CHILDREN'S USE OF METAPHORS AND ANALOGIES WHILE EXPLAINING MATTER TRANSFORMATIONS

Ingemar Holgersson, Kristianstad University, Sweden

Introduction

To explain natural phenomena is a central purpose of science. Explanations are therefore one of the most important activities also in science education. Traditionally the use of metaphors has been seen as rhetoric or decorative means in explanations and other kinds of stories. Lakoff & Johnson (1980, 1999) and others have changed this view by arguing that metaphors are the essential means that we use in order to understand any phenomenon that has some degree of complexity. Sutton (1992) has revealed that the language of science is impregnated by metaphors and analogies that today no longer are overt, and has argued that to revive these will enliven and humanize scientific thinking for students.

In the literature on metaphors and analogies in science education research there has been a focus on the deliberate use of them in teaching to facilitate learning (see Duit (1991) for a review of the use of analogies). Which metaphors students and primary teachers judge as good or not so good have been investigated by Ogborn & Martins (1996), and how teachers go about explaining science in the classroom has been studied by Ogborn e.a. (1996). In the later paper they argue that metaphors and analogies play an important role in explanations. Not only to "make ideas more palatable, more vivid, more accessible" (p. 73). But in close resemblance with Lakoff & Johnson they argue that "They [metaphors] *are* thinking. And they *are* the making of meaning" (p. 76).

In which ways the students themselves use metaphors and analogies have however not been investigated in any detail. In this study we will try to make a contribution to this area. We do this by investigating the way children use metaphorical thinking while explaining some phenomena concerning transformations of matter. In the term metaphorical thinking we will include the use of genuine metaphors (i.e. without explicit reference to the mapping domain), the use of analogies and the use of references to their own experiences of different phenomena. In which ways do children use metaphors and analogies? In what situations and for what purposes? What kind of domains do they use as references?

Methods

We use data from a longitudinal study conducted at the University of Kristianstad (in cooperation with Gustav Helldén, Lena Löfgren and Ann-Charlotte Lindner) of how children explain three scientific phenomena. About 60 children, born in 1990, have been interviewed every spring from 1997 until 2002 (2 interviews per individual in 1997, 1999 and 2001, and one interview in 1998, 2000 and 2002), i.e. between 7 to 12 years old, and all interviews have been transcribed verbatim. The interview situations have been:

Situation 1. Leaves.

We started by presenting the children with some leaves that had been lying on the ground during the winter. They showed different stages of on-going decomposition. Then we asked:

What do you think will happen to the leaves if they are left lying on the ground?

and later on we asked:

What will become of the leaves?

Situation 2. Candles.

After this we presented them with two candles, one long and one short. Then we lit the longer one and asked:

This candle (pointing to the shorter) *has been as long as this one* (pointing to the longer). *What do you think has happened to all the wax that was there before?*

Situation 3. Water.

The third situation we presented them with was a glass jar with some water and covered with a glass-plate. Mist was formed on the cover. We started by asking:

What do you think it is that we can see on the cover?

Then we continued by asking:

Where do you think it has come from?

and

How do you think it has come up there?

In 2001 we decided to extend the interviews in the following way. In situation A we presented the students both with leaves, dry grass and a peg, all of which we had brought in from the woods. We then asked them about what happens to all of these things. We also presented them with a sample of soil and asked: "*How is soil formed?"*. In situation B we changed the long candles for tealights, one new and one nearly burned out. After asking the same question as above we supplemented with the following question: *"What do you think happens in the flame?"*. In situation C we continued the interview by taking off the cover and laying it on the table. Then we asked: *"What do you think will happen if the jar is left for a fortnight without a cover?"* and *"What do you think will happen to that thing* (the moisture) *on the cover, if it is left like this for a fortnight?"*

Analysis of the conceptions children express during the interviews have been presented in Holgersson (2001), Holgersson & Löfgren (2002) and Löfgren & Helldén (2003). However when you penetrate the data in some depth it becomes more evident that language and especially the idiomatic and metaphorically side of language is important in the formation of conceptions, much in the same way as expressed by Sutton (1992).

This paper is therefore devoted to analysing to what extent and in which way the children use metaphors and analogies in their explanations. We use a sub-sample of 15 students coming from a school where the students have dominantly middle-class background. The longitudinal design makes it possible to pursue if there are changes for individuals over the years. For a more detailed description of the design of the study see Holgersson & Löfgren (2002).

The theoretical framework for the study has been the special kind of constructivism that Joseph Novak has termed human constructivism (Novak, 1993). Founded on Ausubel's assimilation theory it states that one of the characteristics of human beings is to form conceptions of perceived regularities and to fit them into the structures of what they already know. This formation is not done in social isolation, but on the contrary is highly dependent on social interactions and the language we learn to use in explaining and making sense of what we perceive.

The data sample for this paper consists of 7 – 9 interviews for 15 individuals, in total 124 interviews. In analyzing the data we have marked instances where they use metaphors, analogies or direct references to experiences of phenomena they find similar. The distinction between metaphor and analogy is not always easy to make, but metaphor is often viewed as a broader category encompassing analogy, see Gentner & Jeziorski (1993) and Lakoff & Johnson (1999). Here we have used a pragmatic distinction: An analogy is characterized by an explicit reference to some other phenomenon, while in the case of a metaphor this reference is not overt. We also include explicit references to experiences of phenomena used by the children to guide their explanation, i.e. they can be regarded as a special kind of analogy. Sometimes the children use some kind of a more general rule or principle as an explanation for a phenomenon. These have also been recorded. Still there are problems categorizing some statements. Antropomorphic thinking is common both in the situation with the leaves and the situation with the water. However there is hardly ever an explicit reference to human beings, so these are most often categorized as metaphors instead of analogies.

Results

When the children explain the different phenomena they tend to be very descriptive and almost exclusively use basic-level categories (Lakoff, 1987). But now and then they also use overt metaphors, analogies with other phenomena, or references to personal experiences of some phenomenon they find analogous. The total number of instances recorded is given in table1.

Table 1. The number of recorded instances depending on situation.

Situation	Metaphors	Analogies	Experiences	Principles
Water	49	11	33	12
Candle	56	23	27	6
Leaves	77	1	38	3
	182	35	98	21

As can be seen metaphors are much more abundant than analogies. Experiences are also rather numerous whereas stated principles are rather few. There are also differences between the situations, which we will comment on further down.

However individual differences are big. All the children tend to be very descriptive trying to explain the different phenomena, but some children also use metaphors etc rather frequently. Others hardly ever use these "tools". In table 2 we give the number of instances recorded per individual depending on the kind of category of metaphorical thinking that is used.

Table 2. The number of different categories of metaphorical thinking per individual.

Type	Least	Mean	Most
Metaphor	5	11	23
Analogy	1	2	5
Experience	1	5	19
Principle	0	1	5
Total	11	20	44

Metaphor is the most common category used with a mean of 11 recorded for an individual. The variation is however quite large (between 5 and 23) and with 2 individuals giving 23 % of the total number of metaphors. The use of the category experience shows the same kind of distribution as for metaphors. The number of analogies and principles recorded is not large, but still there are just a few individuals responsible for a large proportion of the total number of instances.

In table 1 we can see a variation of category with context. To understand this variation we have to look into the different metaphors, analogies, experiences and principles used. In table 3 – 5 we have recorded the most common themes used.

Table 3. Examples of instances of different categories for situation 1: Leaves

Metaphor	**Analogy**
• Can fall apart or into fragments or turn to ashes • They do not get any food, water, power or energy • The become old, wrinkled and ugly • They curl to keep warm • They hurt themselves when caterpillars trot on them • Animals can have them as a food store • Soil is nourishment for nature • The soil eats them, drag them down • They lie there for no use	• They become old as human beings, and in the end they die

Experience	**Principle**
• Leaves in our compost turns into soil • It rots just like apples, chestnuts or wooden board • Animals like worms or wood-lices eat on them • Other experiences with plant-louses, rabbits or cows • Things are black when they have been lying in soil • Old leaves can blow away • Old leaves have disappeared when the snow is gone	• When things get too old they can become soil • Everything goes to pieces and becomes soil • Water might make them transparent

What turns out to be typical for situation 1 is that there are hardly any analogy or principle stated. The situation is rich of features on a descriptive level and the number of basic-level categories to use in an explanation is large. Everyday language is however rich in metaphors about leaves: they sit on the tree, they fall down, they lie on the ground etc., and often there is an antropomorphic theme of getting old and not

getting nourishment enough etc. that comes along with leaves viewed as living objects. Children also have many experiences with leaves that they use when asked to explain their fate. But the situation is complex and connections between leaves, animal activity and soil are not evident.

Table 4. Examples of instances of different categories for situation 2: Candle

Metaphor	**Analogy**
• The wax becomes watery • There is a little sea there with floating pieces • When the pit gets full, it runs out • It becomes ice • Becomes steam • The wick is a piece of string, a fuse or some cloth • The flame likes oxygen or lives on it • The wax shrinks from the heat	• Is as a liquid and it evaporates • The same as with the water experiment • Is as steam • Melts from heat as does ice or snow • Is as water, very hot water • Is as paper, so it melts away • It looks like a waterfall • The wick burns as a match or a string • The flame is as us, we need oxygen to survive • The candle is almost as a tree in the desert

Experience	**Principle**
• Flame goes out if covered by a glass jar • It usually runs down on the side and you can burn yourself if you get it on you • Someone can tear off the solidified wax and take it away • You make candles from melted wax in a hot kettle • Mummy has told that there can be holes in the candles • Different half-scary experiences with burning candles	• The longer the wick, the faster it burns • When things are hot they start to burn • Becomes less when it becomes water

Situation 2 about the candle is not nearly as rich in features on a basic level. Not much can be understood from just watching it, and the variation of different experiences recorded is much less than for situation 1. Instead this is the situation that has the most analogies recorded with water as the dominant analog compared with. But also the wick and the flame the children seek to understand by analogies. We also note that some children refer to an experiment, covering a candle with a jar, to explain why the flame needs oxygen.

Table 5. Examples of instances of different categories for situation 3: Water

Metaphor	**Analogy**
• Molecules are water droplets, small dots and can float in the air • The water has flown up, blown up or shaken up • The air has sucked it up • It fastens on the cover • It has lumped together or stuck together • It looks like a dense mass • The water wants to rise to the clouds • Water has to breath, else it can choke • No fresh molecules, they might die out	• Steam rising, same steam as in clouds • As a water puddle when the sun shines • As with carbonated water

Experience	**Principle**
• Experiment performed in class • Homework on the water cycle • Steam from a boiling kettle or from your breath when its cold outside • Mist on the mirror in the bath-room or on a car-window • Squirted water-drops as from the pool • Frost on the grass • Been standing for long? • Snow that have fallen on the ground will become ice	• Goes in a circle, a water-circle • Cold is heavier than warm • Warm rises • The warm goes up to the cold • When it is cold it does not evaporate • The more humid, the more it evaporates • Becomes damp when there is no oxygen

For situation 3 about the covered glass of water, the descriptive level and the number of metaphors used in everyday language is somewhat in the middle of that for situation 1 and 2. This can be seen in the number of analogies used. There is also an antropomorphic theme in this situation. Because the glass is covered many students think of the water as struggling to come out of the glass to avoid choking. The special feature for this situation is the number of principles stated. We see this as an expression for the children's familiarity with water and its behaviour. Some children use molecules to explain how mist is formed on the cover. But when they do so, and since the molecule is an abstract concept, we can also notice a tendency to use metaphors to explain the behaviour of the molecules, much in the same way as a teacher does in class (Ogborn e.a., 1996). For this situation there are quite a few students that refer to an experiment with melting snow that later on vanishes through evaporation.

Conclusions and implications

When children explain scientific phenomena they spontaneously use metaphors and analogies, not abundantly but now and then to make their explanation more understandable. In this paper we have studied this use together with their use of references to concrete experiences and stated principles. We find that in order to understand a phenomenon, children frequently refer to experiences they find similar to some feature of the phenomenon, or else they construe analogies and metaphors to make things more intelligible. There are however context dependencies. A situation, which is rich in perceptual information, does not seem to stimulate the use of analogies in the same way as a situation which is more deplete of such information. The level of abstractness of the process studied has the same influence.

There is a rather large variation between individuals and this presumably to a certain extent reflects personality. But cultural factors such as the language used in their family also might be influential.

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