Concept Maps: Theory, Methodology, Technology
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ELECTRIC MAPS

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Abstract. "*Electric maps*" are a new way of scaffolded concept mapping so that checking the accuracy of the relationships between concepts *is* a game. The "electric" concept map is obtained by replacing the connection lines of a common concept map with aluminum strips which are electric connections between the nodes and the linking phrases of the map. This electric circuit is closed within a folded cardboard so that it is not possible to see the connection lines from outside but only the nodes, some of which are provided with labels referring to concepts and/or relationships. Each box - node is provided with one or two contact points made through an access hole situated over the aluminum strip. The teacher can make these circuits from the concept maps of his/her pupils or, in the best conditions, the pupils can build them in order to involve other classmates. The pupils reconstruct this "puzzle" by exploring the structure with a connection detector. They draw all connection lines and complete the map by highlighting the labels suited to the nodes and to the linking words. This educational strategy suggested for pupils attending from the third to the fifth grade primary classes, has turned out to be exciting and very efficient to increase both the level of knowledge sharing, the accuracy and the meaningful comprehension to build each proposition.

1 Introduction

To better understand what are the electric maps and why we think they are very efficient in our reality, it is necessary to describe how they were originated and the context within which pupils started to use them.

1.1 The Circuit Game

According to one of our common science activities that we call "circuit game", the pupils shall highlight the electric connections, that are made up of glued aluminum strips, which are hidden inside a two-folded sealed cardboard provided with eight contact points from A to H. In order to find the connections of the hidden circuit the pupils try all connections between these contacts with a simple detector. For instance, if contacts A and C are touched with two copper wires of the detector and if the light-bulb of the detector is switched on, we can conclude that the circuit is closed and that there is a connection between A and C. On the other hand, if the light-bulb is not switched on while trying contacts A to D, it means that there is no connection between them. At the end of this game the pupils draw a map of the connection grid, open the cardboard and compare their drawing with the true circuit. In the most advanced form of this game the pupils build the hidden circuit by themselves while the others try to draw it by testing the connections.

1.2 Wire Card Quizzes

One day some of the pupils decided to replace letters A-H of the circuit game with questions and answers. If the light-bulb of the detector switched on it would signal the correct answer of a given question, thus changing a game of pure logic into a test to be submitted to other mates. Figure 1 shows one of the products of this initiative which is a grammar test.

Based on the circuit game, this quiz, which enables *to build and check the accuracy of the relations between concepts*, has given the hint to build the electric concept maps. The success of this path relies mainly on a sound educational principle of seizing, supporting and guiding the natural creativity and ability of pupils to find alternative ways to check and to learn, thus making them the authors of these choices. Therefore, the positive impact on both motivation and learning is not negligible.

1.3 Electric Maps

At this point there were all conditions to make a step forward: the construction of concept maps based on the same principle as the circuit game. As a matter of fact, for many years pupils have practiced the concept mapping in the scientific, linguistic, mathematical and historical domains as well as in other subject areas. It was clear why pupils were self-confident and positive since on the one hand they knew the experiment they wanted to carry out, and on the other they were fully aware of the ability necessary to achieve the final result. Therefore, the idea to build "electric" concept maps was encouraging and challenging both for us, the teachers, and for the pupils!

The electric map is obtained by replacing the connection lines of a common concept map with aluminum strips which are electric connections between the nodes and the linking phrases of the map. This electric circuit is closed within a folded cardboard so that it is not possible to see the connection lines from outside but only the nodes, some of which are provided with labels referring to concepts and/or relations. Each box - node is provided with one or two contact points made through a hole situated above the aluminum strip. The first electric maps, built by the pupils themselves, showed only the concepts in the relative nodes and had to be completed by drawing the connection lines and the linking words. This task was assigned to pupils of the parallel classroom. The pupils made the detectors, too, by means of 4.5 volt flat batteries, a wire and a light-bulb, whose screw was twisted at one of the ends of the electric wire. The other end of the wire was connected with one of the two foils of the battery. The connection between the two contacts could be checked by touching a contact with a plate of the battery and the other contact with the base of the light-bulb as shown in figure 1.

Figure 1. A *wire-card quiz* made by pupils along with the battery - bulb tester.

2 The Use of Electric Maps in Classroom Activities

This section shows the details of the activities suggested in the way they have been defined and prepared in the first trials carried out only on three educational units in the second half of the school year and only in three four grade primary classes out of five. The following descriptions can be applied to any educational domain although in our case we focused on the scientific, linguistic and mathematical subject areas.
During the classroom activity on a specific topic, the pupils build concept maps on paper and in some cases they transfer them on CmapTools software (i.e. Figure 2)

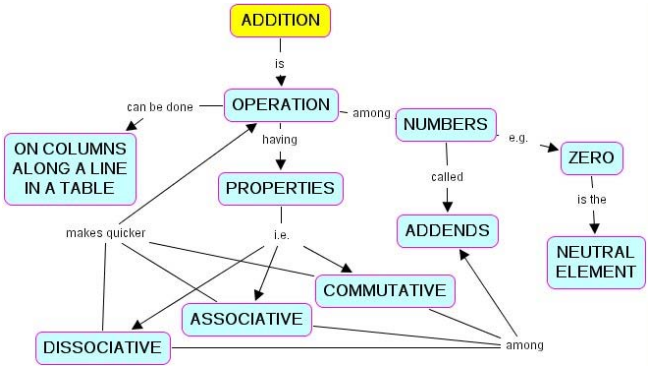

Figure 2 Example of concept map transferred on cmap format by a three grade pupil.

2.1 Electric maps Built by the Teacher

In the first phase the teacher uses some of these paper maps to build the electric maps to be submitted to pupils who shall complete exploring them with the detector (fig. 3).

Figure 3. Pupils looking for a connection

We devised two types of these electric maps.

2.1.1 Electric Map with all concepts and without links

Outside the first type of the electric map it is possible to see only the nodes provided with concept labels, organized in a pyramidal arrangement with the most important concept situated on the top without any connection line. Inside, in the hidden side of the cardboard, there are the aluminum strips that bind only the pairs of concepts that must be connected (fig. 4). After finding the connections with the bulb detector, the pupils must draw the relative lines and arrows between the concepts and suggest also the appropriate linking words that shall be written down on the map itself.

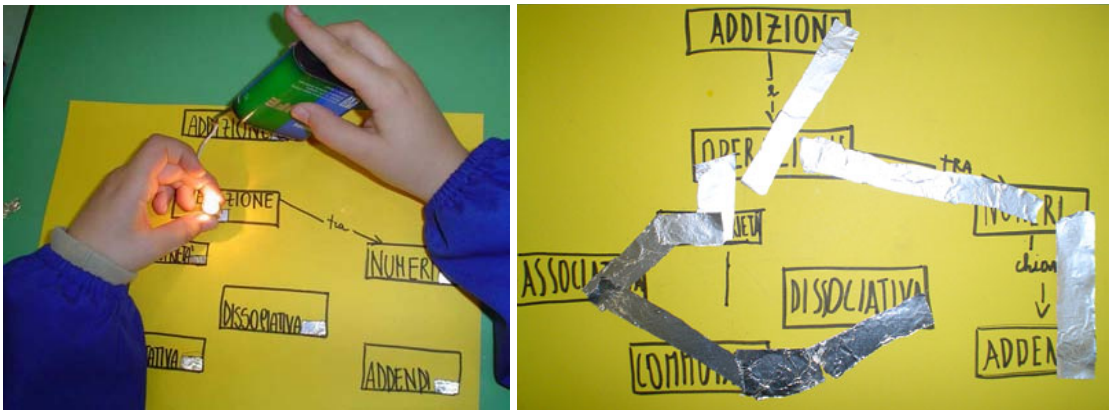

Figure 4. Outside and inside of the first type of *electric map* on addition built by children.

2.1.2 Electric Map with nodes, lacking for some labels and without links

As for the second type of electric maps, which is similar to the first type, some nodes are not provided with concept labels, and show, however, the relative linking phrases. Therefore, only the first or the second part of the propositions (concept – link phrase) is clear, and they are not provided with any connection lines. By means of their bulb detector, the pupils must find the connections between the linking phrases and the nodes that altogether complete the propositions; consequently, they must write the missing concept labels and draw lines and arrows.

Only in the second type of electric maps each node and each linking phrase is provided with two holes equipped with electric contacts otherwise pupils would identify which pairs of contacts are connected simply by checking the number and the arrangement of contacts. Furthermore, this system also prevents all nodes of the underlying

circuit from being electrically connected among them. Moreover, compared to the positions held in the original map, the concept nodes are slightly moved vertically between one level and the other.

The two kinds of electric maps show gradual difficulties; the first type is simpler and when pupils master it they can work with the second type.

2.2 Electric Maps Built by the Pupils

In a following step the pupils can easily build the first type of electric maps. In our trial, this activity was carried out by groups of pupils who decided autonomously to share the tasks. An important step forward was made when the pupils asked to build the electric maps by themselves. After building and sealing the electric maps with the tape, the pupils submitted them to the mates of the parallel class.

3 Results

These electric maps allowed us to
1. assess the knowledge of each pupil,
2. highlight their cognitive processes (more easily than with other tools),
3. check how they master the concepts and the relative relations of hierarchical inclusion.
4. testify to the integration of new knowledge in the preexisting cognitive structure.

3.1 Motivation

It was very encouraging to remark that the pupils asked repeatedly to build the electric maps for all subject areas. We are aware that this motivation is the prime mover in both learning and knowledge. Also the expectation of pupil's wish to play was not disappointed at all!

3.2 Interaction between Pupils

The good level of interaction in the classroom played a significant role on the whole activity since it helped children to grow up and to make progress. As a matter of fact, while the pupils were working in groups, we often noticed that they corrected each other to choose the way to make the connections with aluminum and explained the reason for these choices. The pupils gave sound reasons and agreed on the position of the holes. In particular, they decided not to put the hole in the middle of the node since their mates would link the concept only with the one below and they decided to make all the holes in the same position. The construction of these electric maps showed the pupils' ability to use and understand the effective strategies for the organization of knowledge retrieval. This type of understanding was very important to design challenging and accessible puzzling tasks for their pairs. These group dynamics add value to the strategy of electric maps, because they testify to the knowledge and awareness of ones' own and others' cognitive process, thus starting *metacognition*.

3.3 Quality of Knowledge

The pupils have tested and completed these electric maps on a field of knowledge they knew about by using different strategies, thus making a custom-made product, even when these maps originated from the one built by the teacher. The need to decrease the hierarchical levels of the electric map to three or maximum four, encouraged the pupils to look for the most important concepts within the domains their knowledge was much wider. Common concept maps do not show this need that adds value to the strategy of the electric maps we are suggesting and turned out to be very efficient in strengthening the significance of current concepts.

The following map (fig. 5) summarizes the educational-pedagogic reasons of our trial.

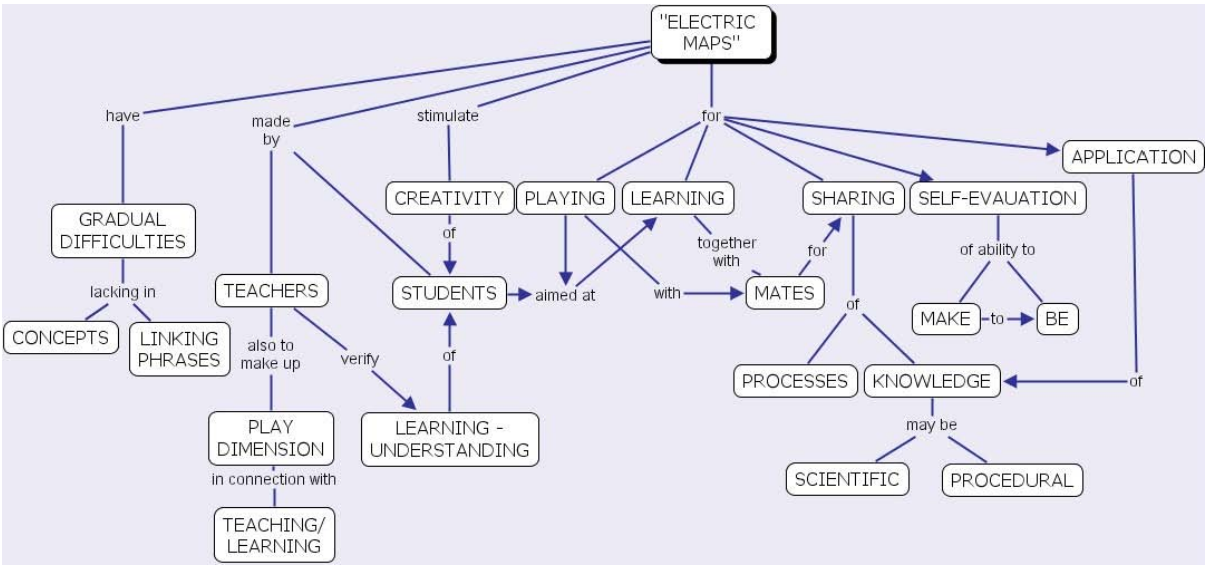

Figure 5. Electric maps in Our Educational Context

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