Concept Mapping: Connecting Educators
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# USING CONCEPT MAPS TO ENHANCE KNOWLEDGE ABOUT SOUND

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**Abstract**. This presentation is based on research carried out at a junior high school in Portugal. This research intended to assess the potential of the concept map's practical use in acquiring knowledge related to the topic area of Sound, by young learners in the eighth grade. The obtained data points to indicators revealing that using concept maps with learners can indeed, from our point of view exploit their full educational value: the potential in educational innovation which can change the way how students and teachers learn, feel and live their school life.

## 1 Introduction

Since the beginning of this century various profound social, economic and cultural changes have challenged traditional teaching models, leading to the need for a new educational project which can assist in overcoming the challenges of an online society (Castells, 2004) in which we live. It is in this context that the notion of concept maps emerges (Novak e Gowin, 1999).

Consequently, numerous studies showing the educational role of maps, as well as various advantages of their use for meaningful learning by students, were presented in two international meetings on concept maps that took place in Pamplona (Cañas, Novak & González, 2004) and in Costa Rica (Cañas & Novak, 2006).

Researchers presented several studies, proving their teaching value and full potential when applied as a means of more efficient learning. Moreira and Novak (1988), for example, highlighted studies with students who, in that model, were divided into a group subjected to a curriculum organized for meaningful learning and another group exposed exclusively to so-called more traditional teaching methods. The obtained data revealed that the first group not only got the best results in problem-solving tasks, but also improved their results in the overall course, as opposed to the second group subjected to the more conventional learning process. Furthermore, according to the same authors, the teaching and learning process can be improved if we know the way human beings create and value knowledge, as well as the psychological processes which enable them to understand knowledge.

This knowledge, theoretically based on constructivism and meaningful learning, may be reached by using the tools that teachers have at hand, especially the above mentioned concept maps.

## 2 Concept maps and their role

The idea of the concept map was developed in the 1970s in the Department of Education at Cornell University, being one of the main work approaches in the Program of Education in Science and Mathematics of this department (Galagovsky, 1993). Although Ausubel does not speak of concept maps, these derive from his theory. In fact, the concept maps appeared as instructional resource from the ausubelian model for meaningful learning, according to which science is based on concepts that range from the most general (supracommanded concepts) to the most specific ones (little inclusive concepts), passing one or more intermediate hierarchies (subordinated concepts). The concepts are related to each other through propositions, using connecting words in order to show the conceptual organization of a given topic, as well as the knowledge of the pupils concerning the same one (Novak & Gowin, 1999). At the top of this diagram there are the supracommanded concepts and, as one goes down vertically, the concepts of lesser hierarchy are displayed.

Among several others uses, concept maps “allow the assessment of previous knowledge and the diagnosis of alternative concepts” (Trowbridge & Wandersee, 1998, p.116). Apart from this aim, concept maps have other functions. On one hand, they are a way of illustrating the hierarchical, conceptual e proportional aspects of knowledge and, on the other hand, they are a metacognitive way of helping learners to reorganize their cognitive structures into stronger integrated patterns (idem). After finishing off a learning task, concept maps show a schematic summary of what was learned (Novak & Gowin, 1999). Further important aspects could be considered in relation to the usage of concept maps, such as generating enthusiasm; arousing curiosity about learning; improving interpersonal relationships; and stimulating playfulness.

## 3 Using ICT in school context

Regarding the demands of the society based on information and knowledge (Drucker, 2000), educational issues begin truly to be viewed in a completely different light. Today's society understands the limits of the traditional school and, opposing it, demands a school to be a place where you learn how to like learning, where you find meaning for what you are doing, where you begin the discovery of knowledge, where you explore paths, get encouragement, motivation and each other's rhythms and feelings are respected. That is, a culture which is not based on a merely passive, reproductive knowledge, but one of active thinking, capable of keeping alive the constructed knowledge.

In this regard, ICT can be an important supporting tool, capable of helping change the teaching experience, abandoning traditional methods inducing routine learning, in favour of more dynamic and meaningful learning. The computer gets an important role as a teaching aid to help teachers move away from the world of blackboard and chalk (Gates, 1999).

## 4 Methodology

### *4.1 Sample*

The case study of this research took place in a junior high school in Portugal, during the school year 2007/2008, in two classes of the eighth grade taught by the same Physics teacher. Characterizing both classes comprised collecting data referring to age, gender, family members and their qualifications, as well as other data about school life, including possible failure in the previous year leading to the repetition of the eighth grade presently. Further data was added, namely the one obtained from qualitative analysis of student-constructed concept maps before teaching the topic Sound.

After analyzing the characterization data of both classes, the control class (N=28) and the experimental class (N=28) were chosen, being the necessary procedure for the methodology used in this research: *semi-experimental plan*. Another important factor to be stressed is that the obtained data was similar in both classes, as required by this research technique. As the obtained data was similar in both groups, the experimental class was chosen randomly.

Preparing the students in both classes for the process of constructing concept maps was similar. Before teaching the topic Sound, learners had been taught the technique of constructing concept maps, having later conceived several maps in relation to subject of Physics, namely the topic area of Optics taught before in class. After having constructed the maps, students discussed them in depth with the teacher during class, reorganising them afterwards.

### *4.2 Obtaining data*

Obtaining data from this research was based on combining a qualitative method, by direct and detached observation, with a quantitative one, on a *semi-experimental plan*. During the final stage of research, data was also obtained through a questionnaire on usage of concept maps and a test paper on knowledge about main areas of Sound.

While observing, the researcher took down information in a custom-made table. Verbal interactions between students and teacher were noted in this table as they were constructing the maps. The main purpose was to assess the level of satisfaction/dissatisfaction with the map-constructing strategy, the main difficulties felt during the construction, the type of learning taking place in relation to the subject of Physics, and more specifically the topic of Sound, and whether the concept map was indeed constructed with the cooperation of all group members. This way the teaching and learning process was assessed.

Although the researcher made notes in the same way in both classes, the teacher adopted different teaching methods while going through the topic of Sound in the two classes. Thus, in the control class lessons on the topic Sound were fundamentally conveying information, without any concept maps, while in the experimental class lessons took place in a constructivist environment for learning, during which the students conceived progressive concept maps at the same rate at which the concepts of Sound were being taught with the prevailing principles of authors like Savery & Duffy (1995) and Brooks & Brooks (1999): (1) learning is an active and

involving process; (2) learning is a process of constructing knowledge; (3) learners should have access to a metacognitive level; and (4) learning should include "social negotiation".

In the experimental class, students constructed progressive concept maps while the topic area Sound was being taught. These maps were progressively self-corrected and enlarged so as to include new concepts as they were being taught. The maps revealed the process of structuring and restructuring of knowledge as a result of discussion among students and, naturally, between students and teacher.

The table below characterizes the moments of constructing the concept maps and the methodology used in both classes for this research.

| **Moments of constructing the concept maps** | **Methodology** | **Recording material / device** | **Class** | |
|---|---|---|---|---|
| Before teaching Sound | Individual | ICT | Experimental | Control |
| While teaching Sound | In groups | Paper | Experimental | Experimental |
| After teaching Sound | Individual | ICT | Experimental | Control |

**Table 1:** Concept maps constructed by the students

The analysis of the concept maps constructed by the students was essentially qualitative (a scale of three rates was used: weak, acceptable, good) and it was based on suggested characteristics by several researchers, namely Novak & Gowin (1999) and Mintzes, Wandersee & Novak (2000). The characteristics were the following: *hierarchical organisation of concepts ( that is, considering the context in which a concept map is constructed, is each subordinate concept more specific and less general than the concept above it?)* ; *linear structure versus ramified*; *number of concepts adequately connected; linking words; and cross links.*

The research showed that, before the topic area Sound was taught, the hierarchical organisation of concepts, the linear structure versus *branch structure*, the number of concepts adequately connected, the linking words and the cross links in both classes were considered weak. On the other hand, the linear versus ramified structure was considered acceptable in both classes.

After the topic area Sound was taught, the maps constructed by the students of the experimental class (EC) revealed a cognitive evolution when compared with the ones by the control class (CC), as shown on Table 2.

| **Avaliation** / **Features** | **Weak** | | **Acceptable** | | **Good** | |
|---|---|---|---|---|---|---|
| | Control class | Experimental class | Control class | Experimental class | Control class | Experimental class |
| Hierarchical organization of concepts | X | | | X | | |
| Linear structure versus ramified | | | X | | | X |
| Number of concepts adequately connected | X | | | | | X |
| Linking words | X | | | | | X |
| Cross links | X | X | | | | |

**Table 2:** Evaluation of the concept maps organized by the students in individual work, after teaching Sound

Concerning the elaboration of the progressive concept maps by the experimental class, these were constructed after the subtopics of the topic area Sound were taught, such as sound production, sound travel, sound phenomena, sound characteristics, the sound perception and sound pollution. As a mere example, two maps constructed by the same group after the first three subtopics were taught, are presented below (Figure 1):

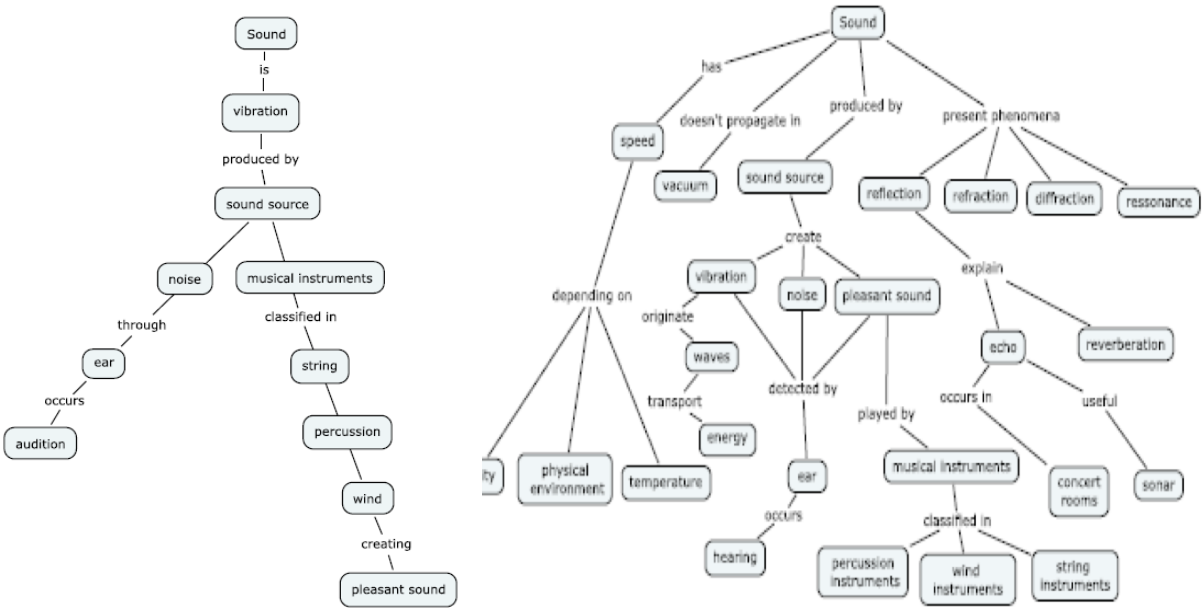


**Figure 1.** First and third map designed by the same work group.

After comparing them, we can see that the second map shows a reorganisation of the concepts involved in the first map as a result of the discussion by the group members, as well as the introduction to new concepts during the lesson.

The main difficulties detected by the teacher when analyzing the maps constructed by the students of the experimental class (EC) were, above all, the hierarchical organisation of some concepts, as well as the establishment of cross links among them. These aspects were confirmed in the answers given by the students of the experimental class (EC), when they were questioned about the difficulties they had while constructing the maps.

These students were also asked about two other aspects. The first one was concerning their perspectives on the advantages of using the maps. In case of a positive answer, they were asked to order the the following items of a list given in the questionnaire, according to a degree of importance:

A – they make it easier for the student to learn;
B – they are a good means of representing the relationships between concepts through propositions;
C – they help organising ideas and information;
D - they enable information summarizing;
E – they enable students to construct their own knowledge;
F – they help the discussion of several concepts;
G – they are a resource for self-learning available to the student;
H – they are tools that allow a cooperative activity;
I – they show the concepts and the fundamental propositions in an explicit and concise language;
J – they help develop the awareness that knowledge is constructed by mankind and evolves with time;
L – they help the relationship between teacher and student in their elaboration;
M – they help the relationship among students in their elaboration;
N- they increase students' self-confidence in their skills.

The obtained results showed that 80% of the students considered the use of concept maps to be advantageous. The characterization of those advantages can be found in Figure 2:

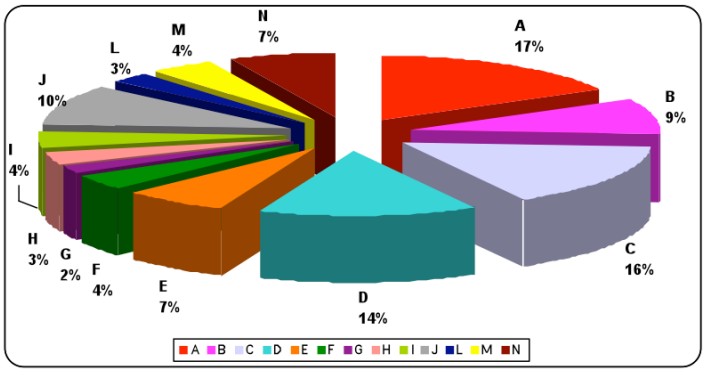


**Figure 2.** Advantages of using concept maps

As we observe in the Figure 2, the students tend to select often the following four items: A – they make it easier for the student to learn (17%); C – they help organising ideas and information (16%); D - they enable information summarizing (14%); and J – they help develop the awareness that knowledge is constructed by mankind and evolves with time (10%).

The second aspect that we intended to analyse in this research was to find out what the pupils thought about using Information and Communication Technologies (ICT) for making concept maps.

By asking the question "Which method did you enjoy using the most for making maps?, " we obtained the multiple-choice answers as shown in the following figure:

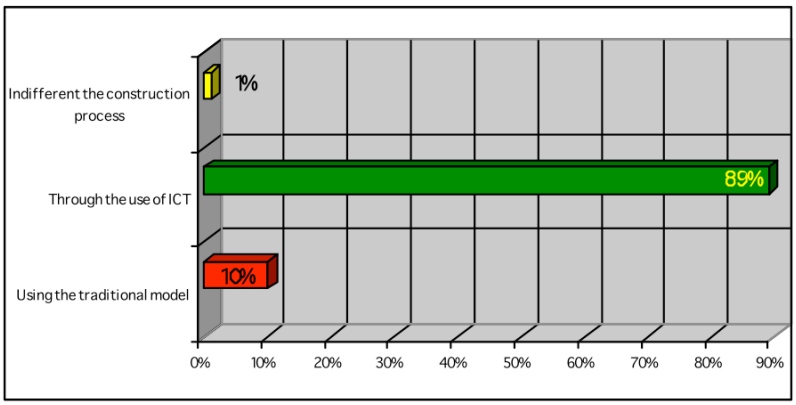


**Figure 3.** Tools used by the students for the construction of the concept maps

As we can see in Figure 3, the results show clearly that the pupils express their significant support for constructing progressive maps using ICT (89%). Adding to this, they assumed a much more moderate answer in relation to the possibility of using the traditional method (written by hand), considering that only 10% of them openly confessed to prefer it. Agreeing with this clear answer of the pupils supporting ICT, we should emphasize the very low percentage of pupils who answered that it indifferent to them which method the teacher should adopt to make the above maps (1%).

The pupils' eagerness for using the technological tools can be explained by the fact that they adapt themselves to the user's interests and speed (Drucker, 2000). In addition, the skills, which the teaching institution develops, play an important role in this particular aspect. It is precisely because of the evolution of the present-day society that Charlot (2007) advises, "school must take into account the new logical issues in its own organisation" (p. 131). The truth is that in a global economy and in a network society the main challenge for the contemporary society nowadays must be, as Magalhães (2007) reminds us, "the one of a truly widespread ICT use, especially of computers" (p.281).

Thus, using ICT for constructing concept maps, the teacher can motivate his/her pupils to construct their own learning in a meaningful way. With this strategy, in a certain way an innovative one, we think we are helping to change teaching in Portugal.

After having taught the main syllabus topics concerning Sound, we compared the marks of the classes (both experimental and control) in a knowledge test. The obtained data enabled putting together a global assessment matrix, gathering information answer by answer of the above pupils. The results are shown in the figure below:

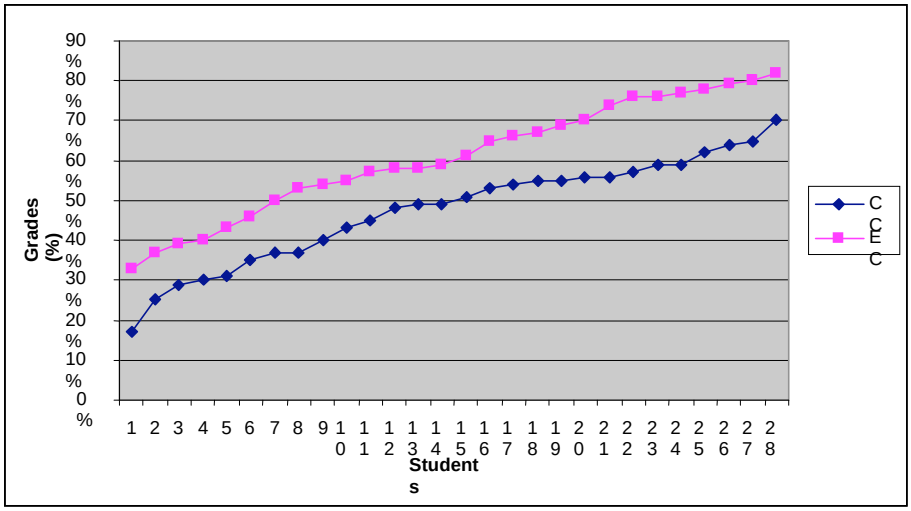


**Figure 4.** Global assessment by answer, concerning pupil's knowledge test on Sound

As Figure 4 shows, we can see a significant positive performance of the pupils in the experimental class (EC), concerning the topic Sound.

## 5 Conclusions

Generally speaking, concept maps are hierarchic diagrams that aim at showing the conceptual organization of a source of knowledge, being an important variable in learning. Using then means giving a new sense to teaching, a new meaning to teaching concepts, learning and even the assessment of the learning process. The analysis of the conceptual structure of the source of knowledge and the use of this analysis for the learning and teaching process as a means of enabling meaningful learning is obvious nowadays. Meaningful learning is a key concept that the teacher should bear in mind when teaching. This learning is opposed to learning by heart, unfortunately preferred in our classrooms during more traditionally taught lessons.

Even if our obtained data cannot be generalised due to their limited scope, they clearly show the contribution of concept mapping in the classroom, when the maps are made in a constructivist environment, helping pupils in their meaningful learning. In the light of the evidence gathered in this research, which was briefly presented before, we can conclude from emerging indicators that pupils would clearly tend to support the integration of concept maps into the school environment.

Therefore, we think it is legitimate to conclude from this research that using concept maps can indeed exploit its full pedagogical value: the potential for educational innovation that can transform the way pupils and teachers learn, feel and live their school life in the 21st century.

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