links with already existing concepts were introduced
- Misconceptions were cleared

3 Results

In the following section, the biological development of two students participating in two different site visits will be discussed. This is part of a larger research presented as a Masters in Science Education thesis for the University of Malta.

3.1 Visit to the Greenhouses

This visit was implemented as part of the topic 'Photosynthesis' being tackled in class. The focus question was 'What do plants need to grow?'

As shown in her pre-visit concept map (Figure 1), Roberta focused mainly on factors related to photosynthesis such as 'carbon dioxide', 'chlorophyll', 'light', 'water', together with plant adaptations like 'thin leaves' as essential elements for growth. However, it was clear that the student failed to extend her ideas beyond what was being discussed in class and was unable to relate this focus question to the real world of plants.

After the visit, her concept map (Figure 2) showed greater awareness of plant needs including 'temperature', 'green manure', specific minerals like 'phosphate' and 'nitrogen'. She showed knowledge of how the farmer helps to improve plant conditions like 'crop rotation' and preventing 'direct water on plant leaves'. After the visit, Roberta realized that some statements written in her first concept map were useless to the focus question and were not repeated in her post-visit concept map.

Question 6 of her Vee (Figure 5) was essential to add information which she did not write in her concept maps, but which she learned through observation and questioning on site. This new information is underlined in her Vee.

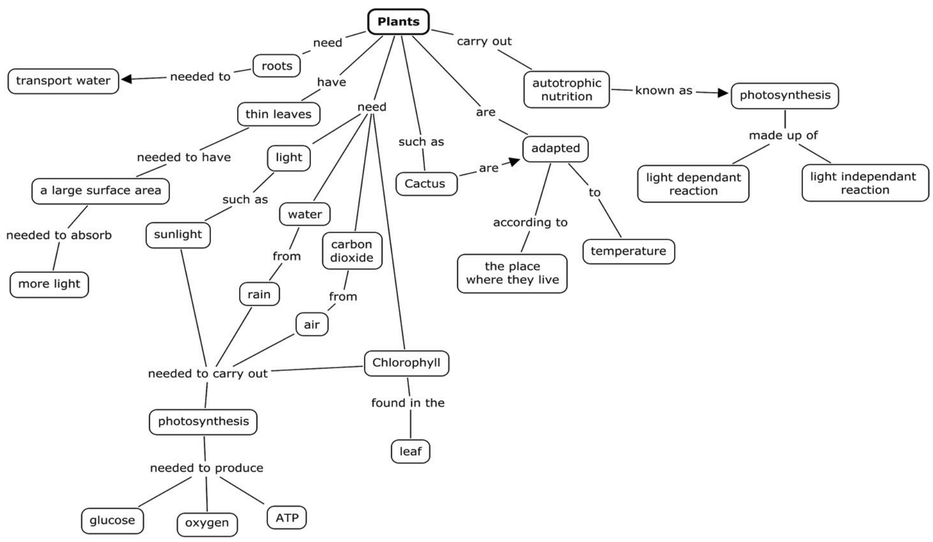


Figure 1: Roberta's pre-visit concept map

3.2 Visit to the National blood bank

This visit was implemented as part of the topic 'Transport in animals' being tackled in class. The focus question was 'What happens to donated blood?'

Being an action research carried out along the scholastic year, and since this research was being used for personal evaluation, some improvements were carried out from one activity to another. For this visit, a questionnaire was given to the students before the questions of the planning phase of the Vee were distributed. This was important for me to assess what knowledge students have about specific points related to blood donation. Questions included the amount of blood donated, who is not allowed to donate blood, what tests are carried out on donated blood and on the donor, amongst others. This phase together with the planning phase of the Vee were fundamental for the students to realize that there is a lot of information they do not know even though they are very curious about it. This helped to increase enthusiasm and motivation for the visit whilst helping them realize that the visit is not just an outing away from school routine but is a learning experience.

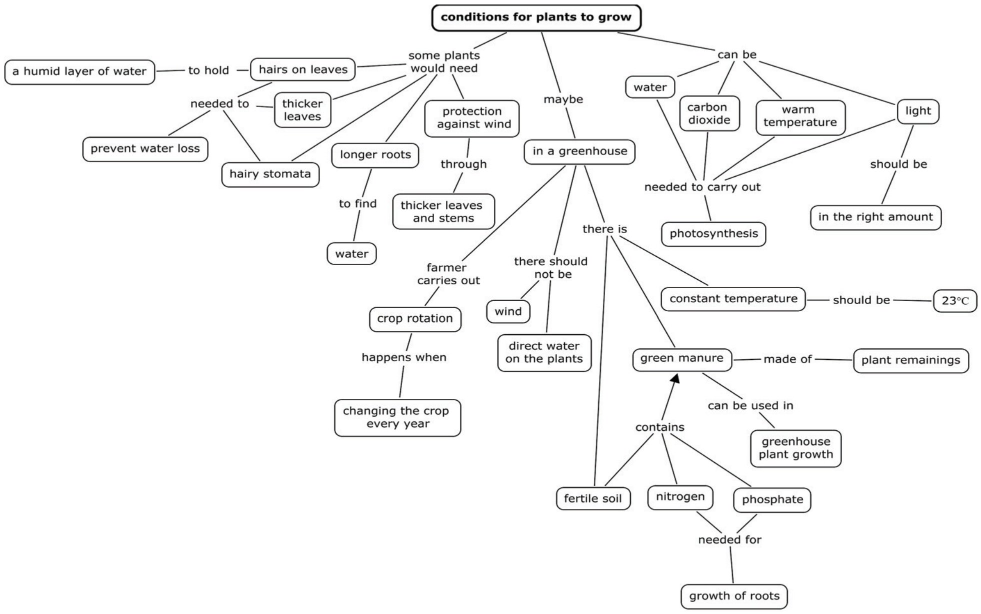


Figure 2: Roberta's post-visit concept map

As shown in her pre-visit concept map (Figure 3), Joanna had scant information about blood donation. Most of her concepts are very general and misconceptions emerged, such as blood is tested for glucose level and cholesterol.

In her post-visit concept map (Figure 4), it is immediately noticed that the amount of concepts and links increased. The information now is more specific and she gives clear details about blood components and how they are stored, the tests carried out on donated blood, the kind of patients that would need the blood, the amount of blood donated and specific procedures that make blood donation a hygienic and accurate process.

In question 6 of her Vee diagram (Figure 6), she added further information which she did not include in her Vee. These statements are underlined. She also pointed out her misconception that was cleared after the visit, stating that 'blood is not tested for cholesterol, glucose level or high blood pressure'.

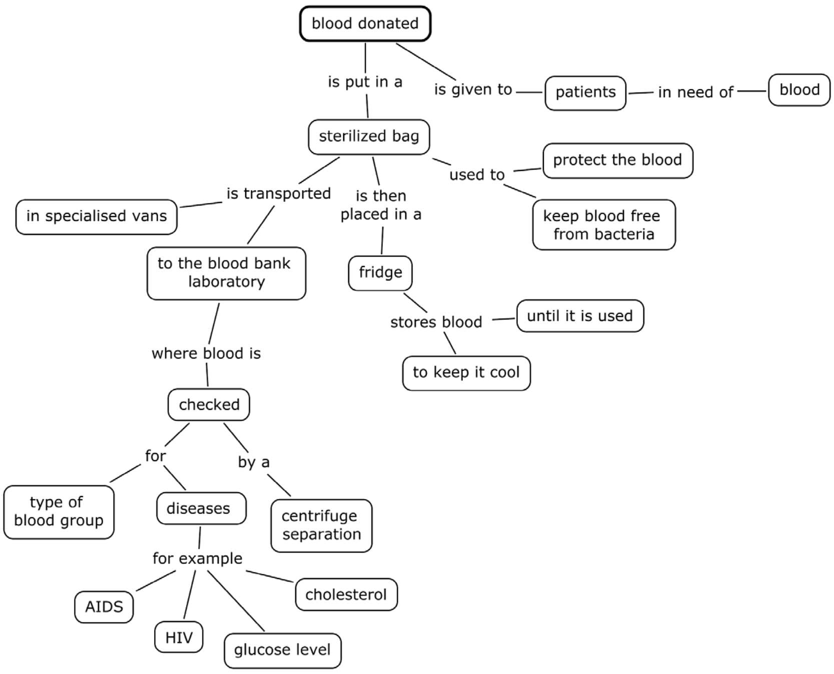


Figure 3: Joanna's pre-visit concept map

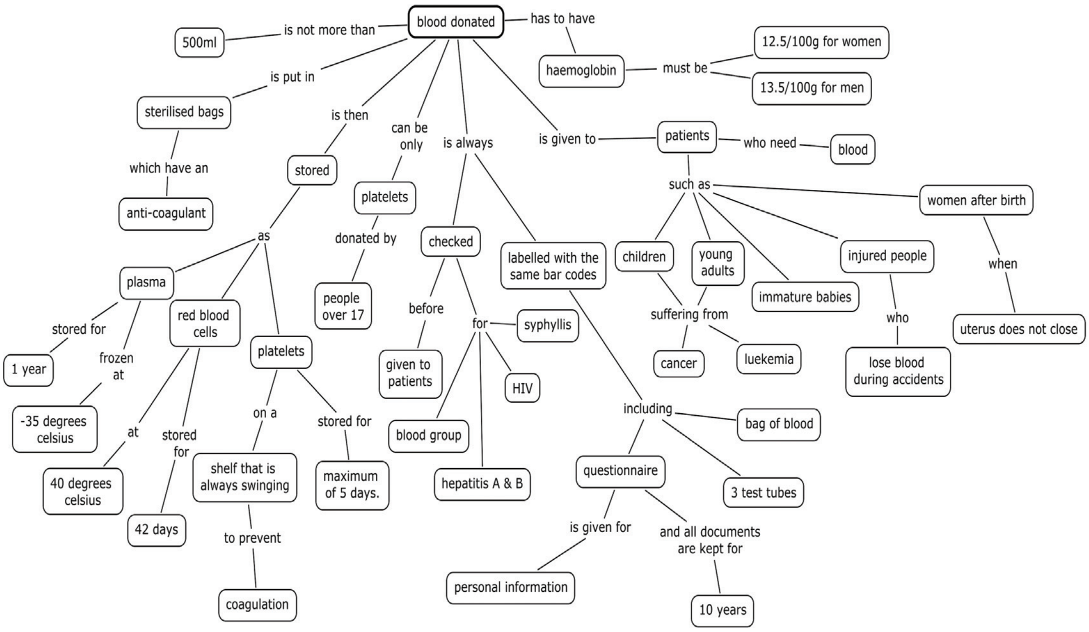


Figure 4: Joanna's post-visit concept map

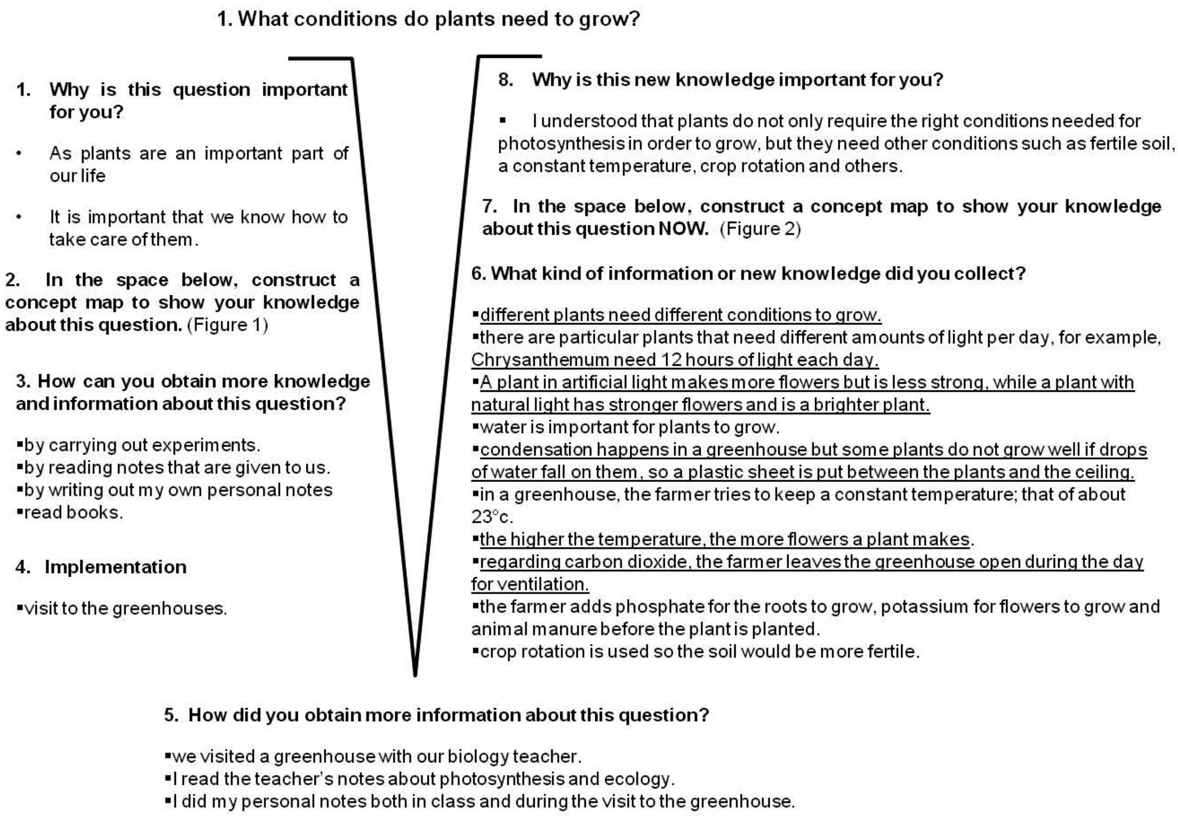


Figure 5: Roberta's Vee Diagram

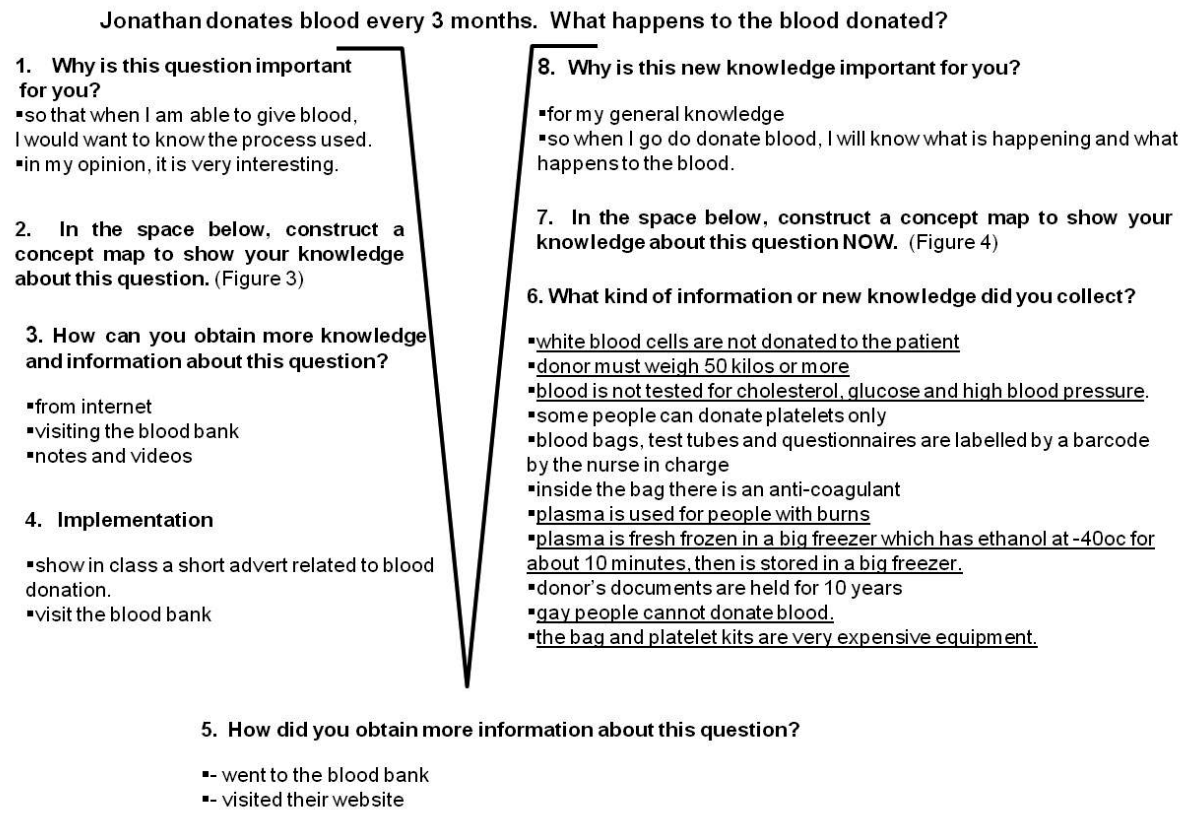
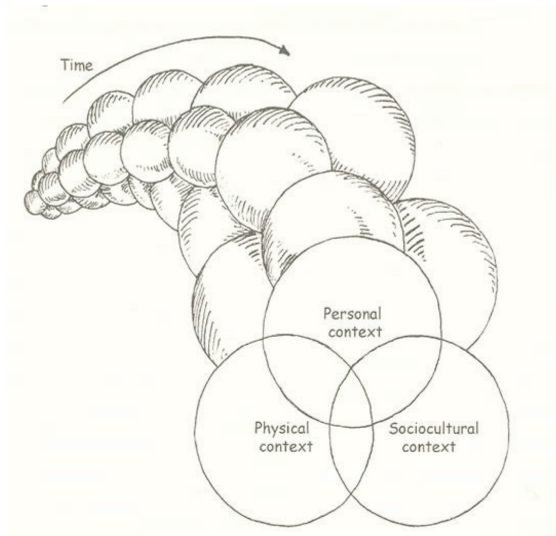


Figure 6: Joanna's Vee Diagram

4 Discussion

This research revealed that the classroom tends to be a restricted environment that limits the development of biological concepts. Whereas in the classroom, theoretical knowledge transmitted is restricted by syllabus boundaries, on site the information is more context specific and students could easily link theory to the physical setting. On the field, students meet experts who can give the information which is not necessarily found on text books but is more practical and often obtained through hands-on everyday experiences.

Falk & Dierking's contextual model of learning (2000 p.12) explains that learning is not an isolated experience, but is a dialogue between the students and the surrounding environment, through time. It was evident during each site visit that students became autonomous learners, free to choose what interests them most, free to observe and ask questions while socializing with their classmates and sharing experiences in a more relaxed environment than the classroom. They linked inert theory learnt in class or past experiences to what was observed on the premises and linked issues discussed to their personal life making biology more authentic and useful.



Falk & Dierking's (2000:12) contextual model of learning

The methodology used moved away from the traditional transmission model of learning and induced students to think critically while experiencing a desire to discover, ask questions and debate on various socio-scientific issues that arose whilst on site.

This methodology avoided the filling in of worksheets and reports often used during site visits which serve to kill the students' enthusiasm to explore new environments (Griffin & Symington, 1997). Through this approach, students were not rewarded for memorizing facts and definitions but allowed them to understand the relevance and application of biology to everyday life. This was evident during the post-visit class discussions when the students were enthusiastic to voice their feelings and opinions about what was learned during the visit.

This not only was useful to make students aware that their opinions are valued in class and help them discuss together and tolerate each others' opinions but it was useful to observe that site-visits offered multiple learning outcomes for the students including:

1. sharing information with family and friends.
2. less compartmentalization between academic subjects
3. consolidation of classroom work
4. introduction to a career and to the world of work
5. positive changes in attitudes towards various aspects of biology
6. more social belonging and social responsibility *(like donating blood some time after the visit)*
7. appreciation of the world around them

Concept maps allowed the students to represent their knowledge in an organized, visual format so as to be able to identify their learning 'at a glance' and points to discuss in class were more easily accessible (Orue, Alvarez & Montoya, 2008). Unlike writing traditional reports, through concept maps, only relevant information was added and overwhelming detail that may not pertain to the focus question was avoided. Motivation to learn is in the hands of the learner. This methodology served to encourage learners to think about what was heard and observed on site. Rather than promoting definitions and memorization, students were encouraged to learn meaningfully and follow their interests. Infact, every student's concept map was unique in terms of information and depth which revealed how learning depends on the student's interest, background, learning style and academic ability.

5 Conclusion

As Burns, O'Connor & Stocklmayer (2003) explain, any changes in awareness, enjoyment, interest, opinion and understanding all represent personal learning outcomes for the students. This is the major advantage of site visits and the reason why they go hand in hand with constructivist tools. Together, they offer both students and teachers a holistic learning experience that goes beyond the academic subject to a more worthwhile learning experience that links theory learned in class to everyday life situations. Concept maps and Vee diagrams offered students a way to express their biology knowledge in a direct, concise way, linking knowledge from different topics and academic subjects together yet not limiting themselves to knowledge alone. Through this exercise, students were able to observe, question, reflect, criticize, evaluate and discuss various issues. These represent valuable skills for our future generations!

6 Acknowledgements

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THE NATURE OF THIRD GRADE STUDENTS' EXPERIENCES WITH CONCEPT MAPS TO SUPPORT LEARNING OF SCIENCE CONCEPTS

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Abstract. To support and improve effective science teaching, educators need methods to reveal student understandings and misconceptions of science concepts and to offer all students an opportunity to reflect on their own knowledge construction and organization. Students can benefit by engaging in scientific activities where they build personal connections between what is learned and their own experiences. Integrating student-constructed concept mapping into the science curriculum can reveal to both students and teachers the conceptual organization and understanding of science content, which can assist in building connections between concepts and personal experiences. This paper describes how a class of third grade students used concept maps to understand science concepts through revision of content and structure as new ideas occurred to them during class discussions and interviews. This paper also reports how students' understandings and misconceptions were revealed through their construction of concept maps over time. Students were introduced to concept maps at the onset of a year-long science unit on watershed systems. Students then went on to build a series of concept maps over the course of the science unit using a software program. Each concept map built upon the previous map in the sequence for a total of seven maps per student. A concept map evaluative rubric displayed changes over time in students' concept map structure and content. A formal assessment of watershed concepts was implemented four times during the course of the science unit. Data suggests that by working on concept maps in science class, students were able to reflect on their work and to appropriately revise their knowledge construction and content.

1 Introduction

The study of student misconceptions in science has been the topic of discourse and investigation by the National Research Council (2007), and others in the fields of education and social sciences (Novak & Cañas, 2008; Smith, diSessa, & Roschelle, 1993). Smith *et al* (1993) uses the term misconception "to designate a student conception that produces a systematic pattern of errors" (p.119). Misconceptions for many science concepts have been recognized over the past 20 years in the literature and some of these misconceptions have been demonstrated to be well established within a student's cognitive structure, resisting even innovative teaching (Chi, 2005). When children harbor perceptions about specific objects or events in their lives, and those perceptions are at odds with scientific knowledge, challenges to resolving those specific misconceptions can result (Smith, diSessa, & Roschelle, 1993). However, children's misconceptions can present a roadmap for guiding a student from a series of misconceptions to a more authentic understanding of that particular domain (NRC, 2007). The assumptions about the natural world that young children bring to the classroom can provide jumping off points for science instructors as they create and leverage a bridge to new knowledge from established understandings (Lederman, Lederman, & Bell, 2004).

Student-constructed concept maps can support cognitive change, leading to meaningful learning within the domain of the natural sciences (Jonassen, Howland & Mara, 1999; Hay, Kinchin, & Lygo-Baker, 2008; Novak, 2002) from which the learner is then able to construct new understanding (Ausubel, Novak & Hanesian, 1978; Novak, 2002). Constructivism, where all experience filters through the existing lens (perspective) of the learner, supports knowledge modification over replacement, a process which guides the learner in restructuring understandings (Smith, diSessa, & Roschelle, 1993). Constructivism supports knowledge modification over replacement guiding the learner in restructuring their understandings. Gains in proficiency have more to do with cognitive restructuring than with the accumulation of discrete facts. Through becoming aware of how students construct understanding of science concepts, teachers might be able to intercede where misconceptions override content. Using information made available from a student's concept map, a teacher may intervene so conceptual knowledge can be grounded in scientifically valid understanding, which can lead to meaningful learning.

2 Background

2.1 Student Misconceptions

Children are likely to bring preconceived ideas to their school experiences about how the world around them works. These understandings can conflict with scientific teachings at times. It is not always easy for the teacher to discern student misconceptions. Children might appear to understand and accept a new explanation for an observed event while maintaining their original mental model of the phenomenon. An example of a concept about which students in this study were unclear was the water-table. This concept, within the context of the watershed study, came up many times. However, it existed in an abstract nature to most children; the phrase 'water-table' represents an idea and is that idea. Young children do not have prior experience or personal knowledge of a water-table. However, they may have personal experience of drought and flooding. The teacher worked at tying those ideas together for students to make the connection between classroom content and personal experience. The NRC (2007) suggests in order for children to develop a conceptual framework embracing new and possibly conflicting notions about the world, they need to "break out of their familiar frame and reorganize a body of knowledge" (p.120).

Children's conceptual knowledge builds on prior experiences, personal knowledge and understandings, a process which provides foundational platforms upon which subsequent knowledge is constructed. Children acquire new information through direct experiences and classroom teachings. Children then endeavor to create coherent explanations reflecting earlier ontological understandings of the mechanisms and classification of things. Misconceptions arise as children work to conflate earlier conceptual understanding with scientific knowledge that is not always intuitive, such as the notion of 'force'. Children often conceptualize force as something associated with movement. The notion of equilibrium does not connect with an understanding of force. When more than one observable force acts on an object, children often perceive the actions as either winning or losing (NRC, 2007).

2.2 Meaningful Learning

Meaningful learning refers the quality of knowledge-building that humans experience, beginning at birth. Research into meaningful learning and retention is typically focused on how meanings are constructed and then incorporated into existing cognitive structure (Ausubel, 1963). Meaningful learning has been proposed as necessary in order for cognitive growth and change to occur. According to Ausubel's learning theory, cognitive structure is organized hierarchically.The most inclusive and general concepts are positioned at the apex in the hierarchical structure of knowledge, while the less inclusive and more specific ideas and subconcepts are incorporated or subsumed within the more inclusive ones. Meaningful learning occurs when new ideas are able to be subsumed under already existing or anchoring ideas. Through subsumption, ideas that were initally dissociable from established knowledge units in the hierarchical knowledge structure are able to be retained and assimilated into the existing knowledge units. The desired outcome is for the learner to gain meaningful and useful knowledge from which to construct new understanding (Ausubel, Novak & Hanesian, 1978; Novak, 2002).

The single most important factor influencing learning (learning is defined for these purposes as *acquisition, retention and transferability of knowledge*) is the learner's prior knowledge, meaning what he or she already knows or thinks to be valid (Ausubel, 2000, Novak & Gowin, 1984). Using student-created concept maps, this information can be made available to the teacher.

2.3 Concept Maps & the Facilitation of Meaningful Learning

Concept maps are representational models of knowledge structures which can be constructed either with paper and pencil, or through the use of a computer-based software or online program. Included in these maps are nodes or bubbles housing concepts (ideas); connecting lines indicating a relationship between concepts; and linking words or phrases placed on connecting lines describing a connection between the two concepts, creating a propositional statement (Novak, 2002; Novak & Cañas, 2008). Propositions, also known as *semantic units or units of meaning* (Novak; Novak & Cañas), are made up of at least two linked concepts, along with linking words which create a complete or meaningful thought. Concept map structures can be created as *spokes, chains,* or *networks* (Hay, Kinchin, & Lyogo-Baker, 2008). Learning becomes visible through the use of student-created concept maps, as each concept map shape can reveal conceptual understanding of the learner. Thus, a concept map created with hierarchical structures is indicative of a hierarchical cognitive structure and of material subsumed onto already existing concepts (Novak & Cañas).

Inspiration® software technology was used for this project. Students would log onto the software and locate their most recent concept map in the files. To add, revise or rearrange a concept map, students would click on icon/tools displayed at the top of the open file window, or on the bottom of the page for additions and changes to the current cmap displayed. The program's procedures were intuitive for most students. Overall, students had familiarity with word processing and using the laptops for a variety of research and writing activities.

3 Method

3.1 Research Approach & Design

One third-grade classroom in a small rural elementary school (K-8) was the setting for this study, which lasted for six months of the school year (November – April). The participating classroom teacher ('the teacher') taught all the science units over the course of the school year. All students received training on the construction of concept maps using paper and pencil first, then the software. The teacher received instruction before the beginning of the study on the use of the software technology, constructing concept maps, and was given a brief introduction to the theoretic framework underpinning the study.

Data were collected from three different sources, science class observations, student and teacher interviews (occurring three times) and artifacts. The study incorporated a What I **K**now, What I **W**ant to Know, What I **L**earned (K-W-L) chart as a tool to access student prior knowledge; a pre and post science unit assessment comprised of a collection of selected responses and short answers; and a concept map evaluative rubric (after Novak and Gowin [1984] and Hay and Kinchin [2008]).

The students' first encounter with building concept maps was paper and pencil followed by the use of a concept mapping software program. Student ideas were included in their concept maps, and the structural organization of the map displayed how information was organized hierarchically and connected to other concepts.

Using information made available from students' maps, the teacher intervened so concepts based in scientifically valid understanding occurred. This, in turn, contributed to a more grounded foundation of understanding as evaluated through techniques described in the following section, a process which provided additional support to students' learning as science concepts build upon prior understanding.

3.2 Concept Map Evaluative Rubric (CMER)

The Concept Map Evaluative Rubric (CMER) (after Novak and Gowin [1984] and Hay and Kinchin [2008]) was a tool used to record changes over time on student-constructed concept maps. The CMER displayed changes in structure, content and scientific conceptions for each participating student. The CMER captured snapshots of each student's perceptions of science content by recording frequencies of concepts, lines, and linking words (valid linking words and clearly stated propositions). The rubric also noted hierarchical structure for each concept map. Three raters evaluated each concept map. One of the raters was a science content expert who evaluated each map for science content validity. The other two raters, a non-participating teacher within the school, and the author, scored each concept map for structure and qualitative changes in hierarchical levels and concept validity.

3.3 Assessment

The assessment protocol used throughout this study was a set of questions on general watershed concepts. Some questions named specific bodies of water in the region, while others were of a more general nature. The children took the assessment four times during the science unit (September, December, and twice in April). Questions were constructed to test student knowledge, comprehension, application, and analysis of watershed concepts. Types of questions included short answers, true/false, multiple choice, and interpretive exercise. The assessment was a way to gauge application of learned concepts in a more formalized context while applying test-taking skills.

3.4 Accessing Prior Knowledge

K-W-L charts tapped into students' prior knowledge about watersheds. The teacher conducted a whole-class K-W-L chart-building activity at the beginning of the watershed study in the fall (Table 1, left-hand column). K-W-L charts were then revisited in February, and again in April. Children received their own copy of the original chart with the class information on it. They filled in the What I **L**earned column in February. In April, using the same chart, students added onto what they had listed in February. The middle column (What I **W**ant to Know) was included in April. This gave the students an opportunity to reflect on their then-current fund of knowledge and subsequently to apply their own personal connections to watersheds and the learned content to target specific areas for further investigations.

KWL: A Watershed		
What I **K**now (November 2010)	What I **W**ant to Know (April 2011)	What I **L**earned (February & April 2011)
It has something to do with water A shed with water inside A windmill A shed with things we use on the water The name of a boat Shedding water Like a greenhouse with barrels of water	What would happen if one of the steps of the water cycle was taken out? Why doesn't the ocean overflow? What percent of water is saltwater? Why do lakes and rivers connect? I want to know why they named it the watershed? Why do people dirty up our watershed?	I learned about biomagnification And precipitation, evaporation, condensation, H_2O, and water cycle, and zones (Feb. 2011) I learned that what we thought it[watershed] was, was not true. That a watershed is mostly ridgelines. I learned that where ever you are, you are in a watershed. I know about pollution, oil, water, sun, food, people, life in the ocean, ponds, lakes, rivers, fish, animals, estuaries, anadromous and catadromous fish. Biodiversity, eutrophication, ecology, nonpoint pollution and point-source pollution (April 2011)

Table 1. What I **K**now, What I **W**ant to Know, What I **L**earned chart

4 Results

The students' process of creating, recognizing, and building connections within their concept maps (cmap) provided the means for the teacher to identify student misconceptions. The content and structure of their concept maps revealed their understandings of what they were learning. Students' personal connections to science content occurred in class and one-on-one discussions, and were displayed in concept map structure and content. Once misconceptions were identified by the teacher via concept map structure, content, and student discussion, she re-taught and re-contextualized the science concepts. Re-contextualizing the concept involved embedding the idea within a learning situation connected to the student's personal experience and prior knowledge. Through class discussion and probing questions on the teacher's part, she was able to determine whether knowledge modification had occurred in the student's understanding of the misconception. Structure and content of the student's follow-up cmap would contribute to the teacher's data on how content was being understood and connected to already embedded knowledge.

Through the process of building concept maps, the connections among watershed concepts and between concepts and personal knowledge became apparent to the students. During interviews and class discussions, students shared their perception behind each connection created in a particular concept map. This process provided a window of opportunity for both student and teacher to view the hierarchical organization as best representing each child's knowledge structure. Established information bits in concept maps were used as anchors for adding onto and building extensions using new information. Four examples of student-constructed concept maps (and associated interviews) are included in the following sections.

4.1 Rachel's Concept Maps

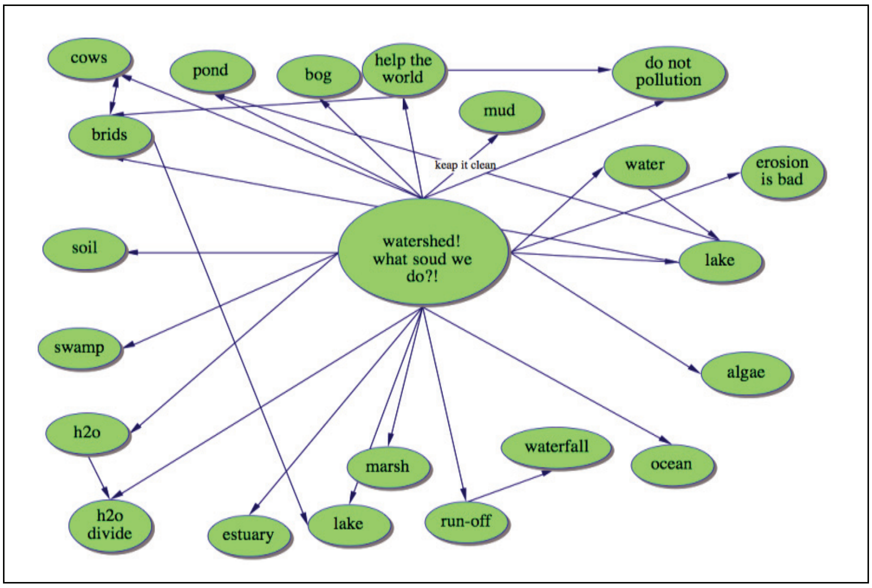

Figure 1. Rachel's Concept Map 1 (first)

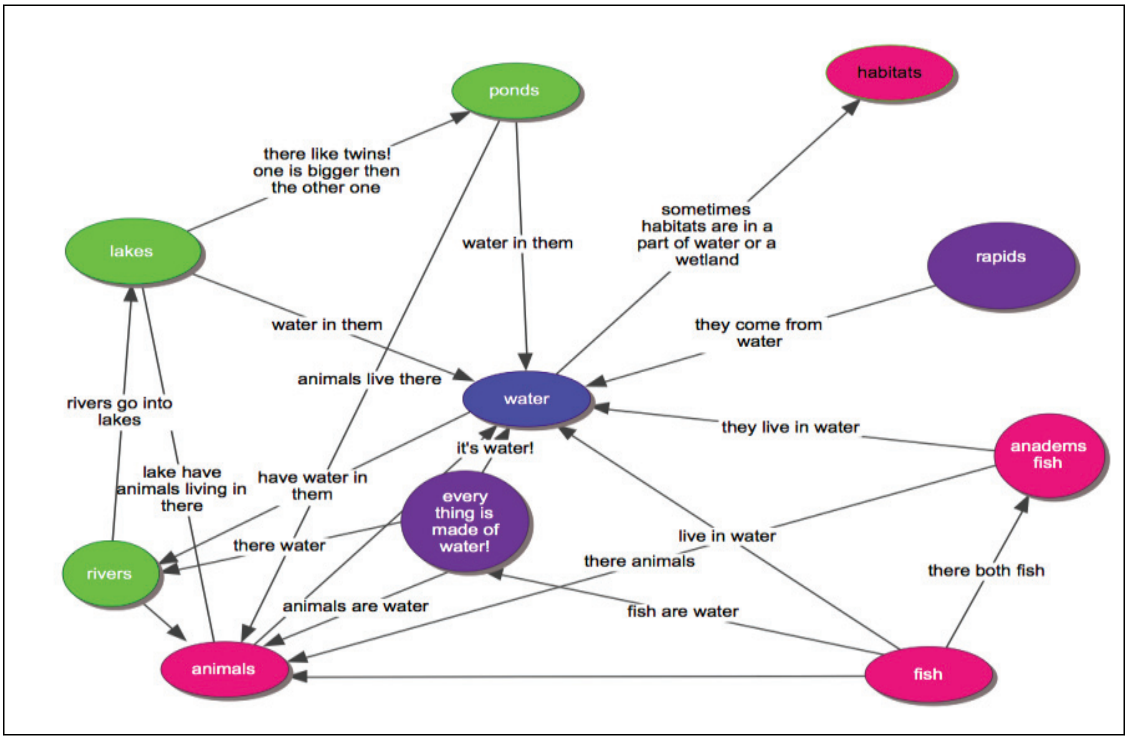

Figure 2. Rachel's Concept Map 7 (final)

4.2 Interview Excerpt with Rachel (1/25/11)

Rachel: I knew that everything would connect to watershed and then I had to think what would they be connected to, so I thought of all these different things and when I thought about them, I had to add new ones too [ideas]. I thought of new ones too, its like, um well the fertilizer would go with food 'cause fertilizer is food for the soil so those three would go together and then the cows would go with the food 'cause cows eat food and the cow…
Interviewer: Explain connections between ponds and oceans.
Rachel: They are both bodies of waters and so is lakes so those three connect and so does that does too 'cause a bog is a part of a water [bog and watershed].
Rachel: But I think a bog and a lake would be connected because they are sort of like the same thing.
Interviewer So a bog and a lake are connected because they are similar?
Rachel: Yes.
Interviewer: In what ways are they similar?
Rachel: Well, um, well they both are like, um I forget the question [question is repeated], well, I think they could connect to each other like they could run into each other, like a bog is like a lake because it has um... like what was I going to say, a bog is like a lake, they have lots of plants together - and they can both be muddy probably, sort of connected. Well, then I thought that mud and bog would probably go together because bogs can be muddy like on the bottom.
Interviewer: What is the water-table?
Rachel: It's like a um, sort of like, um..., the water-table is sort of like, I can picture it in my head I just don't know.

4.3 Critique of Rachel's Interview

Rachel's understanding of watersheds at this point in the study was revealed through her comments on her map content and structure. Her map was a *spoke* shape, with most of her ideas radiating out from or into the central theme of watersheds. Her map structure shows her centralized perception of the information she was learning. She was in the process of organizing all the watershed ideas as they connected to her main idea. Rachel included everything she had learned so far about watersheds in the first map. Hierarchical structure and organization of concepts were not apparent in her initial concept map. The connections she created and then explained in this interview excerpt show how Rachel's understanding of watershed-related ideas, as they connected and related to the watershed, had not evolved beyond her conviction that all her concepts were connected to the watershed with equal importance and validity. There was little variation in how things connected to her central idea. Her final concept map revealed an organized hierarchy of ideas as they connected with her central idea of water, which had grown out of her initial thinking on watersheds.

The process students experienced as they built and revised concept maps helped them make sense of their newly acquired knowledge on watersheds. Experimenting with ideas and the connections to other ideas allowed for comparisons among concepts, which in turn helped students develop an awareness of the attributes of each idea, the similarities and differences, and how one thing connects to another thing.

4.4 Anne's Concept Maps

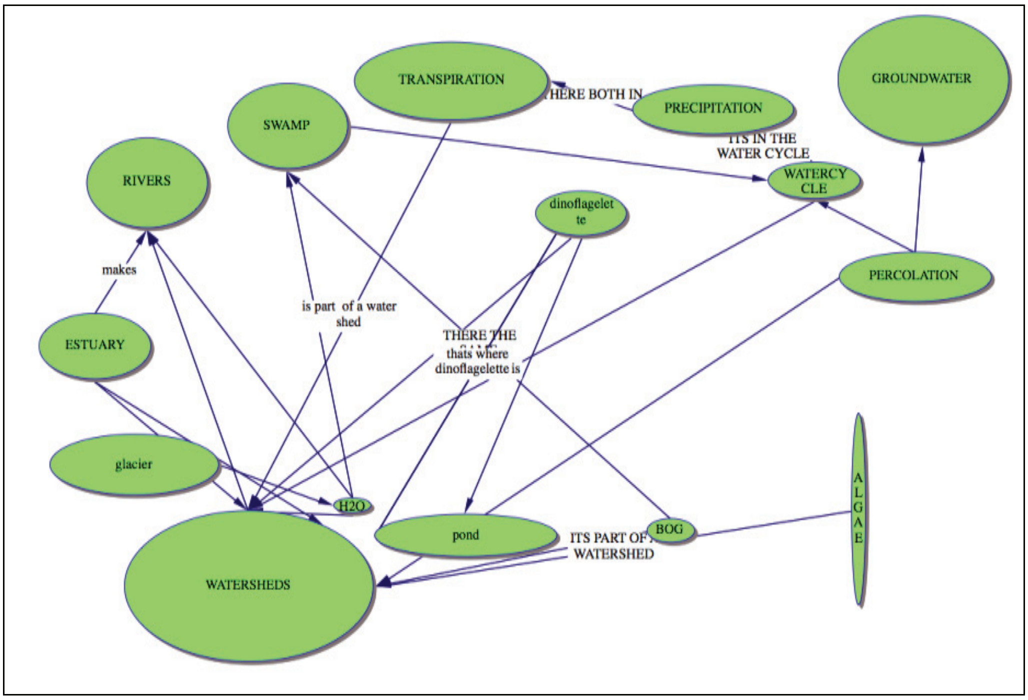

Figure 3. Anne's Concept Map 1 (first)

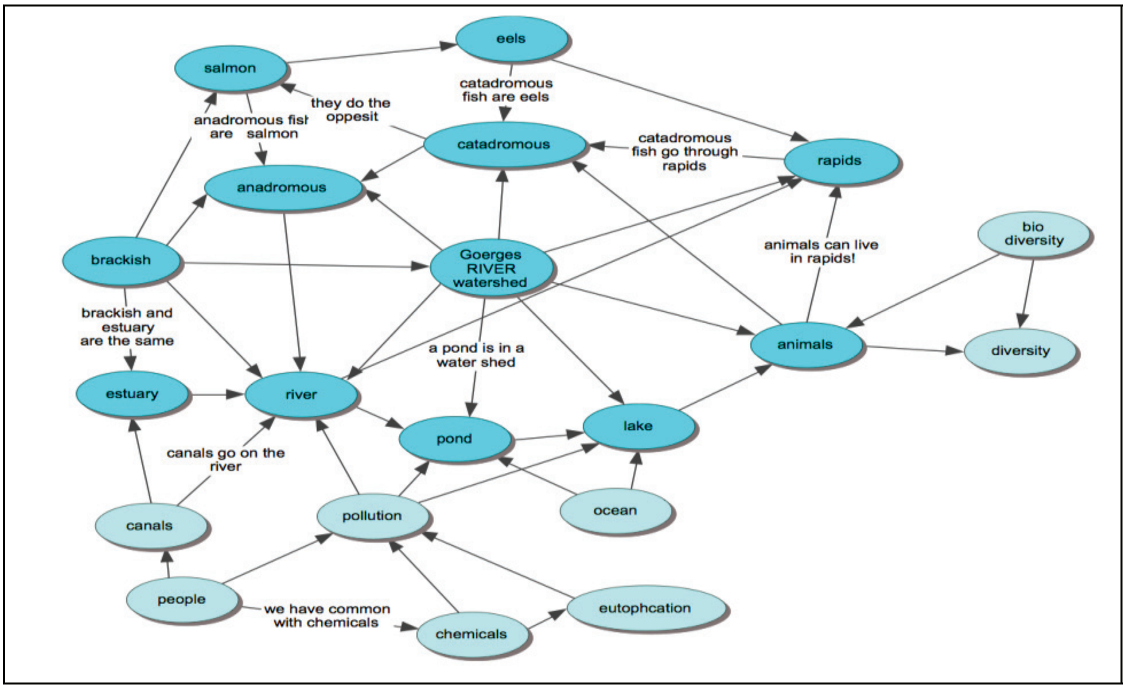

Figure 4. Anne's Concept Map 7 (final)

4.5 Critique of Anne's Concept Maps

Anne's concept maps developed from *spoke* shape to *network* shape over the course of the science study. Her content as well as structure were complex with many thoughtful concepts and connections. Anne was one of the few in her class who developed her concept maps with linking words. Her final map contained several hierarchical levels of information. Her color-coding used two colors on her final map but they were appropriate to her scheme of understanding of what she had created.

During one of Anne's interviews (4/29/11), she shared her perspective on creating concept maps.
Anne:…it's kind of like a puzzle of figuring what goes with what and all that."
Interviewer: "How did you figure or what process did you use when you were putting your puzzle together?"
Anne: "I just put one [bubble] on there and thought about it and put another one on there [bubble] and I thought about that one and then, well, just put some on that that I really thought were interesting and then I would see if they [ideas] would go together."
Interviewer: "How did you decide what goes with something?"
Anne: "I was thinking 'cause I had chemicals and biomagnification and then I thought about it and yeah, that would be kinda the same so I put that there."

5 Discussion

This work's theoretical premise that student-constructed concept maps when used in science class for the duration of a science unit supports student learning while providing a window into student cognitive organization and understanding, is primarily founded upon the work of Novak (2002), Ausubel (1963, 2000), Kinchin (2000) and is supported by the empirical outcomes of this research project.

This study blended the use of prior knowledge and concept mapping for both displaying student misconceptions and aiding the student in achieving gains towards meaningful learning in science class.
To support effective science teaching, educators need methods to reveal student understandings and misconceptions of science concepts, which can offer all students an opportunity to reflect on their own knowledge construction and organization. By using student-created concept maps developed and revised over time in science class, students experienced those opportunities to reflect on their own knowledge organization. The teacher was also provided with a pedagogical tool for displaying student misconceptions within the content and structure of each student's concept map.

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Valletta, Malta 2012

THE STRATEGICAL USE OF CONCEPT MAPS IN READING COMPREHENSION OF STUDENTS WHO ARE DEAF

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Abstract. The aim of this paper is to examine the effectiveness of semi-completed concept map instruction in reading comprehension of students who are deaf. An intervention study based on ABA research design took place, which involved scaffolding instruction on the use of concept maps in the reading comprehension of narrative texts. A 10-year-old deaf student born to deaf parents participated in our study. The effectiveness of concept map instruction in reading comprehension was evaluated based on the student's responses to seven multiple choice reading comprehension questions and text recalls in Cypriot Sign Language. The instruction on concept maps improved the student's reading performance, as indicated mostly in text recalls.

1 Introduction

Reading comprehension is a challenging task for students who are deaf, which is partly attributed to their prior language and background experiences before entering school (Andrews & Mason, 1991; Perfetti & Sandak, 2000). Based on schema theory, children rely on their prior knowledge, which is stored in memory in the form of abstract cognitive structures called schemata, to construct the meaning of a text (Schirmer, 2000). Deaf students are often brought up within an environment where they have a limited access to language, reading and world experiences (Andrews & Mason, 1991). Therefore, they develop poor schemata that affect negatively their ability to derive the meaning of a text (Schirmer, 2000; Stewart & Kluwin, 2001), especially in intermediate or higher grades when texts become scriptually implicit and their understanding requires more background information (Gardill & Jitendra, 1999). For deaf children born to deaf parents, the situation is different, because they have access to communication and acquire a sign language (Marschark, 1993; Musselman, 2000), but at school they are required to learn to read in a second language (Perfetti & Sandak, 2002), a highly challenging task, especially considering that the transition from a signing to the written form of an unknown spoken language is a more complicated procedure compared with the transition from a spoken to the written form of the same spoken language (Goldin-Meadow & Mayberry, 2001; Marschark & Harris, 1996).

Consequently, students who are deaf or hard of hearing have diverse language needs and encounter various difficulties in reading comprehension, such as understanding vocabulary and syntax, and applying metacognitive reading strategies (Andrews & Mason, 1991; Kelly, 2003; Paul, 1998; Strassman, 1997). Therefore, teachers are required to plan and implement instruction that respond effectively to their reading needs. This is an aim hard to accomplish, considering that despite years of research it has not been identified which practices are effective to promote learning and specifically reading comprehension in students who are deaf (Spencer & Marschark, 2010). Among the practices that can enhance reading comprehension in deaf students, are visual strategies, considering that deaf students have a limited auditory access but a total visual access to information (Easterbrooks & Baker, 2002; Luckner, Bowen, & Carter, 2001). The aim of this paper is to examine the role of graphical tools or graphical strategies, namely concept maps, in reading comprehension of students who are deaf and hard of hearing.

Concept maps are graphical tools for organizing and representing knowledge. They are used to categorize information into a graphic form, create a visual representation of the concepts within the text, the relationships among them and the text structure (Sturm & Rankin-Erickson, 2002). They include concepts enclosed in boxes and relationships between concepts through the use of connecting lines and words linking two concepts (Novak & Cañas, 2006). Graphical tools convert a linear isomorphic text into a nonlinear graphic presentation, which makes the macrostructure of the text more salient. Their spatial properties help readers identify, compare and retain information or draw inferences about relations, supporting, in this way, cognitive processing that do not overload students' working memory. The content within a text becomes conceptually transparent and therefore it becomes easier for the readers, especially the ones with poor language and reading skills, to understand, retain and retrieve it (Chang, Sun & Chen, 2002; Novak, 1991; Novak & Cañas, 2006; O' Donell, Dansereau & Hall; Vekiri, 2002).

All the above characteristics of graphical tools can play a positive role in reading comprehension for deaf students, who due to their poor schemata experience various difficulties in processing a text, understanding the syntax, the concepts and the structure of the text. However, very few research evidence exists regarding the role of concepts maps and in general graphical tools, in deaf students' reading comprehension. Castillo, Mosquera and Palacios (2008) explored the effectiveness of concept maps to foster reading comprehension skills in a 13-year-old deaf student. They compared the comprehension of a text with comprehension of its transcription to a concept map format, both with and without illustrations. According to the results, the concept map format improved the student's understanding of the text and also motivated the students' interest more so than the text format. Furthermore, Nikolaraizi and Vekiri (2012) examined the perceptions of teachers regarding deaf students' behavior while reading digital narrative texts along with three visual resources Greek Sign Language videos, concept maps and pictures, presented within a software entitled "*See and See"*. Based on teachers' comments, all students were motivated to read the texts but they used the visual resources depending on their prior experience. In particular, they rarely used the concept maps because they had no prior knowledge regarding concept maps and they were not instructed on how to use them in reading comprehension. The researchers concluded that instruction on visual literacy strategies is required for students to learn to use concept maps effectively.

Considering the limited research, this study aims to further explore the role of concept maps in deaf students' reading comprehension. Specifically, the aim of this study was to examine the effectiveness of concept map instruction in a deaf student's reading comprehension of narrative texts. Previous research with hearing students (see O'Donell, Dansereau & Hall, 2002) as well as the study with deaf students by Nikolaraizi and Vekiri (2012) indicated that students' training regarding graphical displays affect the way that they use them. In this study a single-case study took place, based on ABA research design, which involved concept map instruction. The following research questions were stated in our study: 1)What was the effectiveness of the concept map instruction in reading comprehension of narrative texts as indicated through reading comprehension questions, and 2) What was the effectiveness of concept map instruction in reading comprehension of narrative texts as this was indicated through text recall.

2 Methodology

2.1 The participant

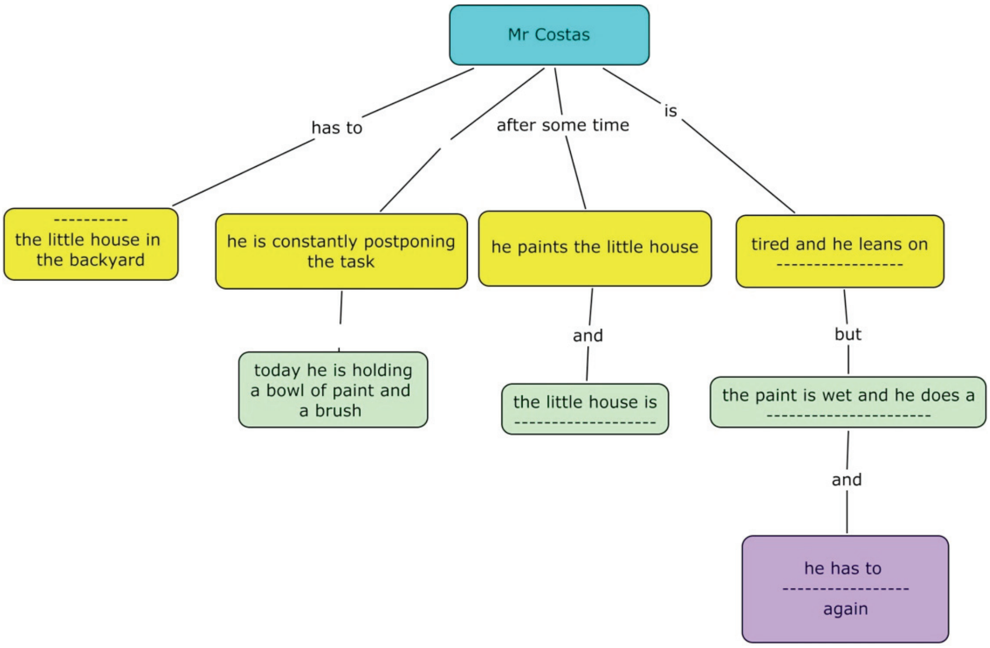
In this study one participant was involved, Maria, a 10-year-old student with profound hearing loss, who was born to deaf parents, communicated in Cypriot Sign Language (CSL) and attended a special school for the deaf. We selected a single participant, because she was born to deaf parents and she was proficient in a sign language, specifically CSL, allowing the instruction to take place which required a high level of language skills. Deaf children born to hearing parents rarely have such language skills in a sign language, because in contrast with deaf children born to deaf parents, they do not have full access to communication since their birth, as explained at the beginning of our paper. Another reason for selecting one student concerns the fact that Cyprus has a small population of approximately 800.000 and deaf children with deaf parents constitute a very small minority among deaf students considering that 90% of deaf students are born to hearing parents (Moores, 1996). Maria attended the 4th grade and her reading performance based on teachers' reports was in the 2nd grade. Also, we assessed her reading comprehension performance through reading texts and replying to reading comprehension questions and recalling texts and we found out that she was very poor in recalling tasks. A test that examined her short-term memory took place before the intervention took place, which indicated that Maria was capable of recalling a high number of information that was presented visually to her.

2.2 Materials

In our study, we used 21 reading narrative texts which were selected according to Maria's reading level. For each text a semi-completed concept map was designed. Specifically, each concept map contained some boxes including part of the main elements of the narrative text (e.g. characters, the setting) and some empty boxes which concern the rest of the information of the narrative text (e.g. plot resolution). In order to fill in the missing information within the concept map, the student had to identify the relevant information within the text. Following, an example is provided of a text titled "The painter" and the accompanied semi-completed concept map.

"<u>The painter</u>
During the past few weeks Flora's mom has been asking her husband to paint the little house in the backyard. Her husband, Mr. Costas is constantly postponing the task. But today he is holding a bowl of paint and a brush in his hands.
He opens the bowl, he puts the brush in and he starts working.

"What an awful work to do", he says.
He puts his brush in the bowl. Why does he hate painting so much? After some time he finishes painting the little house.
"Finally"
He puts the brush down and looks at it. The little house seems nice. Mr. Costas is very tired and he has a backache. He leans on the little house. He soon realizes what he has done. He just leaned on the wet paint. He jumps right up. There is a big stain where he leaned.
"Oh no! Now I have to do the painting all over again"
Poor Mr. Costa!



For each text, the researchers developed seven reading comprehension multiple choice questions, including five textually explicit questions, to which the answers were explicitly mentioned in the passage, and two textually implicit questions which require the reader to combine various points of the text to reply to them. It is important to note that most of the questions addressed the important information of the text, which were also presented within the concept map.

2.3 Research design and Procedure

A single subject research A-B-A design was followed in the study. *In phase A*, the researchers collected baseline data regarding Maria's performance for six consecutive days. Specifically, each day the student was asked to read one narrative text along with an incomplete concept map and a set of seven reading comprehension multiple choice questions. After reading the text, the student was asked to read the concept map, fill in the empty boxes and then answer the reading comprehension questions. When this task was completed the participant was requested to recall the text in CSL. The student was videotaped during her text recall.

In phase B, the intervention was implemented for nine consecutive days. At the beginning of this phase the scaffolding instruction took place, during which the researcher guided the student how to read and use the incomplete concept map. Instruction included the following steps: 1) The researcher read part of the text and then asked the student to read the rest of the text, 2) the researcher read the concept map from top to bottom and from the left to the right and then asked the student to read part of it, 3) the researcher read again the concept map in the following way: each time she encountered a completed box she read the information within the box and then returned to the text to identify the information in the text. Similarly when the researcher encountered an empty box she went back to the text and searched the text to identify the missing information and fill in the box. The researcher went back to the text and forth to the concept map several times until she identified the missing information in the text and completed the relevant part in the concept map. Next, the researcher guided the student to follow the same steps, 4) when the researcher and the student completed the concept map they replied to the reading comprehension questions, which addressed the important points that could be identified in the text and the concept map. The researcher instructed the student how to reply to the questions. Specifically, the researcher read each question and all the available answers, then she went back to the text and the concept map and searched for information that could help her answering the questions. Each time the researcher identified the relevant information for the question in the concept map she pointed out this information to the student and then proceeded to answer the question. The researcher went back to the text and forth to the questions several times in order to find the relevant information to each question. Next, she guided the student to do the same, 5) after replying to all questions the researcher read once again the concept map and also guided the student to do the same, 6) at the end she recalled the text in CSL and also encouraged the student to do the same. During the first days the researcher demonstrated and guided the student's learning by following the above steps, while gradually the researcher's guidance was being removed.

In the final post-intervention *Phase A*, Maria was asked to read six narrative texts for six consecutive days, fill in the semi-completed concept maps, reply to the reading comprehension questions and recall the text in CSL. The guided instruction was completely withdrawn.

2.4 Analysis

Our data analysis was based on the student's performance in multiple choice questions and in text recall in CSL, which were videotaped and then transcribed by two researchers who were fluent in CSL. Following, we analysed student's recalls using pausal units. A pausal unit stands for the phrase break which occurs when a reader briefly stops reading in order to take a breath. All texts were broken down to pausal units with the use of slash marks (/), after three fluent hearing adults read the texts to the researchers who noted the pausal units designated by the readers. The final number of pausal units was agreed by at least two of the three readers. These pausal units formed the basis upon which we calculate the scores of recalling of our student. Specifically, the student's recalls were analysed based on two measurements. The first measurement regarded the quantity of recalled pausal units that is the number of the text's pausal units that the student recalled. The second measurement was the weighted quantity of recalled pausal units, that is the level of closeness of each recalled pausal unit to the original pausal unit of the text (Andrews, Winograd & Deville, 1994). Following, an example of the analysis is provided, based on a section of the text titled "The painter":

<u>Text</u>:
English: During the past few weeks Flora's mom has been asking her husband/ to paint the little house in the backyard./ Her husband, Mr Costas is constantly postponing the task./ But today he is holding a ball of paint and a brush in his hands
Greek: Εδώ και βδομάδες η μαμά της Φλώρας ζητάει από το μπαμπά της μικρής/ να μπογιατίσει το σπιτάκι του κήπου./ Ο κύριος Κώστας το αναβάλλει συνέχεια./ Μα σήμερα κρατάει την μπογιά και τη βούρτσα του στα χέρια του./

<u>Text Recall</u>:
English: Mom is asking constantly Costas her dad,/ to paint the house and he is postponing it./ Now Costas decided to paint/ and he is holding the paint and the brush.
Greek: Η μαμά ζητάει συνέχεια από το Κώστα τον μπαμπά/ να μπογιατίσει το σπίτι και αυτός συνέχεια το αναβάλλει./ Τώρα ο Κώστας αποφάσισε να βάψει/ και κρατάει μπογιά και βούρτσα./

<u>Analysis</u>:
Pausal units in the original text abstract: 4
Recalled pausal units for this abstract: 4
Level of closeness of the four recalled pausal unit to the original pausal units in the text: 14 (87.5%)

Pausal units in the text (4)	**Recalled pausal units (4)**	**Level of closeness (Total 14)**
During the past few weeks Flora's mom has been asking her husband	Mom is asking constantly Costas her dad	3
to paint the little house in the backyard	to paint the house it	3
Her husband, Mr Costas is constantly postponing the task	and he is postponing	4
But today he is holding a bo of paint and a brush in his hands.	Now Costas decided to paint and he is holding the paint and the brush	4

3 Results

3.1 Multiple choice reading comprehension questions

The student's responses to the multiple choice questions of the 21 narrative texts indicated that performance in Phases B and A was similar. Specifically, the average percentage of right answers achieved by the student for the six narrative texts during the Baseline Phase A was 95%, whilst in the intervention Phase B a slight increase of right answers is noted, achieving a percentage of 100%. During the Maintenance Phase A, the percentage of right answers remained steady at 100% (see Figure 1).

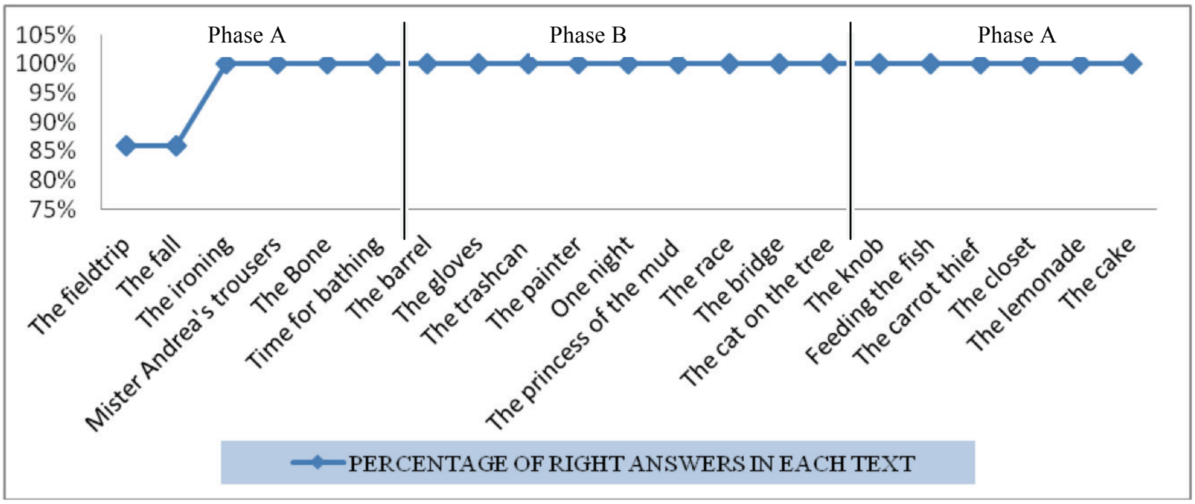


Figure 1. Percentage of right answers in each text

The similarities regarding the student's performance between Phases A, B and A are indicative of the minor effect of the intervention, as the student was able to answer correctly almost all multiple choice questions for the 21 narrative texts used in all Phases. A slight increase from Phase A to Phase B was only evidenced.

3.2 Text recall

The analysis of the text recalls, based on the quantity and the quality of recalled information, is summarized in Figures 2 and 3. Regarding the first measurement, that is the quantity of the recalled pausal units, an upward trend was identified. In Baseline Phase A, the average quantity of pausal units that the student recalled was 22% of the total number of pausal units in the original text. In Intervention Phase B, that the concept map instruction took place, the average quantity of the recalled pausal units increased to 36%. In the Maintenance Phase A, the average quantity of the recalled pausal units reached 46%, illustrating that the effect of the intervention remained (Figure 3).

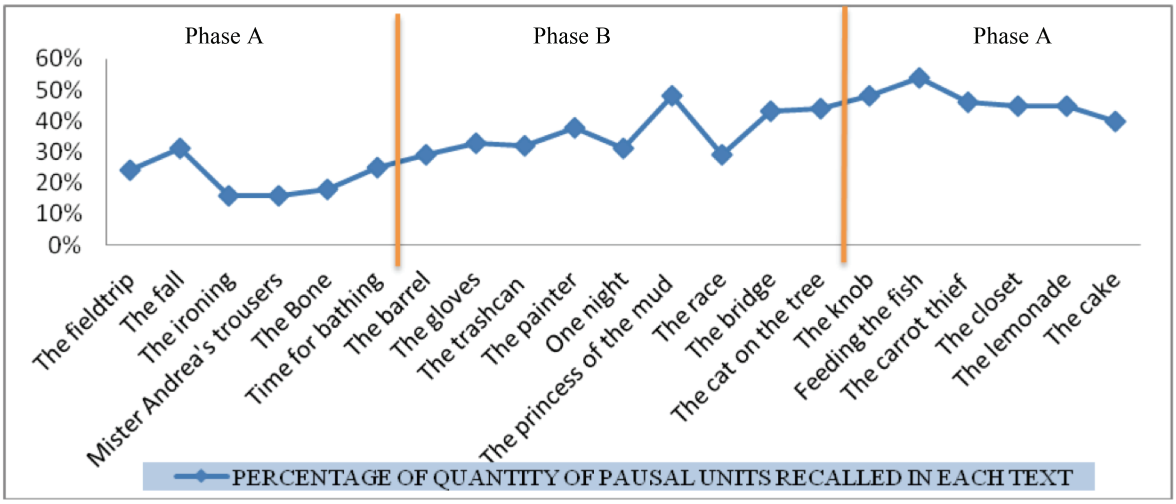


Figure 2. Percentage of quantity of the recalled pausal units in each text

Student's performance regarding the second measurement of weighted quantity of the recalled pausal units is noticed to have changed also. In Baseline Phase A, the average percentage of weighted quantity of recalled pausal units was 72% comparing with the meaning of the original pausal units of the texts. In Intervention Phase B, the student's performance improved as the average percentage of weighted quantity of the recalled pausal units increased to 84%. In the final Phase A, the average percentage of weighted quantity of the recalled pausal units remained high at similar levels as in phase B reaching 88%.

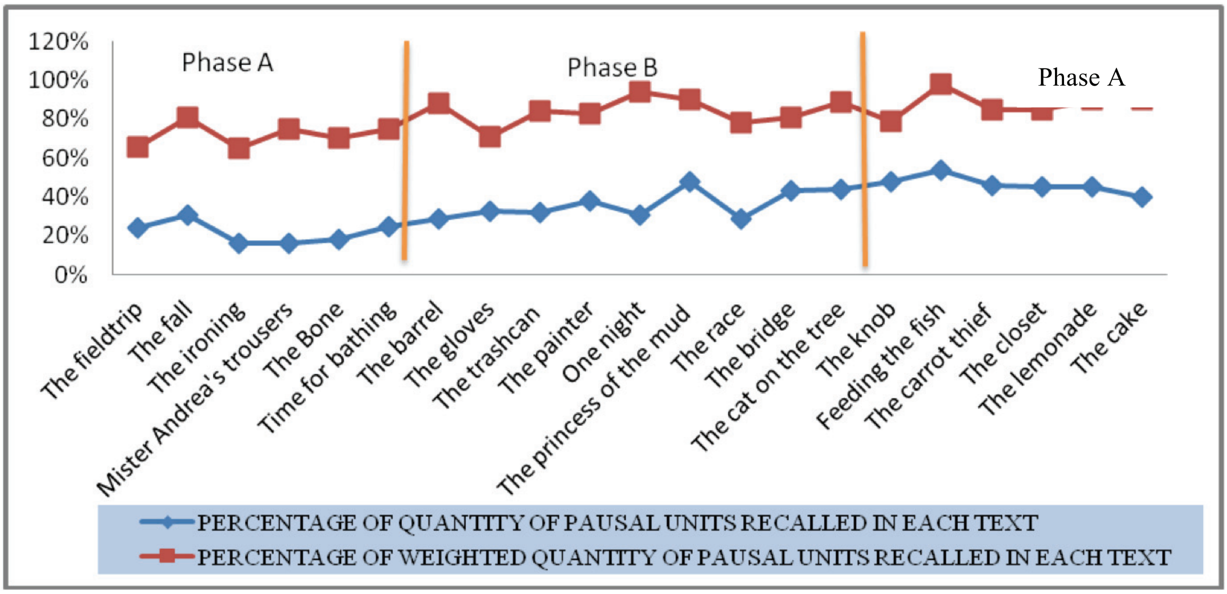


Figure 3. Percentage of quantity and weighted quantity of the pausal units recalled in each text

Figure 4 summarizes the results from all measurements obtained from the student's responses in reading comprehension questions and the text recalls based on the quantity and the quality of the recalled pausal units in all Phases. It is evident that the student's performance in general was improved during Phase B that the intervention took place and this improvement remained in the final Phase A. This improvement was particularly evident in text recall.

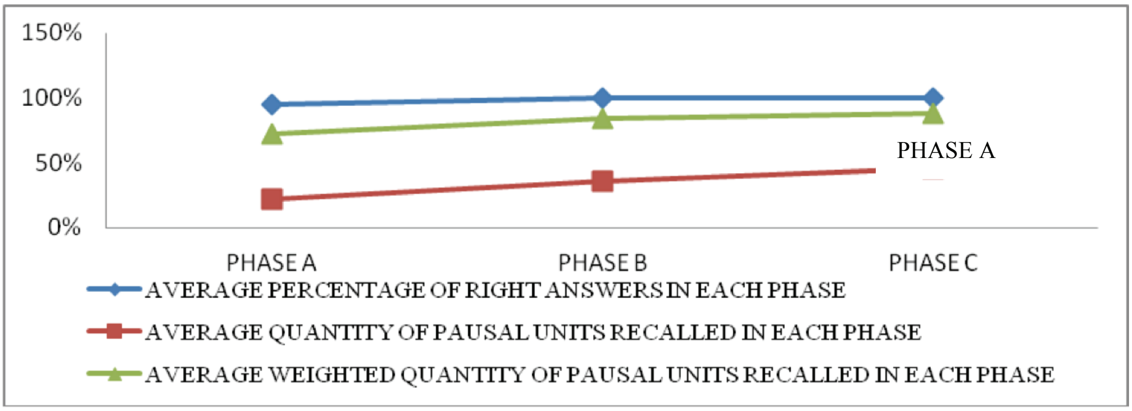


Figure 4. Average scores of student performance in reading comprehension questions and text recall

4 Discussion

According to the results of this study, the concept map improved the student's performance as this was indicated through text recall, while no improvement was observed in reading comprehension questions, where she had a good performance from the beginning. Possibly, Maria's prior knowledge with completed concept maps aided her reading comprehension as this was indicated through her responses in reading comprehension questions. Prior research (Chmielewski & Dansereau, 1998) has indicated that prior knowledge and training regarding graphical tools affect students' ability to use them effectively.

However, although Maria has prior knowledge with concept maps, her performance in text recall from the beginning was lower compared with her performance in the questions and an improvement in text recall was observed during the intervention phase. Possibly, through instruction in completing semi-completed concept maps rather than using ready-made concept maps, Maria was encouraged to get more cognitively engaged in understanding the concept map and the text which helped her also to retain more information. Also, during the instruction the student was instructed on how to use the concept map in a strategic way, because she was guided and encouraged to read multiple times the concept map and different parts of the text and relate the information within the concept map and the text. This instruction probably helped Maria to recall the text in a more effective way as this was indicated though both measurements, the quantity and the weighted quantity of the recalled pausal units.

Our study indicates that the effective use of concept maps in reading comprehension by students who are deaf or hard of hearing requires the systematic instruction on the strategic use of the concept map. By making students aware of the value of visual aids and instructing them on how to use them strategically, readers who are deaf or hard of hearing as well as other students with or without special educational needs can benefit from visual information and learn to exploit visual aids effectively in order to enhance their reading comprehension performance (Nikolaraizi & Vekiri, 2012)

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THE USE OF MIND MAPS AND CONCEPT MAPS IN QUANTUM MECHANICS AT HIGH SCHOOL LEVEL

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Abstract: In this paper, we discuss some preliminary findings based on the implementation of a Potentially Meaningful Teaching Unit (PMTU) in four different classrooms of the third year high school, in a public school in a hinterland town of Rio Grande do Sul, the southernmost state of Brazil. The proposed content for this implementation deals with concepts linked to quantum physics (quantization, uncertainty, state, and superposition of states), which we have organized according to the principles of the Meaningful Learning Theory (MLT), such as progressive differentiation and integrative reconciliation. It analyzes mind maps and concept mapping, with a focus on their structure and on the changes that have occurred in the process of comparing these maps. It also includes students' comments on the development of their own understanding of the concepts this research proposal has approached. Notwithstanding the incompletion of its results, this study can provide some evidence of the occurrence of meaningful learning, which constitutes the main objective of the implementation of a PMTU.

1 Introduction

The teaching of physics in high school has not managed to go along with the scientific and technological advances of these last decades. The curriculum is not up to date and contextualized. It is in this direction that we look for finding a way of bringing together classroom contents to the reality of our context today. Thus, we aim at promoting more meaningful teaching and learning.

When the contents of physics are presented in the traditional mode, they can cause in the students the lack of motivation and interest, mostly if they are approached expositively and monologically, without the use of resources and instruments that might call the students' attention and arouse the interest of this generation heavily linked to technology. At this point we get to the contents of physics taught in the classroom, in which in spite of the various initiatives of including Modern and Contemporary Physics to the high school curriculum (Silva & Almeida, 2011; Carvalho Neto et all, 2009; Ostermann & Moreira, 2000), its teaching still meets many drawbacks and it does not even happen. Consequently, many topics that are relevant for the understanding and observation of the way of life of this new generation are not taken into consideration.

In order to, at least partially, attend to this state of affairs, we believe that the insertion of contents of quantum physics in the high school curriculum is really necessary so as to face technological advances and the dissemination of feasible alternative representations, which might lead to hindrances in understanding them. However, the approach to quantum physics cannot be made in the conventional way it is usually done; instead, it needs to be addressed in such an engaging manner that students can get motivated to its lessons. This proposal has been developed according to the steps of the Potentially Meaningful Teaching Units, or PMTUs (Moreira, 2011), according to which, initially, a survey of the students' prior knowledge is made and, then, content is presented in a more general form. Next, each topic of the content receives a more specific treatment aiming at its progressive differentiation and integrative reconciliation.

2 Theoretical Framework

This proposal agrees with the perspective of the Meaningful Learning Theory, MLT (Ausubel, 1968; Ausubel, 2000), and it is based on the protocols of the Potentially Meaningful Teaching Units, PMTU (Moreira, 2011).

The PMTUs comprise stages that, in the sequence in which they are proposed, attempt at promoting meaningful learning. They consist of eight steps, or stages, that serve as a guide for the development of the PMTUs (Moreira, 2011) and it is up to the teacher to look for the best way of following these steps and to adapt them to his/her school reality. Therefore, the content has been carefully selected and organized so as to make the quantum physics instructional materials potentially meaningful, that is, they should present logical meaning (such as structure, organization, examples, adequate language) and, furthermore, they should be related to the needs of the third year of high school. The basic concepts to be developed here should be quantization, uncertainty, state, and superposition of states.

According to Ausubel (1968; 2000) the isolated variable that has the greatest influence on the learning of new contents is prior knowledge, or subsumer, to which new knowledge will be anchored. A subsumer can incorporate representations, schemes, models, personal constructs, alternative conceptions, invariant operators, which means that it includes cognition processes that already exist in the learner's cognitive structure and that are available to be related to the content he/she is to learn.

Therefore, we verified the students' prior knowledge by using mind maps (Buzan & Buzan, 1994; Ontoria, De Luque & Gómez, 2004) and by asking them about their ideas about quantum physics, which they answered orally in the classroom as a whole. Mind maps display totally free associations and present key-ideas that are interrelated and ramified so as to form a structured network, with nodes and connections, which are especially adequate when one wants to identify subsumers.

As an immediate follow-up, we developed the PMTU proposal that considered the principles of progressive differentiation and integrative reconciliation, which deal closely with the programmatic approach of the content. Progressive differentiation estimates the most general and inclusive concepts or ideas of the content that should be introduced right at the beginning and be progressively differentiated along the teaching process, in terms of details and specificities, whereas integrative reconciliation anticipates that teaching should explore linkages between or among ideas and concepts, pointing out relevant similarities and differences while reorganizing knowledge and clarifying ideas.

Thus, concepts were simultaneously approached, initially at a maximum level of inclusiveness and, little by little, they were presented again at increasingly higher levels of specificity, but always linked to what had been already studied. We promoted progressive differentiation by starting at the most general and inclusive and moving on to the most specific level, while integrative reconciliation occurred when we re-approached general level ideas and concepts based on specific ideas and concepts.

New knowledge, which was generated by the interaction between subsumers and information presented, seems to be naturally different from the latter, and it was shown by the students in the construction of their concept maps (Novak, 1997; Novak, 1980) as well as in a set of activities prescribed in the PMTUs. A concept map is a hierarchical diagram of concepts and linkages between, or among, concepts through which we can perceive that some of them are more relevant, more inclusive, more structuring than others. Associations are directly related to the context of the subject matter, whereas mind maps deal with associations that are always free. In a concept map, relations between/among concepts are evidenced through lines that link them together. It is on these lines that propositions are placed, and they help to make explicit the kind of relation there is between/among the linked concepts and they attempt to reveal the conceptual structure of the content that is being diagrammed.

This proposal follows the principles we have so far described. Hence, at first we surveyed the students' prior knowledge, then, we introduced the content in a general manner. Afterwards, each key-concept was dealt with in a very specific and detailed mode. The basic concepts developed in this PMTU were quantization, uncertainty, state, and superposition of states, which are rated as crucial for the understanding of quantum physics.

3 Methodology

Implementation of classroom activities occurred with four different third year high school classes in the E. E. E. M.[1] Carlos Antonio Kluwe, Bagé, RS, Brazil. The four classes were divided into two groups of two classes each, with the goal of better evaluate the efficacy of this proposal and to allow for modifications in the original proposal whenever needed. The first group started its activities on the 10th of October 2011, and it had 18 meetings, while the second group started on the 31st of October, 2011, with 15 meetings.

The concepts–quantization, uncertainty, state, and superposition of states—were approached conceptually and according to Copenhagen interpretation. The purpose, here, was to value phenomena interpretation and the simplest equations without entering more advanced mathematical complexities, having in mind that this implementation occurred in high school.

Since meaningful learning and the mastery of a field of knowledge are progressive, the focus of this paper in on the students' progress along the process and not on their final outcomes. For this reason, questions and situations that aimed at verifying the students' comprehension and assimilation of meanings throughout the course of the PMTU implementation were proposed.

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[1] Public (State) High School Carlos Antonio Kluwe in Bagé, a town in Rio Grande do Sul (the Southernmost state of Brazil).

For a better knowledge organization, the students were asked to produce some kind of material (task) at each step of the PMTU as a learning outcome. Altogether there were six tasks developed by the students: mind map, initial questionings, free choice task developed after the first text, concept map, individual evaluation/self evaluation, and class newspaper/paper. Students' tasks are clarified in Table 01 and they are related to the steps of the PMTU steps.

Table 01: Tasks performed by the students at each step of the PMTU.

Step	Step objective	Student's task
1	Theme definition.	-
2	To externalize subsumers.	Development of mind maps in pairs. Discussion about some of the guidelines proposed by the teacher, by the large group (the whole class).
3	To sharpen students' curiosity and to relate knowledge using introductory level advance organizers.	Reading of the article *Física Quântica para Todos* (partially adapted from Nunes, 2007). Text discussion in small groups. Production of a free-choice material, in groups.
4	Presentation of concepts relating them to previous examples and discussions.	Watching the documentary film *Tudo sobre Incerteza – Mecânica Quântica* (Discovery, 2007). Construction of concept maps by the same pairs as in step 2.
5	To approach the same content again, using the comparison of the maps in step 2 with the ones obtained in step 4, so as to address ideas that have been disclaimed and to observe what has been added.	Qualitative comparison between mind maps and concept maps, in pairs, according to participation in the previous steps. Oral and written report of this moment.
6	Closing of the content with concept presentation at the maximum level of complexity, but in agreement with the level of schooling.	Large group discussion about the approach used in drawings (illustrations) and charges about quantum physics concepts. Production of a small class newspaper in the large group, with various resources, such as small articles, charges, comic strips, and/or illustrations/drawings about the studied topics. Resources are those selected by the group.
7	Summative evaluation. Formative evaluation. The teacher evaluates students' performance and it is based on the two evaluations in an egalitarian manner.	Individual summative evaluation happens in the classroom with open questions involving the unit key-concepts. Individual formative evaluation according to the activities developed by the students and to the teacher' s notes along the PMTU.
8	Evaluation of the PMTU itself. Final integrative comments about the studied contents.	Oral analysis of the proposal as a whole, including students' performance in the evaluations and tasks, and the teaching strategies as well as the students' own learning.

For this proposal, activities described in steps 2 and 4 were selected together with their modifications along the process presented here were discussed, as well as the evolution in the comprehension of concepts and in the established linkages between/among them, which had been displayed in the students' mind maps and concept maps. These features can be viewed as an indication of the occurrence of meaningful learning.

The use of mind maps allows the students to express themselves freely and, therefore, this tool permits us to look for external influences in the process of subsumer development, such as, for instance, issues that are treated by the media, contributions that come from previous years of schooling, or from school contents students have already studied. On the other hand, concept maps, because of their own structure, do not enable students to have the same freedom they have with mind maps and, thus, it might be more difficult for the researcher/teacher to verify the external influences in the development of subsumers and in the grasping of meanings derived from the subject matter studied. In this study, we expected the external influences upon quantum physics to become spontaneously extinct. However, the students did not receive any guidance towards the choice of concepts they should use, though they were instructed to follow the rules for concept mapping and to relate to the concept maps their knowledge of quantum physics.

4 Findings

We present here some signs, or indicators, of meaningful learning shown by the students in their maps: the presence/absence/modification of ideas when comparing the mind maps, in the early stages of this intervention, with the concept maps that were developed after the presentation of the quantum physics contents. The relations observed in those maps were qualitatively analyzed, and some of the students' comments on the evolution of these linkages when they compared the two activities (mind maps and concept maps) are also presented.

Maps of three pairs of students are discussed: the first two figures correspond to pair A, pair B drew figures 03 and 04, and pair C constructed the last two maps.

Figure 01 shows a mind map by pair A, and it presents a radial format around the central concept. We can also notice the presence of terms linked to the pair' s prior knowledge (Planck, uncertainty, photon, black body, etc.), though they are directly connected to quantum physics, they do not have a hierarchical organization and linkages that might indicate the kind of relation the students have established. Whereas, the concept map of this same pair, figure 02, displays how concepts are hierarchically in the pair's cognitive structure. At the very top of the map, it shows atomic particles related to classical physics, but without any connecting element. From classical physics it branches out in three: Newton and gravitational theory; superconductiveness and electronic devices; and quantum physics, in which the connective used indicates that classical physics has opened the way to quantum physics. It might be stated that this map shows this sequence as a result from the way this content have been treated in the classroom. We can also notice that some concepts that appear in the mind map have been reorganized: from quantum physics on they follow new linkages, such as uncertainty, duality, superposition of states that lead to the present atomic model. All these concepts are related to modern physics, and from it they branch out into ramifications of examples of quantum physics applications in the macroscopic world.

This map, as all the others, was drawn in the classroom. Notwithstanding that some of its concepts do not present any connectives and that some of the ideas appear without a hierarchical definition—they do not appear as concepts or as connector, or linkages—we can notice that there is clearness in the relations established, which agree with quantum physics, Thus, we might say that these characteristics point out that this particular pair has meaningfully learned the given contents, as they have organized their prior knowledge adequately.

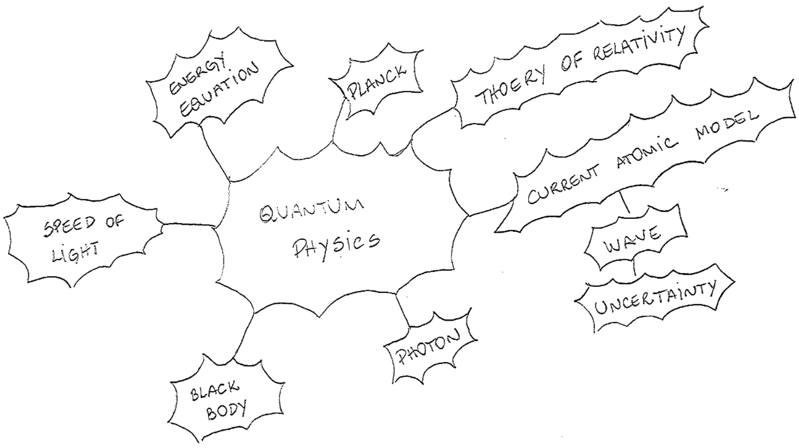

Figure 01: mind map of pair A

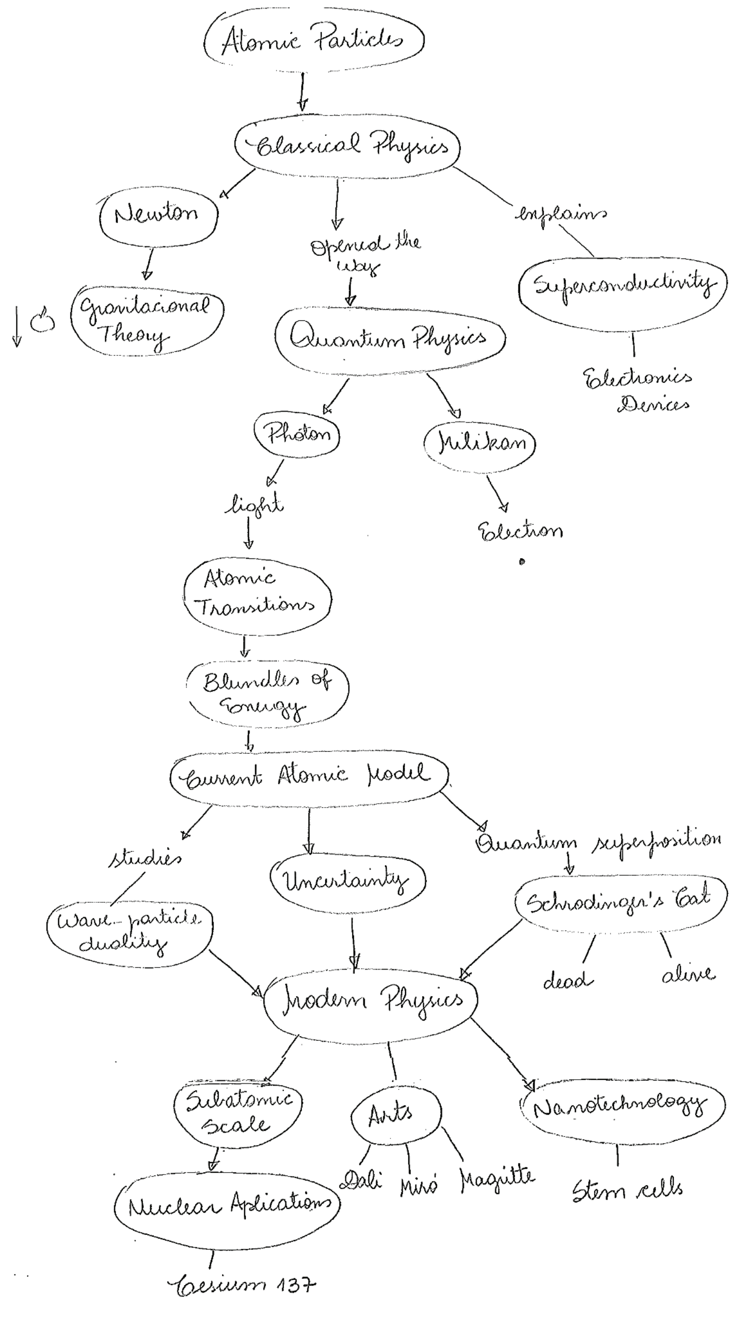

Figure 02: a concept map of pair A

Figure 03 displays a mind map developed by pair B, and its associations have to do essentially with atomic particles (protons, electrons, etc.) and with concepts they have already studied in previous situations in the disciplines of physics and chemistry (electromagnetic waves, quantum numbers). We cannot perceive in it linkages between/among the concepts, but only first-degree linkages with quantum physics, without any connectives. This pair has used a cloud formal to indicate concepts, which can be linked to thoughts since this is a free creation.

The concept map this pair has constructed, figure 04, comprises most of the concepts approached in the PMTU. Knowledge seems to be more organized, which can be observed in the linkages between/among concepts and in the connecting words they have used here. We can also notice the formation of small tree-like forms with the concepts directly organized among themselves. Although it does not shows all the connecting words (connectives), linkages agree with quantum physics. This pair demonstrates a fairly good understanding of content, which serves as a sign to the occurrence of meaningful learning of the externalized concepts.

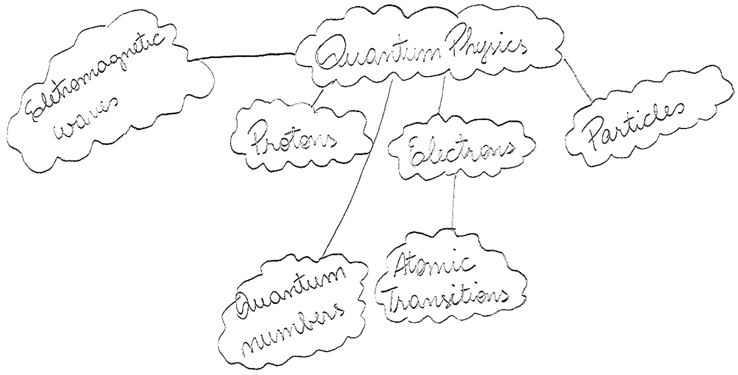

Figure 03: mind map of pair B.

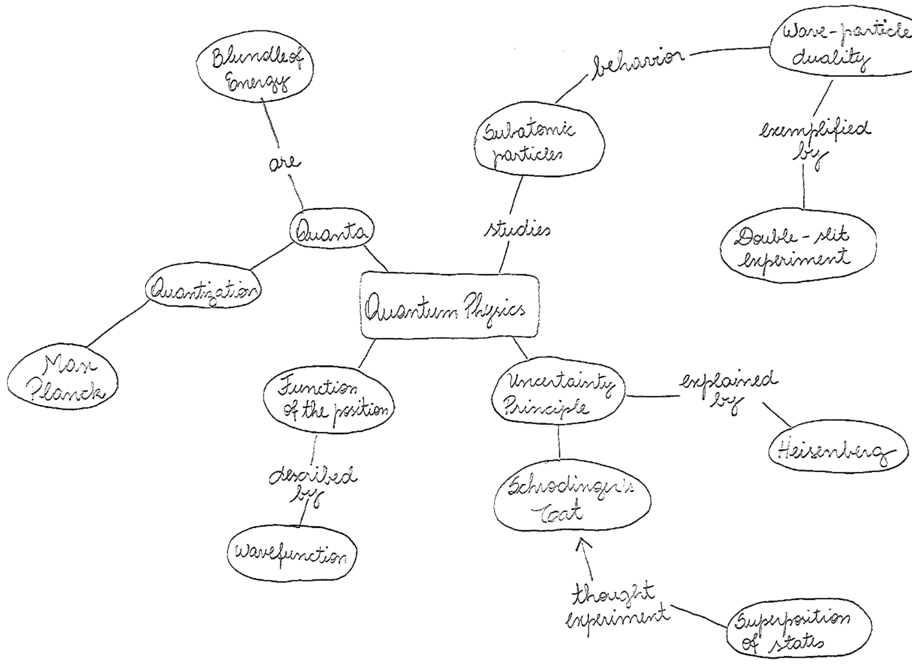

Figure 04: a concept map of pair B.

According to figure 05, which presents the mind map of pair C, students have performed free associations, without connecting elements and, possibly, without knowing how each term relates to quantum physics. This might be noticed in some unbound terms, such as "variety" and "universe". There is a hierarchy for magnetism and magnet, as well as between numbers and formulae, but these concepts and others presented through the map are not related directly with quantum physics, but to electromagnetism (electricity, polarity) and to the traditional approach to contents of physics (quantity, theories).

The concept map in figure 06 displays some of the concepts more than once (electron, proton, atom), while the concept 'quantum' that is highly considered in quantum physics appears there just as a connecting word. The sentence "quantization is a mathematical procedure for the construction of a quantum model for a physical system", as well as application examples such as "development of faster computers" and complements to theory like "modernness" and its ramifications. Furthermore, these students do not seem to have a clear view of the concepts since, basically, the contents presented in the classroom is shown as linked to the central concept by means of the connecting word "subdivisions", which does not correspond to the scientifically accepted relation between these concepts. Linkages that are seen as external to the quantum theory, which in this concept map are represented as related to spirituality and consciousness, might be there as outcomes from verbal interactions in the classroom and we expected, at the end of the activities involved in the development of the chosen content, these issues not to be related to quantum physics anymore. Although some of the relations between/among concepts already appear in quite a clear way, this pair needs to clarify others. We can proceed to say that learning is evolving, though it has not become effective yet.

Figure 05: mind map of pair C.

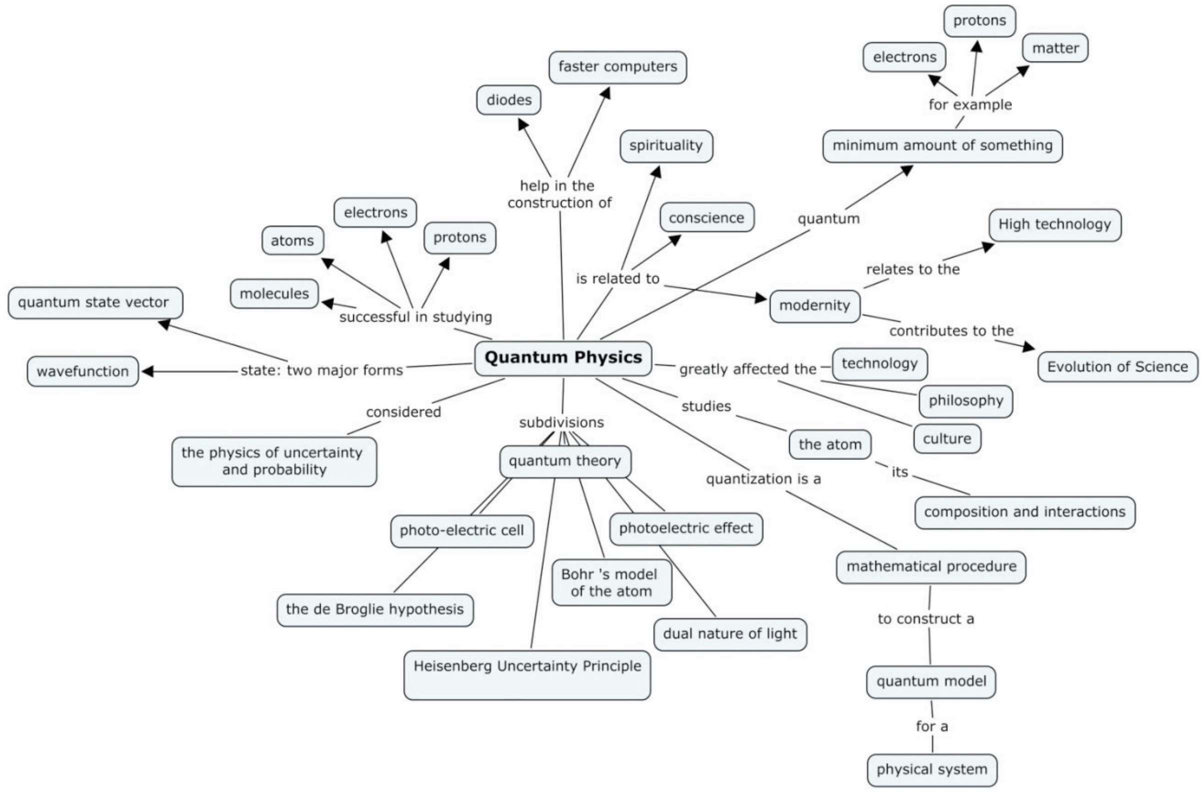

Figure 06: concept map of pair C.

Considering the statements already made, some signs of meaningful learning were found here because the students expressed concepts and relations as they are scientifically accepted in the quantum physics area, in agreement with the level of understanding expected at high school. Besides, each pair of students thought about the evolution of their maps, as it is presented in table 02, which corroborates these observations.

More evidences of meaningful learning might be found in the other performed tasks developed by the students since this research is still in the data collecting stage.

Pair A	"The second map was a lot different from the first one because our idea about each presented concept had changed, and this helped us improve our understanding of each part of the content. And the connecting words between/among the concepts helped us to better retrieve the subject matter".
Pair B	"In the first map, we did not have a hint on what we were writing, and we just placed irrelevant terms there. In the second one, we knew the concepts and linkages we wanted to place there, since our knowledge had increased a lot."
Pair C	"Comparing the maps, we can perceive a relevant evolution from the first map to the second one. Besides the indicated program for developing our work, the examples of maps were of great importance. Classes in the multimedia classroom were another important constant. However, there is a lot to improve notwithstanding our evolution from the first to the second map. We did not have a concrete opinion about the topic, which was unknown to us, so that we wrote words that could have any linkages and, furthermore, we did not have enough knowledge to construct a concept map."

Table 02: students' thoughts about the comparison of their mind and concept maps.

5 Final Remarks

Although data analysis has not be concluded yet, it seems possible to anticipate some evidences of meaningful learning when we compare mind maps—drawn at the beginning of this intervention as a means to detect subsumers—with concept maps—indicators for the evolution of the students' knowledge of quantum physics—exploring the relations between/among concepts scientifically accepted. The use of maps has been a good resource to observe knowledge evolution, and it has helped the teacher/researcher and the students to identify linkages that have been assimilated, as well as comprehension gaps, facilitating the review of concepts that have not yet been totally elucidated in the next steps of the PMTU proposal.

We still need to examine the data related to all the other activities performed by the students, in which we expect to obtain more consistent indicators of meaningful learning. The approach to quantum physics in high school has shown itself feasible and it has brought promising outcomes. The use of PMTU as a methodological proposal is innovative for it comprises quite an up-to-date approach.

The use of PMTU, with resources such as mind maps and concept maps, can be much more than a tool to promote meaningful learning: it can become a motivating option for curriculum improvement and for the insertion of quantum physics topics of modern and contemporary physics in high school

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UNA EXPERIENCIA DE INTRODUCCIÓN DE LOS MAPAS CONCEPTUALES EN ALUMNOS DE EDUCACIÓN INFANTIL

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Abstract. Se presenta en este estudio el diseño, implementación y resultados de una experiencia que tuvo como objetivo principal la introducción de la estrategia de los mapas conceptuales (MMCC) en alumnos de educación Infantil en un colegio de Pamplona (España). La experiencia fue llevada a cabo por un grupo de alumnos del grado de Maestro en Educación Infantil de la Universidad Pública de Navarra, en el marco de la asignatura Practicum III. Esta asignatura complementa a otra titulada Didáctica del Medio Natural y permite poner en práctica con el alumnado de Infantil la metodología de los MMCC que, naturalmente con otro alcance desarrolla el alumnado universitario. La metodología implicó trabajo a dos niveles por un lado el de las alumnas en prácticas, en concreto la elaboración del módulo instruccional correspondiente, con el uso del Cmap Tools y por otro el del alumnado infantil poniendo en práctica el diseño realizado. Los resultados evidenciaron un aprendizaje significativo de la estrategia de los MMCC así como una aumento de la autoestima en los niños y un incremento notable de las ganas de aprender.

1 Introducción

En la Figura 1. Se detalla el proyecto de investigación implementado en el aula.

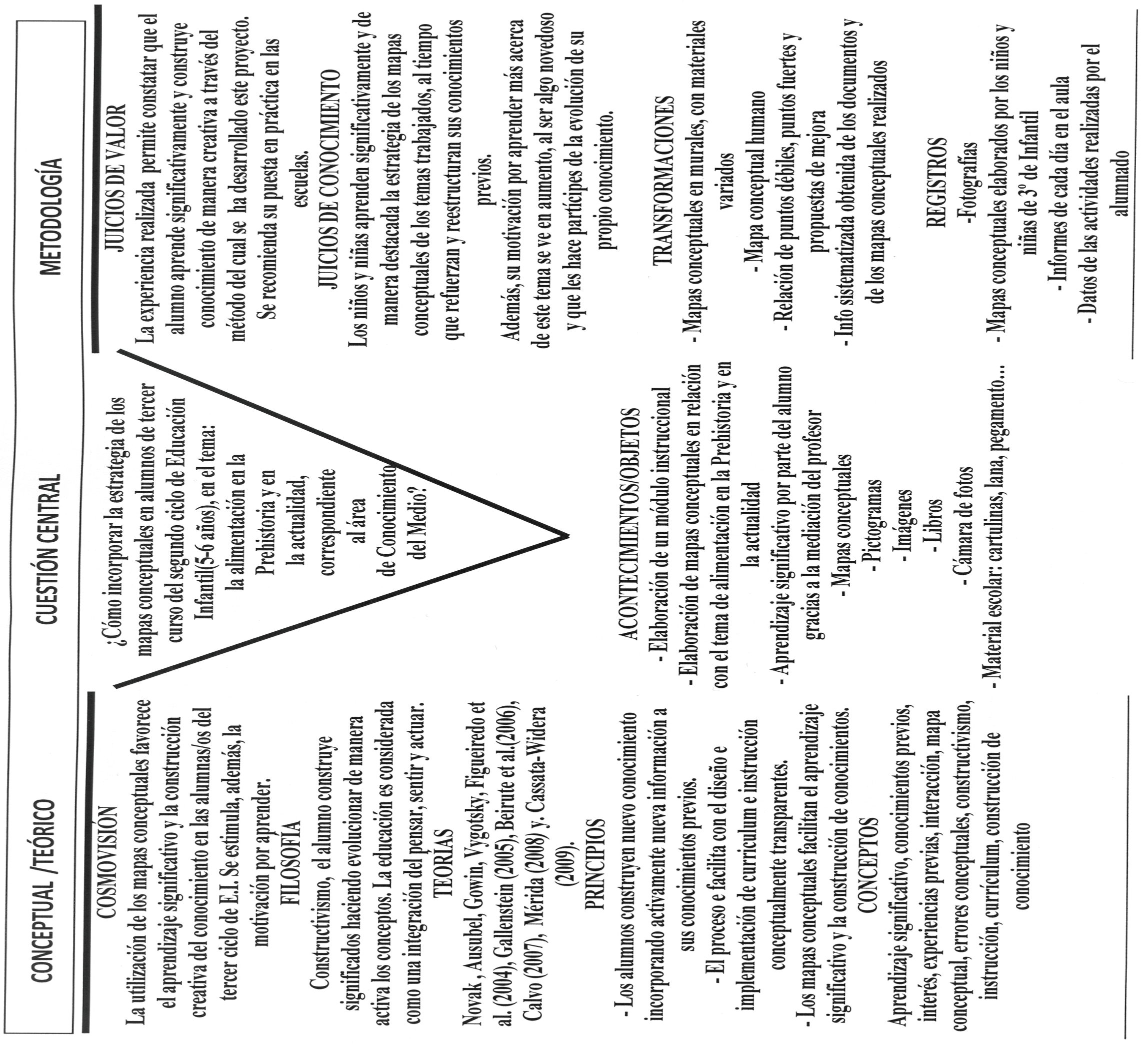

Figura 1. Diagrama UVE detallando el proceso de la investigación realizada.

El proyecto que se presenta se realizó durante el mes de noviembre de 2011 por un grupo de cinco alumnas de la Universidad Pública de Navarra. Ésta actividad se enmarcó dentro de la semana dedicada a la asignatura denominada Practicum III que complementa a la asignatura Didáctica del Medio Natural, correspondiente al quinto semestre de la Titulación de Maestro de Educación Infantil y que fue diseñada siguiendo las directrices del Espacio Europeo de Educación Superior. La experiencia fue tutorizada por profesorado de la universidad y del Colegio Calasanz de Pamplona, centro donde se realizaron dichas prácticas. La asignatura Prácticum III permite poner en práctica con niños y niñas en la escuela, la metodología desarrollada en la asignatura universitaria mencionada.

La preparación del proyecto (despacho) se llevó a cabo en una semana, y la aplicación en el centro(campo) del mismo se desarrolló durante las mañanas de la semana siguiente. Cada mañana se dedicaron dos horas a la puesta en práctica del proyecto en dos aulas distintas, con el alumnado del 3º curso de Educación Infantil, y con una media de 24 niñas y niños por clase.

El proyecto se inspiró fundamentalmente en los marcos teóricos de Ausubel (1976), Novak y Gowin (1988) y Vygotsky (1978). Desde el punto de vista práctico/metodológico, se analizó literatura relacionada, con especial énfasis en los trabajos de Figueiredo et al. (2004), Gallenstein (2005), Beirute et al. (2006), Calvo (2007), Mérida (2008*),* González García (2008) y Cassata-Widera (2009).

La visibilidad de todo el proyecto puede hacerse a través de la siguiente ruta de Cmap Tools: Shared Cmaps in Places→Universidad Pública de Navarra.(España)→Asegroup

2 Metodología

La metodología implementada se basó en una participación activa del alumnado. Así, tenían que reflexionar acerca del tema a tratar conectando los conocimientos previos y los nuevos, para entonces conseguir un buen anclaje en su estructura cognitiva. Para introducir la estrategia de los MMCC, que desconocían, se comenzó con un tema común a ellos: La FAMILIA. El tema había sido tratado con anterioridad por lo que el proceso iba a ser más fácil para ellos. Posteriormente se decidió continuar con el tema que se estaba impartiendo en el aula: La PREHISTORIA. Para ello se preparó un modelo de conocimiento, formado por un mapa conceptual (MC) básico y recursos asociados. En la Figura 2 se muestra un aspecto parcial del mismo. Concretamente la información relativa al tema a tratar.

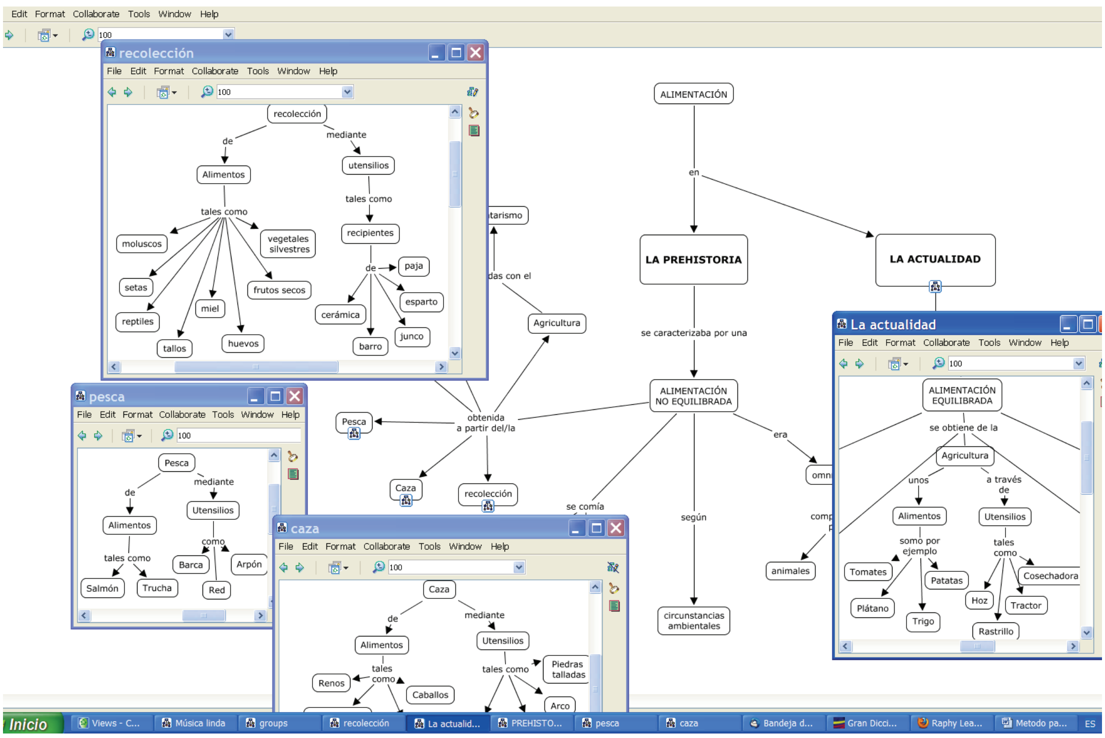

Figura 2. MC del tema alimentación en la Prehistoria y en la actualidad.

El mapa incluyó el diseño instruccional correspondiente, adaptado a los niveles, intereses, necesidades, etc. del alumnado y a las características del aula. Posteriormente, se desarrollaron actividades en las que se iban dando progresivamente responsabilidades al alumnado a la hora de su elaboración(ver Figura 3). De este modo, fueron adquiriendo los conocimientos poco a poco.

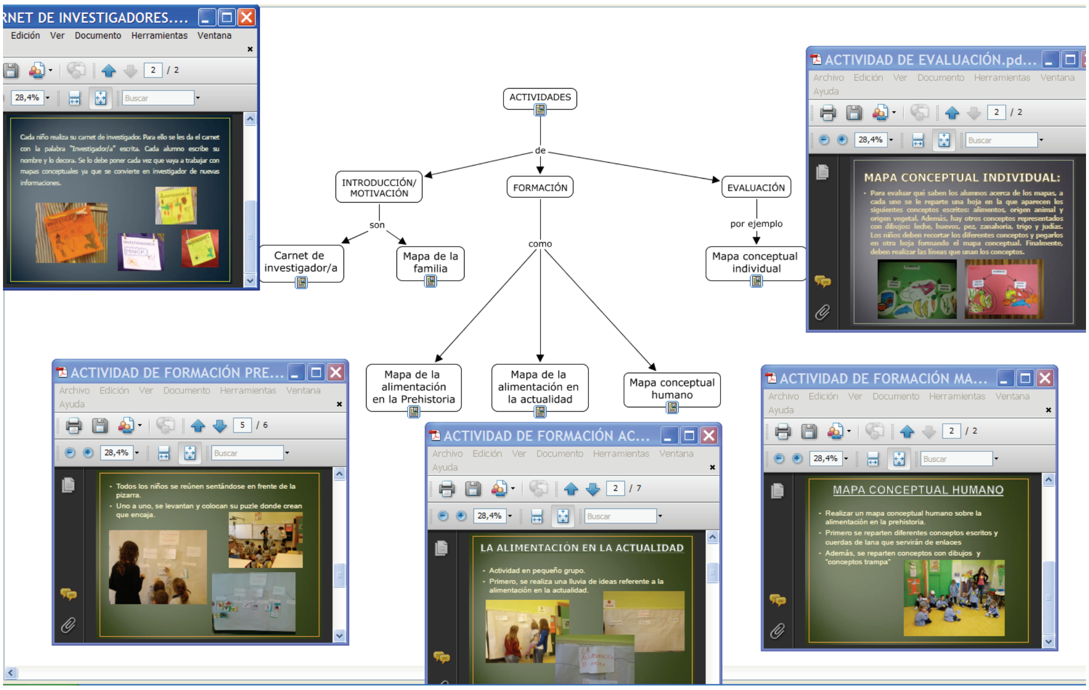

Figura 3. MC de las ACTIVIDADES con recursos desplegados.

Teniendo en cuenta que el juego en esta etapa es un importante factor motivador, se intentó introducir cada día dinámicas lúdicas en cada actividad (puzzles, pintar…). Asimismo, como estímulo diario, se incluyó lo que se denominó “Carnet de Investigador/a” (ver Figura 3). Con ello se trató de recordar a los alumnos y alumnas lo esenciales que son cada uno de ellos en la realización de los MMCC, y de conseguir un ambiente que propicie la imaginación.

Para la optimización del proceso se crearon situaciones en las que el propio alumnado podía expresar sus dudas a sus compañeros, y estos podían responder con los conocimientos adquiridos a lo largo del proceso de aprendizaje. Su actitud fue en todo momento receptiva, resultando una fuente de motivación extra el hecho de escuchar las explicaciones entre iguales. En coherencia con lo anterior las actividades que se decidió realizar fueron las siguientes*:*

Actividades de introducción/motivación: Carnet de investigadores, MC de la Familia.

Actividades de formación: MC de la alimentación en la Prehistoria, MC de la alimentación en la actualidad.

Actividades de Evaluación: MC individual.

El hecho de disponer en el Centro de dos aulas con alumnado distinto, permitió observar las diferencias de cada grupo, y ello obligó a adaptarse a cada uno, de modo que se aplicaron en el proyecto dos metodologías distintas, aunque con la misma fundamentación teórica.

En una de las clases se comenzó trabajando los mapas sin incidir en el sentido de las flechas que unían los conceptos en el mapa, sino que esa parte se les daba hecha. Poco a poco y con la elaboración de más mapas, se fue matizando su sentido. Para el tercer día de la experiencia, los niños y niñas ya sabían colocar la flecha apuntando en el sentido correcto. En cambio, en la otra clase desde el primer momento se optó por introducir el sentido de las flechas. Aunque el primer día resultó muy difícil y se les tuvo que ayudar mucho, se comprobó que para el tercer día, el sentido de las flechas no resultaba ya un problema. Por tanto, aunque los inicios fueran diferentes ambos métodos dieron buen resultado.

También en las actividades de evaluación, se experimentaron dos procedimientos distintos. En una clase se ofreció soporte al alumnado por parte del profesorado y de los propios compañeros, que podían ayudarse entre sí. En cambio, en la otra clase se les dijo a los niños y niñas que trabajaran únicamente de forma individual. Se observó que la ayuda suministrada por parte de sus compañeros y compañeras era complicada de controlar, ya que en ocasiones se "chivaban" sin explicar correctamente los porqués de sus respuestas. Por ello, en el aula donde esto se permitió hubo más aciertos, pero no pudimos confirmar que todos ellos fueran por una buena asimilación de las ideas. Sin embargo, en el aula en el que no hubo ayuda externa, la evaluación fue más objetiva corroborándose así que alumnos y alumnas habían interiorizado las ideas.

Se pudo comprobar que cada grupo respondía a las actividades de una manera distinta y por tanto sus respuestas son las que marcaban el ritmo y la metodología a seguir. Es obvio que si se hubiese trabajado de igual manera en las dos clases, no habríamos podido comprobar las reflexiones anteriores.

2.1 Contenidos

Para la realización de este proyecto, por un lado se agruparon los contenidos que tenían que ver con las diferentes informaciones que se trabajaron en los MMCC, esto es: modos de obtener alimentos en la Prehistoria, modos de obtener alimentos en la actualidad. alimentos y utensilios propios de la Prehistoria, alimentos y utensilios propios de la actualidad, origen vegetal y origen animal y, por otro lado, se tratan los contenidos que corresponden a la noción de MC: MC como forma de organizar la información, conceptos, líneas de enlace.

2.2 Actividades

Para la enseñanza de los MMCC, se llevaron a cabo las siguientes actividades agrupadas en tres bloques:

2.2.1 Actividades de Introducción / Motivación

2.2.1.1 Carnet de Investigador

La idea de esta actividad era añadir un elemento motivador para los alumnos frente al nuevo conocimiento que se les iba a presentar: los MMCC. Se pretendía que los mapas les convirtieran en protagonistas de su propio aprendizaje. El material ofrecido para ello, fue un carnet de investigador, en el cual cada alumno escribía su nombre y lo decoraba. Este carnet se lo ponían cada vez que íbamos a trabajar con MMCC.
La valoración para esta actividad transversal a todo el proyecto fue muy positiva. Resultó ser un gran incentivo para los niños y niñas el hecho de sentirse los protagonistas del proceso de una manera tan tangible.

2.2.1.2 MC de la Familia

Esta actividad fue ideada con el objetivo de introducir el término y la enseñanza del propio MC antes de entrar de lleno en el tema planteado para el proyecto. Para ello, se colocó en la pizarra un papel con el concepto "Mi Familia", y se preguntó a los alumnos qué miembros pueden integrar una Familia. Conforme los iban diciendo, se colocaron en una hilera en la pizarra los conceptos correspondientes ilustrados por imágenes.

A continuación se explicó que todos los miembros de la Familia estaban en desorden y que existía una forma de ordenarlos. De esta forma, se fue confeccionando un MC, formulando preguntas como: ¿Quiénes son los más mayores de la Familia?, ¿Los abuelos de quiénes son padres?, etc., y colocando los conceptos en orden cronológico (de arriba a abajo) que ellos deducían. Una vez colocados los conceptos, se dibujaron los enlaces a través de diferentes líneas. Por un lado, líneas verticales para indicar que un concepto "es hijo" de otro, y por otro lado líneas horizontales para explicar que dos conceptos "están casados o viven juntos".

La experiencia resultó muy interesante, porque se pudo constatar que los niños tenían mucho interés en aprender y enseguida entendieron muy bien qué era un MC. También se pudo, así, constatar el punto desde el que partíamos con estos nuevos alumnos. Además, al empezar con un tema conocido y que dominaban como la Familia, se sentían motivados y participaban constantemente. Lo más importante de esa actividad fue que los niños comprendieran que en un mapa debe haber conceptos y líneas.

2.2.2 Actividades Formativas

2.2.2.1 MC de la Alimentación en la Prehistoria

Esta actividad permitió la introducción del alumnado en el tema pensado para trabajar por medio de los MMCC. Se pretendió realizar un MC no demasiado guiado, sino permitiendo a los niños y niñas la capacidad de error y aprendizaje, sobre la alimentación en la Prehistoria (Figura 4)

Primero se realizó una lluvia de ideas acerca de los artilugios que se utilizaban durante esa época y alimentos que se comían. Esto lo hicimos como introducción a la actividad, para que tuvieran claros los conceptos del los cuales tenían que partir, y como toma de contacto con sus conocimientos previos. Tras ello, les repartimos unos puzzles que contenían la mayoría de alimentos y utensilios que habían dicho. Individualmente, en sus mesas, los construyeron y pegaron en cartulinas, escribiendo luego el nombre del dibujo. Ya reunidos en grupo, fueron diciendo qué tenían cada uno, y pudimos agrupar los conceptos que tenían en “cosas que se comen” (alimentos) y “cosas que se necesitan para obtener alimento” (utensilios).

A continuación, se rescataron las ideas antes dichas en el inicio de la actividad por los niños y niñas acerca de donde se obtienen los alimentos: pesca, recolección y caza. Se fueron poniendo en el mapa, haciendo hincapié en que esas ideas partían de una idea más general: “La alimentación en la Prehistoria”. Desde aquí, se les hizo ver que de los conceptos pesca, caza y recolección, podíamos también sacar las ideas de “alimentos” y “utensilios” que tenemos en cada grupo (podemos cazar este alimento con este utensilio, por tanto las cosas de caza se pueden dividir en alimentos y utensilios).

Así, fueron de uno en uno colocando sus cartulinas donde creían más conveniente (el que tenía un pescado, tenía que razonar que aquello era un alimento que se conseguía mediante la pesca), siempre con la revisión del resto de sus compañeros que estaban atentos para corregir.

Fue un proceso muy interesante que puede llevarse a cabo de diferentes formas, según lo guiada que se quiera realizar la actividad (Figura 5?). En todo momento la mayoría de los niños y niñas se mostraron muy dispuestos y motivados con la idea de realizar todos juntos un mapa tan grande, lo que se consideró muy positivo.

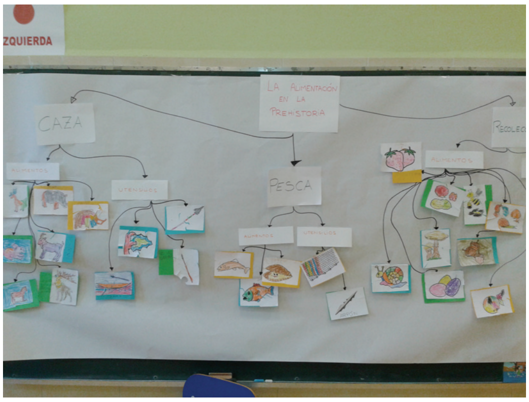

Figura 4: MC de la alimentación en la Prehistoria

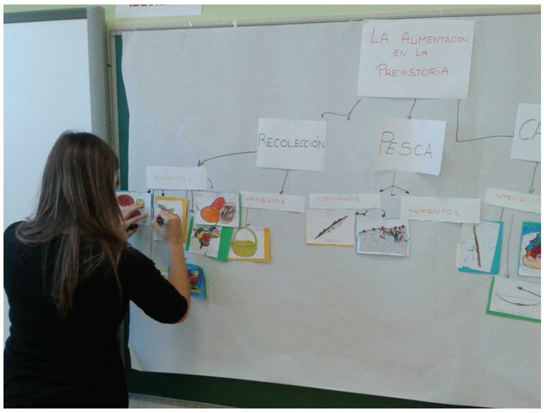

Figura 5: Proceso de elaboración del MC

2.2.2.2 MC de la Alimentación en la Actualidad

La siguiente actividad que realizamos con los niños y niñas fue un MC sobre la alimentación en la actualidad (Figura 6). El fin de esta actividad era por un lado afianzar la realización de MMCC y, por otro, comparar mediante los MMCC nuestra alimentación, con la alimentación de la Prehistoria trabajada anteriormente.

El mapa de la alimentación en la actualidad lo realizaron los niños y niñas en pequeños equipos. Primero, se realizó una lluvia de ideas referente a la alimentación en la actualidad, para que comprendieran que no iban a incluirse los mismos conceptos que en la Prehistoria. En vez de caza, era ganadería; en vez de recolección era agricultura; mientras que la pesca se mantuvo. Los conceptos de alimentos y utensilios también se mantuvieron. Después de esto, los niños se sentaron en las mesas en pequeños grupos. Cada grupo se encargó de un concepto determinado como alimentos de ganadería, utensilios de ganadería, alimentos de agricultura, utensilios de agricultura, alimentos de pesca y utensilios de pesca. Para ello, cada niño dibujó en una cuartilla algo de lo que le había tocado: un alimento/utensilio de cualquier de las tres categorías. Después, pegaron todas las cuartillas del grupo en una cartulina, con el título que correspondía en la parte de arriba (por ejemplo, alimentos).

Finalmente, cada grupo salió a la pizarra y pegó la cartulina sobre el papel de estraza, realizando las líneas y formando el MC (Figura 7).

Consideramos que los resultados que obtuvimos con esta actividad fueron muy positivos. Los niños y niñas ya comenzaban a realizar los MMCC de manera autónoma ya que en todo momento sabían cómo y dónde colocar los dibujos que ellos mismos habían realizado.

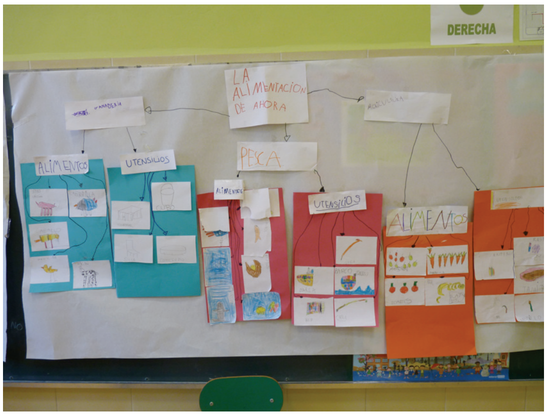

Figura 6: MC de la alimentación en la actualidad

Figura 7: Grupo de niños/as pegando los alimentos de la agricultura en el gran MC

2.2.3 Actividades de Evaluación

2.2.3.1 MC Individual

Finalmente necesitábamos una actividad que evaluara todo el proceso seguido y que comprobara si cada niño/a había entendido qué era un MC y para qué se utilizaba. Para ello a cada alumno/a se le repartió una hoja en la que aparecían los siguientes conceptos escritos: alimentos, origen animal y origen vegetal. Además, había otros conceptos representados con dibujos: leche, huevos, pez, zanahoria, trigo y judías (Figura 8). Los niños debían recortar los diferentes conceptos y pegarlos en otra hoja formando su propio MC (Figura 9). Finalmente, debían realizar las líneas que unían unos conceptos con otros.

Mientras los niños y niñas realizaban la actividad, las profesoras en prácticas procuraron no influir mucho en sus decisiones para valorar realmente qué es lo que habían aprendido. Se pudo constatar que más de la mitad de los niños y niñas habían realizado el mapa correctamente. Los fallos más comunes que pudimos observar fueron, por un lado, la clasificación de los alimentos (en origen vegetal o animal) y el sentido de las flechas que unían unos conceptos con otros.

Valoramos la actividad muy positivamente ya que los niños y niñas estaban muy motivados en la realización de los mapas individuales. Consideramos que el método fue acertado, ya que los niños y niñas podían ver su evolución personal y se sentían muy contentos al ver que ellos solos podían realizar MMCC.

Figura 8: Niñas/os pintando los conceptos del MC

Figura 9: Niñas realizando su propio MC sobre el origen de los alimentos

3 Discusión y Resultados

El resultado global de este proyecto ha sido realmente positivo y satisfactorio no solo para el alumnado infantil sino que también para las alumnas en prácticas y futuras maestras. La experiencia vivida acercó los mundos de la teoría y la realidad a ambos colectivos. Al trabajar los MMCC basados en la teoría de Ausubel y Novak se ha comprobado cómo se lleva a cabo un aprendizaje significativo a través del cual los alumnos y alumnas incorporan nuevos conocimientos a la estructura cognitiva preexistente.

Como se puede observar en la Figura 3, se partió de un MC como modelo de conocimiento para describir la alimentación en la Prehistoria y en la actualidad contrastándose su virtualidad en la práctica. De una consideración crítica del trabajo desarrollado se extraen una serie de aspectos a reseñar. Por un lado, como puntos fuertes, se puede citar el apoyo recibido por parte del centro y la motivación y buena disposición hacia el trabajo del grupo de niños y niñas. En cualquier caso queda clara la necesidad de promoverlas antes y fomentaras durante la actividad, en línea con Calvo (2007).

Respecto a la metodología, se debe tratar de hacer partícipes a los alumnos y alumnas de su propio aprendizaje partiendo de un tema de interés y a través de una dinámica interactiva facilitada por el diálogo, confirmando datos de Beirute (2006). Por esta razón, además de trabajar los MMCC, se introdujeron actividades cercanas (dibujar, recortar, hacer puzles…) que ayudasen a construir los mapas y facilitándose el aprendizaje significativo. Esto se puede observar en la Figura 4, donde se muestra el MC que desglosa las actividades, así como imágenes del proceso y los resultados.

Otro aspecto esencial fue la realización de los mapas con preconceptos, es decir, imágenes, dibujos y símbolos que facilitan la comprensión. La utilización de esta metodología es compartida por otros autores como Calvo (2007), Mérida (2008) y Figuereido (2004). A las imágenes o símbolos se les puede añadir la grafía correspondiente, reforzando el aprendizaje de aquellos alumnos y alumnas que ya se desenvuelven a niveles aceptables en sus capacidades de comprensión lectora y escrita.

Debe tenerse en cuenta siempre que la realización de MMCC con niños y niñas de corta edad debe ir muy apoyada por explicaciones orales, una introducción común y dialogada del MC, así como por una interpretación oral. Estos aspectos han sido enfatizados también en los trabajos de Calvo (2007 y Beirute et al. (2006).

A destacar, finalmente, que los maestros y maestras deben estar totalmente abiertos a las sugerencias del alumnado y en ocasiones deban añadir nuevos conceptos que no estaban previstos y surgen de las intervenciones infantiles, en concordancia con Figuereido et al. (2004)

4 Conclusiones

Como reflexión final y a la luz de la experiencia realizada, nos parece oportuno reflejar algunas consideraciones para ser tenidas en cuenta en trabajos posteriores.

Los MMCC suelen ser una herramienta totalmente desconocida para los niños y niñas, por lo que en un principio este hecho puede parecer un obstáculo. Por ello, es necesario trabajar previamente con esta herramienta y conocerla a fondo, antes de llevar el trabajo a la práctica con el grupo clase.

También puede ser un inconveniente no conocer al grupo de alumnos y alumnas con el que se va a trabajar, ya que no se sabe lo suficiente acerca de sus necesidades y conocimientos previos y esto puede dificultar la preparación de las actividades. Es aquí donde cobra especial importancia la comunicación anterior con el centro y los tutores.

Por otra parte, el proyecto se llevó a cabo en una semana, un tiempo escaso ya que se condensa demasiada información sobre un mismo tema y el alumnado puede cansarse. Por ello, creemos que la mejor forma de trabajar con esta herramienta sería durante un tiempo más largo y de actividad menos intensa, alternando con otro tipo de actividades e integrándola en el día a día, coincidiendo con Mérida (2008) y Calvo (2007).

La investigación realizada permite certificar los MMCC son una herramienta muy eficaz para el aprendizaje, y que puede ser utilizada en diversos contextos y situaciones. Las diferentes metodologías utilizadas en las dos clases, pusieron de manifiesto que la mayoría de niños y niñas comprendieron e interiorizaron la idea del MC, aumentando su autoestima personal y sus ganas de aprender.

Finalmente la convivencia en el centro entre tutores maestras profesionales, alumnas en prácticas y alumnado infantil ha permitido el trasvase en todos sentidos de teoría y práctica que ha permitido un enriquecimiento mutuo y un ambiente de aprendizaje y emocional realmente gratificante, validando con creces esta modalidad formativa.

5 Agradecimiento

A Lourdes Gastearena por la maquetación del texto.

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UNCOVERING DIFFERENCES IN THE CONCEPTUAL VIEWS OF EXPERT AND NOVICE TEACHERS THROUGH CONCEPT MAPS PRODUCED BY SCONSAT INTERVIEWS

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Abstract. This study describes the use of concept mapping in regard to teachers' views on the meaning of knowledge, learning, and expertise of teachers, as produced by SConSAT (Standardized Concept Structuring Analysis Task) interviews with expert and novice teachers. The study is based on the assumption that concept maps are cognitive and meta-cognitive tools that make it possible to reveal covert and overt aspects of one's inner perceptions and to represent relationships between the concepts and the ideas associated with them in a flexible manner and in a variety of modes of representation (both verbal and graphic). The study suggests an informative and innovative analysis of concept maps and shows that concept maps can reveal differences in the conceptual views of novice and expert teachers, characterize them, and identify their connection to teachers' reflective thinking.

1 Introduction

Concept map is a tool that provides an external graphic representation of one's inner cognitive structure. It is the organized body of knowledge stored in one's long-term memory in the form of a semantic network of concepts, patterns, and systems of opinions, beliefs, and products (Ausubel, Novak & Hanesian, 1978). Many studies therefore, describe how concept maps are used to evaluate learners' knowledge structure, with a wide variety of goals and ways of constructing the map and interpreting its data (Cañas et al., 2003). Over the years concept maps have been used extensively both for purposes of teaching and knowledge structuring and as a tool for educational research (Hibberd, Jones & Morris, 2002). Moreover, some studies also describe the use of concept maps as a tool for revealing views, values, beliefs, or theories that constitute and reflect worldviews (Levine & Simon, 2009; Pomson & Hoz, 1998). Based on the research literature, which shows differences in the reasoning and functioning of expert and novice teachers (Berliner, 2004), the purpose of the current study is to examine how differences in the conceptual views of expert and novice teachers are manifested in conceptual mapping developed through SConSAT (Standardized Concept Structuring Analysis Task) interviews (Pomson & Hoz, 1998). The interviews and construction of the maps are further discussed in the methodology section.

The term "conceptual view" is defined as a personal mental structure that includes one's ideology, beliefs, perceptions, opinions, ideas, or theories, reflecting a significant integrated essence, a type of knowledge schema referring to a particular, spiritual, or actual entity (Levin & Simon, 2009; Pomson & Hoz, 1998). Conceptual views are therefore characterized by the following features: they are subjective and not always conscious; they could develop from theories, from practice, or from one's inner world and interactions with the world and society; they have a comprehensive, integrated, coherent and organized nature, and can be justified and defended by the person holding them; they are dynamic entities that can undergo changes based on practice and / or exposure to other sources of knowledge including other people. Since the study makes use of concept mapping to reveal the conceptual views of expert and novice teachers, we shall present in short major features of the thinking and reasoning of experts, and particularly of teaching experts.

2 Features of teacher expertise

Knowledge of expertise is based mainly on studies conducted in different disciplines where experts were asked to "think aloud" while performing problem solving tasks in their field (e.g. Berliner, 2004; Ericsson & Simon, 1998). The research literature shows that the exceptional performance of experts with domain-related knowledge has to do not only with their wider, richer, and more complex knowledge base, but also with its different organization compared to that of novices (e.g. Ericsson & Lehmann, 1996). Some claim that the multi-dimensional organization of experts' knowledge base reflects the quality and efficiency of their thinking, and that: 1. Knowledge representations of experts are constructed around domain-related key concepts and organized by abstract and inclusive laws and principles (Ericsson & Lehman, 1996). 2. Experts' knowledge schemes make it possible for them to reach deep analyses and complex conceptions of given situations, linking them with other similar situations (Popovic, 2003). 3. The high quality of the mental representations of experts' knowledge enables them to predict future situations based on a relatively small number of cues, and to adjust rapidly to changes in external circumstances (Ericsson & Lehman, 1996; Berliner, 2004).

Following the research on expertise in general, teacher expertise was studied as well (e.g., Berliner, 2004; Hogan, Rabinowitz & Craven, 2003), emphasizing mainly the behaviors of expert and novice teachers and the representations of reasoning and decision making processes they employ in the classroom. Based on an extensive research review, Hogan et al. (2003) describe clear differences between expert and novice teachers as related to decision making and problem solving in teaching. Expert teachers focus on the learning process and on students' ability to understand the concepts taught, address short and long-term teaching goals simultaneously; employ alternative teaching strategies corresponding to students' difficulties, easily identify problems that arise during the lesson, and spontaneously use multiple solution strategies. In contrast, novice teachers focus on their own abilities to implement the teaching process, focusing mainly on short-term and discrete teaching goals, use detailed plans for each part of the lesson and implement it strictly as planned, and do not always discern problems in lesson management in the classroom.

The research literature shows that experts' knowledge base is constructed through a lengthy training process focusing on one domain, and that this is the main reason for experts' distinct exceptional performance in that domain (Ericsson & Lehmann, 1996). It takes about four and a half years for successful teachers to learn how to teach well (Berliner, 2004), and teachers only reach maximal success in promoting student achievements after some seven years of teaching (Berliner, 2004). However, lengthy experience is not enough. One of the major conditions for the development of expertise is the existence of reflective and meta-cognitive processes, as part of the self-direction and supervision that accompanies the process of experiencing and learning. Since the literature shows that concept mapping relies on and activates reflective and meta-cognitive thinking, the main research question was: What are the similarities and differences in the conceptual views of expert and novice teachers concerning three major concepts: knowledge, learning, and expertise?

3 Methodology

3.1 Research type

The study is a mixed method study examining conceptual views of history high school teachers, both expert and novice, concerning ideas associated with the concepts of knowledge, learning, and expertise, using both qualitative and quantitative methods of analysis.

3.2 Participants

This study presents the concept maps of ten in-service high school history teachers, five women and five men, with 1 to 29 years of experience, from five different cities throughout the central region of Israel. It is part of a larger study exploring teachers' personal epistemology and self efficacy beliefs. The ten teachers were chosen by experience and gender from a convenience sample of 35 high school history teachers who gave their consent to be interviewed at the end of a questionnaire measuring teachers' personal epistemological beliefs. Based on Berliner's (2004) heuristic model of teacher development, novice teachers were defined in this study as teachers with 1-3 years of teaching experience, and expert teachers had 4 or more years of experience. Novice teachers had a B.A or B.Ed degree and expert teachers had an M.A. degree.

3.3 Research tools

3.3.1 Concept map produced by the SConSAT interview

The concept map produced by SConSAT (Standardized Concept Structuring Analysis Task) interview is web-type, not necessarily hierarchical, and describes the links between concepts by using whole sentences that explain in detail the essence of the link as perceived by the interviewee (Pomson & Hoz, 1998). Thus, on a sheet of paper the interviewee organizes a selected set of concepts chosen by the researcher, depending on how he or she perceives the relationship and the links between the concepts. The set of concepts selected by the researcher represents a relatively wide area and is regarded as suitable for examining participants' views of it. The SConSAT interview has several distinct stages (Pomson & Hoz, 1998). First, each concept in the set of concepts selected by the researcher is written on a separate card, and all the cards are spread in front of the interviewee on a table. Second, the interviewee is asked to : (1) Define or explain each concept verbally. The definitions are written by the interviewer. (2) Spatially arrange the concept cards on a large sheet of paper, such that this arrangement reflects perceived relations between the concepts. When the interviewee is satisfied with the arrangement, it is copied by the researcher onto the sheet of paper. If concepts are arranged in a group, they are circled by the researcher and marked with a Latin number. (3) Give each group a title, explaining the nature of the group. (4) Verbally express meaningful relations among the concepts or groups of concepts. These linking sentences are recorded by the researcher on lines connecting the concepts. If more than two concepts are linked, the lines connect in a dot on the map. Each link is numbered. The interviewee is allowed to modify the map until he or she is satisfied. (5) Re-inspects the map and add new concepts that are missing from the selected set of concepts according to his or her conception. Appropriate links are added. (6) Provide a title for the whole map. Concepts that the interviewee chose not to include in the map (omitted concepts) are recorded and the interviewee is asked to explain their omission.

The set of concepts used in this study was related to the theory of personal epistemology, self efficacy, and expertise. Based on the literature we selected the following 17 concepts for the SConSAT interview: Knowledge, information, justification, inquiry, truth, evaluation, ambiguity, flexibility, decision making, reflection, learning, insight, thinking, efficacy, control, expertise, experience.

3.4 Research setting and procedure

The SConSAT interviews were conducted in the teacher's home or in a quiet room at the teacher's place of employment. Each interview and development of the concept maps took 45-50 minutes on average.

3.5 Concept map analysis

3.5.1 Map structure and content analysis of the conceptual views

A concept map describes three prominent visual elements reflecting components of one's conceptual view and their interrelations (Yukhnovetsky, 2000): 1. Placement of concepts in the map space; 2. Organization of concepts within each group; and, 3. Linking sentences among/between groups. Map analysis focused therefore on both the structure of the concept map and content analysis of verbal statements.

3.5.1.1 Analysis of concept map structure

Structure analysis of the concept maps was performed in this study through some modifications of the four dimensions of analysis suggested by Yukhnovetsky (2000): **A**. Spatial structure - Features of cognitive structure according to spatial organization of the constructed groups of concepts in the map. **B.** Consolidation - Degree of integration between components of the conceptual view as reflected by the nature of links in the map. **C**. Focus - Major issues in the conceptual view as expressed by concept organization and the prominence of specific concepts. **D**. Depth and wealth of ideas - Complexity and depth of views as reflected by the entanglement of concepts and links

3.5.1.2 Scoring scheme for each dimension of the concept map's structure

In order to analyze and compare the concept maps of different teachers, numerical values were assigned to the data for several characteristics within each of the above mentioned dimension. Scores (in ordinal scale) were determined by a scoring rubric. Using the scoring rubric, each of the dimensions was rated and a general score for the whole map was calculated as well. The scoring scheme is presented in Table 1:

A. Spatial structure	Score
Diffuse arrangement: Displays groups in the map without a clear direction or organization clearly showing how the various parts of the conceptual view fit together.	1
Divided / differentiated arrangement: Displays discrete components of the conceptual view arranged next to each other.	2
Symmetrical arrangement: Displays components of the conceptual view as either related to each other or at odds with each other.	3
Sequenced arrangement (linear or circular): Organization of the components indicating a direction of a process which reflects an idea.	3
System arrangement: Organization indicating a multi-dimensional and a contextual view	4
B. Consolidation	
Simple link Level 1 - Several independent links, each between a pair of concepts within a group. These multiple individual links indicate a non coherent view. Scoring of each link.	1
Simple link Level 2 – A link between a pair of concepts organized in two different groups and also a link between a single concept (outside any group) and an existing group. Scoring of each link.	2
Complex link Level 1 – Links among three or more concepts within a group. Multiplicity of complex relationships indicating an integrative or coherent view. Scoring of each link.	3

Complex link Level 2 – Links between three or more concepts / within or across groups. Scoring of each link.	4
C. Focus	
a. There are no key concepts: Score=0. b. There is a key concept with multiple links: Score=1 c. There is a centrally located key concept: Score=1. d. The location of the key concept and its content/idea/role-based centrality are compatible: Score=3	1-3
All concepts are organized in groups.	3
Concepts are left outside the defined groups or concepts are unlinked (indicating no inclusion within the mental structure or being emotionally loaded concepts.	1
Concepts added to the map (highlighting, expanding, or creating new meanings): For each concept added to the map.	1
All concepts are considered and included in the map (i.e. no concept is left out).	1
D. Depth and wealth of ideas	
1. Coherence of linguistic representations of ideas in the map title and the group titles: a. There is no coherence in content or language representation of the map title and the group titles: Score=0. b. There is a connection of content or linguistic representation, but the group titles in the map represent discrete components of the teacher's view: Score=1. c. Group titles represent connected components of the same context, whereas the map's title represents a different context: Score=2. d. All titles are related thematically and present a coherent view: Score=3.	1-3
2. Complexity of linking sentences,: a. The sentence explains the link's direction: Score=1. b. The sentence describes a process, an opinion, or a belief: Score=2. c. The sentence explains the nature of the process or presents causes and reasons for a certain opinion or belief: Score=3	1-3 for each sent.

Table 1: Scoring scheme for each dimension of the concept map's structure

3.5.2 Content analysis of verbal statements in the map: definitions of concepts and linking sentences

The SConSAT interview generates two types of verbal components: 1. Definitions given by each teacher for the 17 concepts chosen. 2. Linking sentences in the map. Content analysis of these verbal components was carried out in two stages. First, we analyzed the definitions given by all teachers using categories derived by themes emerging from the definitions (emic). Second, we used these categories to analyze the linking sentences connected to central consensual key concepts appearing in the maps of most teachers.

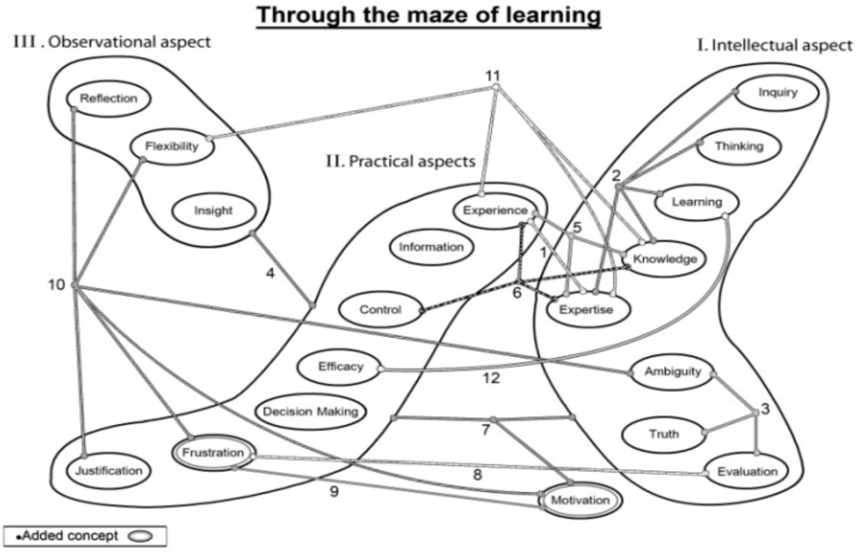
4 Results

First, we present two selected maps generated by an expert and a novice teacher, using the SConSAT interview. The expert teacher's concept map represents the map with the highest general score and the novice's map depicts the one with the lowest score. Following these maps we present the results of the structure analysis of all participating history teachers' maps, according to the levels of their teaching expertise.

4.1 Concept map of Expert Teacher 1 (28 years of teaching)

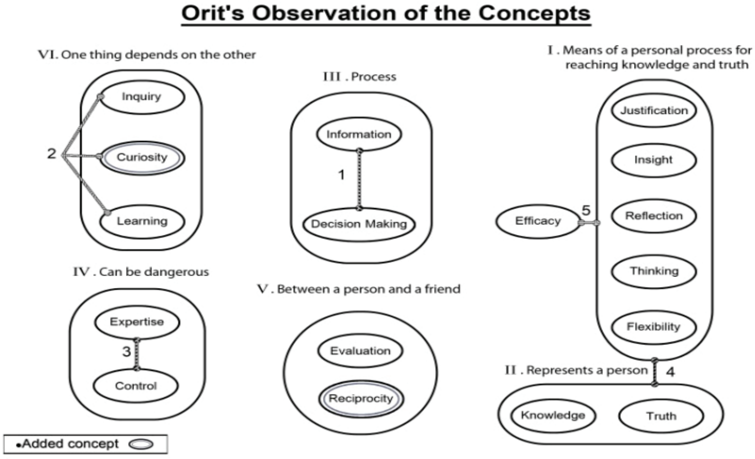
Map Title: Through the Maze of Learning. **Group titles**: I. Intellectual aspect. II. Practical aspects. III. Observational aspect. Key concepts: Expertise, Knowledge. **Omitted concepts**: none. **Added Concepts**: Motivation, Frustration.

Linking sentences: 1. Expertise stems from experience and experience stems from expertise, one leads to the other. 2. The tendency to inquire or to explore is the foundation. It leads you to thinking, and thinking develops a desire to know and leads to learning. In the absence of exploration, learning becomes automatic and lacks depth. This process, of course, leads to knowledge. Putting all of these together, it leads to expertise. 3. Ambiguity is the opposite of the truth. In order to leave things ambiguous, sometimes the truth remains unspoken. These three concepts undermine the process of inquiry, exploration, and thinking, it sounds like indoctrination. You re-evaluate, you check yourself. 4. There is a continuum. Experience leads to ability, to better control, and to meaningful decision making. This is a clear way of thinking; in some way it is a formula. I can justify the whole process I went through. On the other hand, if I don't have reflection, flexibility, and



insight, everything might be undermined. I need to know how to use them. I should have the ability to place myself on the outside, to reflect, to break the rigid formula. Such, that it would not seem that everything is clear to me and understood by me, a kind of doctrinaire ideology. It saves me. **5**. Knowledge leads to expertise and expertise is the basis of experience. **6.** When I accumulate more knowledge, I can control the situation better. When you're talking to some professionals, "selling ice to the Eskimos", your knowledge actually gives you a better sense of control and security. This way, you can convince people to learn something new even when they think they know everything there is to know in their field. **7**. Efficacy is a precondition of the ability to learn. **8**. If I begin a process of inquiry, I need motivation to start the process, something that urges me to take this direction. **9**. In all the steps we take there are delays and frustration. Things do not flow, we depend on others and it's not what we thought it would be. In a way, it causes frustration. **10**. If my motivation is strong enough I can overcome my frustration. **11**. Sometimes reflection leads to frustration. Then, if you are not flexible enough you try to justify the process you went through at all costs. The motivation to justify your moves is strong. If you are really frustrated, you prefer your conclusions to be vague (when you make a decision). **12**. When a person is not sure of his knowledge, his insecurity can lead him to doctrinarism, because his lack of knowledge keeps him in one place.

4.2 Concept map of Novice Teacher 4 (1 year of teaching)



Map Title: Orit's Observation of the Concepts. **Group titles**: I. Means of a personal process for reaching knowledge and truth. II. Represents a person. III. Process. IV. Can be dangerous. V. Between a person and a friend. VI. One thing depends on the other. **Omitted concepts**: Ambiguity, Experience. **Added Concepts**: Reciprocity, Curiosity.

Linking sentences: 1. Information is the basis of decision making. **2**. Curiosity and inquiry are essential for learning. **3**. Expertise and control are problematic or dangerous because they can create vanity. **4**. These are means to arrive at the truth and achieve knowledge. **5**. Efficacy is the result of a process that uses and includes all the concepts.

4.3 Structure analysis of the maps

Structure analysis of the maps shows that there are distinct differences between teachers by level of expertise. The concept maps of teachers with over three years of teaching received higher scores (general scores range from 47 - 86 among experts, compared to 23 – 46 among novices) (see Table 2 and Figure 1). Namely, the maps of expert teachers are more coherent and focused than the maps of novice teachers and they show a greater depth and wealth of ideas.

Expertise	Spatial structure	Consolidation	Focus	Depth and wealth of ideas	Total Score
Expert 1	4	38	11	33	86
Expert 2	2	24	7	35	68
Expert 3	3	23	9	28	63
Expert 4	3	19	9	21	52
Expert 5	3	22	3	21	49
Expert 6	3	19	2	23	47
Range	2-4	19-38	2-11	21-35	47-86
Novice 1	2	15	7	22	46
Novice 2	2	19	4	21	46
Novice 3	3	14	6	9	32
Novice 4	A	11	3	8	23
Range	1-3	11-19	3-7	8-22	23-46

Table 2: Structure analysis scores by levels of expertise

It is important to note that Table 2 shows a greater distribution of scores in the expert group than in the novice group (39 points difference between the lowest and highest general scores, compared to 23 points difference, respectively). In addition, the results show that the general scores of two novice and two expert teachers fall in the same range (score range 40-49, see Figure 1), indicating that in some cases the coherence and depth of the conceptual views of expert teachers are similar to those of novices.

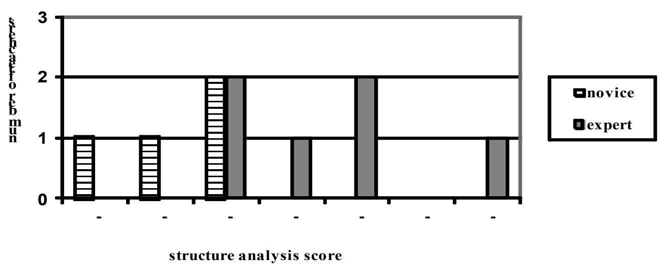


Figure 1: Distribution of structure analysis scores of novices and experts

5 Discussion

Structural analysis of the concept maps in this study demonstrates distinct differences between novice and expert history teachers in the graphic representation of their views concerning ideas associated with knowledge, learning, and expertise. Expert teachers portrayed a more consolidated arrangement of concepts and a higher degree of integration within and between components of the conceptual map. This integration is manifested in: 1. A higher correspondence between the various headings on the map, indicating existing conceptual coherence of teacher views. 2. A greater number of links between concepts; and 3. A larger number of key concepts linked to other concepts. The complexity and depth of expert teachers' conceptual views are also manifested in the linking statements, which show a higher level of reasoning and explanation of their beliefs and ideas.

The findings of this study, which show complex structure and high connectivity expressed in the conceptual maps of expert teachers, are compatible with the findings of other studies exploring differences in the graphical representation of knowledge schema between experts and novices in other fields (e.g. product designers, Popovic, 2003). These studies indicate that the concept maps of experts display a complex structure and contain more links between key or prominent concepts. The findings of the present study also show congruence between the high level of conceptual complexity and the integrative nature of expert teachers' conceptions about knowledge, learning, and teaching, and the stated behavioral and instructional characteristics of expert teachers, as suggested in the literature (Berliner, 2004). The findings show that expert teachers' experiences during their years of teaching, leading to expansion of their knowledge (Hogan, et al., 2003), contribute to the coherence and depth of their conceptual views as revealed in the concept maps.

However, in line with claims by other researchers (e.g. Berliner, 2004), the high variance within the expert group found in this study suggests that teachers' years of experience by itself is not an indication of level of expertise. It is important to distinguish between 'experienced' teachers and 'expert' teachers. Namely, expert teachers are characterized not only by their large knowledge base of accumulated facts from similar processes that recur over time, but also by their ability to respond in an inventive and flexible way to unfamiliar challenges (Berliner, 2004).

The findings of this study also suggest a possible explanation for the differences between novice and expert's conceptual views, i.e. expert teachers' high level of reflective and meta-cognitive thinking. More specifically, the results concerning the dimension 'Depth and wealth of ideas' show that the concept maps of expert teachers reveal more representations of reflective thinking than those of novice teachers. Moreover, linking sentences in the maps of the expert teachers express the idea that experience strengthens teachers' expertise only if accompanied by reflective thinking, as one teacher wrote: "One nurtured the other, expertise feeds reflection and reflection nurtures, inspires and improves expertise". These results are compatible with research in the area of expertise regarding reflective thinking as one of the primary conditions for the development of expertise (Ericsson & Lehmann, 1996; Levin & Nevo, 1998; Tsui, 2009), In particular, Tsui (2009) claims that teacher expertise is developed by constant reflective processes that translate experiences and practical insights into principles of action, organize teachers' practical knowledge as a personal theory, and allow teachers to implement new theoretical knowledge in their teaching practices.

The results of this study, demonstrating more representations of reflective thinking among expert teachers compared with novices, validate and strengthen the usefulness of concept maps in revealing differences characterizing experts' and novices' conceptual views. This is because concept maps as a tool for exposing conceptual views actually activate reflective thinking and meta-cognition (Levin and Simon, 2009). More generally, the advantage of the SConSAT interview presented in this study as a tool for exposing conceptual views is that it is based on active and creative cognitive processes allowing teachers to express their views in a complex way that is both graphic and verbal. Specifically, the creation of the concept map takes place in defined stages and allows teachers to construct their view using various means of representation: words, graphics, and spatial placement. In contrast to other types of qualitative research tools such as interviews, where one’s ideas are verbally communicated linearly one after the other, the concept map affords teachers the flexibility to expose the network of connections between ideas and concepts that constitute their conceptual structure by using multiple presentation modes, where each might reflect a different layer of one's involvement with a particular idea or belief. This flexible and open process reinforces the use of the concept map as a unique instrument for exposing latent components of one's conceptual understanding or beliefs, which are sometimes not even conscious and therefore hard to formulate clearly in words (Pajares, 1992) and do not always emerge in oral interviews.

An additional strength of the concept map as a research tool is that the researcher's impact on the process and its products is very limited compared to the use of other tools for exposing conceptions, such as questionnaires or semi-structured interviews, whose phrasing and even the order of questions can influence respondents’ answers. In this context, it is important to note that although generating a concept map in a SConSAT interview relies on the initial set of concepts chosen by the researcher, the list is not absolute and teachers creating the map may add or subtract concepts in order to present the cognitive structure of their conceptualization as they see fit. Adding new concepts to the map facilitates the reflective process by contributing to the exposure of latent or ambivalent aspects of the teacher's view, thus displaying the conceptualization and its changes with greater clarity. We could therefore say that the concept map is a unique tool that offers a real opportunity to manifest the conceptual ecology of the teacher and can reflect the variability of the teacher's network of cognitive products.

In conclusion, this study describes the unique use of concept maps produced in a SConSAT interview as an instrument for studying differences between expert and novice teachers' views. In contrast to the customary use of concept maps as a knowledge evaluation tool, we presented an approach to concept mapping which makes it possible to collect and analyze data in order to reveal teachers' conceptual views and monitor differences in both visual representation of the perceptions and their verbal-conceptual manifestations. However, due to the limited number of participants in this study we recommend further research to establish the use of concept maps as a valid and multi-representational tool for investigating conceptual views of teachers teaching different subjects at different levels of formal education.

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USING AUTOMATICALLY GENERATED CONCEPT MAPS FOR DOCUMENT UNDERSTANDING: A HUMAN SUBJECTS EXPERIMENT

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Abstract. Concept maps present information in a concise and easily-understood form. Consequently, concept maps of documents are a useful vehicle for summarizing the documents' contents. Concept-map based summaries can in turn be used as the basis for browsable indices to help guide navigation through documents to find material of interest. However, using concept maps in this role depends on the ability to generate a concept map for each document. Especially for large document sets, constructing the needed concept maps by hand may be prohibitively expensive. This paper addresses this problem with an algorithm to automatically generate concept map fragments to aid in document understanding. The algorithm was evaluated with a human subjects study assessing the value of its results to facilitate locating and understanding portions of a document of interest. The study compared subjects' speed and accuracy in answering questions about material contained in a document when using only the document, a manually constructed concept map, or an automatically-generated concept map fragment. The study showed that providing automatically generated concept maps improved user speed while retaining accuracy, for documents whose size enabled capturing most key concepts in a single concept map..

1 Introduction

Concept maps (Novak & Gowin, 1984) provide a useful medium for organizing document information in a concise and accessible form. When captured with electronic concept mapping tools supporting the annotation of concepts with documents, concept maps can serve as a tool to help humans visualize document sets and access documents in an efficient way. Concept maps may also be used to summarize the content of single documents, to facilitate understanding of key concepts and relationships within a document. Those document concept maps may in turn be used as an index for related text passages within the document, to facilitate access to material of interest within the document. Concept map based document summaries and indices could be applied in many contexts to aid document assessment and location of useful material. For example, in training contexts, a concept-map-based summary of a manual could help a user to decide its relevance to a new problem. Likewise, a concept-map-based index captured by an electronic concept mapping tool could help the user find important information within the manual. In the context of intelligence analysis, analysts must identify relevant documents within a huge pool of candidates, without time to read each one. In this case, a concept-map-based summary could assist in rapidly identifying relevant documents, and, when documents are found to be relevant, at identifying the areas of the document to scrutinize for useful information. Here the concept map summary of the main concepts within a document could enable rapidly forming a "big picture" understanding of the document, for determining whether a document merits further examination. If the concept map summary is annotated with information about where within the document may be found the material associated to each of the concept map's concepts, it can also provide an index for finding passages about relevant concepts.

Unfortunately, the feasibility of using document-based concept-maps to support document understanding has been impeded by a serious knowledge modeling bottleneck. A manual approach to generating the maps, in which a human analyzes each document to generate the associated concept map is prohibitively expensive, especially if the goal—as in intelligence analysis—is to alleviate the need for analysts to read each document. Automated concept-map generation tools for this task could significantly help overcome this obstacle. Previously we investigated automated methods to help bridge the gap between documents and concept maps by generating concept map fragments (Valerio and Leake, 2006), and in this paper we examine how an extension of such methods can benefit human document understanding.

The difficulty of automated document understanding is well known, and full automated document understanding remains beyond the state of the art in AI. Consequently, it is important to note that our methods for generating concept maps from documents are not intended to achieve full document understanding. Instead, our aim is to use natural language processing and text mining techniques in order to reach an intermediate level of analysis, deeper and more refined than keyword-based methods, and to present the results in the form of concept maps. We believe that the automatic generation of concept maps of sufficient quality to support document summarization and indexing for training and analysis is feasible. Such maps can be useful even without capturing all the information contained in a document, provided that they capture a sufficient set of the top-level concepts and relations to (1) aid in a quick skim of the document to see if it may be relevant to a topic of interest to the user, and, if the document is potentially relevant, to (2) to serve as a conceptual summary/index to assist in a basic understanding of the document and of where in the document the user can find useful information.. Thus our criterion for success is whether the methods are sufficient for aiding a human understander.

This paper presents research on the automated construction of concept map fragments and evaluates its value for helping humans to (1) determine the relevance of textual documents, and (2) understand key points faster and more accurately than relying on the document alone. For this task, the central natural language processing requirement is accurate labeling of concepts and linking phrases. The paper presents an algorithm we have developed for this task and its evaluation with a human-subjects study. The study shows that providing subjects with the automatically-generated concept map can improve subjects' speed at answering questions about the content of a document. Consequently, we believe that our algorithm a promising step towards automated concept map generation for this type of support role. In addition, we believe that our algorithm may prove a useful step towards more sophisticated automatic concept map generation from documents.

2 Concept maps as a representation of text documents

Concept maps present information in a concise and easily-understood form. Consequently, a concept map of the content of a document is a useful vehicle for summarizing what a document is about. In addition, if the concept map is annotated with pointers to relevant passages in the text, the concept map can provide a browsable index to help guide navigation through documents to find material of interest. However, despite the relative ease of concept map construction, it may be time consuming to determine the right content for a map or its related resources. This problem is further aggravated when considering the large amounts of information available in document collections.

In order to assist users in the creation of better concept maps, as well as finding relevant resources with which to enrich them, researchers have previously aimed to develop tools for automatic support of concept map generation from source documents, as summarized in (Kowata, Cury, & Silva Boeres, 2010). Most of these approaches use natural language processing techniques at the core of their algorithms. Such techniques are commonly used to automatically extract information from unstructured text documents, for example during automatic population of ontologies (Alani et al., 2003). Syntactic parsers are at the core of these automatic processes and provide deep (Charniak & Johnson, 2005) or shallow structural analysis (Abney, 1996) of natural language sentences.

The work in (Alves, Pereira, & Cardoso 2001) uses WordNet to extract a hierarchy of nouns from the text (building an initial list of concepts), followed by several iterations with a human user to obtain relationships between pairs of concepts and find the linking phrases. Another approach relies on a predefined list of domain specific concepts provided by an expert (Clariana & Koul, 2004). This method considers two concepts to be related if they occur in the same sentence, but does not suggest possible linking phrases. These two approaches share a common drawback of requiring user input during their processing.

Another alternative focuses on word sense disambiguation (Rajaraman, & Tan, 2002), using the meaning of nouns and verbs to search for Noun-Verb-Noun structures in the sentences, which become the *concept - linking phrase - concept* relations. In (Leskovec, Grobelnik, & Milic-Frayling, 2004) a semantic graph is constructed from a document which is used for automatic document summarization. In (Zouaq & Nkambou, 2008), domain ontologies are built from text for educational purposes using a semi-automatic framework that produces a domain concept map from text, which is then used to derive a domain ontology.

The text mining and natural language processing techniques outlined above can be used to effectively harness information from documents. Through them, our approach exploits the syntax of document sentences to identify the topic, objects and relations described in such documents. This information is then used to generate a structural representation of the document content.

Our approach uses the syntactic structure of the sentences and their dependency information to find relations between the words. The relations are not retrieved from predefined ontologies, but are generated from the document itself. This enables our approach to be applied in any domain and makes the results potentially more sensitive to the intentions of the document author (which is important to the document summarization task). For example, even if two concepts are related in a particular ontology, the author of a document might have intentionally ignored that relation, because it did not correspond to the desired level of abstraction; in such circumstances, our approach would not include the relationship in the document description. In addition, our algorithm produces concepts based on a sentence parser trained to recognize specific syntactic structures rather than producing concepts based on individual words, making the concept labels more complete.

3 Automatic Generation of Concept Maps to Assist in Document Understanding

We have presented our algorithm for automatic generation of concept maps in previous work (Valerio, Leake, & Cañas, 2008a). In this section, we present an overview of the algorithm (as seen in Figure 1) and describe the modifications necessary to generate concept maps for the specific task of assisting in document understanding.

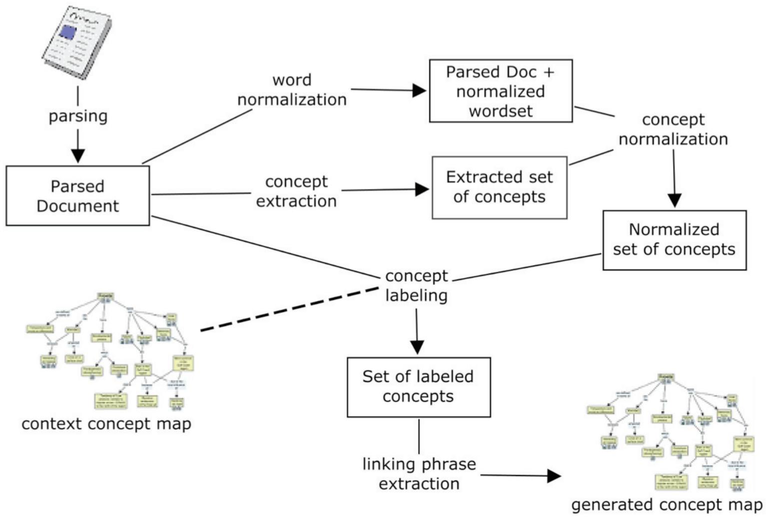

Figure 1. Procedure to construct a concept map fragment automatically from a document.

We assume the input document is "well-written" and that it contains the description of a concept or set of concepts. Each step in the algorithm is responsible for generating different parts of the final concept map, such as a list of concepts or linking phrases. Where appropriate, we use available natural language processing tools in order to generate the parse trees from the incoming document that are needed to construct a concept map. Our algorithm refines the quality of the output at each step to ensure the final output of the algorithm is not merely a graph of interconnected nodes. Instead, the goal is to generate a hierarchical structure with a root node that matches the topic of the document and that shares the characteristics of well-constructed concept maps.

In its simplest form, a concept map is a set of propositions where each proposition is a triple of the form concept - linking phrase - concept. We assume that concepts can be found in the noun phrases of the text and that linking phrases correspond to verb and prepositional phrases. After parsing the document, the resulting parse trees are used as input for the next steps in the algorithm. First, the algorithm takes all the nouns from the parse trees and performs word normalization, by grouping words considered to be equivalent based on the lexical root of the word, or words that are found to be synonyms.

The concept extraction step takes the noun phrases from the parse trees and tags these as potential concepts. Concept normalization combines the results of word normalization and concept extraction by removing morphological variations on words and performing anaphora resolution. The result is a list of abstract concepts, each composed of a set of noun phrases that are considered to be equivalent. The algorithm next assigns a concept label to each of the abstract concepts, with the label selected from the concept's associated set of noun phrases. By default, it selects the longest noun phrase, assuming it will be the most descriptive label. However, in this step it is possible to consider the input of context in the form of other concept maps, which may help choose a more appropriate label, based on the similarity of the topic of the context concept map and the concept labels contained within.

Finally, the algorithm finds the relationships between the concepts by finding the verb and prepositional phrases in the parse trees that connect the concepts that it has identified and tagged in previous steps. After finding the linking phrases that connect the concepts, it is left with a set of triples that can be used to construct a concept map that summarizes the information contained in the input document.

For the purpose of our human document understanding experiment, we tuned our algorithm to generate maps with certain characteristics resembling those of concept maps built by humans. Heuristics based on previous work (Valerio, Leake, & Cañas, 2008b) made the automatically generated maps resemble human maps in terms of the average number of concepts and linking phrases, cross-links, and overall hierarchy and taxonomy of the concept map.

The characteristics of concept maps generated by our algorithm depend on the length of the source documents, which has a direct effect on the number of concepts identified during the concept extraction phase. Because we want our generated concept maps to resemble human-made concept maps, and for our concept maps to be readable for the subjects, we limit the number of concepts in the automatically generated concept maps to 30, as well as performing some trimming of the final concept map, removing leaf nodes with no siblings and isolated sections with only 1 or 2 concepts. As a result, it is possible that some information is lost in the automatically generated concept maps of the longer documents, which may be information needed in order to correctly answer the reading comprehension question.

Note that these limitations are not needed when the automatically generated concept maps will be processed by some other automated procedure, when human readability is not a primary concern. However, in the context of a reading comprehension experiment, more information in the concept map might generate too many visual elements for the subjects to process, reducing their reading comprehension capabilities. Furthermore, our main concern in this experiment is not to provide complete document summaries, but rather general overviews that can be quickly understood and that can give a subject a general idea of the topic of the document and the relation between the most important concepts present in the document.

4 Overview of the Approach

We hypothesize that providing concept map fragments generated automatically by our algorithm to users will enable them determine the relevance of these documents and to help them understand key points faster and more accurately than by relying on the document alone. To test this hypothesis we designed a human subjects reading comprehension experiment, in which users are presented with a reading comprehension task. In this task, users must answer questions about a document, given one of three different representations of the same document: the document in its original form, a human-made concept map based on the document, and an automatically generated concept map from the document. The experiment then measures their reading comprehension skills (in terms of both accuracy and speed) with each of the three representations. The test evaluates the accuracy and efficiency of subjects when answering questions about the content of the document. This evaluation not only tests the ability of the concept maps to help humans understand documents, but also gives evidence of the quality of the concept map that is produced.

Previous experiments have tested the usefulness of concept maps as a means to assist users in the reading comprehension of texts of English as a second language (Dias 2010, Rosenberg & Saif, 2010). In these studies the researchers found a clear improvement in students' reading comprehension skills, which they attribute to the fact that concept maps can help a student to visualize how ideas are organized by the author of a text. Concept maps were also evaluated as a comprehension aid for students with hearing impairments (Castillo, Mosquera, & Palacios, 2010). In this study, the subjects were able to raise their reading comprehension levels while increasing their attention spans on a particular subject.

Another experiment presented a group of students with three different types of concept mapping tasks in order to measure in which one reading comprehension levels increased the most (Chang, Sung, & Chen, 2010). In the first task students were given concept maps constructed by teachers. These concept maps purposefully contained erroneous information, which the students were required to correct. In the second task, students were presented with a complete and correct concept map on a particular subject. Over the course of the term, the provided concept maps contained less information, forcing the students to complete the concept map. By the end of the term, the students were expected to construct their own concept maps. The results of this experiment showed that while students in all three conditions showed an overall improvement in their reading comprehension skills, those that were required to correct the concept maps achieved the best overall results. The proposed explanation was that map correction requires the students to apply critical and analytical thinking of a subject which leads to deeper processing of the new information.

Our experiment studies the use of concept maps to assist users with general reading comprehension tasks. Although there exist several methods for representing and summarizing text in the context of reading comprehension tasks (Kozminsky, Nathan, & Kozminsky 2010), it is not our intention to compare concept maps with other types of representations. Rather, we are interested in determining if the concept maps generated with our algorithm are good enough to help users to better understand a document, and if they are comparable to human generated concept maps.

This experiment is different from the previous tasks described in that our concept maps are automatically constructed, while all of the above experiments use human-made concept maps or other forms of structured representations of documents. We are aware that our automatic concept map construction may not accurately represent some relationships (e.g., those that are given by the order in which a particular text is written), and are testing whether our algorithm is able to extract enough information for the resulting concept map to be useful in helping users understand the text and correctly answer the reading comprehension questions.

5 Experimental setup and results

Subjects in our experiment complete a series of reading comprehension questions. For each question, subjects are presented with the necessary information in order to answer the question. This information may be presented in one of three different representations: a plain text document, a human made concept map, or a concept map that was automatically generated with our algorithm. Both concept maps are constructed using their corresponding plain text document as source. Subjects do no know whether the concept maps they see are human made or automatically generated. Figure 2 illustrates a question with information provided as a plain text document, and Figure 3 shows a question with information provided by a concept map.

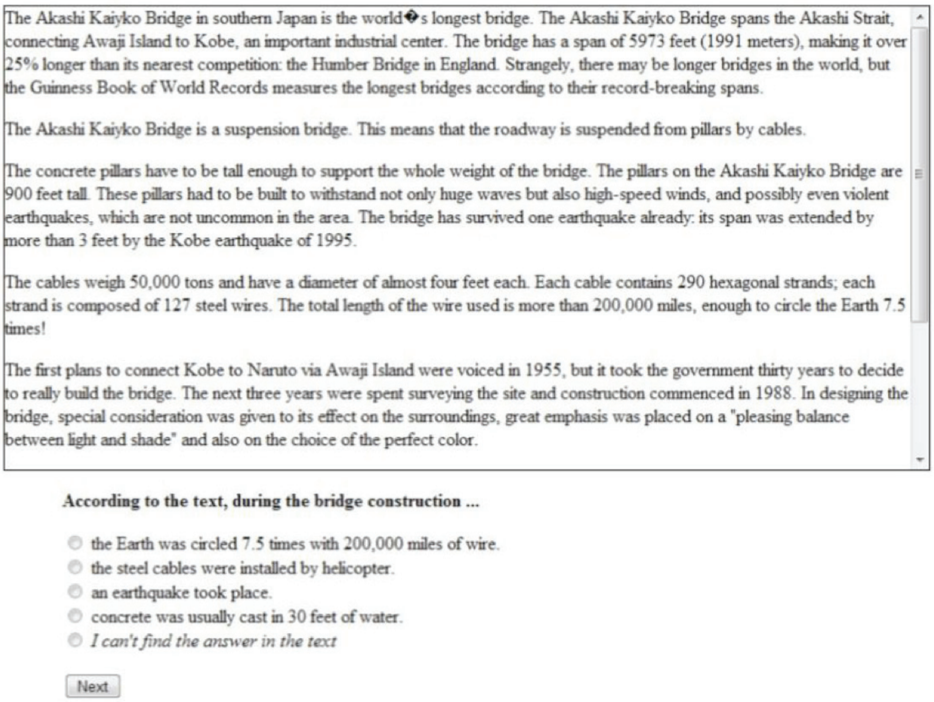

Figure 2. Human subject reading comprehension experiment: plain text document question.

The text and corresponding reading comprehension questions are taken from standard Q&A tests designed for middle school students at the 7th and 8th grade level. The subjects of the experiment were Indiana University students, both undergraduate and graduate, who were compensated for their time. In total, there were 16 participating subjects. Each subject answered a total of 60 reading comprehension questions, with 20 questions for each different representation: plain text, human made concept map, and automatically generated concept map. The subjects were divided into three distinct sets such that each question was given in a different representation to each set of users, as shown in Table 1.

For each question, we recorded both the accuracy of the response (as given by the answer key in the reading comprehension test) and the time it took each subject to answer the question. We added a *"Could not find answer"* response as an option in all of the reading comprehension questions. This is of particular importance in the case of the concept maps: As we have already mentioned, it is possible for some information to be left out during concept map generation. A choice of *"Could not find answer"* by the subjects was treated as an incorrect answer to the question. Our experimental objective is to measure whether concept maps can assist in helping user's reading comprehension skills. If our approach fails because the concept map did not contain the relevant information, or because the subject was not able to understand the concept map, the algorithm has failed its objective.

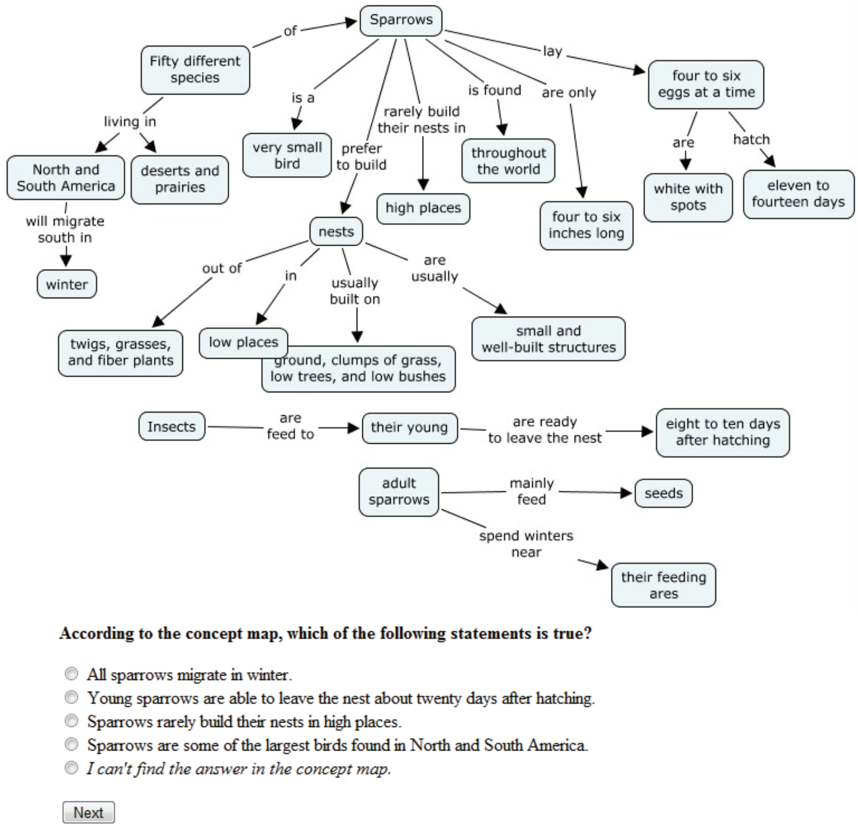

Figure 3. Human subject reading comprehension experiment: concept map question.

Our analysis compares both the accuracy of the subjects' answers and the amount of time they needed in order to answer a question in each of the three representations of the information. Additionally, we clustered the documents according to their length: 1 to 2 paragraphs, or 4 to 5 paragraphs, in order to measure the effect of concept map trimming on reading comprehension. The main results of our experiment are shown in Table 2 and Figure 4.

	Text	Human-made	Automatically generated
Set 1	Questions 1 - 20	Questions 21 - 40	Questions 41 – 60
Set 2	Questions 21 - 40	Questions 41 - 60	Questions 1 – 20
Set 3	Questions 41 - 60	Questions 1 - 20	Questions 21 – 40

Table 1: Human subject experiment: question distribution for sets of subjects.

Overall, we see that the use of concept maps does not increase the accuracy of the subjects' reading comprehension skills, and in fact, provides worse accuracy than plain text. However, we note the trade-off between accuracy and speed. While the use of automatically generated concept maps resulted in an overall average decrease in accuracy of 16% when compared to the text document versions, it also accounted for an average decrease of 43% of the time that subjects took to answer questions.

	Accuracy (1-2 parags)	Time (1-2 parags)	Accuracy (4-5 parags)	Time (4-5 parags)
Text	86%	41 seconds	68%	61 seconds
Human-made	81%	23 seconds	53%	38 seconds
Automatically generated	75%	24 seconds	47%	32 seconds

Table 2: Human subject experiment results

A closer look suggests the importance of document length. The difference in the accuracy results shown between the 1-2 and 4-5 paragraph documents suggests that there is indeed a loss of information in concept maps generated automatically from larger documents, due to the limit imposed on the number of concepts in the automatically generated concept map. While in the 1-2 paragraph documents accuracy degrades by an average of 11% compared to text, the degradation is on average 21% for the 4-5 paragraph documents. The average time decrease of 43% is shared by both types of documents, suggesting that concept maps are a more effective way in which to quickly convey information to users.

When considering the difference between the two types of concept maps, our goal was to automatically generate concept maps that were similar to human-made concept maps. It appears that we succeeded in this goal for the 1-2 paragraph documents, for which the performance of both types of concept maps showed no significant difference. However, we found a trade-off between accuracy and speed for the 4-5 paragraph documents, where the human-made concept maps allowed subjects to answer the questions with an average of 11% more accuracy, while the automatically generated concept maps allowed them to answer the questions an average of 16% faster than the human-made concept maps.

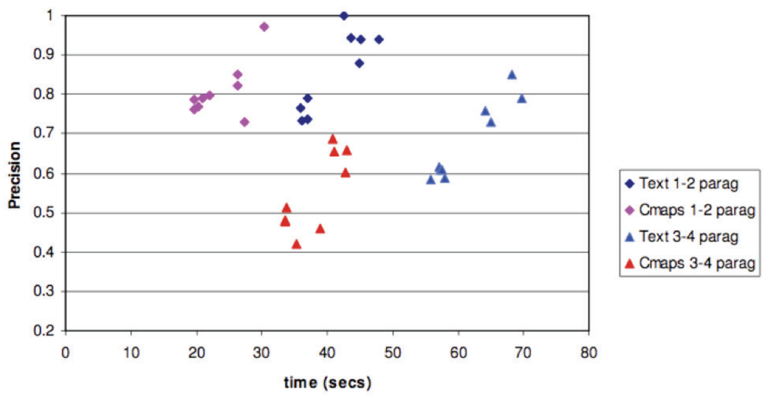

Figure 4. Scatter plot of average time and accuracy per user on the reading comprehension task.

From the results we conclude that providing concept maps did not assist users in improving accuracy compared to providing the initial text. This is more evident for longer documents, in which restrictions on the number of concepts decreased the information provided. However, the accuracy results still indicate that the major concepts of the document were correctly recognized and were available to the subjects, to allow for an understanding of the overall topic of the document. In addition, when the needed information is present in the concept map, subjects are able to find the correct information much faster than in the source document. Therefore, we conclude that our automatically generated concept maps help users improve their performance in document understanding tasks, in terms of the speed in which they can find the required information.

6 Summary

Our experiments investigated whether automatically generated concept maps, produced by our algorithm, could assist humans in a document understanding task. We showed that our concept maps allow users to substantially improve their reading comprehension skills in terms of speed. In particular, we found that for smaller documents with fewer concepts, almost every concept is reflected in the constructed concept map, giving users comparable accuracy in reading comprehension in addition to a significant speedup. For larger documents, the accuracy of the answers decreased but the speedup was maintained. We conclude that our algorithm is promising for tasks where the size of documents is small or when the response time is of major importance. The key to the usefulness of this method is to highlight information which might otherwise be hidden in a large document library. In general, we have found that the automatically produced concept maps are of similar quality to those authored by humans, and we believe the steps taken in this research are an important step in the direction of enhancing automatic processing of documents into concept maps.

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A. J. Cañas, J. D. Novak, J. Vanhear, Eds.
Valletta, Malta 2012

USING CONCEPT MAPPING TO ASSESS A LARGE-SCALE PROJECT

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Abstract. Concept maps have been used in many research studies to analyze content knowledge transformation, but very few studies examine their use in large-scale projects. The purpose of this study is to evaluate the growth of in-service teacher content knowledge across 37 professional development projects, which include over 1,000 mathematics and/or science teachers. Project directors participate in an orientation to concept maps, which provides a rationale for using them, and instruction for creating an expert C-map. During the project director training, each project director generated C-maps. The C-maps are specific to the content for each institute and align with the major project content objective. The C-maps are used as a template for the creation of S-maps, which are used as pre/post-assessment tools for the evaluation of in-service teacher content knowledge. A team of researchers including science/mathematics education faculty and academic faculty verify the C-maps and provide feedback to project directors prior to the construction of the S-map template. In addition to the concept maps, the number of content courses taken by the in-service teacher and interviews are used for purposes of analyzing teacher content knowledge.

1 Introduction

While concept mapping is a tool often utilized to assess misconceptions and transformations in knowledge of particular concepts in a content area, there currently are very few research projects that use concept maps as an assessment tool for larger scale studies. The vast majority of concept map research studies involve less than 100 participants (Nesbit & Adesope, 2006). In a meta-analysis that focused on the reliability and validity of concept mapping of research studies in science grades K-12, Himangshu and Cassata-Widera (2010) included only one out of 25 studies that contained over 600 participants (Schau, Mattern, & Weber, 1997). Four studies included at least 100 participants, with the remaining studies using less than 100 participants. In a brief survey of the current research, we found even fewer studies related to large-scale use of concept mapping to assess knowledge of mathematics concepts (Bolte, 1999; McGowen & Tall, 1999; Schneider & Stern, 2010). Furthermore, the authors of this manuscript have not found research studies in concept mapping to date that have addressed large-scale use of concept maps for in-service teachers.

This paper describes the development of an assessment tool to be used for large-scale projects designed to meet the evaluation needs of a state educational institution that is situated in the United States. The state institution is comprised of 37 grant awards and predominantly serves over 1,000 secondary mathematics and science teachers with a few awards focused on primary grades content.

While creating this assessment tool, the authors considered the issues of reliability and validity of scaling up the use of concept maps for large research studies. Himangshu and Cassata-Widera (2010) suggest using the select and *fill-in-the-map* (S-map) as well as the *create-a-map* (C-map) concept map techniques to support concurrent validity. The authors point out that "by their nature, 'fill in maps' are not designed to detect misconceptions or depict a student's unique structure of knowledge" (p. 63). In addition, "fill in maps" may not provide opportunities for students to express personal experiences connected to the concept nor would they allow the freedom for students to make connections to a larger conceptual framework or other domains outside the particular domain.

Two other considerations with regard to the use of "fill in concept maps" in large-scale assessment studies should be addressed. The first issue has to do with the affordance of the instrument (Carey & Shavelson, 1989), that is what economic resources are available to collect and score results. The second consideration deals with the possibility of teachers teaching to the test and the consequences associated with low-level knowledge such as memorization (Shavelson, Carey, & Webb, 1990).

2 Model Development

2.1 Project Components

In order to better understand the complexity of needs associated with evaluating the success of this large-scale project, a description of the common components of each grant is listed below. Each project requires:

- 50 hours of training during the summer to increase content knowledge for specified concepts;
- Monthly academic meetings during the school year to increase teacher effectiveness for specified concepts;
- Teachers to teach within the specified content and associated grade-level (band) assignment in order to participate in project (e.g., biology, algebra);
- A minimum of 20 teachers per institute
- All institutes must focus on the development of mathematics or science pedagogical content knowledge

2.2 Instrument Selection

The state educational institution is federally funded. For the 2012-2013 award cycle, there are 37 awardees that were selected through a competitive state grant review process. The state director and the state evaluation director for all projects require a common assessment tool for the grant recipients to demonstrate teacher content knowledge change. The directors recruited the authors to design an evaluation plan for a large-scale study that would specifically measure content knowledge of mathematics and science teachers over the course of the instructional intervention.

As a result, the authors selected concepts maps as an assessment tool to evaluate in-service teacher content knowledge. Although C-maps are associated with higher validity and S-maps are associated with higher reliability, based on time and expense involved in the creation, scoring, and analysis of approximately 1,000 concept maps the use of low-directed S-maps was better suited. These maps may tap a different aspect of content knowledge compared to C-maps but still provide an acceptable technique, which can be used to measure content knowledge. The tool includes the implementation of a pre- and post-concept map assessment for all participants that were associated with the content knowledge addressed through institute objectives and using S-maps. Additionally, interviews will be used as another way to assess cognitive activity. The nature of participant verbalizations as correlated with knowledge exhibited on the pre/post concept maps will also be explored. The authors will collect the data from all 37 grant awards, analyze the data, and provide the results to the state directors at the conclusion of the evaluation period for the grant (Table 1).

State Director Evaluation	Project Director Evaluation
Summative	Formative
Pre- and Post- concept maps	Pre-concept maps • Mastery of concept • Misconceptions • Pre-planning of professional development

Table 1: Purpose of Concept Maps for State Director and Project Directors

2.3 The Process

The evaluation plan will involve the use of C-maps in the form of expert maps and low-directed S-maps that will constructed by the participants. The C-map program will be used for the creation of all maps. Each of the expert maps must be validated by a science/mathematics education expert and a content expert. Feedback will be provided to project directors to finalize the expert map. The research team will create S-maps within a modification of the C-map program and each participant will put these concepts and linking word/phrases together. A pre/post administration will occur at the beginning and end of the institute. The research team will conduct participant interviews. The transcripts from interviews will be used to assess the degree to which verbalizations are correlated with pre/post concept maps. An open-interview technique will be used.

2.3.1 Creating the Expert Maps

The first step in the process requires that the project directors create an expert map for each of their institutes. The function of these is to use the expert maps is to create the S-map assessment tool. The expert concept map includes: (1) a main idea and (2) no more than 30 subordinate ideas. All of the concepts are either connected to the main idea or to other subordinate ideas associated with the superordinate concept.

Directors were given preparation materials prior to a 3-hour training session, which occurred over a two-day period. Each project director was provided research articles related to the construction and use of concept mapping as assessment tools to facilitate the organization of the content topic using subordinate concepts. This topic was to associate with the major project content objective (i.e., What are the profound points of understanding you want teachers to take away from your project?)

The first day of training focused on three primary questions: 1) How do we determine what teachers know? 2) How do project directors purposefully help teachers construct knowledge that is meaningful? and, 3) How do we know when teachers have mastered a concept?

With these questions guiding the training, the training of concept mapping proceeded through these main topics:

1. Definition of terms such concept, concept map, proposition, C-Concept Map, & S-Concept Map
2. What are not concept maps
3. Why use concept maps
4. Types of concept maps
5. Advantages and Disadvantages of concept maps
6. What are propositions
7. How create C-maps and S-Concept Maps
8. The Frayer Model as a tool for brainstorming
9. Cmap software
10. Training video to be shown during institute prior to pre-assessment

At the conclusion of the two-day training, the categories of concept maps were related back to the tasks of the project directors and the expert map created by the project director (Table 2).

Project Director	In-service Teacher (Participant)
C-Concept map	S-Concept Map
Constructed from memory and without assistance	• Provided concepts • Provided linking words and directional arrows • Identification of common misconceptions • Create the propositions from the provided concepts and linking words to create the concept map

Table 2: The Category of Concept Map and Relation to Project

Project directors were purposefully grouped according to project content similarity. Discussion and revision were used to generate drafts for expert maps during the training. An additional three weeks would be provided in which the project directors would continue to refine the expert map prior to review by the research team.

2.3.2 Verifying the Expert Maps

The project directors submitted concept maps by e-mail according to their content specialization, science or mathematics education. Upon receipt of the concept map by the lead researcher, verification is made that the file can be opened and read. The file is then labeled and put into a secure server that is accessible to the research team. This includes both science/mathematics education as well as discipline faculty. Each concept map is reviewed by one education expert and one discipline expert in mathematics or science (chemistry/physics/biology/Earth science). Each expert reviews the map independently followed by a joint review. Recommendations are generated during the joint review and shared with the project director so that modifications to the expert concept map are made prior to the pre-assessment. Additionally, recommendations include misconceptions and additional linking phrases to increase the rigor of the S-maps.

2.3.3 Participant Concept Maps

Two training videos on concept mapping, one for mathematics and one for science, were created to establish reliability of training in concept mapping. The actual length of the video runs no longer than 10 minutes but since the video is interactive the project director is directed when in the video to stop so that the in-service teachers are able to complete an activity. For example, the in-service teachers construct an S-map on matter for science. Working in pairs the teachers create the concept map from the given concepts and linking phrases (See Figure 1). This experience is similar to what the project directors experienced in the first day of training.

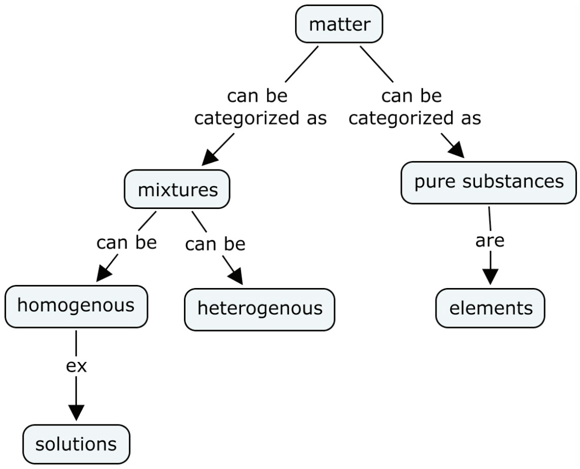

Figure 1. Concept map created by in-service teachers during training video.

A programmer was hired to investigate and then develop a program to score the in-service teacher's S-map against the expert map. The score generated included the number of correct propositions out of the total propositions possible as indicated on the expert concept map. Using *Figure 1* a correct proposition would be *matter can be categorized as mixtures*. No points are deducted for incorrect propositions.

The following list is an outline of events for conducting the evaluation of the large-scale project.

1. Conducting a training session on how to construct a concept map with project directors
2. Administration and analysis of pre-assessment concept maps and associated narratives of participants
3. Administration and analysis of post-assessment concept maps and associated narratives of participants
4. Administration and analysis of interviews for concept maps
5. Evaluation report

3 Methods

3.1 Sample

The total number of participants will include ~ 1000 paired concept maps (i.e., 1000 pre- and a 1000 post-concept maps each accompanied by narrative data). Each map will include approximately 30 propositions. Approximately 20-30 participants will be interviewed. Various researchers suggest sample numbers of participants for qualitative triangulation. Cresswell (1998) suggests 20 to 30 participants per group depending on saturation of themes. Sandelowski (1995) suggests 30-50 interviews per group depending on saturation of themes.

In order to show that the qualitative analysis is representative, numerical analysis will be applied to ascertain the proportions of concept maps and narratives expressing particular themes and hence how far they are representative of the total sample (Francis, Skelton, Carrington, Hutchings, Read & Hall 2008; Silverman 1993).

3.2 Analysis

We will use a thematic analysis approach to analyze concept maps and narrative data. The concept maps will be analyzed for thematic content following the analysis procedures as described by Boyatzis (1998). The narrative section explaining the participants' concept map (not a description of the concept map, but an *explanation* of the concept map – i.e., an explanation of their understanding of the superordinate concept and the connections to the subordinate concepts depicted in the concept map) will be key in the purposeful sampling of the participants that will be interviewed. We will use the standard "saturation of data" to determine the total number of interviews needed in relation to, the heterogeneity of the population; the number of selection criteria; the extent to which 'nesting' of criteria is needed; groups of special interest that require intensive study; multiple samples within one study; types of data collection methods use; and the budget and resources available (Ritchie, Lewis, &, J. & E. Gillian, 2003).

Subgroups could be initially organized around the following groups:

1. *No gains*
   a. unsophisticated conceptual knowledge on both the pre and post S-map, thus showing no gain in content knowledge.
   b. average conceptual knowledge on the pre S-maps who show no gain in conceptual knowledge as displayed by the post-concept map;
   c. sophisticated conceptual knowledge represented by their pre and post S-maps, thus disallowing a significant gain in content knowledge

2. *Average gain*
   a. unsophisticated conceptual knowledge on the pre S-maps who show an average gain in conceptual knowledge as displayed by the post S-map
   b. average conceptual knowledge on the pre S-maps who show an average gain in conceptual knowledge as displayed by the post S-map

3. *High gain*
   a. unsophisticated conceptual knowledge that show a large gain after the intervention on their post S-maps.

We will also investigate anomalies such as those that score higher on the pre-concept map than the post, as well as those that do not make any significant gains following the intervention or "treatment" (i.e., the professional development training). The background knowledge and academic history, (i.e., transcript documents) would be important data to identify as possible reasons for the gains or lack thereof.

The use of qualitative methods and analysis are appropriate for program implementation studies like the present study because qualitative research methods provide the mechanism for: (a) documenting and monitoring implementation; (b) examining the ecological or contextual fit of the intervention; and (c) guiding modifications to achieve ecological fit (Nastasi & Schensul, 2002). Thus, qualitative inquiry both permits the naturalistic study of interventions and provides a systematic data-based approach to decision making about program adaptations. Through ongoing data collection, project staff can identify what is not working, explore why it is not working, generate solutions based on this evidence, document decision making, and track the effectiveness of modifications. The careful study of adaptations provides the in-depth description that is necessary for transferring or generalizing programs to other contexts. When conducted across multiple settings, documentation of the adaptation process can lead to understanding of the program's core elements (i.e., those that are necessary for outcomes) and development of guidelines for flexible program implementation (i.e., how to maintain integrity of core elements while permitting adaptations; Nastasi, Varjas, Schensul, et al., 2000). Furthermore, qualitative methods permit the study of unintended outcomes as well as individual variations in intended outcomes (Nastasi, 2002).

4 Summary

As described previously there lacked research models in concept mapping for conducting large-scale research studies especially studies that involved in-service teachers (Bolte, 1999; Himangshu and Cassata-Widera 2010; McGowen & Tall, 1999; Nesbit & Adesope, 2006; Schau, Mattern, & Weber, 1997; Schneider & Stern, 2010). This paper provided model development for assessing a large-scale project that included over 1,000 in-service teachers. How and what data was to be collected for the project as well as factors such such as time and money for the number of participants being evaluated were some of the considerations for the model development.

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USING CONCEPT MAPS TO ASSESS AND CATEGORIZE ELEMENTARY PRESERVICE TEACHERS MISCONCEPTIONS

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Abstract. This research study reports on the use of concept maps as an assessment tool to investigate elementary pre-service teacher knowledge about dissolving. Propositions from pre/post concept maps were scored using the total proposition accuracy scoring technique (TPA) and were also used to classify concepts as scientific or spontaneous using Vygotsky's theory of concept development. Vygotsky (1986) described spontaneous concepts as un-unified and employing concrete, factual groupings, while scientific concepts are organized hierarchically and have a system. After the instructional intervention, statistically significant improvement was shown on a paired sample t-test ($t = -4.154$, $p<.001$) and many spontaneous concepts which appeared on the pre-concept maps, were either reduced or eliminated (i.e., disappearing and melting). Although medium statistically significant gains were noted for the t-test, these findings suggest that the elementary pre-service teacher science content knowledge about dissolving is weak as the average TPA score was less than two accurate propositions ($n=49$) and many teachers continued to hold the same misconceptions as reported for K-12 students in previous studies (Calik & Ayas, 2005; Kind, 2004; Kikas, 2001; Ebenezer & Erikson, 1996). This research also suggests the teachers have well-developed idiosyncratic conceptions about dissolving that will take considerable time and effort to reduce and/or eliminate. Recommendations to improve the content knowledge for elementary pre-service teachers include: adding a non-majors chemistry course, focusing on the particulate nature of matter during methods course work, and using screening practices to eliminate pre-service teachers who display weak science knowledge about the subjects they will teach to children.

1 Introduction

The use of concept maps for assessing conceptual understanding of students was introduced by Novak in 1972 (Novak & Musonda, 1991). Novak and Canas (2008) have pointed to the advantages of using concept maps for understanding the complex knowledge structure exhibited by students which can include higher order thinking as well as lower order thinking. Concept maps have attracted the attention of other research groups that set out to address the pragmatic use of concept maps by developing design and scoring methods for the use of concept maps for assessment of student conceptual understanding (Ruiz-Primo, 1996, 2000;Yin et al., 2005).

While there have been numerous research studies that address student understanding of important science concepts such as dissolving, there has been only few that address common scientific understandings held by elementary pre-service teachers (Dawkins, 2008). Common student misconceptions reported in the literature include confusing dissolving with melting (Calik, 2007; Ebenezer & Erickson, 1996; Kikas, 2001; Othman et al., 2008; Valandis, 2000) and confusing dissolving with disappearing (Calik & Ayas, 2005; Kikas, 2001; Longden, et al., 1991;). Only a few studies reported misconceptions involving pre-service teachers (Calik & Ayas, 2005; Calik, 2007; Calik, Ayas, & Cool, 2007; Valandis, 2000; Ruiz-Primo, 2000).

This research effort aims to address this gap in the literature by investigating conceptual understanding of dissolving by elementary pre-service teachers enrolled at a large university in the US. The purpose of this study is to assess conceptual understanding and identify the type of concepts held by the pre-service teachers. Specifically, this study investigated elementary pre-service teacher knowledge about dissolving and categorized pre-service teacher knowledge using Vygotsky's (1986) theory of concept development. That is, the scientific concepts and spontaneous concepts held by the pre-teachers were identified according to concept type.

2 Research Study

2.1 Research Design

The research methodology for this study involved a mixed-method approach. The quantitative research design utilized a pre-experimental research design-the one group, pretest-posttest design. The research design was informed by a pilot study completed during the previous year. The qualitative research method used was a thematic analysis approach (Boyatzis, 1998; Braun & Clark, 2006). A forced-consensus model was used to identify and classify propositions as scientific or spontaneous concepts using the pre-service teacher concept maps. Each pre and post concept map was individually examined and marked as either a scientific or spontaneous concept. Spontaneous concepts are described by Vygotsky (1986) as lacking a unified system and employing objective-concrete, perpetual-factual groupings, while scientific concepts are characterized by use of a hierarchical organization system.

2.2 Sample

A total of 49 elementary pre-service teachers who were enrolled in a science method courses before the student teaching semester participated in the study. The students were elementary pre-service teachers enrolled in a university professional development school program. Three out of 49 pre-service teachers were male. The ethnicity of the participants in this study included: White (33); Hispanic (11); Asian (4); and African American (1) teachers. Only three pre-services teachers had taken a course in general chemistry. The majority of the elementary pre-service teachers (72%) scored an A or B in their conceptual physics course which was blocked for elementary teacher candidates instead of a general chemistry course taken by non-majors.

2.3 Procedure

This research effort used (1) pre/post concept maps; and an (2) instructional intervention. The concept maps were low-level directed concept maps that rely on students providing their own list of key concepts as well as linking phrases for making their own concept maps (Ruiz-Primo, 2000).

The instructional intervention used the 5E Model of constructivism in which the participants is first engaged with the content through a video clip of mercury and gold dissolution. This is followed by the exploration of the concept to be learned. The results from the learning experience were explained by the participants and additional information related to the lesson was added using direct instruction. The experience was elaborated using real-world connections (e.g., bone density, cooking) and the participants were evaluated. The scientific concepts associated with the learning experience included:

1. The process of making a solution takes place as a solute (usually a solid substance or one in a lower quantity) dissolves in a solvent (usually a liquid or the substance in greater quantity) to create a solution.
2. A solution is a special type of mixture which is homogeneous.
3. Solutions display optical clarity.
4. Dissolving is a physical change as opposed to a chemical change (one phase and substances do not react).
5. The process of dissolving begins when enough energy of enthalpy is vested into the system to break solute-solute particle intermolecular forces as well as solvent-solvent particle intramolecular forces (van der Waals forces).
6. The process of dissolving may be facilitated through stirring, heating, pressure, or concentration.
7. A hydration shell forms around the solute.
8. The process of dissolving is reversible using evaporation or distillation.

2.4 Data Analysis Procedures

The concept maps were scored by four science education experts using a forced consensus model in an effort to create a cooperative dynamic and make the best possible decisions for the study. That is, concerns were raised and resolved one-by-one. The method for analyzing and scoring of concept maps involved a total count of correct propositions as determined by the consensus of four experts (three science education faculty and one doctoral student). The same procedure was employed to classify concept map propositions as scientific concepts and spontaneous concepts using Vygotsky's theory of concept development.

Total proposition scores on the pre and post concept maps were used to conduct a two-tailed paired sample t-test. SPSS 20 statistical program package was used to conduct the two-tailed paired sample t-test. Effect size was calculated using Cohen's d statistic.

2.5 Pilot Study Results

Several changes were made as a result of the pilot study. Additional instruction about concept mapping was provided prior to pre-service teacher creation of concept maps and the concept maps were checked for completeness prior to submission (i.e., missing linking words and missing directional arrows). Changes were made to the instructional intervention such as emphasizing the particulate nature of matter and linking this micro-view of dissolving to the concrete learning experience. Finally, a forced-consensus scoring protocol using the *total proposition accuracy scoring (TPA)* method was employed. Prior to the study, pre-service teachers received thirty minutes of instruction for creating concept maps. In addition to instruction, the teachers completed group and individual concept maps to assist in their mastery of how to make a C-map. A C-map is created by the participant without the benefit of word banks, linking phrases, or templates. Each pre-service teacher completed a C-map prior to instruction (pre-concept map). One week following the three-hour instructional intervention, the teacher completed a second C-map (post concept map).

2.6 TPA Results for Paired Sample t-test using SPSS 20

Results for pre- and post-concept maps were analyzed using SPSS 20 statistical package to conduct a paired-sample t-test. The results for the paired t-test for the topic of dissolving are presented in Table 1. Results indicate a statistically significant difference exists between the pre/post concept map scores. The instructional intervention was larger for the post concept map (M=1.54, SD=1.722) compared to pre-concept map scores (M=.61, SD=1.201); t=-4.154, p=<0.001. The results are shown below in Table 1.

T	*P*	df	Mean(pre)	SD(pre)	Mean(post)	SD(post)	Effect size Cohen's *d*	N
-4.154	<0.001	45	0.61	1.201	1.54	1.722	-0.626	46

Table 1: SPSS Dissolving Results of two tailed paired t-test of pre and concept maps scores.

2.7 Results for Identifying Misconceptions about Dissolving Using Pre and Post Concept Maps

Results for the identification of pre-service teacher misconceptions for dissolving are shown in Table 2. Categorization of misconceptions identified in pre-service teacher concept maps with regard to dissolving show that the majority of misconceptions exhibited by pre-service teachers involved the following misconceptions:

- Dissolving involved a change of state (12%)
- Dissolving involved disappearance (12%)
- Dissolving involves the break-down of substances (13%)
- Dissolving involved the mixing or combining of two substances into a mixture (22%)
- Dissolving involved a chemical change (9%)
- Dissolving is affect by variables such as heat, physical agitation and concentration (11%)

After receiving a three-hour instructional intervention, some misconceptions, such as dissolving is melting were abandoned while other misconceptions were significantly reduced. Dissolving is disappearing decreased from 12% to 2%, dissolving is a change of state decreased from 12% to 6%. Other misconceptions proved to be more robust. Dissolving is mixing decreased from 41% to 27% and dissolving is when substances break down decreased from 25% to 18%. Dissolving involves a chemical change increased from 10% to 16%.

A small percentage of students developed scientific conceptions about dissolving including the instructed concept of formation of hydration shells in the process of dissolving (4%) and the concept that dissolving is affect by variables such as heat, physical agitation, and concentration increased from 11% to 28% on the post-concept maps. The scientific terms of solute and solvent as forming a solution was featured in 16% of the pre-service teacher concept maps.

Dissolving is…	Pre concept map	Post concept map
	frequency and percentage of concept or misconception	
when an item sinks to the bottom then dissolves	1 (1%)	0 (0%)
related to density	1 (1%)	0 (0%)
happens through osmosis	3 (3%)	0 (0%)
a substance is cut into small particles or particles are granules	3 (3%)	0 (0%)
when a solid is dissolved in a liquid	5 (5%)	0 (0%)
melting	7 (8%)	0 (0%)
a chemical change	9 (10%)	14 (16%)
combining or blending substances to form a mixture	20 (22%)	13 (15%)
breaking down a substance	13 (12%)	9 (10%)
involves a change of state	11 (12%)	5 (6%)
disintegrating, eroding, deteriorating, disappearing, gone, invisible, absorbed	11 (12%)	2 (2%)
when a solute and solvent come together and form a solution	0 (0%)	14 (16%)
forming a hydration shell	0 (0%)	6 (7%)
affected by stirring, heating, concentration	10 (11%)	24 (28%)
formation of hydrogen shell or is when small particles are surrounded by large particles.	0 (0%)	3 (4%)
Total	93 (99%)*	70 (103%)*

Table 2: Categorization of common misconceptions for dissolving derived from student concept maps (N=44). Percentages do not equal 100 due to rounding error.

2.8 Discussion for Using Instructional Interventions to Target Spontaneous Concepts Interfering with the Development of Scientific Concepts.

Very little content knowledge about the concept of dissolving was displayed on the pre-concept maps. Only the concept of heat or stirring affecting the rate of dissolving was mentioned in 10/93 propositions (11%). The number of correct propositions increased to 49% on the post-concept map where 44/87 propositions were coded as representing an accurate relationship between scientific concepts. The pre-concept map data shows 32 pre-service teachers (65%) created a pre-concept map with no correct propositions. After instruction, the number of post-concept maps with a score of zero was reduced to 14 (28%) which represents a large number of pre-service teachers who are not able to form even one accurate propositional relationship for the concept of dissolving.

As shown on the paired t-test, the mean number of correct propositions on the pre-concept map was less than one correct proposition per pre-service teacher (M=0.61, SD=1.201) and was less than two correct propositions for the post-concept map (M=1.54, SD=1.722). These results suggest the instructional intervention for the topic of dissolving did have a positive effect on pre-service teacher knowledge as measured using the TPA scoring method for concept maps. The effect size, as measured by Cohen's d, was medium for the instructional intervention (-0.626). Although this represents a statistically significant gain (t=-4.154, p=<0.001) given the target learning objectives for the instructional intervention, there remains a good deal to learned by the pre-service teachers about the topic of dissolving. It should not escape our attention that pre-service teachers must be scientifically literate in order to plan lessons which will help students learn about this important topic which is taught in grades 4-6 in the US. Scientific literacy requires the use of language, specifically academic vocabulary and the assignment of word meaning.

Vygotsky (1986) described the importance of language as the process that leads to concept development. First, he described the formation of spontaneous concepts which arise as a result of encounters with everyday concrete experiences (e.g., sugar dissolves in tea). If these experiences establish the lower boundary for instruction, then it is here that the starting point for instruction begins (zone of proximal development). Secondly, the academic vocabulary associated with dissolving (e.g., solute, solvent, solution) must be taught because it is not part of everyday language. Next, the abstract characteristics of the concept are taught as they not evident in the concrete experiences that accompany everyday life and require the help of an instructor in order to be understood. It is within the context of abstract characteristics that we encountered the most challenge with regard to pre-service teacher concept acquisition.

In this study, pre-service teachers lacked knowledge about the micro-level processes associated with dissolving. The pre-service teachers created concept maps that showed everyday concrete spontaneous concepts which sometimes included a few members of the set of knowledge for dissolving which are unified with others, but not all of the concepts were organized into a unified system that is characterized as a scientific concept. Using Vygotsky's concept development theory, a number of spontaneous concepts were identified in this study. Specifically, the pseudo-concept stage, dominated the pre-service teacher understandings about the concept of dissolving. Vygotsky (1986, p. 122) describes the pseudo-concept as the "shadow of a true concept." That is, a student can learn the meaning of a word, such as melting, yet erroneously apply it to a process such as dissolving which is unrelated to melting. Pseudo-concepts often masquerade as scientific concepts, but can be exposed in the attempt to generalize the pseudo-concept to a context for which the student is unfamiliar.

For example, when the pre-service teacher describes salt dissolving in water as melting, the pre-service teacher reveals a pseudo-concept which lacks a unified system associated with melting. That is, because the pre-service teacher does not understand the micro-view of dissolving, they attempt to generalize the meaning of the unrelated word, melting to include the concept of dissolving. Since this concept appears during kindergarten (Driver, 1985; Kikas, 2001) the instructor is challenged with the task of providing the academic language and learning experiences needed to help the pre-service teachers develop scientific understandings about the nature of melting and dissolving and why they are different. In an effort to ameliorate this lack of understanding, one of the learning experiences used in this study involved the investigation of dissolving without the addition of heat or stirring.

A persistent pseudo-concept present in this study was dissolving involves a chemical change. This particular pseudo-concept generally appears during high school (Nusirjan & Fensham, 1987) and proved to be a robust misconception. The incidence of occurrence on the concept maps increased post instruction from 10% to 16%. Interestingly, one scientific concept taught during the instructional intervention included the idea that, unlike a chemical reaction, dissolving is a reversible process. Although the students did not evaporate water from a solution, each of the pre-service teachers handled a beaker filled with salt crystals. The solution had previously been placed on the window sill until all the water had evaporated. Reduction of this particular pseudo-concept will require additional research.

Similarly, the pre-service teachers' understanding of mixtures was more akin to mixing. The teacher concept maps revealed a lack of a unified system for the concept of mixtures. This pseudo-complex was also robust, but did decrease from 22% to 15% after the instructional intervention. The concepts maps show that pre-service teachers do not understand that the superordinate concept of mixture involves homogeneous and heterogeneous mixtures, and that solutions are a special type of homogeneous mixture. Furthermore, the pre-service teachers do not know how colloids or emulsions fit into this system as subordinate concepts to homogenous mixtures. Again, this lack of an organized scheme represents a challenge for the instructor to bridge the gap between the pseudo-complex and scientific conceptual understanding as necessary prior knowledge is needed to understand this process (i.e., mixtures) and absent from the Pre-service teacher schema.

The pseudo-concept of "dissolving is breaking down a substance" decreased slightly from 12% to 10% on the post-concept maps. It was not clear from the concept maps if "breaking down" meant a physical or chemical change, thus we left this meaning open to the interpretation of the reader. Considerable effort was made during the instructional intervention to discuss the particulate nature of matter via technology as a tool showing computer animations of how salt-water and sugar-water solutions are formed. As the abstract understanding of dissolving is the source of many of the pseudo-concept identified in this study, more examples, discussion, and additional time to process information about the particulate nature of matter is warranted if pre-service teachers are to move toward the development of a unified system to understand the process of dissolving.

A pseudo-concept related to melting that generally appears during middle school, is change of state (Prieto et al. 1989; Abell & Deboer, 2008). The concept maps showed little evidence of a unified system for understanding what is meant by change of state. The pre-service teachers inappropriately applied generalized concepts for evaporation and condensation to dissolving. The pre-concept maps show 12% of pre-service teachers associated dissolving with change of state (e.g., evaporation, condensation) and this number was reduced to 6% on the post-concept maps. In an effort to develop scientific conceptual knowledge, discussion questions associated with the learning experience asked the pre-service teachers to describe what was happening to the sugar and salt as they were combined with water and formed a solution. Also, a computer animation was used to address what the pre-service teachers could not see during the laboratory; that is, "What happened to the solute and solvent? and "Did the solute change state?"

The pre-concept maps showed a number of other pseudo-concepts such as disappearing, absorbing, eroding, deteriorating, and disintegrating (12%) which appear as early as kindergarten (Kikas, 2001). These misconceptions were almost eliminated after instruction (2%) with only two pre-service teachers continuing to hold on to this particular misconception. Again, the use of computer animations and discussion were key instructional strategies used to target these misconceptions.

The post concept maps show the most common concept to be derived from the instruction intervention was that of dissolving is affected by stirring, heating, and concentration. Twenty-eight percent of post-concept maps showed propositions related to this idea compared to 11% on the pre-concept map. The instructional intervention did use investigations that specifically addressed how heat, physical agitation, and concentration affected the process of dissolving salt in water and sugar in water.

The use of academic language associated with dissolving such as solute, solvent, and solution is taught during middle school (Calik & Ayas, 2005). Two pre-concept maps attempted to use academic vocabulary, but reversed the terms solute and solvent. This reversal of vocabulary also appeared on the post-concept maps. Fourteen propositions (16%) used the terms, solute, solvent, and solution to describe the process of dissolving. Vygotsky's theory of concept development places a premium on communicating through gestures, language, sign systems, mnemonic techniques, and decision-making systems to help the individual derive meaning and conceptual understanding. For this reason, it is the instructor who plays a central role in the learning process. More attention to the acquisition of academic vocabulary is needed so pre-service teachers can explicate their knowledge about dissolving and in turn, communicate this knowledge to future students.

Although targeted efforts were made to assist the pre-service teacher with the understanding of the micro-processes associated with dissolving, only six teachers used propositions that correctly conveyed information about the concept of a hydration shell (7%). Three teachers incorrectly identified the hydration shell as a hydrogen shell on the post-concept maps (4%). This lack of understanding stems from the absence of knowledge about the particulate nature of matter (Nakhleh, 1992) and/or a lack of understanding about the role of inter-molecular forces involved in the process of dissolving (Kind, 2004). Again, a focus on the particulate nature of matter and mastery of academic vocabulary is needed.

2.9 Conclusion

In general, the 49 pre-service teachers in this study had no prior knowledge about dissolving as demonstrated on the pre-concept maps which showed only 11% of the propositions as representing a relationship between two or more scientific concepts. The instructional intervention was statistically significant and raised the number of propositions representing an accurate relationship between scientific concepts to 51%. However, 51% represents an almost equal number of misconceptions continued to be held by the pre-service teachers. These findings also indicate that pre-service teachers hold on to robust misconceptions. In this study, the concept of dissolving involving a chemical change (16%) and dissolving means combining or blending substances to form a mixture (15%) appear as robust misconceptions.

Using Vygotsky's Theory of Concept Development, the concept maps show that pre-service teachers continue to think in pseudo-complexes about basic science concepts which are taught during elementary school. The results show that students use macro-level descriptions for the processes involved in forming solutions, such as forming a mixture or that substances breakdown upon dissolving. The teachers continue to struggle with the process of dissolving on the micro-level. Moreover, analysis of academic transcripts showed that out of a population of 49 elementary pre-service teachers, only three student teachers enrolled in a college level general chemistry class although all pre-service teachers completed at least 12 semester credit hours of science coursework for elementary majors. For this reason, few students were able to utilize instruction about hydration shells and their role in enabling dissolving of ionic and molecular substances even after receiving instruction.

In summary, the misconceptions held by the pre-service are the same as those held by students in grades K-12 (Calik, 2007; Valandis, 2000; Kind, 2004; Nusirjan & Fensham, 2007; Kikas, 2001). In this study, the average number of total propositions (correct and incorrect) was 6.04 for a pre-concept map and 9.81 for the post-concept map. However, 65% of pre-concept maps received a TPA score of zero and 29% of the post-concept maps were scored as zero. Thus, the teacher knowledge about dissolving is dismally low (Alonzo, 2002, Heller, Daehler, & Shinohara, 2003) and many of the pre-service teachers have well-developed idiosyncratic conceptions about dissolving which will take considerable time and effort to reduce and/or eliminate.

3 Summary

The teachers who participated in this research study were enrolled in a teacher preparation program that is nationally-recognized and certifies approximately 300 teachers each year. The purpose of this study was to use concept maps as an assessment tool to investigate conceptual understanding of pre-service teachers for the concept of dissolving. Pre/post concept maps were used to document changes in teacher knowledge as the result of a three-hour instructional intervention. The intervention was designed to address common misconceptions about dissolving which occur in the research literature and to and create learning experiences that would increase the likelihood of developing an organized and unified system of knowledge about the process of dissolving.

A pilot study was used to improve the design of the study. Concept map training, the instructional intervention, and scoring method were changed as a result of the pilot study. Specifically, a standardized 30-minute training block for concept mapping was implemented, adjustments were made to the instructional intervention, construction of concept maps were checked before submission, and the TPA scoring method using a forced consensus model was used to improve the research study.

The total proposition method for scoring concept maps (TPA) proved to be an adequate method for using pre/post concept maps as assessment tools to document growth in teacher knowledge. The pre-concept maps provided information about the misconceptions held by the pre-service teachers and allowed for instructional adjustments to be made which were specific to the participants in the study.

The results for the instructional intervention were statistically significant (t=-4.154, p=<0.001). However, robust misconceptions identified in this study included: dissolving is a chemical change (16%); dissolving involves making mixtures (15%) or dissolving is the breakdown of substances (10%). These data confirm what has already been reported in the literature for K-12 students and informs future instruction for elementary pre-service teachers enrolled in teacher preparation programs. Acquisition of scientific concepts included propositions that used academic vocabulary (i.e., solute, solvent, and solution), variables that affect the rate of dissolving (i.e., heat, physical agitation, and concentration) and the formation of hydration shells. Propositions that were scientifically accurate increased in frequency from 11% to 49% after the instructional intervention.

The results of this study demonstrate these elementary pre-service teachers' knowledge about dissolving, as measured using pre/post concept maps, is dismally low and that the teachers have developed elaborate, mostly, concrete, unorganized understandings about the process of dissolving. In general, there is a complete lack of understanding about the particulate nature of matter.

Three recommendations are made based on the results of this study: (1) all elementary pre-service teachers should enroll in at least one non-majors chemistry course as a requirement of the degree; (2) an increased focus on science concepts, particularly the particulate nature of science, should be included in science methods course work that leads to teacher certification; and (3) pre-service teacher knowledge routine should be routinely screened and individuals who display weak science knowledge about the subject they will teach should be removed the certification program.

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USING CONCEPT MAPS TO PROMOTE THE EMERGENT LITERACY SKILLS OF 3- TO 5-YEAR-OLD CHILDREN

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Abstract. In this paper we report the findings from a study designed to investigate the associations among young pre-reading children's concept development, oral language development, and emergent writing skills when their teachers used concept maps to support instruction. The 40 sampled children attended 12 classes in four elementary schools. The children's classes included children of poverty and with special needs. Data included pre- and posttest writing and language samples. Concept mapped language samples provided the concept development measures. Findings suggest that, on average, girls' writing samples scored higher than boys' at pretest. Results indicated that children made gains from pretest to posttest in concept map scores and the number of words and the number of different words in the language scores. Gains made from pretest to posttest were not differentiated by gender. Finally, gains made on concept map scores were associated with gains in number of words and number of different words, but not with mean length of utterances.

1 Introduction

In this paper we describe a professional learning series in which participating teachers engaged in face-to-face training sessions, webinars, and coaching. Researchers used concept maps in the delivery of the series and taught teachers how to use concepts maps with children in their classes. The 2011-12 academic year, an exploratory year, was the first of a 3-year project designed to enhance young pre-reading children's content knowledge and oral and written language development. The project (HUBS) design involved formative and summative evaluation of the developmental changes of the children taught by participating teachers.

Research documents a school readiness gap between children living in poverty and their more affluent peers (U.S. Department of Education, National Center for Education Statistics, 2003). When children enter kindergarten with limited readiness skills they are more likely to develop reading difficulties and require remedial education (Schweinhart, 2003). What and how much children learn is highly dependent on the adults with whom they interact and the environments in which they learn. Thus, to close the readiness gap, successful professional learning opportunities increase teachers' awareness of the importance of engaging children in high-quality classroom conversations, and providing opportunities for children to participate in multiple activities designed to enhance their concept development and literacy skills

Key learning opportunities necessary for young children to achieve school success include language development activities, instruction in phonological awareness, opportunities for children to engage in writing and drawing, and the frequent reading of informational texts (Neuman, Roskos, Wright, & Lenhart, 2007). Using informational texts with young children improves their language skills while increasing content area knowledge (Pentimonti & Justice, 2011). Neuman (2006) emphasized the connection between children's background knowledge and their reading comprehension. Siegler (2001) emphasized learning as the central connection between instruction and cognition; thus, the more one knows about a topic, the better one understands, learns, and remembers related information.

Language plays a key role in young children's learning. Language allows children to voice their thoughts and feelings, helping them to better understand themselves, others, and new experiences (Bell & Westberg, 2009). It is the challenge of teachers to assure that the children who come to school with few language experiences are provided with the opportunities they need to become successful, life-long learners (Justice, Mashburn, Hamre, & Pianta, 2008).

Children who are encouraged to draw and write stories in the preschool years more easily and confidently become writers than children who have not had early writing experiences (Schickedanz & Casbergue, 2009). The goal of writing instruction is to teach children about writing as a form of communication rather than how to correctly form letters of the alphabet (Bodrova & Leong, 2007). Preschool provides a wonderful opportunity for teachers to model writing skills and engage children in writing activities that support and encourage their development as writers.

2 Theoretical Background

Cognitive and learning sciences provide insights and strategies that form the foundation for the teaching and learning processes that support children's emergent literacy skills. Strategies include working with children's preexisting understandings; building competence by scaffolding children's factual knowledge while developing a conceptual framework using strategies that facilitate retrieval and application; and using Vygotsky's zone of proximal development to help teachers scaffold children's learning using questions and discussions in ways that advance their thinking and problem solving (Vygostsky, 1978).

Educational researchers have long seen concept mapping as a powerful tool to promote meaningful learning (e.g., Novak & Cañas, 2008; Novak & Gowin, 1984). Concept maps are non-linguistic, two-dimensional, hierarchical diagrams that result from systematically mapping the relationships among concepts, and their use helps individuals visualize the structure of the mapped knowledge. On concept maps, directional lines articulate the relationship between related concepts. Linked concepts form propositions and, when read, propositions form meaningful statements. Cross-linked propositions link concepts across different map segments.

The Institute of Human and Machine Cognition (IHMC) broadly summarized the uses of concept mapping in educational settings as support for learning, assessment of learning, and for the organization and presentation of knowledge. Support of learning applications include schematic summaries of what children know, displays of children's prior knowledge, summaries of what has been learned, and detection of misconceptions. Assessment applications of concept mapping include formative and summative assessments and the documentation of changes in children's conceptual knowledge. Teachers use concept maps as advance organizers to scaffold learning and present knowledge for course and curriculum development. Teachers also use classroom concept maps, constructed by teachers or other experts, to present a global overview at the beginning of a unit and also to scaffold learning throughout the unit (Coffey et al, 2003).

3 Intervention

A university research center located in the southeastern United States is working in partnership with a large urban school district to implement a professional learning series designed for teachers of general education and special needs children between the ages of 3 and 5 years. Traditionally, these teachers have trained and functioned in isolation but, in this project, they work together in a professional learning hub (HUBS) building a collaborative network of teachers using technology applications to improve instructional and interactional classroom practices. HUBS, a 3-year project began in November 2011 and will end in June, 2014. Teachers participate in 90-minute, biweekly professional learning seminars and webinars focused upon improving children's concept development, strengthening their oral language skills, and moving them along the emergent writing continuum. Additionally, on-site coaching includes biweekly classroom visits by a center researcher, along with additional visits for technological support.

During the professional development sessions, teachers learned to increase children's background knowledge and concept development through the use of informational texts and class concept maps. Furthering this effort, project researchers developed a set of informational books designed to support young children's concept development related to physical health. Each book includes a concept map that summarizes the structure of the knowledge presented in the book and provides a graphic organizer for children to use to visualize the connections among concepts. Monthly, teachers received a new book and engaged in discussions concerning strategies for using the book and the embedded concept map to explicitly teach the connections between presented concepts and the children's previously held knowledge. (See Figure 1 for an example of a class concept map.)

Teachers also learned to support the development of children's oral language and discourse skills by increasing the quality and quantity of classroom conversations involving individual children. During the training sessions, teachers learned how to use strategies facilitating oral language development and promoting conversations. These strategies included *cueing talk through expectant looks, using comments as well as questions to encourage child talk, making words more salient through stress or repetition,* and *rewording children's responses to expand on what they say* (Justice, Mashburn, Hamre, & Pianta, 2008). Teachers and researchers revisited these strategies during webinars and classroom visits to demonstrate learning activities using informational books and concept maps.

Training session topics also included strategies that teachers can use to support the development of children's writing abilities. Teachers learned to engage children in writing activities and to assess student progress biweekly by collecting writing samples from each child and then rating the samples using the Emergent Writing Rubric (McLemore, 2011). Teachers used the results to plan instruction designed to move children along the writing continuum.

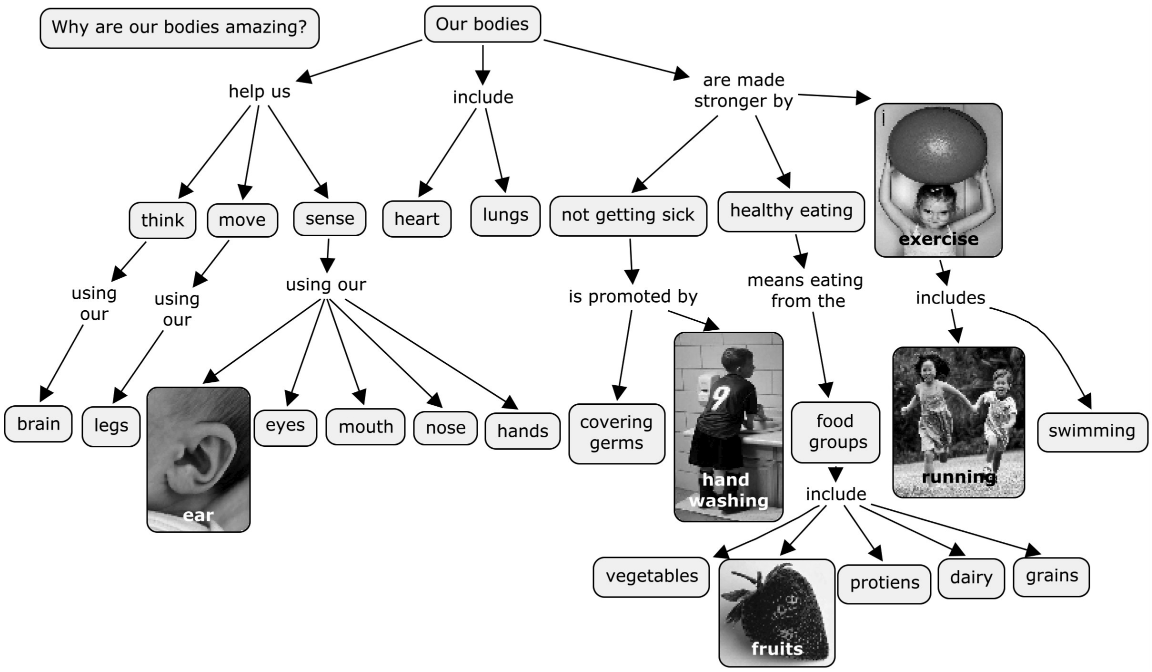

Figure 1: The class concept map with all but five pictures removed. The concept map used with the children had pictures for all concepts.

The purpose of this paper is to present results of a study, embedded in the HUBS project, designed to investigate relationships among young, pre-reading children's concept development, oral language, and emergent writing skills when using concept maps to support instruction. Research Questions (RQ) include:

RQ1 What was the children's initial developmental status in writing, language, and content knowledge relative to the physical health lessons? Was the initial status of the children relative to the physical health lessons differentiated by gender?

RQ2 Did children make statistically significant gains from pre- to posttest in the development of their writing, language, and content knowledge relative to the physical health lessons? Were gains differentiated by gender?

RQ3 Were gains in the children's development in writing, language, and knowledge content relative to the physical health lessons different, thus, indicating differentiated development in these areas?

4 Methodology

The sample included 40 children attending 12 classes enrolling 3- to 5-year-old children in four elementary schools primarily enrolling children of poverty. The classes included six general education classes enrolling 4- and 5-year olds, one blended class that included special needs children, and five classes enrolling 3- and 4-year-old children with special needs. We sampled four children from each class; collecting pretest writing and language samples from March 26 to April 4 and posttest writing and language samples May 14 to May 30. The children were mostly boys (52.5%), mostly Black (62.5%), and lived in poverty (70.0%). Additionally, 35% of the children were developmentally delayed and at least 5% were English Language Learners (ELL).

The children's teachers collected writing samples and audio-recorded language samples. The teachers first modeled writing and then prompted the children by saying: *You have been learning about your amazing body. Write and draw about your amazing body.* The children used *iDairy* on the teacher's iPad2 or paper, pencil, crayons, and/or markers to create their writing/drawing. We assessed the children's writing using a research-based 8-point emergent writing rubric (McLemore, 2011). A rating of 1 reflects that the child is making marks that show no intention to create a finished product, no understanding of the different purposes for writing, and no connection between the writing and a message; and a rating of 8 reflects appropriate use of letter case, punctuation, a central message, is easily read, and shows that the child is working toward conventional spelling. (See Figure 2 for pretest and posttest writing samples.) The two writing samples were taken from a 4-year-old girl from a low-income family. The first sample, “Me and Mom garden” scored *6* on the Emergent Writing Rubric because she wrote beginning sounds to represent words. The second sample, “I dance” was collected two months later and scored *7* because she wrote letters to represent the beginning, middle, and ending sounds in words.

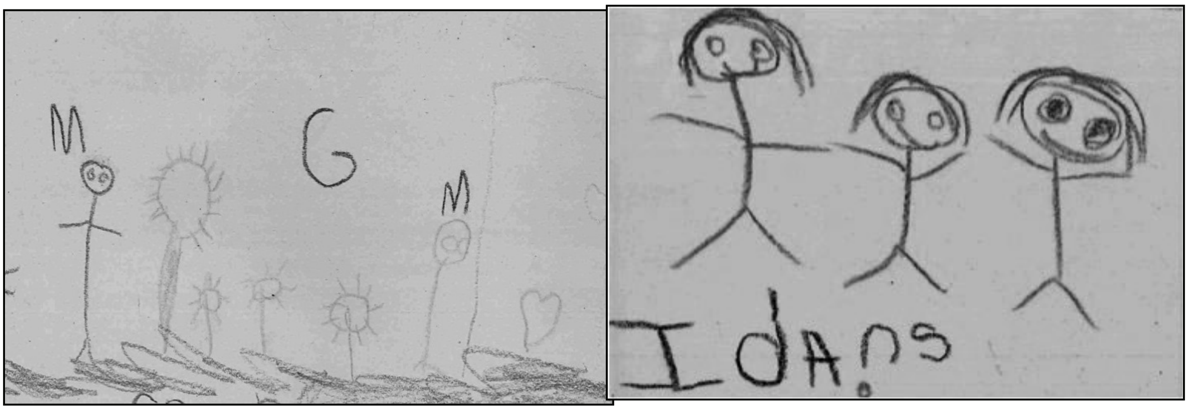

Figure 2: Pretest (left-side sample) and posttest (right-side) writing samples.

The teachers also collected language samples by engaging the children (one-on-one) in a typical classroom conversation by saying *Tell me what you know about your amazing body*. Teachers further encouraged the children to make fuller responses using prompts such as *What else can you tell me?* and *What do you mean by that?* A concept map similar to the one shown in Figure 1 served as a prompt for the conversation; however, the concept maps had pictures depicting all concepts. The concept map used at pretest included just the five senses section of the Figure 1 concept map, and the posttest concept map included all concepts on the Figure 1 concept map. We transcribed language samples and used a computer program to analyze the transcriptions. Output measures included the number of words (NW), number of different words (NDW), the Type Token Ratio (TTR) which is the ratio of NDW to NW, and the mean length of the utterances (MUL). (See Figure 3 for an example of a pretest language transcription.)

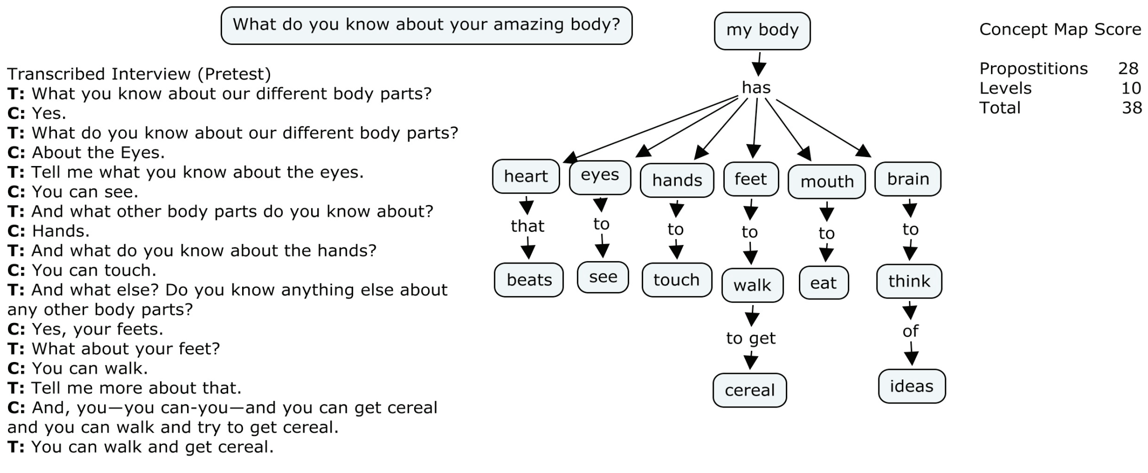

Figure 3: Transcribed interview and concept map.

Trained researchers developed concept maps from the language samples and scored them (Wehry, Algina, Hunter, & Monroe-Ossi, 2008). To address the complexity of the knowledge structure mapped, we differentially scored the quality of the propositions (McClure, & Bell, 1990). In doing so, we increased the threshold for awarding cross-link and hierarchy level points—the concept map components that often reflect creative thinking: Propositions received no points if incorrect or irrelevant; 1 point if correct and somewhat relevant and 2 points if correct and relevant. Cross-linked propositions received 5 points when they linked concepts that were part of a proposition awarded at least 2 points; otherwise, cross-links scored as propositions. Hierarchy level one, the focal concept, received no points. Hierarchy levels two and three received 5 points when three or more concepts formed quality propositions with the next higher hierarchy. (Figure 3 is an example of a concept mapped pretest language sample.)

We analyzed the mean scores of the pretest concept maps and language samples using ANOVA techniques to determine if they were initially differentiated by gender. We analyzed the pre- and posttest mean scores using repeated measures ANOVA techniques to determine whether the children made gains across time and whether gains were differentiated by gender. The writing sample scores were placed on a matrix with pretest scores as rows and posttest scores as columns showing the children's initial status and their gains and showing whether either measure was differentiated by gender. We used Kendall's Tau-b and Hoeffding's Dependence coefficients to determine if the children's growth in concept knowledge was independent of their growth in language.

5 Results

First, we will present results from the writing samples. Table 1 presents the pretest and posttest scores by the children's age and gender (19 girls and 21 boys). The five youngest children were boys and had the expected lowest scores. However, of the children with initial scores of *6* or *7*, 12 were boys and 17 were girls. Of the older children scoring *5* or less, three were boys and two were girls. Thus, we conclude that the initial status of the girls' writing samples was higher than those of the boys. All but one child either made gains or sustained their initial status. Children making gains either advanced one position on the rubric (18 children, 11 boys and 7 girls) or advanced two positions (1 boy).

		Post Writing Level					Total
		3	4	5	6	7	
Pre Writing Level	2	**2^{3}♂**	**1^{3}♂**				4
	3		**(2^{3}♂+1♀)**				2
	4			**2♂**			2
	5		**1♂**	**1♀**	**1♂**		3
	6				**(5♂ + 6♀)**	**(4♂ + 6♀)**	21
	7					**(3♂ + 5♀)**	8
	Totals	2	5	3	12	17	40

Note: 3♂ is 3- to 4- year boy; ♂ is a 4- to 5-year old boy; and ♀ is a 4- to 5-year old girl.

Table 1: Writing Results

Next, we report the sample statistics for the concept map and language sample scores. Statistics for the pretest, posttest, and difference of the two are reported for all sampled children and separately for boys and girls in Table 2. The mean scores indicate a 35-word increase in the number of words spoken (NW) and a 21-word increase in the number of different words spoken (NDW).

		Pre		Post		Difference	
		M	***SD***	***M***	***SD***	***M***	***SD***
Cmap	All	36.3	12.6	59.8	17.4	23.5	17.4
	Boys	35.5	12.6	56.6	16.3	21.1	8.9
	Girls	37.2	12.8	63.3	18.4	26.1	23.7
Language							
NW	All	42.7	20.7	77.9	48.3	35.2	41.1
	Boys	42.2	19.1	71.3	43.0	29.0	37.1
	Girls	43.2	22.8	85.2	53.8	41.9	45.1
NDW	All	25.1	9.6	46.3	18.9	21.2	17.4
	Boys	26.0	10.3	44.2	18.9	18.1	16.8
	Girls	24.1	8.8	48.5	19.2	24.5	18.0
TTR	All	1.7	0.4	1.6	0.5	-0.1	0.5
	Boys	1.6	0.4	1.5	0.4	-0.1	0.5
	Girls	1.7	0.4	1.6	0.6	-0.1	0.5
MUL	All	3.0	2.3	2.8	1.5	-0.3	1.4
	Boys	2.5	1.0	2.6	1.2	0.1	1.0
	Girls	3.5	3.2	2.9	1.8	-0.6	1.7

Table 2: Sample Statistics for the Concept Map and Language Sample Measures

Table 3 presents the statistical results addressing RQ1 and RQ2 for the concept map and language sample measures. As can be seen, regarding RQ1, concept map and language pretest scores (initial status) were not differentiated by gender with *p*-values ranging from a low of .170 for MUL to a high of .884 for NW. Regarding RQ2, statistically significant gains from pre- to posttest were made for the concept map, NW, and NDW scores, but not for the TTR or MUL scores. Gains were not differentiated by gender, nor were any interactions between gender and time evident. Thus, on average, children's language development in the areas of NW and NDW and their concept development improved from pretest to posttest.

Measure	*F*	*p*
RQ1		
Cmap	0.2	.679
NW	<0.1	.884
NW	0.4	.517
TTR	0.5	.492
MUL	2.0	.170
RQ2		
Cmap	72.6	<.001*
Sex	1.1	.297
Sex*Time	0.8	.376
NW	29.3	<.001*
Sex	0.6	.456
Sex*Time	1.0	.328
NDW	58.9	<.001*
Sex	0.1	.766
Sex*Time	1.3	.257
TTR	1.0	.326
Sex	0.6	.430
Sex*Time	<0.1	.922
MUL	1.2	.281
Sex	1.3	.262
Sex*Time	2.7	.108

Note: * Indicates statistical significance.

Table 3: Statistical Results

Lastly, we turn to RQ3. To determine the response, the difference scores were ranked from largest to smallest and using the Kendall's Tau-b and Hoeffding's Dependence coefficients, the number of concordant and discordant pairs of observations was determined and used to detect whether the gain in the concept map scores was independent of the gain in the language sample scores. All language sample scores were used in the analyses. Table 4 presents the results of the analyses. Both the NW and NDW measures show the expected association with the growth in concept map scores. Kendall's Tau coefficient also indicates an association between growth in the TTR measure and the concept map measure (α = .05). The Hoeffding's D analysis is more conservative than the Kendall's D as can be seen by the magnitude of the correlations. Hoeffding's D more strictly controls for tied pairs and has a more well-defined distribution.

	Kendall's Tau		**Hoeffding's D**	
	Tau	***p***	**D**	***p***
Rank NW	.460	<.001*	.131	<.001*
Rank NDW	.417	<.001*	.102	<.001*
Rank TTR	.215	.053	.005	.234
Rank MUL	-.013	.907	-.007	.698

Note: * Indicates statistical significance.

Table 4: Coefficients of Association Results

6 Discussion and Conclusions

Our findings suggest that, on average, girls' writing samples scored higher than that of boys' at pretest. However, the findings did not suggest any initial differences in boys' and girls' pretest language measures and resulting concept map scores. Children, on average, made pretest to posttest gains in concept map scores and NW and NDW language scores. and the gains were not differentiated by gender. Finally, gains made on concept map scores were associated with gains in NW and NDW but not with MUL.

The number of utterances (sentences or independent clauses) increased over time. At pretest, the average number of utterances was 18 with standard deviation of 9.8 and, at posttest, the average number of utterances was 27 with standard deviation of 6.8. The number of utterances accounts for the increase in the NW and the expansion of the topic accounts for the increase in NDW. The number of utterances in these samples is the same as the number of questions asked and the number of responses made by the children. Increase in utterance necessarily increases NW. Concept maps are created from the different words used in the language sample, thus, the relationship between the growth in NDW and the growth in concept map scores was anticipated. At posttest, the children talked about two facets of physical health, body parts associated with the five senses and healthy habits rather than just the five senses component of physical health. The TTR and MUL measures somewhat control for the confounding aspects of the interviews. The measures of association, because of the use of ranks, indicate whether or not the high ranking scores remained ranked as high for both measure. This was not evident for the MUL growth relative to the concept development as measured by the concept map scores.

Using the class concept map to prompt children's responses has two disparate effects. We have previously found that children with low initial status demonstrate more knowledge when using a concept map to prompt their memory while children with higher initial status are constrained by the use of a concept map (Hunter, Wehry, & McLemore, 2010). Using the class concept map during the interview often prompted one or two word responses, especially at the end of the longer interviews. Short responses suppress the MUL measure, and some children developed a set response pattern in the longer, second interview. Both activities elicit concept knowledge, but suppress language scores.

In our analyses, we ignored that the scores of the individual children were not independent as they learned together in classes. The interviews were collected by school and class, so that in the process of transcribing and scoring the children's language samples, we read the transcriptions by class. Language patterns particular to classes soon emerged. Children in the same classed mimicked the language of their teachers, thus, revealing a lot about instruction and the teacher's language modeling. Some classes of children responded using complete sentences while others were content to use just one word. Possible misconceptions also emerged from the language samples. For instance, children in several classes told us that the purpose of the heart is to help with breathing. Without knowing exactly how the teacher explained the function of the heart, we cannot determine whether this is a misconception or children's simplification of the teacher's explanation.

Future work involves finding ways to separate the measure of concept and language development. We do not think that one language sample adequately serves both purposes. However, two interviews, one used to create concept maps and the other to assess language, must address the same content knowledge. Otherwise, we untangle one issue by creating another confounding issue. We also need to standardize the interview by using a script. To overcome the ceiling effect with the writing samples, we need to collect data earlier in the academic year. Once we overcome these issues, we hope to collect a large enough sample to use hierarchical linear models, thus accounting for dependency in the children's scores.

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USING ENRICHED SKELETON CONCEPT MAPPING TO SUPPORT MEANINGFUL LEARNING

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Abstract. There has been significant interest among researchers in the instructional use of concept maps and collaboration scripts. Some studies focus on students' collaboration on concept mapping tasks; others focus on scripts to structure learning tasks and guide interactions. Little is known about scripted collaborative concept mapping. This article reports a study in which we examine the effects on meaningful learning of scripting students' argumentative interactions during collaborative "enriched skeleton concept mapping". Each concept in the enriched skeleton concept map (ESCoM) contains "annotated factual multimedia information" and an embedded micro collaboration script.

The study was performed in a Biomolecules course of the Bachelor of Applied Science program. First-year students were randomly assigned to an experimental group of 44 students and a control group of 49 students. In the experimental group, students worked together in pairs on an ESCoM guided by embedded collaboration scripts. The control group received the regular course.

The results show that students were able to handle and appreciate the enriched skeleton concept mapping products and processes. Moreover, concept maps appeared to be scored reliable and validly. Finally, the regular course exam showed that the experimental group outperformed the control group. Enriched skeleton concept mapping resulted in a better understanding of the conceptual structure of the domain, the concepts and their relations.

1 Introduction

Students in higher education need to develop a focus on meaningful learning; memorization of facts and procedures is not enough for success (Biggs & Tang, 2007). Graduates from higher education need a deep understanding of concepts to generate new ideas, new theories, new products and new knowledge (Sawyer, 2006).

Meaningful and deep learning has been described as the ability to critically analyze, research and explain new knowledge, facts and ideas by connecting them with existing knowledge, concepts or principles and being aware of one's own development in the learning process (Ausubel, 1963; Biggs & Tang, 2007; Chin & Brown, 2000; Sawyer, 2006). When students are engaged in knowledge construction processes, like collaborative discourse and argumentation, this has a strengthening effect on meaningful and deep learning (Chi, 2009; Mayer, 2002; Nussbaum, 2008). Unfortunately, students in higher education often demonstrate a surface approach to learning (Biggs & Tang, 2007; Entwistle & Peterson, 2004). Moreover, students rarely take the initiative in knowledge construction processes to support meaningful learning (Chi & Ohlsson, 2005; King, 2007). In general, they have to be initiated by a teacher in a face-to-face learning process with students. Given the scarcity of teacher resources, there is a need to develop instructional interventions that are effective in provoking meaningful learning and efficient in requiring a minimum of teacher guidance.

We aim to support meaningful learning by visualizing the conceptual structure of a knowledge domain and regulation of the dialogue between the students. Our visual representation is an enriched concept map.

Students are often asked to start with a "blank sheet" and begin to construct a concept map for some topic. The concept maps are then developed, extended and refined as the students develop other activities on the concepts and increase their understanding (Novak, 1998, 2002; Novak & Cañas, 2008; O'Donnell, et al., 2002). However, to start with a blank sheet may have its drawbacks because asking students to draw a map from scratch may impose too high a cognitive demand to produce a meaningful representation of their knowledge (Schau, et al., 2001). Moreover, students may have misconceptions or faulty ideas about a topic that would impede their learning if they were to begin with a "blank sheet" (Boxtel, et al., 2002; Novak, 2002). For difficult topics, as determined by the teacher's experience, Novak and Cañas (2008) suggest using a "skeleton concept map" as an alternative to having students prepare a concept map from scratch. A skeleton concept map is a partial knowledge domain representation that contains only key concepts and some of the relations between them. The skeleton concept map offers students a foundation to elaborate on by using relevant resources and adding concepts and information resources to their concept map. In this study we provide students with an enriched skeleton concept map. See a part of the enriched skeleton concept map (ESCoM), Proteins, in Figure 1, as an example.

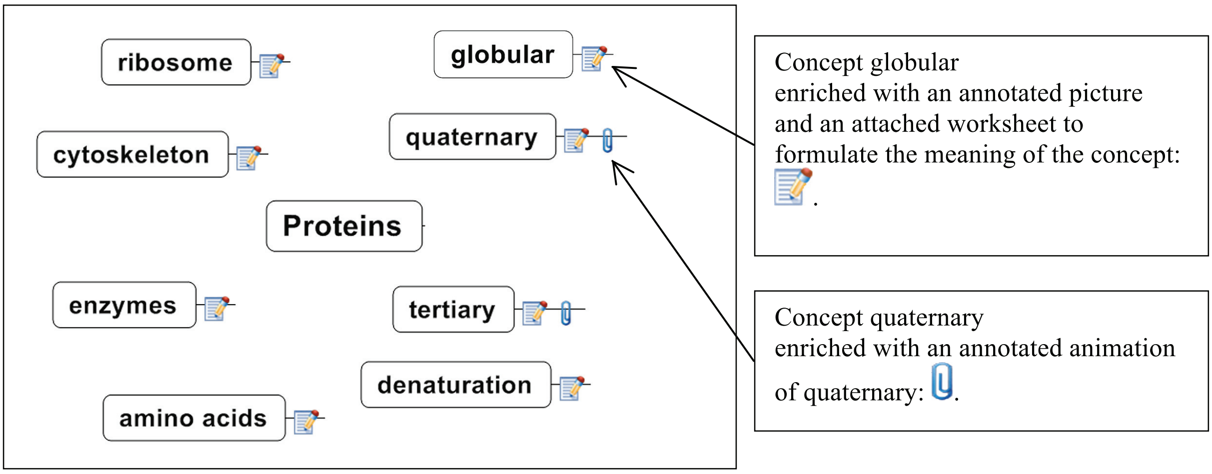


Figure 1. Part of the enriched skeleton concept map, Proteins.

ESCoMs, in contrast to the skeleton concept map of Novak and Cañas (2008), are the visualization of the conceptual structure of a specific knowledge domain, but without the visualization of the relations between the concepts. Each concept in the ESCoM contains (1) annotated factual information (pictures, text or animations) that elaborate on the concept and (2) an attached worksheet to formulate the meaning of the concept. The skeleton concept maps are enriched with multimedia content and a worksheet to provide scaffolds to improve students' knowledge construction. However, to support meaningful learning, we also have to stimulate a meaningful dialogue between the students while they work on the skeleton concept map. According to Nussbaum (2008) and Chi (2009), collaborative discourse and collaborative argumentation are important to meaningful learning because they force students to externalize their knowledge, monitor each other's learning and jointly negotiate the meaning. However, students do not collaborate well if left unaided (Weinberger, et al., 2007). Collaborative learning – be it face-to-face or mediated by a computer – needs to be supported by adequate scaffolds (Fischer, et al., 2007). Collaboration scripts form an important example of these scaffolds.

Collaboration scripts structure students interaction and scaffold collaborative learning through the use of roles, activities, and sequencing of activities (King, 2007). Collaboration scripts can guide students in meaningful discussions and can structure the process of argumentative knowledge construction Dillenbourg and Hong (2008) distinguish "macro scripts" and "micro scripts." Macro scripts are pedagogical models: they describe group formation and the collaboration process using phases, roles and activities. Micro scripts are dialogue models that structure interaction and foster argumentation, explanations and mutual regulation. A micro script may prompt a student to respond to the argument of a fellow student with a counter-argument (Weinberger, et al., 2007). It is expected that students will organize their interaction without the use of collaboration scripts since the scripts will become internalized through practice (Dillenbourg & Hong, 2008; King, 2007).

Until now, empirical research has focused on traditional concept mapping (Novak & Cañas, 2008; Tergan, et al., 2006; Torres & Marriott, 2010). This study aims at demonstrating the potential of the ESCoM with scripted collaborative concept mapping. Our strategy is to guide and support students' argumentative interactions during collaborative concept mapping with collaboration scripts to support students' meaningful learning. We use the skeleton concept map, enriched with multimedia content and an embedded micro collaboration script in the attached worksheet of each concept. The embedded collaboration scripts guide students' collaborative discourse and argumentation. Furthermore, collaboration scripts guide the students to concentrate on the meaning of the concepts and their relations.

This study addresses the following research question:
Does scripted collaborative concept mapping guide and support students' argumentative interaction, leading to better understanding of the conceptual structure of the domain, the concepts and their relations?

2 Method

2.1 Participants

All first-year students (N=93, 31 women, 62 men, aged 17 – 33 years, M = 19.1, SD = 2.4) of the Bachelor of Applied Science program at Fontys University of Applied Sciences took part in this study. Seventy-one percent of the students had a prior senior general secondary education[1] (the regular enrollment) with science orientation; 17% had a previous pre-university education,[2] and 12% had other previous education. In addition, two teacher-experts in the domain of Biomolecules of the Bachelor of Applied Science program took part in this study.

2.2 Design

The experiment was conducted in a Biomolecules course over a four-week period. The students were randomly assigned to four classes. Two classes of 44 students made up the experimental group. The other two classes of 49 students were used as a control group.

The control group received the regular course: one hour of lecture and three hours of tutorials per week. The lecture was structured as a linear sequence of slides the teacher used to explain the subject matter. The tutorials consisted of class discussions about questions from the textbook.

The experimental group was randomly divided into 22 pairs. They spent the same amount of time as the control group: two sessions of two hours per week. During the sessions, the students worked together on the ESCoM following the collaboration scripts. They had no teacher contact hours, and thus, neither lectures, nor tutorials.

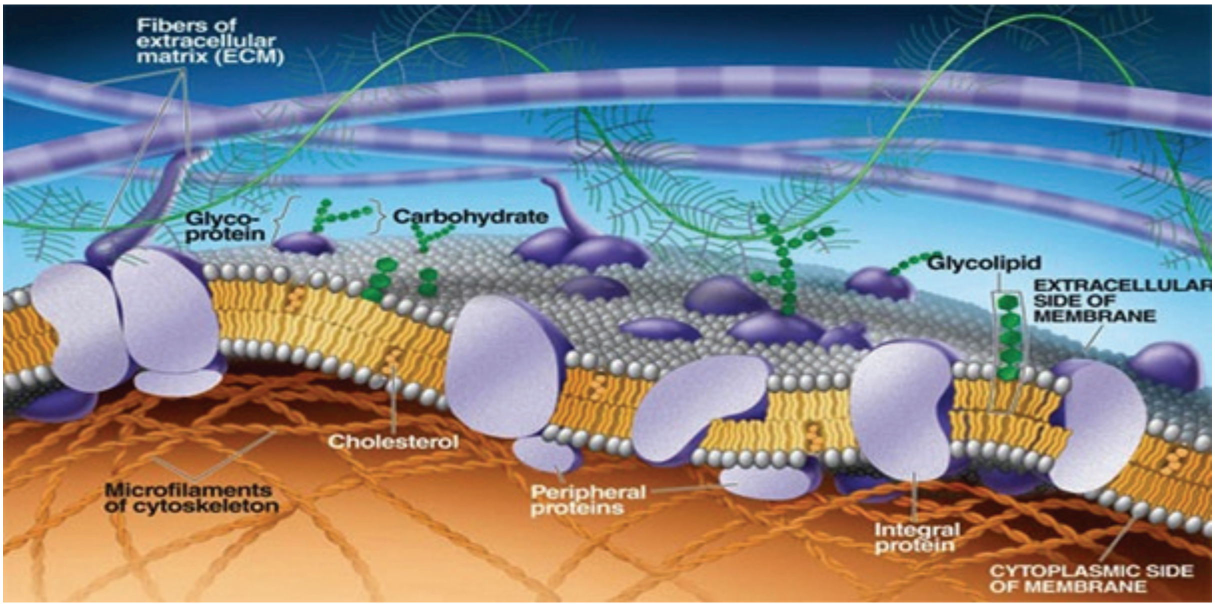
In the week before the course, all students in the experimental group received a two-hour training session in the concept mapping tool, Mindjet's MindManager Pro. The students in the experimental group used a laptop with the concept mapping software tool installed. They learned how to add annotations and data to the concepts and how to create relations between the concepts. Additionally, they were trained to use the concept map in a shared workspace.

2.3 Instruments

The domain concept map was used as a master map for constructing the ESCoM and as a criterion map to compare the concept maps constructed by the students. The domain concept map was created by two teacher-experts in the domain of Biomolecules. The experts worked together and selected 46 concepts and added 44 relations they considered essential for the students as the domain knowledge representation of Biomolecules. The concepts and their relations were grouped in the domain concept map to represent the four subdomains in order to support students' orientation and navigation. Carbohydrates, Lipids, Nucleic acids and Proteins are the four subdomains of the domain Biomolecules (Campbell, et al., 2008). To each concept and relation, the experts added the information they considered essential for the students in a separate worksheet. We refer to this information as the "expert domain information" as a criterion to compare the concept maps constructed by the students.

In this study we provide students with an ESCoM. The ESCoM provided to the students was derived from the domain concept map by deleting the relations. Each concept in the ESCoM contains (1) annotated factual information (pictures, text or animations) that elaborates the concept, and (2) an attached worksheet containing a "5-step collaboration script." See the concept membrane in Figure 2, as an example. Each new relation contains a "3-step collaboration script." Additionally, the experts filled in the annotated worksheets of three concepts and their two relations as a working example for the students.

[1] In Dutch "hoger algemeen voortgezet onderwijs" (havo)
[2] In Dutch "voorbereidend wetenschappelijk onderwijs" (vwo)



Worksheet with the associated collaboration script for concepts.

1. Student A and Student B: Formulate individually the meaning of the concept.

1a. Meaning Student A: < . . . >

1b. Meaning Student B: < . . . >

2. Student A and Student B: Discuss and pose critical questions regarding the meaning of the concept and formulate parts of the agreements and disagreements: < . . . >
3. Student A and Student B: Improve your formulations by additional descriptions, elaborations and/or comments: < . . . >
4. Student A and Student B: Formulate jointly the meaning of the concept upon which they agree: < . . . >
5. Student A and Student B: Formulate jointly an example set of characteristics of this concept in a cell or organism: < . . . >

Figure 2. The concept membrane with (1) a picture with specific terminology as annotated factual information, and (2) an attached worksheet containing the associated 5-step collaboration script for concepts. The students have to fill in the blanks < . . . > in the worksheet.

The collaboration script guides students' argumentative interactions. Moreover, the script structurally supports students in critically analyzing, elaborating and explaining the meaning of the concept to support meaningful learning.

For each new relation that the students added, they filled in an attached worksheet according to a "3-step collaboration script" (Figure 3).

Alternate to the lead role.

1. Lead: formulate the meaning of the relation: < . . . >
2. Alternate student: Formulate parts of the agreements and disagreements and proceed with the formulation of the lead by additional descriptions, elaborations and/or comments: < . . . >
3. Lead and alternate student: negotiate a common description of the meaning of this relation: < . . . >

Figure 3. An attached worksheet containing the associated 3-step collaboration script, for relations. The students have to fill in the blanks < . . . > in the worksheet.

Students' appreciation of the concept mapping products and processes were measured using a 28-item questionnaire on a 5-point Likert-type scale, addressing four topics, which took about 15 minutes after the last peer group session. The first topic referred to the adequacy of the domain representation in the enriched skeleton concept map, related to the information in their textbook, *Biology* (Campbell, et al., 2008). The second topic referred to the effectiveness of the learning activities during the peer group sessions, and the third topic referred to student motivation. Finally, the fourth topic referred to the support offered by the embedded scripts in students' interaction.

The similarity between the quality of the content of a given concept map and a criterion map has been examined (Albert & Steiner, 2005; Ruiz-Primo, et al., 2001; Schau, et al., 2001). Two experts assessed the quality of the annotated content on the students' concept map worksheets. They used a rating scale ranging from 1 (no similarities) to 5 (a great deal of similarities and a complete and correct description of essential information).

In addition, the experts rated the quality of the dialogue with respect to content annotated on each step in order to assess whether the micro scripts guided students to meaningful dialogue and argumentation. The experts used a rating scale ranging from 1 (no dialogue), 2 (moderate dialogue) to 3 (meaningful dialogue).

Finally, the two groups took a test as part of their regular biomolecules examination. The regular exam was composed of 15 multiple-choice items that students answered during a 45-minute period. Exam scores from the course Cell Biology (used as an introduction to Biomolecules) were used to statistically control for differences in students' prior knowledge.

3 Results

The overall means and the standard deviations for the biomolecules exam scores are shown in Table 1.

	N	*M*	*SD*
Experimental Group	41	6.44	1,10
Control Group	45	6.08	1.61

Table 1: Biomolecules exam scores

The reliability of biomolecules multiple choice exam is modest: $\alpha = .64$, and sufficient for this study.

Analysis of covariance demonstrated a significant experimental effect on the biomolecules exam scores between the experimental group and the control: ANCOVA, $F(1,86) = 6.35$, $MSE = 9.86$, $p = .014$, $\eta_p^2 = .071$.

The domain concept map, which contains 43 concepts and 44 relations, was used as a criterion map to assess the concept maps constructed by the peer groups. The quality of the content of the 43 concepts the peer groups added to their concept map was rated independently by the two experts. They used a 5-point rating scale ranging from 1 (no similarities) to 5 (a great deal of similarities and a complete and correct description of essential information). The inter-rater reliability between the experts was rather strong ($r = .74$). The quality of content of the 44 relations was also rated independently with a strong inter-rater reliability of: $r = .82$.

The overall means and the standard deviations for quality of the contents scores of the 19 peer groups' concept maps are shown in Table 2.

	N	*M*	*SD*
Quality of the contents of the 43 concepts	19	3.91	0.41
Quality of the contents of the 44 relations	19	4.44	0.34
Quality of all the 87 contents	19	4.12	0.33

Table 2: Quality of the contents of the concepts and relations of the 19 peer groups.

The quality of the dialogues of the 43 concepts the peer groups added to their concept map was rated independently by the two experts. They used a 3-point rating scale ranging from 1 (no dialogue) to 3 (meaningful dialogue). The inter-rater reliability between the experts was rather strong ($r = .72$). The quality of dialogues of the 44 relations was also rated independently with a rather strong inter-rater reliability of: $r = .73$.

The overall means and the standard deviations for quality of the dialogue scores of the 19 peer groups' concept maps are shown in Table 3.

	N	*M*	*SD*
Quality of the dialogues of the 43 concept	19	2.06	0.46
Quality of the dialogues of the 44 relations	19	1.39	0.41
Quality of all the 87 dialogues	19	1.80	0.37

Table 3: Quality of the dialogues of the concepts and relations of the 19 peer groups.

The correlations between all of the 87 quality of contents and quality of dialogue scores were rather high (r = .62). The biomolecules exam scores were rather strongly correlated to the quality of all the content scores of the peer group concept maps (r = .57).

Evaluation results shows (1) the adequacy of the domain representation in the ESCoM (M = 3.77 on a 5-point scale, SD = 0.36), (2) the effectiveness of the learning activities during the peer group sessions (M = 3.06, SD = 0.60), (3) student motivation (M = 3.26, SD = 0.56), and (4) the support of the embedded scripts in their interactions (M = 3.32, SD = 0.64).

4 Conclusion and discussion

The objective of this study was to examine the effects of guiding and supporting students' argumentative interactions during enriched skeleton concept mapping on meaningful learning. The following conclusions can be drawn. First, enriched skeleton concept mapping resulted in significantly better understanding of the conceptual structure of the domain and the concepts and their relations, as evidenced by the exam scores. Second, concept maps appeared to be scored reliable and validly, as illustrated by the high levels of inter-rater reliability. In addition, strong evidence is provided for content validity of the concept maps, as illustrated by the rather strong correlations between the exam scores and quality of the content scores of the concept maps. Finally, students were able to handle and appreciate the enriched skeleton concept mapping products and processes, as shown by the results of the evaluation questionnaire. Apparently, they were able to control their progress in the scripts and the overall progress in the concept map.

Even though the results of this study show positive effects of the enriched skeleton concept mapping method, there are some caveats to consider. First, scoring the concepts and relations took considerable time. However, scoring all the concepts and relations may not be necessary in educational practice. Ruiz-Primo, et al. (2001) suggested that concept maps can be reliably scored from one random sample of concepts. Further research is needed on developing a procedure to score the concepts and relations more time efficiently. Second, the quality of students' argumentative dialogue with respect to the annotated content was rated on a 3-point scale. Further research should concentrate on text analysis mechanisms to assess the quality of the argumentative dialogue. Finally, this study demonstrated the potential of our method of the enriched skeleton concept map with scripted collaborative concept mapping in educational practice. Further research is needed on developing a procedure for this method to become widespread in educational practice.

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USO DE MAPAS CONCEPTUALES EN UN PROGRAMA DE OBSERVACIÓN POR PARES

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Abstract. La observación por pares es una estrategia de mejoramiento de la calidad de la docencia, en la que un docente es observado por un colega (par) mientras enseña, con el objetivo de recibir retroalimentación que le permita aumentar la efectividad de su enseñanza. Este trabajo reporta sobre una experiencia de observación por pares realizada en la Universidad Tecnológica de Panamá. El diseño del programa involucró el uso de mapas conceptuales a través de las diferentes etapas de la experiencia. En la fase inicial, los participantes formularon su concepción de una docencia ideal en su disciplina a través de un mapa conceptual, el cual sirvió al par observador de rúbrica para las sesiones de observación y ayudó a enfocar la discusión entre los pares hacia la consistencia entre lo concebido y lo implementado durante las sesiones de retroalimentación pos-observación. La explicación del marco teórico para la observación, una docencia basada en experticia, he hizo mediante mapas conceptuales. Al final del proceso, los docentes revisaron sus mapas iniciales para incorporar elementos o relaciones nuevas; algunas de estas revisiones sugieren una mayor sensibilización respecto a la naturaleza de la enseñanza y el aprendizaje. La esperanza es que esta sensibilización se traduzca en una docencia cada vez más coherente y autocrítica por parte de los profesores participantes.

1 Observación por pares

La observación por pares ha sido descrita como "un proceso de observación intencional en el que un profesor universitario asiste a una clase de un colega con la intención de ofrecerle retroalimentación en calidad de un 'amigo crítico'" (Kinchin, 2005). Se inserta dentro de un movimiento que busca "hacer más visible aquello que los docentes hacen para que ocurra el aprendizaje en los estudiantes" (Kinchin, Lygo-Baker, & Hay, 2008). Haciendo uso de los mapas conceptuales (Novak & Gowin, 1984), estos autores han elaborado un modelo para describir la naturaleza de las estructuras de conocimiento intercambiadas durante la interacción docente-estudiante, lo que a su vez les ha permitido entender mejor la brecha entre el conocimiento del docente y el aprendizaje del estudiante, y proponer maneras concretas de cerrarla.

Las exploraciones de Kinchin et al. (2008) también han revelado condiciones bajo las cuales la brecha se convierte en un círculo vicioso en el que docentes y estudiantes son cómplices en evitar un discurso serio y profundo sobre la disciplina en torno a la cual interaccionan. Un resultado de este tipo de interacción puede ser el de "no-aprendizaje", una situación en la que no hay cambios evidentes en la estructura cognitiva del alumno (Jarvis, 1992). Romper estos ciclos de no-aprendizaje requiere, primero, visualizar cómo falla el ciclo de aprendizaje, y segundo, concebir estrategias de enseñanza alternativas. En este sentido, la observación por pares a la vez que contribuye al análisis de la interacción docente-estudiante, provee una fuente de concepciones diferentes sobre la enseñanza.

La observación de la enseñanza a nivel terciario por parte de colegas docentes todavía no es algo común en el mundo. En años recientes, el Reino Unido ha comenzado a desarrollar programas de observación por pares, siguiendo el ejemplo de universidades norteamericanas y australianas (Lomas & Kinchin, 2006). En Panamá los profesores universitarios casi nunca participan en grupos de discusión donde conversan de manera abierta y reflexiva acerca su práctica docente; mucho menos abren las puertas de sus aulas para ser observados por colegas mientras enseñan. Este proyecto buscaba sacar provecho de la experiencia del Reino Unido, para contribuir a forjar en la UTP un ambiente más receptivo a la reflexión personal y al diálogo entre colegas sobre la actividad docente, como un paso indispensable para el mejoramiento de la calidad de la enseñanza en nuestra institución.

2 Participación docente

La participación de los docentes en el proyecto fue voluntaria. A pesar de los esfuerzos que se hicieron por reclutar voluntarios, apenas se consiguió formar 4 pares. Esto ya se anticipaba dada la oposición que suele haber en las universidades a innovaciones educativas, particularmente si se perciben en ellas algún tipo de amenaza al estatus quo (Lomas & Kinchin, 2006). No obstante, desde la concepción del proyecto se decidió llevarlo adelante aun cuando se consiguiesen pocos voluntarios, y éstos fuesen personas ya de por sí receptivos hacia este tipo de intervención, pues se consideró que en ese caso el programa serviría como vitrina para exponer el tipo de programa de desarrollo profesional que se buscaba implementar, a saber, un programa de carácter formativo, no sentencioso, y reconocido a nivel institucional.

Siguiendo la recomendación de Kinchin (2005), se conformaron parejas de disciplinas diferentes a fin de asegurar debates más fructíferos, enfocados sobre la estructura del conocimiento intercambiado durante las sesiones de clase observadas, en vez de contenidos específicos de la asignatura. Las diferentes estrategias de enseñanza entre las disciplinas ayudan a los docentes a verse a sí mismos desde una nueva óptica y considerar el uso de estrategias alternativas (Kinchin, Cabot & Hay, 2008).

Previo a arrancar, los participantes llenaron un cuestionario que inquiría sobre su conocimiento de y actitud hacia la observación por pares. El cuestionario, aplicado de manera anónima, reveló que la mayoría desconocía lo que era la observación por pares, y que sentían emociones encontradas al respecto. Al preguntarles lo que sentían de participar en el proyecto, todos utilizaron alguna palabra que denotaba desasosiego: temor, duda, ansiedad, preocupación, incertidumbre; pero al mismo tiempo, manifestaron expectativas positivas: esperanza, entusiasmo, y confianza en que la observación por pares les sería de utilidad en su práctica docente, principalmente por la oportunidad de aprender de otros y la posibilidad de ver su labor desde la perspectiva de otro docente, evidenciando aspectos que por sí mismos no habrían visto.

3 Implementación del programa de observación por pares

La observación por pares en la UTP se organizó en torno a tres aspectos: capacitación, observación, y retroalimentación. Los mapas conceptuales tuvieron un rol protagónico en cada uno de ellos. A continuación se describen estos aspectos y la manera en que se utilizaron los mapas conceptuales.

3.1 Capacitación

La literatura sobre observación por pares en programas de desarrollo profesional docente destaca la importancia de tener un foco hacia el cual dirigir la observación (Richards & Lockhart, 1990). La experiencia de varios estudios pilotos realizados en King's College de London (KCL) ha mostrado que con la fórmula de observación por pares usando los mapas conceptuales para plasmar el ideal personal de enseñanza, se han obtenido resultados positivos en el sentido de que los docentes se han mostrado receptivos y entusiastas, y para muchos la experiencia ha servido como trampolín para continuar explorando diversos aspectos de su labor docente, haciendo uso de una gama de estrategias más allá de los mapas conceptuales.

Los mapas conceptuales constituyen un buen punto de partida porque, por un lado, tienen la virtud de hacer de la observación por pares algo menos intimidante al permitir que tanto observador como observado se enfoquen en las actividades clave de la enseñanza de manera no amenazante y utilizando un lenguaje que no depende de la disciplina (un historiador y un físico tendrían en el mapa conceptual un marco de referencia común). Por otro lado, los mapas conceptuales hacen de la observación algo más personal al permitir a los participantes expresar de manera individual e idiosincrática los valores y creencias que subyacen a su docencia.

Con esto como antecedente, el programa de observación por pares en la UTP inició con un breve en de mapas conceptuales. Como producto final del taller, cada docente elaboró un mapa conceptual en el que expresó su concepción de una docencia ideal en su disciplina. Dicho mapa sirvió de rúbrica durante la observación, ya que la idea no era imponer un método específico de enseñanza, sino llevar al docente a reflexionar, con el apoyo de un colega, sobre la coherencia entre su práctica docente y su concepción abstracta, a la luz de ciertas pautas teóricas. Es importante señalar que al momento de elaborar este mapa los participantes no sabían el rol que jugaría en su observación.

El taller de mapas se complementó con un taller de capacitación para la observación de pares en el que se presentaron algunas perspectivas teóricas que han emergido del trabajo desarrollado en KCL. Una idea clave fue el de transformación entre estructuras jerárquicas y lineales (Kinchin & Miller, 2011) que ocurre durante una situación de enseñanza. Según Novak & Symington (1982), el problema de moverse de estructuras lineales a estructuras jerárquicas y de vuelta nuevamente a lineales es de alguna manera el problema educativo fundamental.

Como experto, el docente mantiene en su mente complejas redes de entendimiento sobre su materia, pero al enseñar una clase suele explicitar solamente cadenas de práctica, omitiendo el conocimiento tácito que le permite articular e integrar estas cadenas con otros conocimientos relevantes dentro de su estructura cognitiva (Kinchin, 2008). Esta brecha entre el conocimiento conceptual que posee y el conocimiento procedimental que exterioriza al dar sus clases ha sido revelada por Kinchin y Hay (2007) mediante el uso de mapas conceptuales. Para subsanar la brecha, proponen un modelo de docencia basado en experticia, lo que requiere que el docente sea capaz de conectar las cadenas de práctica que denotan "competencia" con las redes de entendimiento subyacentes que lo hacen experto y que soportan el desarrollo académico y crecimiento intelectual del estudiante (ver figura 1).

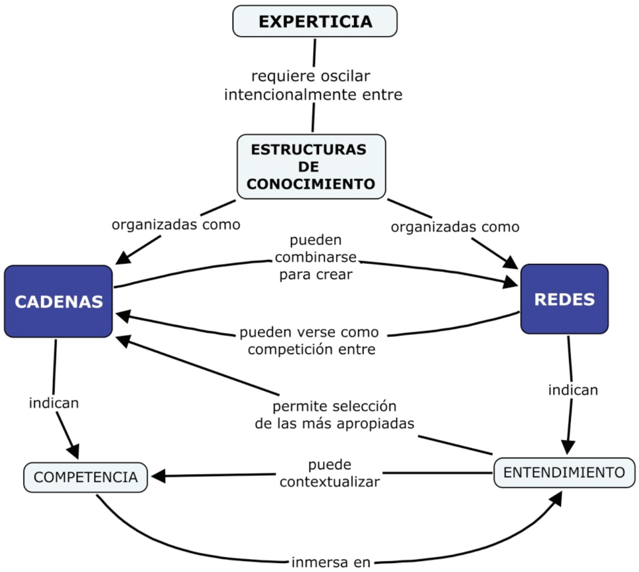

Figura 1. Mapa conceptual de una docencia basada en experticia. Muestra la relación entre cadenas de competencias y redes de entendimiento. Fuente: Kinchin, 2008 (modificado de Kinchin & Hay, 2007; traducción de Miller)

En ramas profesionales como la medicina y la ingeniería la separación entre cadenas de práctica y redes de entendimiento suele ser más pronunciada como consecuencia del énfasis que se hace sobre el dominio de procedimientos, con frecuencia a expensas del entendimiento que los sustenta (Kinchin, Cabot & Hay, 2008). En el caso específico de la ingeniería, por ejemplo, Ellis et al. (2004) mantienen que "demasiado a menudo la educación en ingeniería se ha organizado en torno a la enseñanza y aprendizaje de procedimientos a aplicarse en la resolución de clases particulares de problemas. La pedagogía…en [la ingeniería]… apuesta por que los estudiantes eventualmente obtendrán una visión amplia y podrán integrar y aplicar todos los procedimientos. La realidad, sin embargo, es que con demasiada frecuencia los estudiantes no pueden transferir conocimiento." Un proyecto como este es, pues, especialmente relevante en una universidad como la UTP, dedicada principalmente a la formación de ingenieros.

Durante el taller de observación, la transformación redes-cadenas se consideró en el marco de una dinámica de enseñanza-aprendizaje representada mediante el doble ciclo de Kolb. Ésta es una modificación del ciclo experiencial de aprendizaje de Kolb, el cual describe el patrón cíclico de una experiencia de aprendizaje: experiencia concreta, reflexión, conceptualización, y acción. En el modelo del doble ciclo, dos ciclos interconectados (uno para el docente y otro para el estudiante) son considerados en términos de la morfología de las estructuras de conocimiento presentes en los cuadrantes de cada ciclo (figura 2). Dichas estructuras se ven oscilar entre cadenas lineales de práctica (el saber cómo) y redes jerárquicas de comprensión (el saber por qué). La perspectiva teórica tenía la finalidad de que el docente desarrolle métodos de exploración del saber por qué.

Las respuestas de los docentes a una actividad sobre el doble ciclo de Kolb indican que se sienten 'cómodos' operando dentro de ciertas partes del doble ciclo. Otras, sin embargo, como lo que los estudiantes podrían estar haciendo para construir su propia comprensión de la materia (parte 5), resultan opacas a su mirada. Tienden a enfocarse en las actividades "públicas" de los estudiantes (hacer preguntas, presentar soluciones, etc.), sin ahondar en el tema de cómo éstos desarrollan su propia concepción abstracta de la materia. Reflexiones como la que sigue muestran el valor, en términos de sensibilización y toma de conciencia, de participar en programas de este tipo:

> *"El proceso me ha hecho mucho más consciente de que realmente no sabemos lo que está pasando en las mentes de los estudiantes".*

> *"Debemos mantener en mente el diagrama sobre cómo ocurre y cómo se relacionan la enseñanza y el aprendizaje, a fin de que podamos mejorar el proceso mismo y comprender que 'aprender' no tiene que evaluarse únicamente por medio de una prueba".*

Los mapas conceptuales podrían transformar la opacidad de esta región del doble ciclo de Kolb en el sentido de hacerles más transparente a los docentes las actividades mentales de los estudiantes. Algunos de los docentes se percataron rápidamente de esto. También fue aparente que la discusión de este tema con sus pares fue de gran ayuda para ellos en desarrollar una estrategia para avanzar, y que la oportunidad de observar a sus pares enseñando les permitió identificar aquellos puntos en que podría dársele mayor apoyo al desarrollo de la comprensión del estudiante. El doble ciclo de Kolb, por tanto, proveyó un marco en base al cual los participantes podían evaluarse unos a otros su actividad docente sin sentirse amenazados o juzgados, mientras que el mapa conceptual les ofreció una herramienta para facilitar esto.

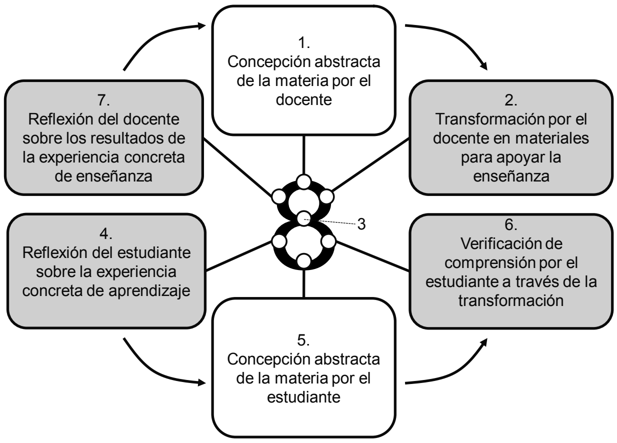

Figura 2. Esquematización del doble ciclo de Kolb. El número 3 representa el aula de clases, espacio público en que se da la interacción docente-estudiante.

3.2 Observación

Las observaciones realizadas por los pares proveyeron un balance práctico para ayudar a los participantes a contextualizar la teoría. Cada par realizó 3 rondas de observaciones mutuas entre Junio y Noviembre del 2010. Las clases observadas durante la primera ronda fueron filmadas. Después de cada observación, los pares se reunieron para discutir sus observaciones, específicamente las coincidencias y divergencias entre lo “esperado”, en base a lo expresado en el mapa de enseñanza ideal de cada uno, y lo observado en el aula.

Generalmente existe cierto nivel de aprehensión asociado con tener a un colega observando una sesión de enseñanza, más aún si ésta se está filmando. Sin embargo, como se aprecia en los siguientes comentarios, los participantes superaron este obstáculo prácticamente desde la primera ronda de observaciones:

“La primera vez estaba muy nerviosa, muy estresada. Pero conversando y riendo después de nuestra primera reunión [pos-observación], el nivel de estrés bajó considerablemente, y las dos vimos que nos podíamos ayudar mutuamente”.

“Al comienzo [sentí] temor; después de la primera sesión pude ver la observación de mi par como que me podía proporcionar alguna ayuda, y no como que me iban a criticar”.

“Al principio… estaba la preocupación de hacerlo bien; después de la adaptación, en general a mí me gustó que viniera otro docente a observarme y yo igual para comparar”.

“En esta tercera reunión de discusión post-observación hubo mayor intercambio de ideas, ya que existe una mayor confianza entre los pares. Esto me permitió preguntarle a mi par preguntas más específicas sobre mi desempeño como docente, sin ningún temor en lo absoluto”.

Sus comentarios muestran, así mismo, que los participantes se abrieron verdaderamente al proceso, esforzándose por seguir las indicaciones a conciencia y sacar el mejor provecho de la experiencia:

“Nos propusimos comparar nuestras observaciones con el mapa conceptual a fin de tener una mejor base para nuestras reflexiones”.

“Encontré muy interesante el poderme observar a mí mismo, gracias a la videograbación, y poder determinar si la concepción de la enseñanza que digo tener es la que realmente pongo en práctica”.

Expresiones como las anteriores sugieren que ésta fue una experiencia positiva de la que los participantes consideran que obtuvieron algún beneficio. La importancia de esto radica en que el desarrollo de una actitud positiva hacia la observación por pares es un aspecto importante de la adopción de esta práctica dentro de una universidad.

3.3 Retroalimentación

Concluidas las observaciones, los investigadores sostuvieron una reunión de retroalimentación con cada par de participantes en la que se les plantearon algunas cuestiones con el objeto de llevarles a reflexionar sobre aspectos particulares del proceso.

El uso de mapas conceptuales como medio para expresar su concepción de una docencia ideal, también supuso un importante ejercicio de reflexión para los docentes. Algunos de ellos expresaron francamente las dificultades que tuvieron:

"Al inicio del proceso… me costó conceptualizar cómo era mi enseñanza… Había muchas cosas que hacía [en clase] que ni siquiera había incluido en mi mapa conceptual."

"Este proceso ha sido muy enriquecedor para mi e inclusive para mis alumnos... de hecho les compartí mi mapa conceptual [para] que me ayudaran a completarlo… [Esto] les explicó mucho del porqué de algunas de mis estrategias..."

Todos los participantes, sin excepción, sintieron que el proceso les fue de provecho. La oportunidad de verse a sí mismos enseñando (a través de las filmaciones y de las reflexiones con un colega), sirvió primeramente para tomar conciencia y darse cuenta de lo que realmente hacen en el aula de clase. Esto incluye todo lo que hacen bien; pero así mismo, también los llevó a percatarse de aquellas áreas en que no están llenando las expectativas que tienen para sí mismos como docentes. De igual forma, consideraron valiosa la oportunidad de ver en prácticas técnicas y estrategias de cómo otros enseñan, que en un momento dado podrían serles de utilidad. Lo anterior se refleja en comentarios como los siguientes:

"Una vez al mes reexamino mi mapa conceptual...para ver si estoy haciendo lo que dije que iba a hacer, especialmente aquellas cosas que me han dicho que son buenas. Para mí, el mapa conceptual es como una fotografía de lo que soy como docente… y me ayuda a ver dónde puedo mejorar."

"Nunca había visto el método de indagación puesto en práctica. Somos colegas pero rara vez tenemos la oportunidad de compartir cómo hacemos las cosas. Pensé que este método me podría ser de utilidad en determinadas situaciones."

"[Mi par], utiliza herramientas y estrategias que me pueden servir a mí también,… como escribir en el tablero sobre una proyección; y preguntar frecuentemente para verificar que todos están enfocados y siguiendo la clase."

3.3.1 Revisión de mapas conceptuales

Concluida la entrevista final, a cada participante se le presentó su mapa conceptual inicial de la enseñanza ideal en su disciplina. Se les pidió reconsiderar, a la luz de la experiencia vivida y la retroalimentación recibida, determinadas partes del mapa particularmente susceptible de ser mejorado. Las figuras 3 y 4 muestran el mapa original de un participante y sus modificaciones, como ilustración de las reflexiones que puede inducir un proceso de observación por pares.

El mapa inicial de este participante muestra una formulación muy bien pensada y articulada del proceso de enseñanza-aprendizaje; no obstante, es una conceptualización que da la impresión que el proceso se tratase de una especie de línea de producción. Un aspecto que llama poderosamente la atención en la configuración de este mapa conceptual es el hecho de que los conceptos "docente" y "estudiante" están arriba a la derecha, fuera de la línea central del mapa; además, aunque aparecen adyacentes, no están interconectados. Cuando el participante recién creó este mapa se le hizo esta observación, y se le preguntó si deseaba establecer algún vínculo entre los conceptos. La respuesta fue negativa. Al formularle la misma observación y la misma pregunta al final del proceso, sin embargo, el docente estuvo anuente a modificar su mapa:

Francamente,… tendría que revisarlo y colocar a los docentes y estudiantes en el mismo centro del mapa conceptual… en este mapa no está claro dónde están parados los docentes y estudiantes en toda esta idea… [El mapa] debía tener algo más que mostrara la interacción entre docentes y estudiantes. Esa es probablemente la parte más importante de la enseñanza. En mi opinión, no se puede tener una clase sin interacción entre docentes y estudiantes."

En el mapa revisado (figura 4) destacan dos cosas interesantes: 1) el concepto “docente” se diversifica en “docentes de ingeniería”, “docentes de física y química” y “docente de matemáticas”, revelando una mayor sensibilidad al papel que juegan sus colegas de las ciencias básicas en la formación del estudiante de ingeniería; y 2) el concepto “estudiante” se mueve a un lugar más central, reflejando un rol protagónico mucho más protagónico por parte de este actor dentro del proceso de enseñanza como lo concibe este participante.

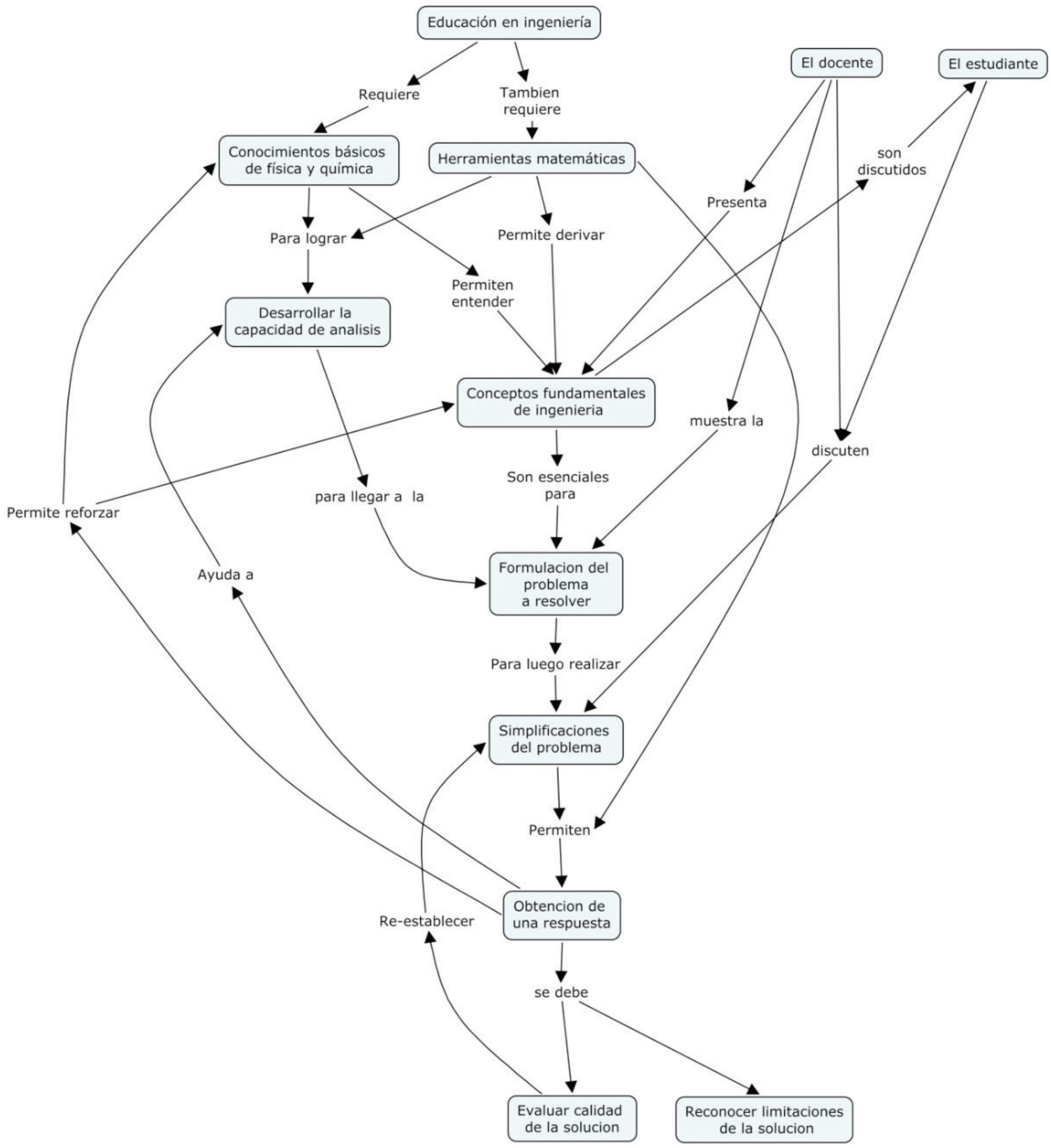

Figura 3. Mapa conceptual inicial de un participante explicando su concepción de la enseñanza *ideal* en su disciplina antes de iniciar el proceso de observación por pares.

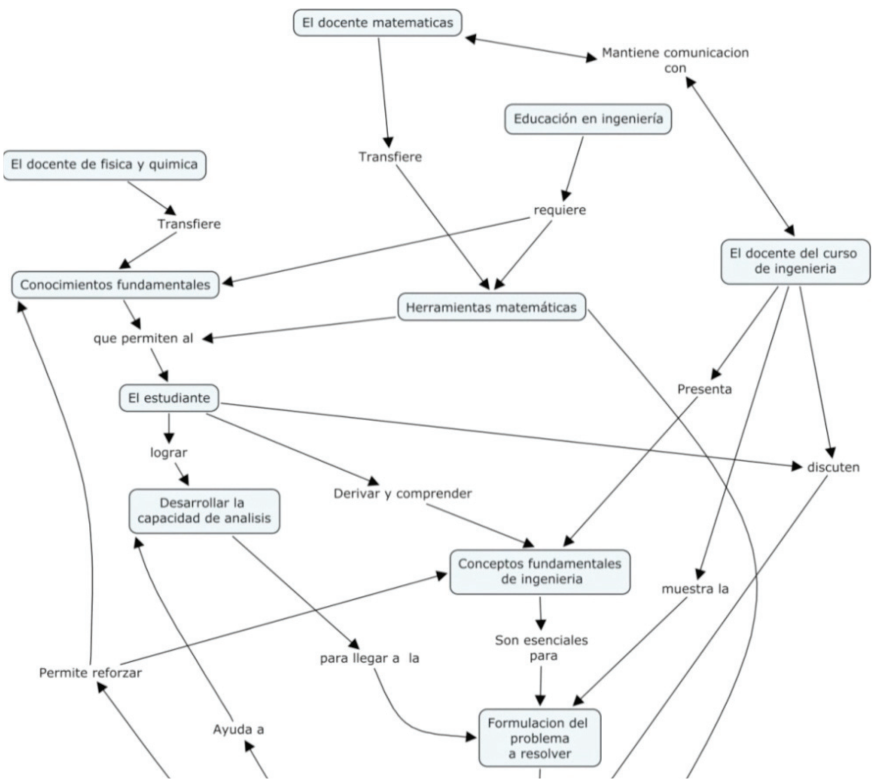

Figura 4. Porción del mapa conceptual revisado al finalizar el proceso de observación.

Lo anterior es una muestra de cómo un proceso como el vivenciado por estos docentes puede sensibilizarlos hacia concepciones que anteriormente no tenían cabida en sus esquemas mentales sobre la educación. La esperanza es que esto, a su vez, redunde en un trabajo de aula más cónsono con sus modelos revisados.

4 Conclusiones

El objetivo primordial de la experiencia de observación por pares implementada en la UTP fue contribuir a fomentar una cultura de reflexión y diálogo sobre la actividad docente que realizan los profesores de la institución. El referente fue un modelo de docencia basada en experticia, en la que más allá de las cadenas lineales de práctica (competencia, saber cómo), el docente hace visible para sus estudiantes las redes conceptuales (entendimiento, saber por qué) en la que estas cadenas se sustentan, alternando entre estructuras de conocimiento lineales y jerárquicas. La perspectiva teórica tiene la finalidad de que el docente desarrolle métodos de exploración del saber por qué. Como marco para entender las interacciones docente-estudiante se tomó un doble ciclo de Kolb, en el cual dos ciclos interconectados (el del docente y el del estudiante) son considerados en términos de la morfología de las estructuras de conocimiento presentes en cada porción del ciclo. Las observaciones realizadas por los pares proveyeron un balance práctico para ayudar a los participantes a contextualizar la teoría, y reflexionar sobre su actividad docente teniendo dicha teoría como referente.

Los mapas conceptuales tuvieron un rol protagónico a través de toda la experiencia. Primeramente, se utilizaron mapas conceptuales para plasmar la visión personal de cada participante acerca de la enseñanza ideal en su disciplina o asignatura. De esta manera no se impuso a los docentes una forma única de enseñar considerada ideal, sino que cada participante describió su propio ideal. Se eligió como medio el mapa conceptual ya que es una de las herramientas más efectivas para hacer visibles y facilitar la discusión de ideas complejas. La función del par consistió en ayudar al docente observado a comparar su desempeño ideal (expresado en su mapa conceptual) con su desempeño real; es decir, ayudarle a comparar lo que el docente dice que quiere hacer con lo que realmente hace en el aula de clases con sus estudiantes. En este sentido los mapas permitieron enfocar la discusión sobre un ente externo a la persona observada, lo que tiende a hacer al docente más receptivo a la crítica que pudiera recibir por parte de su par.

El modelo de enseñanza basado en experticia, con sus inherentes transformaciones de estructuras de conocimiento, se explicó a los participantes mediante un mapa conceptual. Por otra parte, los docentes pudieron percatarse que los mapas conceptuales ofrecen una herramienta para ayudar a exteriorizar aquello que está ocurriendo en las mentes de los estudiantes a medida que éstos interactúan con nuevo conocimiento e intentan relacionarlo con lo que ya saben. En otras palabras, la perspectiva de estructuras de conocimiento que proveen los mapas conceptuales, es también compatible con la comunicación entre docentes y estudiantes, de manera tal que se espera que los logros en la enseñanza por parte del docente puedan traducirse directamente en logros en el aprendizaje por parte de los estudiantes: en la medida que el docente revela las redes que vinculan su conocimiento sobre un tema, facilita que sus estudiantes reconstruyan e integren correctamente la información en sus propias estructuras de conocimiento, contribuyendo de esta forma a mejorar la calidad del aprendizaje de los estudiantes.

Finalmente, la revisión final de los mapas conceptuales iniciales facilitó la toma de conciencia por parte de los participantes de la manera en que el proceso de observación incidió en su concepción original de lo que debe ocurrir en una situación de enseñanza y aprendizaje. La esperanza es que esta sensibilización se traduzca en una docencia cada vez más coherente y autocrítica por parte de los profesores participantes.

5 Agradecimientos

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UTILIZACIÓN DE MAPAS CONCEPTUALES PARA EL ESTUDIO DE LA ESTRUCTURA MOLECULAR Y ESPECTROSCOPÍA MEDIANTE UN CÍRCULO DE APRENDIZAJE

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Abstract. En este trabajo se presenta una experiencia didáctica innovadora que combina simultáneamente dos metodologías de aprendizaje, los mapas conceptuales y los círculos de aprendizaje, utilizando una técnica de trabajos cooperativos denominada rompecabezas o Jigsaw. La experiencia se ha llevado a cabo en el curso académico 2010/2011 con alumnos universitarios de la Facultad de Ciencias en la Universidad de Extremadura (España). El objetivo de fusionar distintas metodologías de enseñanza ha sido que los alumnos se impliquen de una manera más activa en su propio proceso de aprendizaje. Los resultados obtenidos en este trabajo, en las rúbricas de evaluación y en las encuestas de satisfacción, nos han permitido comprobar que el uso de estas metodologías combinadas en las aulas universitarias consolidan de una manera más robusta los conocimientos adquiridos por los alumnos, ya que han permitido a los estudiantes recibir una retroalimentación inmediata y positiva sobre los conceptos más relevantes en el tema de estudio, negociar los significados de los contenidos abarcados e integrar en sus estructuras cognitivas nuevas relaciones semánticas.

1 Introducción

1.1 El Círculo de Aprendizaje para la Construcción colaborativa del conocimiento

El círculo de Aprendizaje se basa como fundamento teórico en la teoría constructivista del aprendizaje, para autores como Bybee (1997), el constructivismo es un modelo interactivo y dinámico de cómo aprenden los alumnos. En este contexto, el círculo de Aprendizaje es un entorno interactivo que permite construir, compartir y adquirir el conocimiento basándose en una estructura grupal participativa que puede llevarse a cabo entre alumnos de una misma aula o alumnos de distintos centros a través de plataformas de e-learning, tanto en contextos formales como informales. (Martínez, Pérez, Suero & Pardo, 2010)

El círculo de aprendizaje es una estructura para el trabajo colaborativo que comparte algunos rasgos con otros tipos de aprendizaje basados en grupos de alumnos, pero también difiere en determinados aspectos específicos. Por ejemplo, para Riel & Polin (2004), el círculo de aprendizaje es una comunidad de aprendizaje basada en la realización de distintas tareas, en contraste con otros autores que consideran que está basada en la práctica o en el conocimiento. De este modo, en lugar de una tarea de grupo compartida, los círculos de aprendizaje se centran en un conjunto de tareas más pequeñas, cada una de ellas dirigida por uno de los participantes del círculo.

La metodología de trabajo en un círculo de aprendizaje implica la construcción del conocimiento a través del desarrollo de las tareas individuales y grupales, potenciando actitudes tales como la confianza, reflexión y diálogo, con el objetivo de lograr una comprensión más profunda de los contenidos tratados, mediante el diseño de actividades de aprendizaje cooperativo para ampliar conocimientos y habilidades. En la etapa final del círculo de aprendizaje se elabora como resultado un informe que puede constar de un documento escrito, un resumen, las pautas para la resolución de los problemas propuestos o en nuestra experiencia en particular, mapas conceptuales.

En este tipo de metodología de aprendizaje, la tarea de dirigir, enseñar y aprender recae en todos y cada uno de los integrantes del círculo. De este modo, cada participante en un círculo de aprendizaje acepta su responsabilidad personal por el éxito del círculo. Cada miembro se compromete a liderar una actividad y especializarse en el contenido de la misma para ayudar al grupo a profundizar sus conocimientos en ese tema, y por tanto, todos los miembros del círculo participan en las actividades y tareas del resto de compañeros. Es decir, hay tanto líderes como participantes. De esta manera, el círculo de aprendizaje es una estrategia que permite a los participantes desarrollar sus habilidades para conseguir una construcción del conocimiento entre todos los alumnos integrantes del círculo. Para Scardamalia (2002), es esencial en un círculo de aprendizaje que exista una "responsabilidad colectiva cognitiva" para la construcción del conocimiento. En este contexto, el proceso de enseñanza en este modelo es un proceso de creación y reconstrucción de materiales y herramientas didácticas para compartirlas, discutirlas y rediseñarlas entre los que integran el círculo, permitiendo un proceso de reconstrucción del conocimiento.

Teniendo en cuenta las características del proceso de enseñanza basado en los círculos de aprendizaje, el objetivo por el que nuestro grupo de investigación ha realizado este tipo de experiencias ha sido facilitar el intercambio estructurado de la información para transformarla en conocimiento, tratando de mirar desde la perspectiva de los demás, es decir, partir de la estructura cognitiva previa de cada alumno y a raíz de ella, proporcionar nuevos conocimientos basados en nuevas estructuras conceptuales a partir de una retroalimentación positiva del conocimiento.

1.2 Los mapas conceptuales como herramientas base en los círculos de Aprendizaje

Algunos autores han mostrado la eficacia de los mapas conceptuales como herramientas didácticas cognitivas (Cifuentes & Hsieh, 2003; Kwon & Cifuentes, 2007) tanto si son construidos de manera individualizada por los alumnos como si se construyen de manera colaborativa donde son aún más eficaces (Kwon & Cifuentes, 2009; Haugwitz, Nesbit & Sandman, 2010). Concretamente, nuestro grupo de investigación tiene una amplia experiencia en trabajar con mapas conceptuales en la práctica docente, por lo que desde hace algunos años venimos adoptando esta herramienta didáctica como metodología de trabajo para la enseñanza de la Física. (Pérez, Suero, Montanero & Pardo, 2001; Pérez, Suero, Pardo & Montanero, 2006; Pérez, Suero, Montanero, Pardo & Montanero, 2009; Pérez, Martínez, Suero & Pardo, 2010).

En la experiencia que presentamos en esta ocasión, hemos unido la potencialidad didáctica de los mapas conceptuales con la metodología de los círculos de aprendizaje, utilizado los mapas conceptuales como las herramientas base de los círculos de aprendizaje. Los mapas conceptuales han sido realizados con el programa CmapTools (Cañas et al. 2004) para facilitar la construcción del conocimiento en los alumnos, debido a las características dinámicas, cognitivas y tecnológicas de este software, pues permite una reconstrucción colaborativa de los mapas conceptuales que se han ido elaborando en la técnica grupal, promoviendo un proceso cognitivo colectivo entre todos los alumnos participantes.

Cada miembro del círculo es el creador de una de las actividades de aprendizaje del círculo, que están basadas en los mapas conceptuales. Cada uno de estos mapas conceptuales elaborados se utiliza en el trabajo grupal para llevar a cabo una construcción significativa del conocimiento a través de la relaboración de los mapas individuales y de la cohesión de los mismos para dar lugar a un mapa final y a una exposición grupal que reúna las proposiciones y estructuras semánticas reconstruidas que aparecen en los mapas consensuados por los integrantes del círculo de aprendizaje. Este resultado final del trabajo grupal es lo que en un círculo de aprendizaje estándar se conoce como informe del proyecto, y que para algunos autores como Bereiter (2004) se denominan "artefactos conceptuales". El diseño del informe final, o en nuestra experiencia del mapa final, es un esfuerzo de colaboración y organización de cada uno de los alumnos participantes en el círculo de aprendizaje, y es la imagen visual de la estructura cognitiva que tiene la parte del grupo de trabajo que participa en la elaboración del mismo. Por otro lado, la utilización del Cmaptools como soporte tecnológico para el desarrollo de los mapas conceptuales hace que sea más fácil, para los grupos de trabajo, la integración de textos, gráficos, enlaces web y animaciones en los distintos mapas conceptuales, haciendo más sencillo el diseño, modificación de proposiciones, enlaces cruzados, adición de recursos y relaboración de los mismos para la construcción grupal de conocimiento tanto de manera asíncrona como sincrónica.

Una de las ventajas del círculo de aprendizaje frente al trabajo individual es el diálogo abierto entre los distintos miembros del círculo. Esta discusión presencial, que es llevada a cabo en el aula, sobre los contenidos tratados es fundamental para la construcción del conocimiento, pues cada alumno expone y defiende ante el resto de compañeros las proposiciones que componen su respectivo mapa conceptual, permitiendo establecer un debate crítico y constructivo sobre las estructuras semánticas incluidas en los mapas. En este contexto, es posible que el alumno modifique la estructura cognitiva original de su mapa conceptual si el resto de compañeros le hacen ver que hay una estructura semántica más idónea para los conceptos trabajados.

Por otro lado, como cada alumno es a la vez líder y participante en el círculo de aprendizaje, es necesario que los compañeros estén dispuestos a colaborar con ellos en el mapa conceptual que originalmente tienen asignado. Y de manera recíproca, tendrán que organizar el proceso de reconstrucción del mapa a través de las posibilidades colaborativas que ofrece CmapTools. Con esta metodología se garantiza la posibilidad de producir cambios conceptuales en las estructuras cognitivas de los alumnos, pudiendo erradicar posibles preconcepciones erróneas que a priori tuvieran sobre determinados contenidos (Suero, Pérez, Montanero, Pardo & Montanero, 2009).

1.3 El trabajo Cooperativo y la técnica del Rompecabezas o Jigsaw

La novedad del trabajo que se presenta es la combinación de técnicas colaborativas y cooperativas para la elaboración de modelos de conocimiento basados en mapas conceptuales. La idea de incluir técnicas de aprendizaje cooperativo viene justificada porque algunos autores consideran que este tipo de metodologías mejoran la calidad de las estrategias de aprendizaje, desarrollan estrategias de procesamiento de la información, favorecen el pensamiento crítico y constructivo, y la capacidad de comunicación y expresión (León, 2007). Para este autor, además de las consecuencias positivas a nivel cognitivo, el aprendizaje cooperativo produce resultados de gran interés pedagógico: motivación intrínseca, actitudes positivas hacia la materia, autoestima, apoyo social, cohesión grupal, participación etc.

Autores como Echeita (1995) o Johnson y Johnson (1989) consideran que hay tres requisitos básicos para lograr un aprendizaje cooperativo. El primero remite a la existencia de una tarea grupal, de un objetivo que los alumnos que trabajan conjuntamente deben alcanzar como grupo. El segundo implica la resolución de esa tarea o problema que requiere la contribución de todos y cada uno de los componentes del grupo. El tercero se refiere a los recursos del grupo tanto desde el punto de vista de la regulación de las relaciones interpersonales, como en lo relativo al desarrollo y ejecución de la tarea. Teniendo en cuenta estas características, en el trabajo que presentamos se presenta una experiencia didáctica innovadora que combina simultáneamente en la metodología de aprendizaje, los mapas conceptuales y los círculos de aprendizaje, a través de la utilización de la técnica de trabajos cooperativos denominada rompecabezas o Jigsaw.

2 Metodología y desarrollo de la Investigación

La técnica de aprendizaje cooperativo que se ha propuesto tiene como objetivo adquirir los conocimientos fundamentales sobre algunos contenidos del temario de estructura molecular y espectroscopía. Esta técnica se ha llevado a cabo con alumnos de segundo ciclo de la Facultad de Ciencias en la Universidad de Extremadura (España) en 7 sesiones de 2 horas durante el curso académico 2010/2011. Se realizó con los alumnos una técnica grupal que combinaba las técnicas del "rompecabezas" y la de "mapas conceptuales colaborativos" utilizando la metodología de un círculo de aprendizaje.

La técnica del Rompecabezas o Jigsaw consiste en dividir el material académico en tantas partes o fragmentos como miembros tiene el equipo. De este modo, cada alumno recibe un trozo del tema sobre el que tendrá que trabajar. A continuación, los alumnos de los diferentes grupos que tienen el mismo fragmento se reúnen en "grupos de expertos", donde se discute y se profundiza en la información de cada parte. Por último, cada estudiante vuelve a su grupo y enseña al resto de compañeros lo que ha aprendido. Entre todos intentan resolver dudas, aclarar, preguntar, explicar... con el objetivo de aprender todo el material.

Durante la realización de la experiencia, el papel del profesor ha sido:

- Planificar y organizar la actividad: Prepara el tema, formar los grupos, explicar las técnicas, entregar el material y la bibliografía a utilizar.
- Realizar el seguimiento de la actividad: Resolver las dudas, animar a los estudiantes a participar, conseguir que se alcancen los objetivos propuestos para el estudio del tema.
- Evaluar los contenidos y el dominio de los mismos alcanzado por los alumnos.
- Evaluar la Participación y el Proceso llevado a cabo.

El desarrollo de la actividad ha consistido en:

Fase 1: Formación de grupos

Los alumnos que han formado parte de la experiencia se dividieron aleatoriamente en 4 grupos de 4 alumnos. Se denotó a los grupos por A, B, C, D y a los alumnos que los constituían por 1, 2, 3, 4.

Cada grupo de alumnos recibió la información relativa a los contenidos sobre los que iban a trabajar, de modo que todos los grupos (A, B, C y D) recibieron el contenido desglosado a modo de rompecabezas en cuatro temas:

- Tema 1: Introducción a la Espectroscopía
- Tema 2: Radiación electromagnética
- Tema 3: Espectros Atómicos
- Tema 4: Espectroscopía de UV-VIS.
  - La figura 1 muestra cómo se llevó a cabo la distribución de los alumnos en los grupos de trabajo según los distintos temas asignados.

	Tema 1	Tema 2	Tema 3	Tema 4
Equipo A	Alumno A1	Alumno A2	Alumno A3	Alumno A4
Equipo B	Alumno B1	Alumno B2	Alumno B3	Alumno B4
Equipo C	Alumno C1	Alumno C2	Alumno C3	Alumno C4
Equipo D	Alumno D1	Alumno D2	Alumno D3	Alumno D4

Figura 1. Distribución de los alumnos en los grupos de trabajo según los distintos temas asignados.

Fase 2: Elaboración Individual de Mapas conceptuales con Cmaptools

Antes de la primera reunión grupal, cada alumno elaboró de manera individualizada un mapa conceptual sobre uno de los temas, así, el alumno nº 1 de los grupos A, B, C y D elaboró un mapa conceptual sobre el tema 1, el alumno nº 2 de los grupos A, B, C y D elaboró un mapa conceptual sobre el tema 2, el alumnos nº de 3 de los grupos A, B, C y D elaboró un mapa conceptual sobre el tema 3 y el alumno nº 4 de los grupos A, B, C y D elaboró un mapa conceptual sobre el tema 4.

Fase 3: **Formación de Grupos de Expertos**: **Elaboración de Mapas Conceptuales Colaborativos**

Los alumnos que habían realizado de manera individual los mapas conceptuales sobre un tema se reunieron en grupos para profundizar y discutir sobre el tema que tenían asignado. De este modo se constituyeron 4 grupos de expertos, constituidos por los alumnos de la siguiente manera: El grupo de expertos numero 1 estaba formado por los alumnos asignados por 1, el grupo de expertos número 2 por los alumnos asignados por 2 etc. Cada grupo de expertos se reunió para elaborar un mapa conceptual de manera colaborativa basándose en los mapas individuales aportados por sus componentes. De esta manera, se obtuvo un mapa conceptual consensuado sobre el tema designado a cada uno de ellos. En esta fase, cada alumno pudo comparar su mapa individual con el mapa elaborado por el equipo de expertos de modo que pudo identificar sus errores conceptuales, sus enlaces entre conceptos y negociar los significados y las nuevas estructuras semánticas que aparecieron en los mapas elaborados colaborativamente. La figura 2 muestra la distribución de los alumnos para la formación de los grupos de expertos.

Figura 2. Distribución de los alumnos para la formación de los grupos de expertos

Fase 4: Los expertos vuelven a sus respectivos grupos

En esta fase, los expertos volvían a sus respectivos grupos y cada alumno explicaba al resto del grupo el mapa consensuado sobre el tema que había trabajado. Cada uno de los grupos (A, B, C y D) debía elaborar un mapa completo y general sobre todos los temas a partir de los mapas de cada experto, estableciendo relaciones cruzadas entre todos ellos y reunificando aquellos conceptos comunes entre los distintos mapas individuales consensuados por los expertos.

Fase 5: Reparto del material: Resolución de problemas

Se repartieron 4 enunciados de problemas sencillos sobre los diferentes temas. Cada grupo (A, B, C, D) debía resolver los 4 problemas simples y proponer el enunciado de un problema más complejo que englobase contenidos de todos los temas.

Fase 6: Segunda sesión de expertos.

Cada grupos de expertos (1, 2, 3, y 4) resolvió uno de los problemas (el relacionado con el tema del cual elaboraron el mapa en la sesión anterior). Una vez encontrada la solución volvieron a sus respectivos grupos (A, B, C y D) para realizar una exposición sobre la resolución del problema. De este modo, cada grupo (A, B, C y D) obtuvo las soluciones a los cuatro problemas elaboradas por los grupos de expertos (1, 2, 3 y 4).

Fase 7: Trabajo y Exposición Grupal

Por último, cada grupo (A, B, C y D) propuso al siguiente (el A al B, el B al C, el C al D y el D al A) el problema global que habían planteado. Una vez resuelto cada grupo (eligió a un portavoz) y expuso al resto de grupos (a los 16 alumnos) el planteamiento y la resolución del problema junto con el mapa conceptual global elaborado. Una vez realizadas las 4 exposiciones, toda la clase (por votación y mediante consenso) eligió el mapa conceptual que consideró más completo y mejor estructurado.

Fase 8: Evaluación de la actividad:

Para la evaluación de la actividad desarrollada se tuvo en cuenta la:

- *Evaluación de los mapas individuales realizados al inicio de la actividad por cada alumno*: Esta evaluación la realizó el profesor y se apoyó en los comentarios del resto de alumnos que componían cada grupo de expertos.
- *Evaluación de los mapas consensuados por los expertos*: Cada mapa consensuado se evaluó por el resto de grupos de expertos, así, el grupo de expertos 1 evaluó los mapas del grupo de expertos 2, 3 y 4.
- *Evaluación de los problemas por los expertos*: Cada problema fue corregido por un grupo de expertos diferente al que ha dado la solución original, de este modo, el problema asignado al grupo 1 lo corrigió el grupo 2, el asignado al grupo 2 lo corrige el grupo 3 ... etc.
- *Evaluación Global:* La realizó el profesor atendiendo a las exposiciones de cada grupo A, B, C y D sobre el mapa conceptual global realizado y el problema general resuelto.
- *Evaluación de la metodología llevada a cabo:* Se llevo a cabo una encuesta de satisfacción en la que los alumnos mostraron su opinión sobre la metodología de enseñanza que se había utilizado.

En las Figura 3 y 4 se presentan algunos de los Mapas Conceptuales realizados por los alumnos, el resto mapas se encuentran alojados en nuestro sitio Cmap "Universidad de Extremadura(España)" dentro de la carpeta "Comunicaciones a Congresos". También se puede acceder a ella a través de la dirección web: http://grupoorion.unex.es:8001/servlet/SBReadResourceServlet?viewhtml donde pueden ser utilizados de manera interactiva mediante la aplicación informática CmapTools.

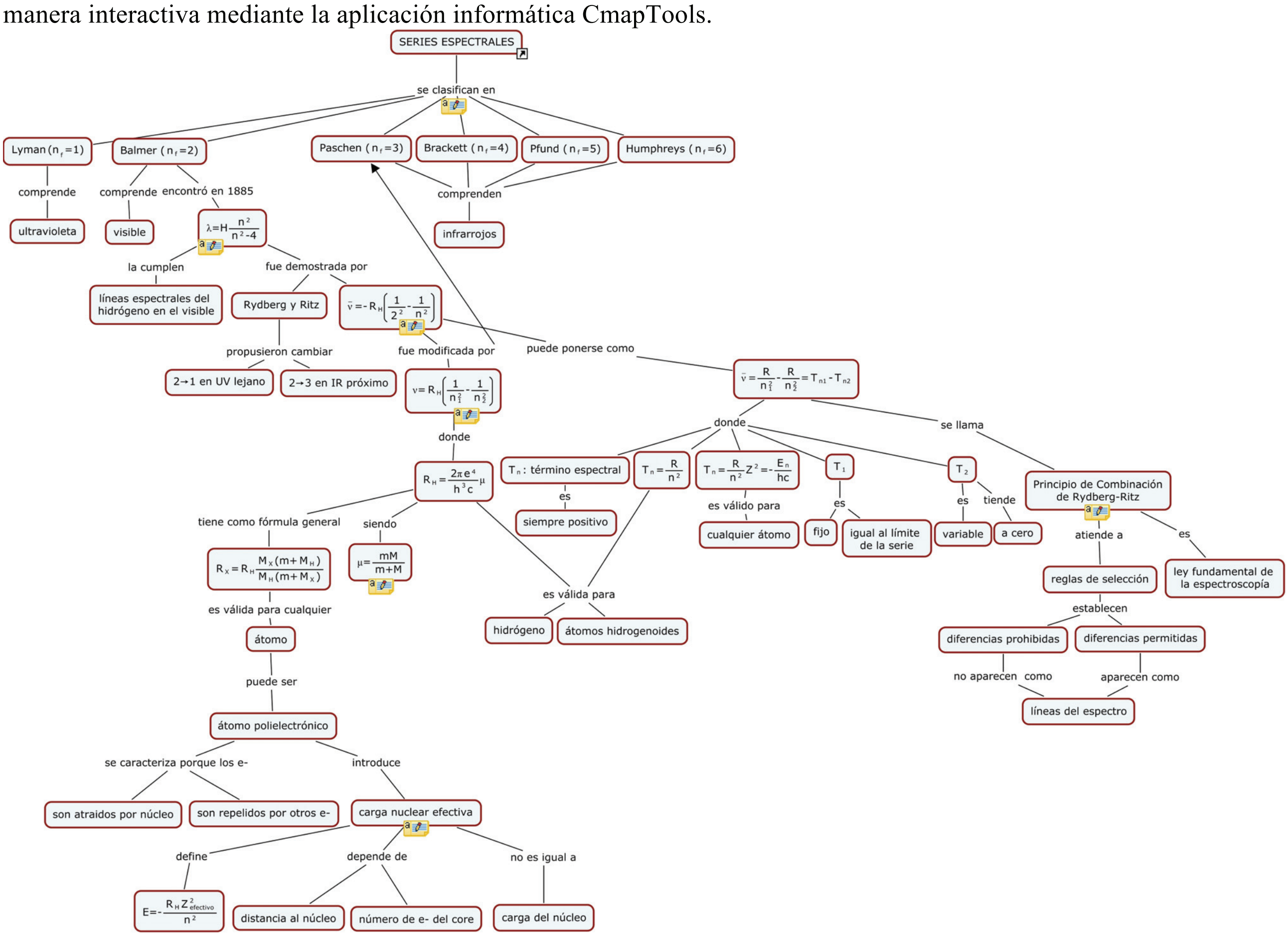

Figura 3. Mapa Conceptual sobre Series Espectrales (MCA3)

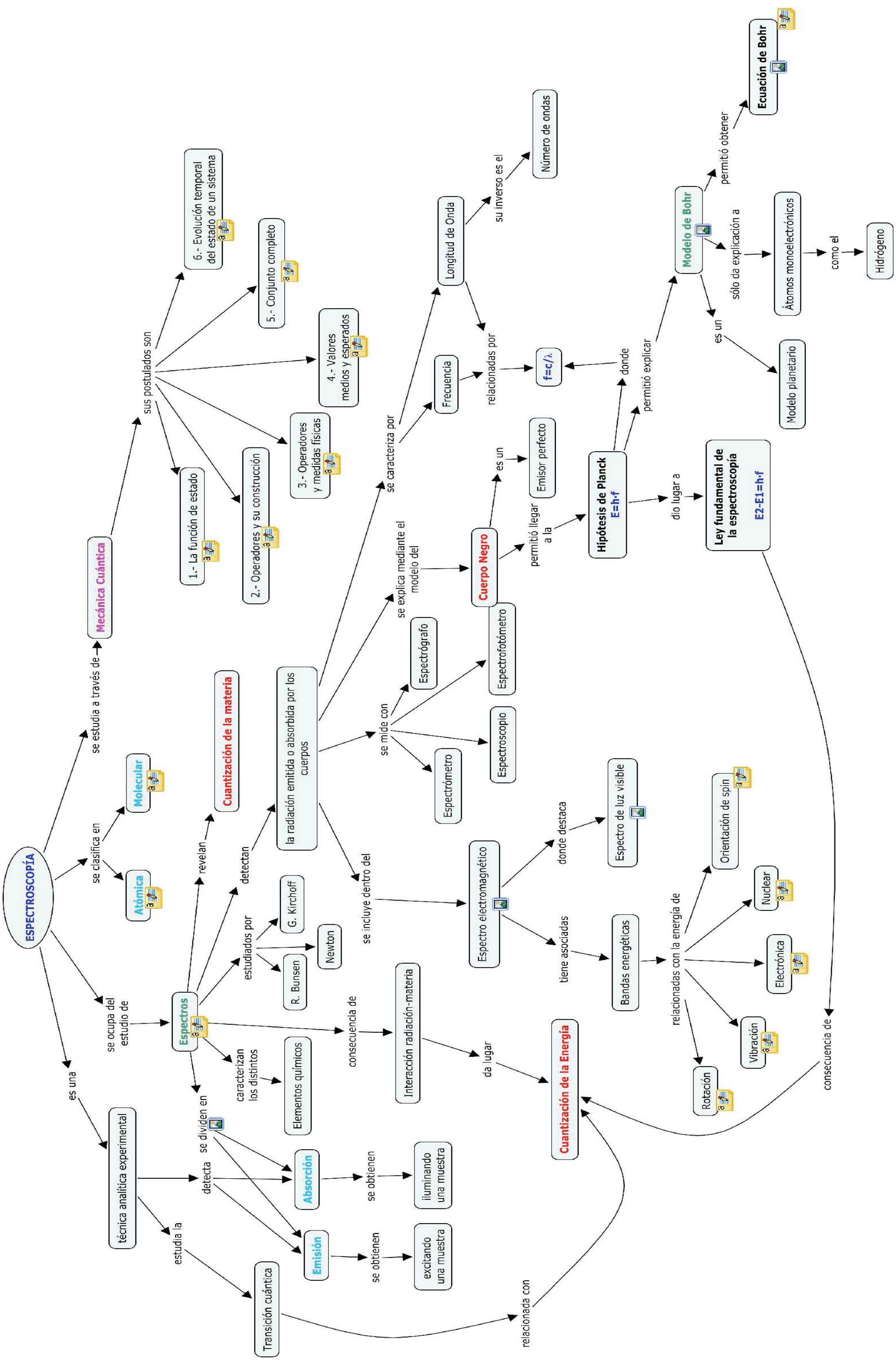

Figura 4. Mapa Conceptual sobre Introducción a la Espectroscopía (MCB1)

3 Resultados y Conclusiones

La evaluación de los mapas conceptuales descrita en la fase 8 del apartado anterior, se llevó a cabo mediante una rúbrica (Domínguez, 2010). La rúbrica es una matriz de valoración en la que se establecen los criterios e indicadores con unas escalas para determinar la calidad de la actividad a evaluar. El objetivo de utilizar este instrumento de evaluación, fue ofrecer al profesor y a los alumnos una herramienta que facilitase la interpretación y la valoración de los mapas conceptuales, tanto los elaborados individualmente por los alumnos, como los elaborados de manera colaborativa por los grupos de expertos. Las dimensiones a evaluar fueron las que se muestran en la tabla 1:

Dimensión 1: **Enfoque y Terminología**	Dimensión 2: **Conceptos Principal y Secundario**	Dimensión 3: **Palabras de enlace y Proposiciones**
Dimensión 4: **Jerarquía y Organización**	Dimensión 5: **Enlaces Cruzados y Creatividad**	Dimensión 6: **Estructura y Habilidad para comunicar**

Tabla 1: Dimensiones de la rúbrica utilizada para evaluar los mapas conceptuales.

La rúbrica completa con el criterio de valoración explicado puede descargarse en la página web http://grupoorion.unex.es. En la figura 5 se representan gráficamente las calificaciones obtenidas en la evaluación de los mapas individuales y de los grupos de experto tras la aplicación de la rúbrica de evaluación.

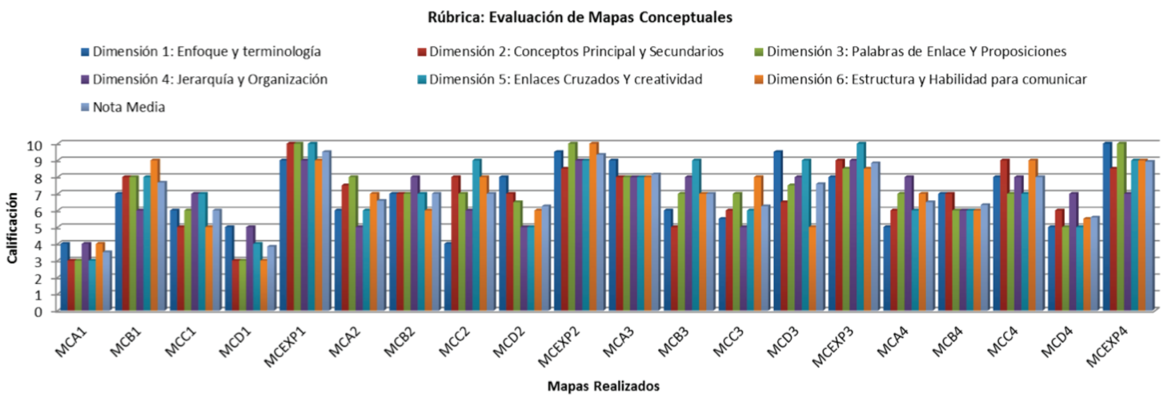

Figura 5. Calificaciones obtenidas en la evaluación de los mapas conceptuales individuales y de los grupos de experto.

En el histograma de la figura 5 podemos apreciar que, en todas las dimensiones que componen la rúbrica, existe una diferencia positiva entre las valoraciones de los mapas realizados por los grupos de experto (MCEXP1, MCEXP2, MCEXP3 y MCEXP4) frente a las de los mapas individuales de la misma temática. Puede observarse por ejemplo, que la dimensión 1 del MCEXP1 tiene una valoración de 9 puntos y la dimensión 1 del MCA1 tiene una valoración de 4, luego hay una diferencia de 5 puntos a favor del mapa de experto. Calculando las calificaciones promedias, en los mapas de experto hay un incremento medio frente a los mapas individuales de 4,25 puntos para el tema1, de 2,6 puntos para el tema 2, de 1,25 puntos para el tema 3 y de 2,4 puntos para el tema 4. Este resultado, que supone un incremento medio del 26,25%, es estadísticamente significativo y refuerza la hipótesis de que el aprendizaje colaborativo y los trabajos grupales cooperativos dan un valor añadido al aprendizaje, potenciando que se produzcan aprendizajes más significativos tras la reconstrucción grupal de los conocimientos individuales.

Por otro lado, se llevó a cabo una encuesta de satisfacción en la que los alumnos podían mostrar su opinión sobre la metodología seguida en esta experiencia. La información recogida en estas encuestas se puede resumir en que el Círculo de aprendizaje basado en mapas conceptuales, proporcionó no sólo un ambiente más dinámico y ameno en el aula, sino que además, se consiguió un aprendizaje más eficiente, a raíz de la retroalimentación inmediata y positiva que tuvo lugar en las sesiones de los grupos de expertos. En dichas sesiones, los mapas individuales se discutieron y re-elaboraron entre todos los miembros del círculo, consolidando de una manera más robusta los conocimientos adquiridos por los alumnos sobre los conceptos más relevantes en el tema de estudio, lo que permitió negociar los significados de los contenidos abarcados e integrar las nuevas relaciones semánticas en sus estructuras cognitivas.

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VISUALIZING IRREGULAR ADVERSARIES: APPLIED CONCEPT MAPPING IN THE MILITARY AND SECURITY DOMAIN

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Abstract. The Socio-Cognitive Systems (SCS) Section at Defence Research and Development Canada—Toronto (DRDC Toronto) has undertaken a Technology Investment Fund (TIF) Project entitled "A Conceptual Framework for Understanding Armed Non-state Actors (ANSAs): Strategic Roles and Operational Dynamics." The aim of this Project is to advance our understanding of (a) the *strategic roles* of ANSAs in the context of violent intergroup conflict, and (b) the *operational dynamics* of ANSAs that facilitate the performance of these roles. To assist us in this endeavour, we have constructed a Concept Map (Cmap) of an Irregular Adversary (Insurgent) [IA(I)], derived from Canadian Army doctrine on land and counterinsurgency (COIN) operations. This "first-cut" IA(I) Cmap will serve as the point of departure for the development of an ANSA Cmap that will provide a means to guide and manage our efforts to explore the intentions and behaviours of ANSAs the Army is liable to encounter in future expeditionary operations.

1 Introduction

We begin with a truism: Insurgencies are not static phenomena; they evolve as insurgents—and counterinsurgents, for that matter—adapt to changing conditions and circumstances within a complex operating environment. Likewise, our thinking about insurgencies and insurgents must evolve and progress. We cannot allow the critical concepts upon which we base our approach to counterinsurgency (COIN) operations to stagnate.

That is the motivation underlying DRDC Toronto's Technology Investment Fund (TIF) Project "A Conceptual Framework for Understanding Armed Non-state Actors (ANSAs): Strategic Roles and Operational Dynamics." The overall aim of the Project is to broaden and deepen our understanding of the *strategic roles* of ANSAs in the context of violent intergroup conflict within fragile or failing states, and, secondly, to understand the *operational dynamics* of ANSAs—that is, the organizational structures and processes in both their internal and external dimensions—that facilitate the performance of these roles, this in light of recent theoretical and empirical advances made in the social sciences and the practical experience gained on the battlefield in the past ten years of irregular warfare in Afghanistan, Iraq, and elsewhere. Broadly speaking, we seek to shed some light upon what ANSAs do and why they do it, situating their motivations, intent, and behaviours in the wider context of chronic intergroup conflict.

We do not start from "square one" in this investigation, however. The Canadian Army already has a detailed conception of an Irregular Adversary (Insurgent) [IA(I)] as set out in two doctrinal publications, *Land Operations* and *Counter-Insurgency Operations*, both produced by the Directorate of Army Doctrine and published in 2008 on the authority of the Chief of the Land Staff. We have sought to capture the Army's perspective in terms of a Concept Map (Cmap), a visual model for organizing and representing knowledge, consisting of a semi-hierarchical arrangement of concepts and propositions. This "first-cut" IA(I) Cmap will serve as the point of departure for the subsequent development of a more general ANSA Cmap that will provide a means to guide and manage our efforts to explore the intentions and behaviours of non-state adversaries the Army is liable to encounter in future expeditionary operations.

2 Applied Cmapping in the Military and Security Domain

From its deep roots in education, the application of Cmapping to problem solving in both industry and government has grown dramatically over the past twenty years. A recent survey of its many and varied applications (Moon, Hoffman, Novak, & Cañas, 2011) set out a sampling of the range of work sectors, domains, and applications in which practitioners have effectively adopted and used this method. A number of authors (e.g., Cañas et al., 2003; Hoffman, 2008; Moon, Hoffman, Eskridge, & Coffey, 2011) have surveyed the applications of Cmapping in the U.S. defence and security realm, and have found a range of uses. In contrast, the application of Cmapping is still in its infancy in the Canadian Army and the wider Canadian defence and security community. One of the pioneering efforts to correct this deficiency is that of Derbentseva and Mandel (2011), two colleagues in the Socio-Cognitive Systems Section at DRDC Toronto. They launched a multi-year research project in 2008, one of the goals of which was to introduce Cmapping to the defence and security community in Canada and to examine its applications. To this end, they engaged in two main activities: they developed a Cmap knowledge model of intelligence analysis as a comprehensive resource on the topic; and they hosted a workshop for Canadian intelligence professionals in February 2010 to introduce them to Cmapping and to the intelligence analysis knowledge model they had developed, as well as to elicit feedback from them on the model and Cmapping more generally (Derbentseva & Mandel, 2011, pp. 111–112).

3 Constructing the Irregular Adversary (Insurgent) Cmap

Our own efforts in this regard have been directed toward using Cmapping to advance our understanding of Armed Non-state Actors (ANSAs). Specifically, we constructed a Cmap to answer the focus question: What is the Canadian Army's concept of an Irregular Adversary (Insurgent)? As mentioned above, the Army has set out its conception in two doctrinal publications: *Counter-Insurgency Operations* (DAD, 2008a) and *Land Operations* (DAD, 2008b). In the latter, there is a combined total of 16 pages, found in one section and one annex, focusing on irregular adversaries in general. In the former, there are some 36 pages, spread across three chapters, describing the characteristics and activities of insurgents in particular. In addition, numerous references to irregular adversaries and insurgents are found scattered throughout the body texts of these field manuals. The challenge we faced was to draw together these disparate strands and create a consolidated picture of an IA(I) to serve as the starting point for our ANSA investigation. How could we distill these extensive writings down to the essentials of an IA(I), and then effectively communicate these essentials to others?

We turned to Cmapping to help us in this endeavour. The elaboration of the propositions in the IA(I) Cmap was a relatively straightforward though labour-intensive process entailing many tens of hours of doctrinal interpretation; transformation into the Cmap structure, however, proved the most challenging task, necessitating multiple iterations before arriving at the version presented below (see Figure 2). In detail, the process involved a careful reading of the *Land Ops* and *COIN Ops* field manuals to identify statements regarding the nature, characteristics, activities, etc., of irregular adversaries in general and insurgents in particular. These scattered statements were clustered by concept and then synthesized to form the *concept* → *linking phrase* → *concept* triples or propositions that make up the skeletal structure of the IA(I) Cmap.

To illustrate, we will briefly describe the construction of the Ideational Core Block, one of the four constituent blocks or interconnected spatial regions of the overarching IA(I) Cmap. First, we derived the key concepts and linking phrases for this block through a plain-meaning reading of relevant sections in the field manuals, such as the excerpts from *COIN Ops* presented in Box 1; the highlighted elements identify the concepts and relational links that were instrumental in elaborating the propositions in the bullet list below [the excerpted section(s) germane to each proposition are listed in square brackets]. From these and other relevant sections in the field manuals, we distinguished 10 key propositions that seem to capture the ideational dimension of an IA(I)—the notion that "ideas matter" when trying to understand the intentions and behaviours of irregular adversaries:

- A core idea is central to a narrative. [§118]
- A core idea articulates a motivating central cause. [§211]
- A core idea is formalized into a guiding ideology. [§118]
- A core idea articulates a desired end state. [§305]
- A narrative articulates a motivating central cause. [§211]
- A narrative creates strategic effects. [§215.3]
- A narrative articulates a desired end state. [§307]
- A narrative motivates, empowers, justifies, & legitimates primary actors. [§§102, 215.1]
- A narrative motivates, empowers, justifies, & legitimates ancillary actors. [§§102, 215.1]
- A guiding ideology envisions a desired end state. [§109]

These propositions were then spatially arranged in the Ideational Core region of the IA(I) Cmap (see Figure 1), and the critical cross-links within the block and with other regions or blocks of the Cmap were drawn (a key step in Cmap construction that gives Cmapping its particular knowledge-generating power).

We must admit that the resulting Cmap is not "scientific" in the sense that another Cmapper independently following this construction method could *precisely replicate* the IA(I) Cmap presented here. Undoubtedly, there would be a large measure of overlap. We are confident that our interpretation of the Army's doctrinal writings is not completely "off base," and that other defence analysts by and large would identify the same concepts and

102. INSURGENCY
7. At the basis of an insurgency will be a narrative, a story. Central to this narrative is the idea that motivates the insurgents and is formalized into an ideology. It empowers the insurgents and lends them legitimacy and provides justification for their ends and means. (p. 1-12)

109. DEVELOPMENT OF AN INSURGENCY
4. Each insurgency will have its own set of causes, aims and desired end-state. Some insurgencies will stem from a political, social and/or religious ideology that envisions an improved (even utopian) state of affairs. (p. 1-12)

118. IDEOLOGY
1. At the basis of an insurgency is a narrative that contains an idea and founding cause for the insurgency. This core idea becomes formalized as an ideology. (p. 1-19)

211. MOTIVATING CENTRAL CAUSE
1. In most insurgencies there will be legitimate grievances that may result in a central, motivating cause to the insurgency…The cause is articulated in the motivating idea and resulting narrative…(p. 2-8)

215. NARRATIVE
1. At the basis of an insurgency is a narrative that contains an idea and founding cause for the insurgency. It motivates the primary and ancillary actors and allows the idea to be formalized as an ideology.

3. …Narratives (or stories) influence the ability to recall and understand history, motivate people to act, temper emotional reactions to events, cue certain heuristics and biases, structure problem-solving capabilities and ultimately perhaps even constitute individual identity. (p. 2-10)

305. UNDERSTAND THE COMPLEX DYNAMICS OF THE INSURGENCY, INCLUDING THE WIDER ENVIRONMENT
3. The dynamics of an insurgency may include:
…b. central idea (the narrative) of the insurgency—this may be an ideology or religious ideal that also identifies a strategic end-state…(p. 3-7)

307. SEPARATE THE INSURGENTS FROM THEIR PHYSICAL AND MORAL SOURCES OF STRENGTH
b. **Moral Separation**. …This narrative will highlight real or perceived grievances and provide a vision and strategic end-state as an alternative to the existing government or society. (p. 3-9)

Box 1. Excerpts from *Counter-Insurgency Operations* (DAD, 2008a).

links between concepts that we have. However, the semantic expression of these essential elements—the concept labels and connecting phrases used to express the propositions—are likely to differ to some degree. In their research involving the development of the human-centered computing prototype STORM- LK (System to Organize Representations in Meteorology—Local Knowledge), Hoffman, Coffey, and Ford (2000) found that external expert evaluation produced changes to approximately 10 percent (on average) of the propositions in the Cmaps (p. 733). Crandall, Klein, and Hoffman (2006) attribute this finding, not so much to differences between experts over the substance of a Cmap's concepts and propositions (though they acknowledge that such disagreements cannot be completely ruled out—more on this below), but, rather, to differences in wordsmithing, "a reflection of their [i.e., the experts'] differing emphases, their judgments of what is important, and the subtleties of word choice (e.g., "promotes" versus "causes")" (p. 63). Indeed, word choice is possibly the most difficult task in constructing a Cmap (Cañas, 2009). As Novak and Gowin (1984) remark, "Often there are two or three equally valid ways to link two concepts, but each will have a slightly different connotation…each proposition thus generated has a similar but not identical meaning" (p. 35). Yet, the choice of linking words and phrases—as well as concept labels—in itself is revealing in so far as it manifests the cognitive framework of the individual Cmapper. The resultant Cmap brings to light "the nuances of meaning a [Cmapper] holds for the concepts embedded in his or her map. When concept maps are conscientiously constructed, they are remarkably revealing of [the Cmapper's] cognitive organization" (Ibid.).

On the other hand, we should not discount the strong possibility that the differences likely to emerge between competing IA(I) Cmaps reflect more than word choice, but may stem from differences in the *fundamental understanding* of the concepts that make up the Cmaps. Harter and Moon (2011) discuss this

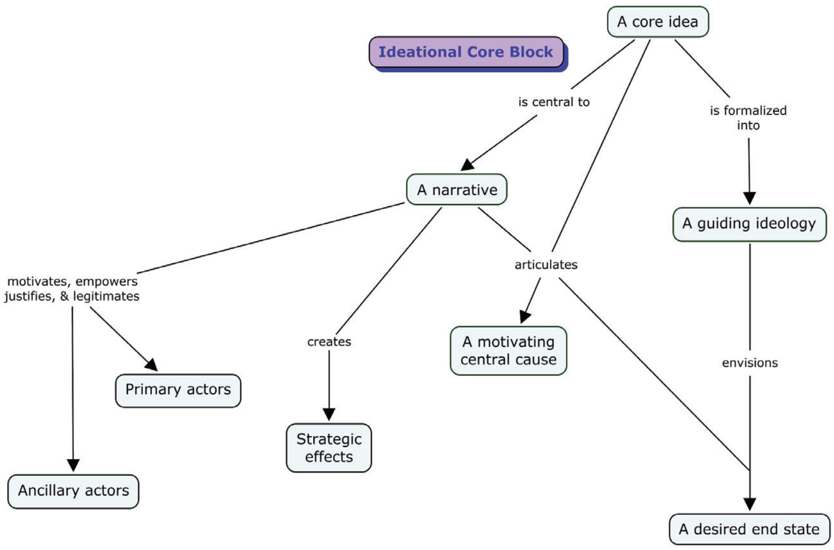

Figure 2. Ideational Core Block.

problem for the security analysis and risk management profession in which key concepts such as "risk," "threat," and "vulnerability" lack standardized meanings and interpretations. They describe a methodology using Cmapping to integrate various definitions of (ostensibly) identical concepts—in their case study, the term "asset"—to create common models and definitions of those constructs. What is relevant from their discussion for our purposes is to note that the unlikelihood that another Cmapper will replicate exactly our IA(I) Cmap may not be just a matter of wordsmithing, but also may be attributable to unspoken differences in understanding of the concepts making up the Cmaps.

Secondly, the spatial organization or arrangement of the propositions reflects our personal visual aesthetics. The importance of visual aesthetics in computer-assisted Cmapping (using CmapTools) and in human-computer interaction more generally has been increasingly recognized. Users' needs go beyond usability and utility to encompass a broader personal experience including emotions and visual aesthetics (Moshagen & Thielsch, 2010, p. 691). Visual aesthetics is a multidimensional construct. Lavie and Tractinsky (2004) distinguish two dimensions to this construct: (a) *classic aesthetics*, referring to orderliness in design, and (b) *expressive aesthetics*, reflecting perceptions of the designers' creativity and originality (cited in Moshagen & Thielsch, 2010, p. 693). Building on this research, Moshagen and Thielsch (2010) identify twelve broad content domains describing the visual aesthetics of websites (p. 692, Table 1). Through their experimental research, they distill these content domains down to four (Ibid., p. 704):

- *Simplicity*, comprising aspects of unity, homogeneity, clarity, orderliness, and balance;
- *Diversity*, comprising visual complexity (also visual richness), dynamics, novelty, and creativity;
- *Colourfulness*, involving the selection, placement, and combination of colours; and
- *Craftsmanship*, defined as "the skillful and coherent integration of all relevant design dimensions" (Ibid., p. 704).

The point here is that our structuring of the IA(I) Cmap is very much a reflection of our choices in these four (and possibly other) content domains—the mix of simplicity, diversity, colourfulness, and craftsmanship that we personally find visually appealing. This will clearly differ among Cmappers depending upon their own aesthetic tastes, though the broader Cmapping community's "best practices" will undoubtedly have an influence as well. In summary, for these semantic and aesthetic reasons, Cmap construction is inevitably idiosyncratic. No two Cmappers will ever independently create precisely the same Cmap, even when using the same reference material. In that sense, Cmap construction is as much if not more an art than a science. Indeed, it may not be too much of an exaggeration to describe a Cmap as a "work of art."

By the same token, we must take care not to overstate the "artistry" of Cmapping. The use of colour, for example, is not solely a matter of aesthetics; it is not simply a way to make a Cmap look "pretty." Colour can convey important information. In the IA(I) Cmap (see Figure 2), there are eight concept nodes corresponding to different agents or actors found in the operating environment. The area or *fill* within each of these nodes is assigned a colour indicating the *affiliation* of that agent—that is, the actor's position or stance relative to the campaign objective—as per the colour conventions in NATO military symbology. Specifically, the colour blue denotes friendly forces (in the Cmap, the two nodes *A supporting nation [SN]* and *A domestic populace*); red denotes hostile forces (*An Irregular Adversary (Insurgent) [IA(I)]*); green denotes indigenous or host-nation authorities and forces (*An established authority [EA]*); white denotes non-combatants or a local population (*A local populace*); and yellow denotes unknown affiliation (*Other elements & entities*, *An external populace*, and *An external state*). The use of this simple colour technique, while undeniably enhancing the visual appeal of the Cmap, greatly adds to its inherent power to transmit knowledge.

The fruit of our labours—the IA(I) Cmap—is presented in Figure 2. As can be seen from the Cmap, the Army's conception of an IA(I) is quite extensive. Indeed, according to our analysis of the relevant sections in the field manuals, there are some 79 major propositions and 78 subordinate propositions that define an IA(I). These are grouped into four major blocks that allow one to focus more easily on smaller spatial regions of the Cmap; these blocks—(a) Organizational and Contextual Block, (b) Strategic Decision Making Block, (c) Ideational Core Block, and (d) Social Competition Block—are saved as separate Cmaps in the Project's IA(I) Cmap folder. In addition, the IA(I) Cmap incorporates 10 nested nodes, identified by heavy-black, dashed borderlines around the nodes. [A *nested node* is an inclusive "parent" concept that encloses, or *nests*, selected "child" Cmap items (i.e., concepts and linking phrases) (IHMC, no date)]. Clicking on a nested node icon expands the node to reveal a series of subordinate propositions related to the parent concept. This facilitates "drilling down" into the concepts, that is, temporarily displaying additional propositions describing complex, multidimensional concepts. Conversely, the facility to collapse a nested node and hide this additional information avoids the problem of congested "spaghetti diagrams" whose visual clutter confuses more than clarifies [for a particularly egregious example of this, see the PowerPoint slide "Afghanistan Stability/COIN Dynamics" in Mail Foreign Service (2010)]. [Unfortunately, given space restrictions, we cannot list here the 157 major and subordinate propositions of the IA(I) Cmap, nor reproduce the four block Cmaps with their expanded nested nodes. All these may be found, however, in a forthcoming DRDC Toronto Technical Memorandum (Moore, 2012).]

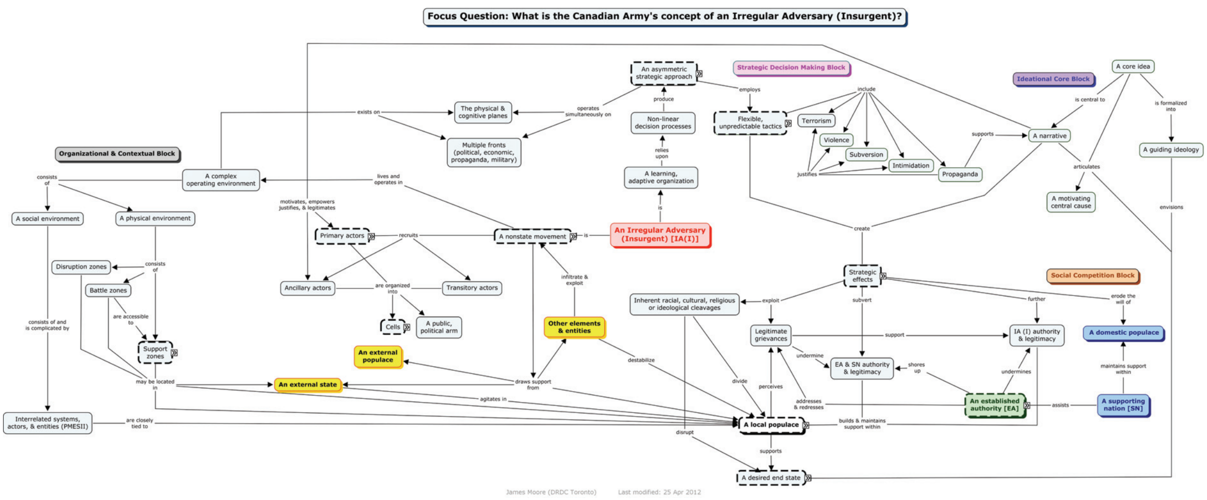

Figure 3. The Irregular Adversary (Insurgent) Concept Map.

4 Reflections on the End Product: The ANSA Cmap

The IA(I) Cmap is not the endpoint but, rather, the jumping-off point for constructing the end product of this Project, the ANSA Cmap, that will provide a means to guide and manage our efforts to explore the intentions and behaviours of ANSAs the Army is liable to encounter in future expeditionary operations. Specifically, the end-product ANSA Cmap will serve as a *cognitive model*—or "primer" on one class of irregular adversary—facilitating the development of a broad knowledge base of the contemporary operating environment in support of future Army COIN and peace support campaigns in failed or failing states. An effects-based approach to operations is predicated on a sound understanding of each actor within the battlespace, "the role they play in the environment, their aims in relation to the campaign and overall success, and the influence they have on other systems within the environment" (DAD, 2008b, p. 5-41). Key to this understanding is the development during force preparation and pre-deployment of a *broad knowledge base* of the operating environment. Drawing upon all available resources, the knowledge base provides the commander with an appreciation of the human environment in which the Army will be operating, such that he/she will know "what, who, and how to engage within the campaign to move towards the desired objectives and end state" (Ibid.).

The ANSA Cmap can play a significant role in the development of this knowledge base. Encompassing the strategic and operational as well as the structural and ideational dimensions of these actors, it will help the military intelligence operator give the commander a more holistic understanding of ANSAs in the context of their environment and their interactions with that environment. But, to be useful, the Cmap must be adapted to the particulars of each individual group and its operating environment. There is no "one size fits all" model of an irregular adversary, all elements of which are equally relevant to all such groups in every conceivable circumstance. The ANSA Cmap will be, in the first instance, a generic conceptual architecture, setting out the range of key concepts and propositions that have been identified as relevant to the description and analysis of these irregular adversaries, without prejudging or predetermining the relative importance or weight that can or should be assigned to each. This, though, is just the point of departure. In its practical application, the elements of the Cmap will necessarily be tailored to the unique circumstances of the particular ANSA under scrutiny. Graphically, the different weights assigned to the relationships in the Cmap can be accented using a variety of visual modalities either alone or in combination (e.g., colour and/or line weight). (The idea to use colour and line-weight modalities came out of informal discussions of the IA(I) Cmap with Canadian intelligence operators.)

To illustrate, consider, for example, the adaptation of our "first-cut" IA(I) Cmap to the specifics of two ANSAs, the Somali jihadist group al-Shabaab and the Afghan Taliban. In the Organizational & Contextual Block of the IA(I), we have two major propositions: (a) "Support zones [that is, sanctuaries, safe havens, rear bases, etc.] may be located in an external state," and (b) "Support zones may be located in a local populace." These two propositions apply in different measure to the two groups. Safe havens located in the frontier regions and provinces of Pakistan are critical to the Taliban's ongoing insurgency in Afghanistan. Sanctuaries in neighbouring countries are far less important to al-Shabaab, which controls large swaths of south-central Somalia and from which it mounts its military operations against the Transitional Federal Government (though its control is under serious challenge from recent Kenyan and Ethiopian military offensives into insurgent-held territory). The differential weight accorded these two propositions for each ANSA can be represented in their respective Cmaps using a heavy-weight, red-coloured line, as in Figures 3 and 4 below. Using these simple line-weight and colour modalities, the generic IA(I) Cmap can be tailored to the specifics of the particular ANSA. As this example demonstrates, in practice, the generic ANSA Cmap that we ultimately construct will be—and, indeed, must be—made case-specific and context-dependent.

Second, the ANSA Cmap will serve as a *knowledge model*, a repository for the information accumulated during the development of the knowledge base. A Cmap is a powerful knowledge structuring and building tool, serving as a "template or scaffold" to organize and manage the overwhelming mass of all-source information on irregular adversaries that comes across the intelligence operator's desk, and making possible the creation of powerful knowledge frameworks that permit knowledge retention and the use of this knowledge in new contexts (Novak & Cañas, 2008, p. 7). The ANSA Cmap will be used to generate and organize information concerning specific real-world adversaries in line with the concepts and propositions of the Cmap. More specifically, it will support the efforts of the intelligence staffs within the Army to provide the National Command Authority and mission commanders with the strategic and combat intelligence required to flesh out as complete a picture of the adversary as possible. As the ANSA Cmap will combine the strategic and operational levels of warfare within a common representational frame, it will also help to overcome the "stove-piping" and compartmentalization that often obscures the emergent linkages and connections between the strategic, the operational, and the tactical levels of activity.

5 Conclusion

Where do we go from here? On the basis of a series of studies and reports produced in earlier phases of the Project, we will refine the concepts and propositions of the IA(I) Cmap—revising (i.e., clarifying or rewording) retained propositions, removing unfounded propositions, and adding strongly grounded ones—such that we can have increased confidence from both a theoretical and empirical perspective in the overall fitness for purpose of the resulting ANSA Cmap. Having refined its skeletal structure, the task will then be to populate the ANSA Cmap, that is, to provide its propositions with substantive content. The intent here will be to create a "back-end wiki" for the Cmap. That is, a wiki page—varying in length from a short paragraph to a 2–3 page summary article, depending on the complexity of the subject matter—will be written for each proposition, providing an overview of the substance of that proposition based on the extant scientific literature. The combined Cmap/wiki

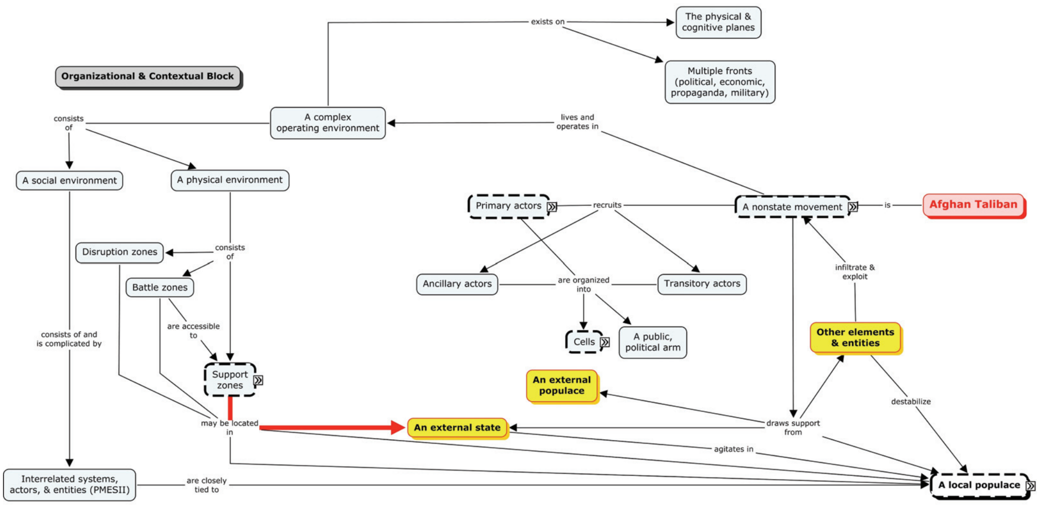

Figure 4. Afghan Taliban Concept Map.

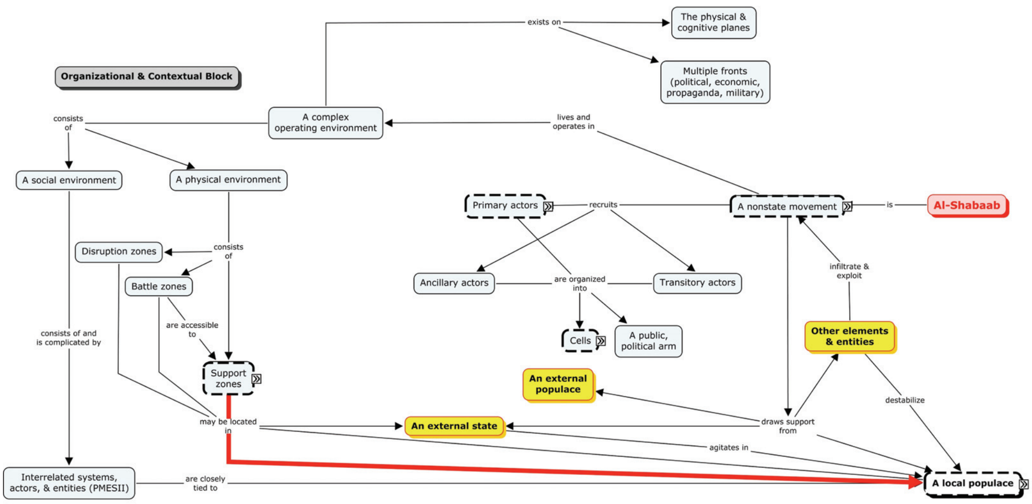

Figure 5. al-Shabaab Concept Map.

format will allow for the evolution—the continual editing and updating—of text entries as further information reflecting the latest scientific thinking becomes available. It will also facilitate the interconnection by hyperlink of wiki pages within the Cmap as well as links to other textual, audio, and video resources on the Web.

Once completed, the ANSA Cmap, with its associated rules and modalities for application, must be validated to ascertain its usefulness as a practical analytical tool for civilian and military intelligence operators (the IA(I) Cmap presented here will not be tested since it is only a "way-station" enroute to the end-product ANSA Cmap). Though it is beyond the scope of this paper to delve into the particulars of the experimental design, suffice it to say that a select group of intelligence operators will be asked to test the ANSA Cmap tool under controlled experimental conditions. How does the Cmap fare against other methods of knowledge acquisition? How well does it facilitate the desired result of the learning exercise—in this instance, increased operator understanding of the motivations, intentions, and behaviours of ANSAs—as compared to, say, an unguided search of the Internet for multimedia resources related to ANSAs (arguably the default option for many analysts absent more specific direction from colleagues or supervisors)? In other words, how effective is the Cmap as a cognitive model and knowledge model, identified above as the principal functions of the ANSA Cmap?

In conclusion, the comment above on the dynamic nature of the Cmap and its associated wiki deserves repeating. The so-called "final" version of the ANSA Cmap built from the IA(I) Cmap presented here will be final only in the sense that it is the end product of this specific Project. Cmaps—as is the knowledge upon which they are based—are not static. They will and must evolve to reflect future theoretical, experimental, and empirical advances in the social sciences. As Crandall et al. (2006) aptly put it, "it is wise to always consider

Concept Maps as 'living' representations rather than finished 'things'" (p. 54). In that sense, the ANSA Cmap we will develop will always be a "work in progress."

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