Concept Maps: Theory, Methodology, Technology
Proc. of the Fifth Int. Conference on Concept Mapping
Valletta, Malta 2012

EVERYBODY TOGETHER WITH " ENERGY" WE ARE PART OF THE EARTH

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Abstract. Being a Montessorian teacher is a challenge in a society characterized by a strong crisis that involves different levels, such as school, family, and society. The answer to the crisis is contained in our method, which aims at promoting humanity. Therefore, school humanization is necessary, connecting the anthropological dimension to the social one. Humanizing school means to create significant learning environments where children can build their knowledge, and learn how to be and how to do, according to their personal needs and times. Children who grow up in settings that do not respect them will turn into weak, irresponsible, unreliable, spiritually impoverished adults. The function of Montessorian education is to let children - as well as future men - discover their place in order to aim at common goals. Educating children to the environment is the correct way to make them aware of the fact that they are an integral part of nature and they have to manage it responsibly for the "Common Good". This requires the use of a flexible, participative, constructionist teaching method. The new vision of science calls for a deep review of purposes and teaching methods of the scientific disciplines. Concept maps accompany all the construction steps of knowledge and are a specific instrument to reinforce cognitive and metacognitive strategies, helping students to build a structured, significant network of knowledge.

1 Introduction

Although Maria Montessori did not speak about investigation-action, her methodology perfectly agrees with such a practice. According to her, children must be allowed to use a scientific method that responds to their personality and needs. Children are spontaneously curious, and are therefore natural scientists. Giving children a global vision of the universe allows them to find an answer to all questions. Moreover, it gives them a kind of organized, systematic knowledge, in addition to favoring meta-cognition processes. This can be achieved by:

- Brainstorming and clinical conversation in order to detect the children's spontaneous knowledge.
- Learning routes that originate from the children's motivations and interests.
- Cooperative learning activities that, through the promotion of positive interdependences and social skills, allow children not only to acquire knowledge, but also to get to know themselves and give value to their person for what they can do.
- Lived body activities, where hands and mind are indissoluble. Children build meanings according to their experiences and mental order.
- Promotion of itineraries that, in addition to stimulate curiosity, allow children to give answers and reflect on their metal routes (meta-cognition). This determines the creation of open, flexible minds.
- Construction of concept maps at general and individual level, in order to give a meaning to the experiences they live, and also develop negotiations with peers and teachers in the so-called "cosmic" laboratory. The cosmic laboratory is the place where knowledge is organized, creates a global vision and allows for the development of intelligence through a significant learning.

2 Cosmic learning laboratory

The scientific laboratory is the cognitive place where to find an answer to the multiple questions and problems that may originate from the observation of a scientific phenomenon. The teacher prepares and organizes materials, procedures and significant situations that urge and guide the learning processes.

The topic is energy, more specifically some of its properties (transfer and transformation) in order to understand interactions between man, plants and the environment. The work involved children from the last year of kindergarten (5/6 years old) and children from the first and second year of primary school (7/8 years old). Given the importance of this topic, it was decided to extend the work to all school levels, including middle school, from a systemic point of view and in order to elaborate a vertical syllabus. The development of the energy transfer and transformation concepts was characterized by investigation, experimentation and construction of meanings by using the body. Concept maps were used in each activity in order to give a systematic organization to knowledge and obtain useful information on conceptual errors (misknowledge). The basic idea of the project comes from the need to develop, starting from early childhood, wide processes in terms of attention and responsibility towards the environment. Talking about the environment is a long, articulated

work that must be carried out during several years. This work offers the opportunity to put together ideas, memories and concepts in order to understand how nature works and how things are mutually interconnected.

METHODOLOGIES

- Brainstorming/clinical conversation
- Cooperative learning
- Lived body
- Tutoring
- Narration
- Problem solving
- Task in situation

STEPS

- Sowing experience with and without light
- Reflections on the concept of energy
- Energy through the body
- The needs of plants
- Concept maps

3 Designing the learning environment

"The Words of Science" project aims at teaching the main concepts of science through experimental activities in order to build the meaning of keywords, such as *object, properties, material, interaction, system, transformation, measurement, energy, and model.* The teacher prepares and organizes materials, procedures and significant situations that urge and guide the learning process from a constructivist viewpoint, interpreting knowledge as the student's active process. The study area is "energy in our lives": what happens in the world around us is the result of energy transfer from the sun to the earth.

Teacher's design map:

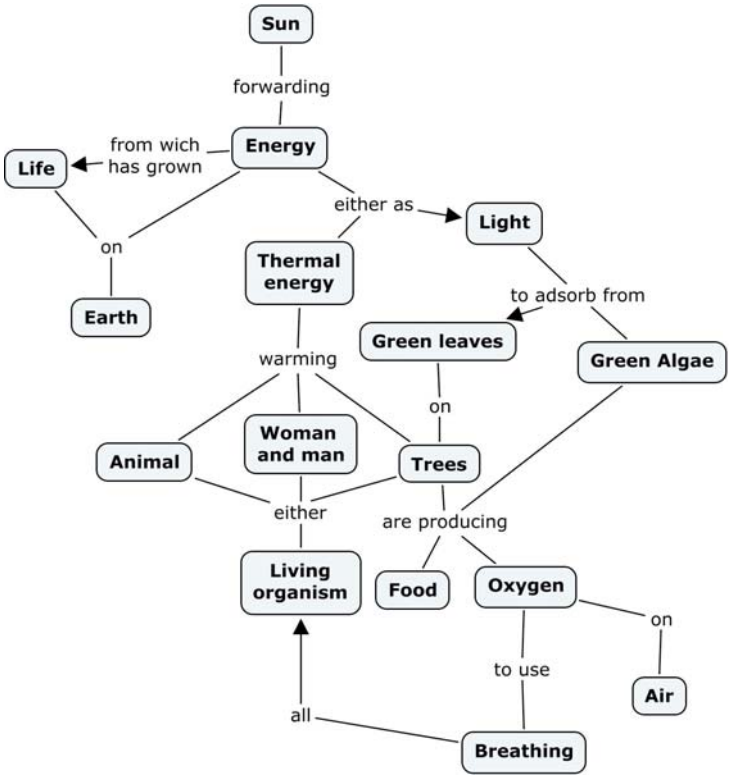

Figure 1. Teacher's design map.

Specific goals:

- Getting to know the functions of energy (transfers and transformations) in order to understand interactions between man, plants and the environment.

Help children to learn concepts while having fun and make them feel the protagonists, developing creativity and interest.

WORK UNIT

TOPIC	Energy and matter in living beings
CONCEPT	"To be alive": which conditions?

WORK STEPS

Step 1: Detect the children's spontaneous knowledge on the concept of heat.

1. Conversation

TEACHER

Have you ever heard the word "energy"? What do you think about when you hear this word?

- *panels*
- *electricity*

TEACHER

Do you know any other forms of energy that are closer to you?

- Children do not answer.

Step 2: Stimulate experiences to enrich their knowledge

2.1. The teacher stimulates a body activity that allows children to experiment a transfer of energy.

At the end of the activity, the teacher invites students to write what they have felt on a piece of paper, following the rules of cooperative activity and using the structure of the SIMULTANEOUS DESK GAME.

2.2. The teacher reads the answers: a variety of heat types is identified

- Heat from our body
- Heat from the wind
- Heat from the sun and from solar panels
- Heat from fire

Step 3: Investigate the concept of heat through experiments.

3.1. After dividing the class into cooperative groups, the teacher works like this:

- The teacher gives a bowl and one ice cube to each table of four students.
- Children pass the ice cube around with their hands.

The teacher asks:

- What happens? What do your hands do? What does ice do?

Children talk together and write answers down.

- What does ice take? *Heat*
- And what do your hands do?
- *They give heat to the ice*
- What happens to the ice?
- *It melts.*

Figure 2. Teacher's design map.

The teacher says that A TRANSFORMATION has occurred, because by using their hands children have transferred energy as heat and the ice has melted. Heat goes from the hands to the ice, which melts.

3.2. Then the teacher uses GENERALIZATION, stimulating reflection with a crucial question**:**

Which other heat exchanges do you know?

- *Heat is exchanged when I touch the radiator.*
- *Heat is exchanged when I take my friend's hand.*
- *Heat warms me up when I lay in the sun*
- *When I feel hot, this is heat.*
- *Heat is my friends' energy.*
- *I feel heat on my hands.*
- *Heat comes from fire*
- *The sun is hot; the fan takes away the heat and creates coolness.*
- *The sun transfers heat to solar panels*

Children have widened their knowledge on the concept of heat through the stimulation of a process based on game and experimental activities, in such a way to perceive the concept at multiple levels: body, motion, sensation, cognition.

Step 4: Favor the awareness of the sun as an essential energy source for the life of plants.

4.1. The teacher brings to the classroom two pots with earth and a bag of seeds and puts one pot into the class locker and one pot on the window sill. Then the teacher invites the students to sow the earth in both pots.

4.2. After some time, the teacher proposes the following PROBLEM SOLVING:

Do plants grow with or without light?

- Plants don't grow without light.

The teacher asks the crucial question “DO YOU THINK IT IS TRUE? HOW CAN WE FIND OUT?

Then, the teacher invites the students to travel on the DISSONANCE and DISCOVERY boat.

Figure 3. Sowing experience with and without light

4.3 Observation of sowing experience with and without light

The teacher guides the observation of the two pots and makes students discover the differences in the color of the leaves and the stem of the two plants. The students observe that the plants that were born and grew without light have white stems and pale, yellow, small leaves. Instead, the plants that were born and grew with light have thicker stems and green leaves.

Then, the teacher asks the question: “What does a seed need to grow?”

In order to answer the question, the teacher starts a step about the knowledge of an artificial and a real leaf.

Step 5: Understand the function of chlorophyll

5.1 The teacher brings to the classroom real and artificial leaves. Then, he/she invites students to observe their shape, color, and size. Then, he/she gives out some posts-it and asks the students to identify whether leaves are real or artificial, explaining the reason why through a series of stimulation questions, such as:

- What is an artificial leaf made of? What happens if you smell it? And if you touch it?
- Do you think that real leaves are heavier than artificial ones?
- What does a real leaf do?
- And the artificial one?
- Where does the leaf live?

5.2 After discussing about the tactile, visual, and olfactory sensations of the leaves, the children are divided in cooperative groups and are invited to represent the properties and differences of real/artificial leaves with words or drawings through the maps

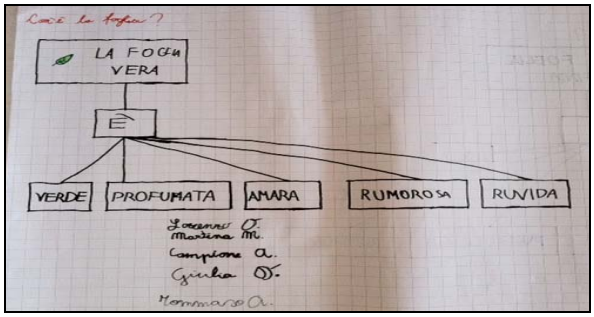

Figure 4. Maps of 5/6 year old children

The real leaf	The real leaf	The artificial leaf
• is green • smells good • is sour • is noisy • is rough	• smells good • is darker	• does not smell • is lighter

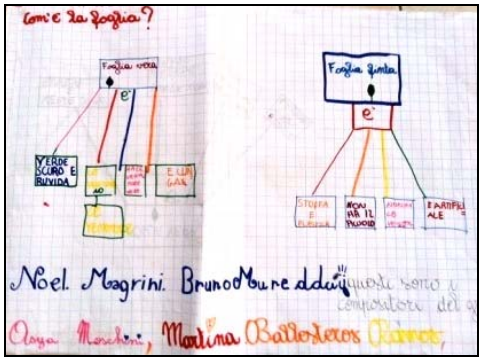

Figure 5. Maps of 5/6 year old children

The real leaf	The real leaf is dark green and rough
• is smooth on one side and rough on the other side. When it dries, the real leaf becomes darker. The artificial leaf • never changes, it is faked, it doesn't die and the stem doesn't come out.	• has real veins, and is long The artificial leaf is made of fabric and plastics. • has no stem and no veins. • Is artificial

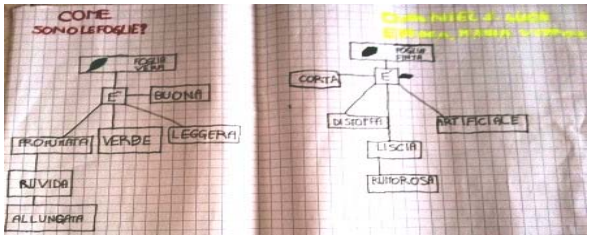

Figure 6. Maps of 5/6 year old children

The real leaf:	The artificial leaf:
smells good, is good, green, light, rough, elongated	is short, made of fabric, artificial, noisy, smooth

5.3. In order to reinforce the understanding on the function of chlorophyll, the teacher uses the narration of a cosmic story, named “Aslan's dream”, which tells the story of a child, called Aslan, who imagines being something else: an animal, a flower, a father.

“I was a basil plant and I lived quietly in my garden: my leaves were straight and green and scented the air, until, all of a sudden, I realized that one of them was different. It was a small, yellow leaf, it bends downwards, as if it was tired and had no longer the necessary strength to stay straight.

While he is telling the story, Aslan gets agitated and yells: “What's happening to my leaf? Why isn't it as green as the other leaves?”

What would you tell Aslan? Write it on your post-it

5.4. Then the teacher divides the class into groups and proposes an experiment named “Searching for the green” in order to discover that leaves contain chlorophyll, giving the following instructions.

1. Take some basil or spinach leaves
2. Put them in a bowl and break them into small pieces.
3. Add alcohol (the one used to make liquors) to the leaves in the bowl.
4. Take a spoon and smash the pieces of the leaves in alcohol. After smashing them for a while, stop and look: is alcohol still colorless?
5. Pour the contents of the bowl in a small vase and close it with the lid.
6. Wrap the vase with tin foil to protect it from the light.
7. Leave the vase like this for two days, then open the vase and see what happened.

At the end of the experiment the teacher asks: “What is chlorophyll for?”

5.5. In order to let students answer the question, the teacher uses the second part of “Aslan's dream"

“Still in the dream, Aslan meets a scientist name Albert and asks him: - What is chlorophyll for? –

Albert replies - You must know that leaves are just like the pots you use to make soup: air gives the carbon dioxide and water, then everything cooks in the pots-leaves and at the end you get a soup made of starch, oxygen and sugars that nourish the plant.

Absorbed in his thoughts, Aslan listens to the scientist and replies:

- How can leaves cook the soup made of carbon dioxide and air, if the fire is not on under the pot?-

(Of course, Albert knows everything, but says nothing: he wants to see if Aslan can understand by himself. Do you want to help him? Suggest your idea).

After a while, Aslan bursts out: - I got it .... it's the sun that cooks the stuff in the pot-leaf, although I don't know how!”

Albert is happy. – That’s a good idea: the sunlight on the leaf is just like the fire under the pot; the sun cooks the water and carbon dioxide in the leaf to create a soup made of starch, oxygen and sugars! But how could you demonstrate this?

Aslan is excited and has no hesitations: - You simply need to cover the leaves so that the sunlight cannot reach them and see what happens, comparing them with the other uncovered leaves.”

At the end of the narration, the students have discovered that plants need a soup where a vital combination between carbon dioxide, light and water takes place. **The energy of the sun creates starch and sugars (which nourish the plant) and liberates oxygen.**

Step 6. Evaluating the cognitive increment

The teacher proposes questions about the concept of heat and energy to evaluate their cognitive increment, according to the requirements of the Montessorian school that measures learning with the "*mneme*" parameter. The students build the new concept maps according to the knowledge retained from the teaching unit.

The existing knowledge is mediated with the group through the dialog and effective strategies can be activated to acquire the new knowledge, operating in what Vygotskij (1980) defines as *proximal development area* through the communicative and social relation with peers and teacher.

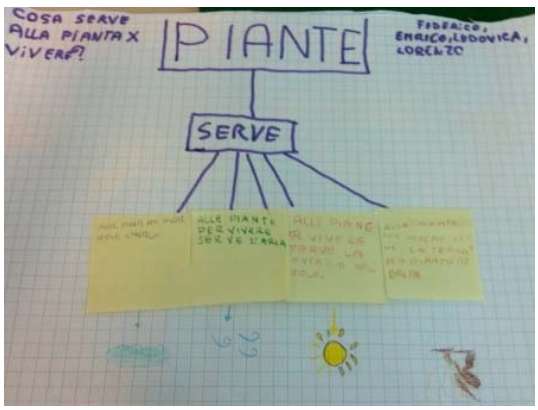

Figure 7. Maps of 7/8 year old children

In order to live, plants need:

- water
- air
- sun energy
- earth (to grow straight)

In order to live, plants need

- earth
- water
- sunlight
- carbon dioxide
- oxygen
- heat
- light

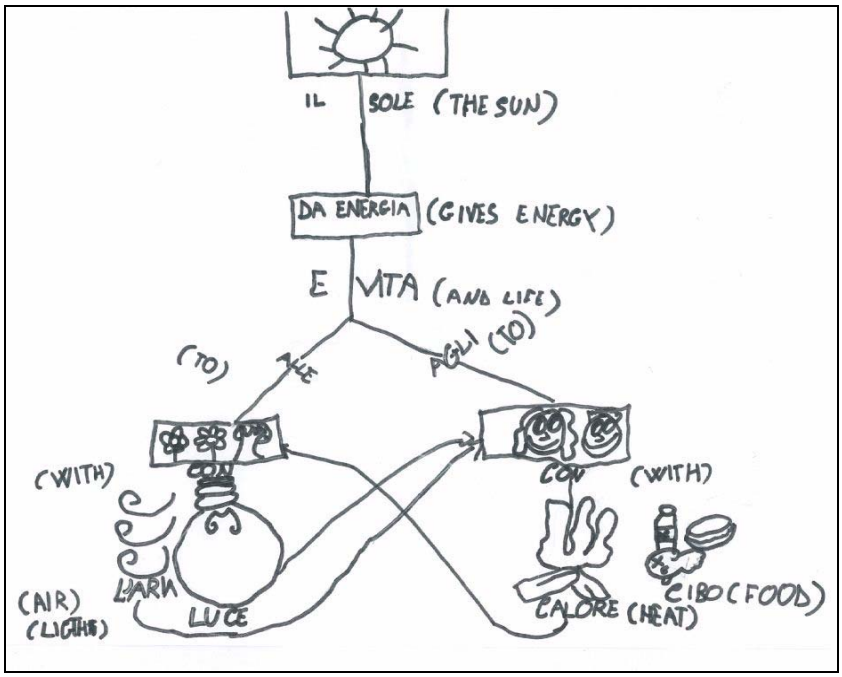

Figure 8. Map of 7/8 year old children

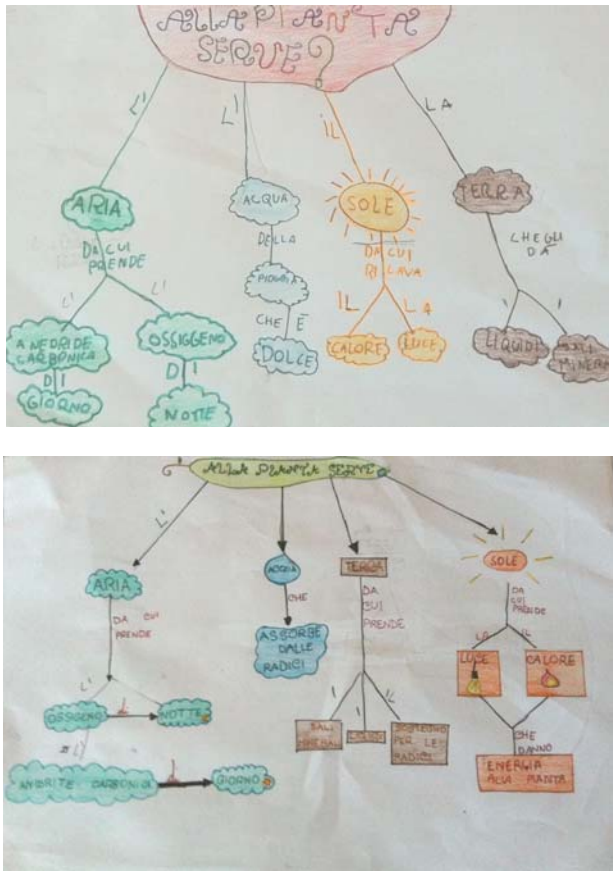

Figure 9. Maps of 8/9 year old children

4 Summary

Children discovered concept maps to be a very good system to organize and represent the knowledge they are building in a significant, solid network. The knowledge referred to transfer and transformation of heat in their reality, i.e. their body and the world closer to their perception, that is the sun and plants. Maps proved to be a crucial instrument to make meanings contained in learning materials emerge. They favored motivation to learn and structured the organized, effective thought in every single learning step. As we demonstrated in this unit, building concept maps is a valid tool for students during understanding. At the same time, it gives teachers suitable information to follow their intellectual development. The maps built by the students clearly show if the desired changes have taken place, or if misconceptions remain. In the latter case review activities and additional conceptual constructions can be started. Therefore **maps acquire a deep meaning in terms of educational evaluation.** The richer the maps, the deeper and the more significant learning will be.

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