From preschoolers' ideas about decomposition, domestic garbage fate and recycling to the objectives of a constructivist learning environment in this context

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Abstract

This study is concerned with tracing young children's ideas about the biological process of decomposition, as well as about everyday waste management, and with using these ideas for shaping the objectives of a potentially effective learning environment in the theoretical context of constructivism. Conducting individual, semi-structured interviews with 28 preschoolers (age 5-6) of 2 public kindergartens at the area of Patras, we traced their ideas about (a) decomposition of organic materials and man-made ones, (b) domestic garbage and their fate after being removed from the house and collected by the garbage trucks, and (c) recycling and its usefulness. The findings of the tracing phase, as well as the shift from these to the objectives of a learning environment for promoting a better understanding of the topic in question and get children engaged in environmentally responsible everyday practices, are thoroughly discussed in the paper.

Keywords

Early year education, decomposition, recycling, constructivist learning environment

Résumé

La présente étude concerne les idées des enfants sur le processus biologique de

décomposition et la gestion des déchets. En utilisant ces idées on essaye de définir les objectifs d'un environnement d'apprentissage potentiellement efficace base sur le cadre théorique du constructivisme. Une série d'entretiens individuels et semi-structurés a été réalisée avec 28 enfants du préscolaire (age 5-6) de deux écoles maternelles publiques de Patras pour tracer leurs idées sur (a) la décomposition des déchets organiques et les produits fabriques par l'homme, (b) les ordures domestiques et leurs développements après avoir été ramasses de la maison par les camions, et, (c) le recyclage et son utilité. Dans cet article nous discutons les résultats de la phase de détection de ces idées et de La définition d'un environnement d'apprentissage qui vise à promouvoir une meilleure compréhension de cette question et une implication des enfants dans des pratiques quotidiennes de responsabilité environnementale.

Mots-Clés

Éducation dans la petite enfance, décomposition, recyclage, environnement d'apprentissage constructiviste

Introduction

Environmental education seems to gather much interest nowadays, possibly in response to a growing list of urging environmental problems such as global warming, depletion of the ozone layer, large scale exploitation of natural resources, shrinking of biodiversity or increasing strain on water. As a consequence, a considerable body of educational research is concerned with children's understanding of science concepts related to the environment (Boyes & Stanisstreet, 1993; Greaves, Stanisstreet, Boyes & Williams, 1993; Palmer, 1995; Qualter, Francis, Boyes & Stanisstreet, 1995; Leach, Driver, Scott & Wood-Robinson, 1995, 1996a, 1996b; Batterham, Stanisstreet & Boyes, 1996; Christidou & Koulaidis, 1996; Bonnet & Williams, 1998; Littledyke, 2004; Ergazaki & Andriotou, 2009), often with the aim of informing environmental education programmes and thus influence children's attitudes and actions regarding the environment. A common thread within this body of research is actually the assumption that constructing knowledge *about* the environment may be a *key* element for developing friendly attitudes *and* behaviors *for* it (Kaiser & Fuhrer, 2003).

The demanding endeavor of helping children develop a strong environmental consciousness is considered as having to benefit *a lot* from an *early* start (Wilson, 1993). Since the emerging 'environmentalism' of even very young learners may be connected with basic ecological knowledge (Palmer, 1995; Palmer & Suggate, 1996), the development of well organized, constructivist learning environments based on their own ideas

in order for the latter to be elaborated and also used for promoting attitudes and behaviors of love, respect and care for the environment, seems to be quite important (Driver & Oldham, 1986; Ballantyne, & Packer, 1996; Wilson, 1993; Hadzigeorgiou, 2001; Witt & Kimple, 2006; Zogza, 2007).

But what is known so far about young learners' ecological knowledge? Biology didactics research within the early childhood has already shed some light on children's conceptions about food relationships (Katsiavou, Liopeta & Zogza, 2000), consequences of human interventions upon nature (i.e. wood cutting, forest fires, greenhouse effect, ozone layer depletion, increase of garbage) (Palmer, 1993, 1995; Palmer & Suggate, 1996; Christidou & Koulaidis, 1996; Paprotna, 1998; Ergazaki & Andriotou, 2009), cycling of matter and decomposition (Leach et al., 1996a, 1996b).

Narrowing down on decomposition and how it may be conceptualized by young children, it is worth noticing the findings of Leach et al. (1996a) concerning the ideas of 30 4-6 year olds about the topic. According to these, half of the participating children were not able to recognize *any* differences between an apple on the tree and an apple that fell off and left on the ground for quite a long time. The other half came up with descriptions of morphological changes (*not* size ones) and used everyday words like for instance 'bad', 'mangy', 'rotten' or 'black'.

Concerning their participants' ability to explain these changes in the fallen apple, Leach et al. found that it was the 45% who actually came up with an explanation. More interestingly, the researchers categorized the provided explanations at 5 different types, according to the specific factor which was thought to be the causal one. More specifically: (a) explanation on the basis of the apple: the cause of the fallen apple's decomposition is its removal from the tree or its *'age'*, (b) explanation on the basis of observable organisms: the cause are insects, worms, or cows that eat it, (c) explanation on the basis of microscopic organisms: the cause are microorganisms that eat it, (d) explanation on the basis of environmental conditions: the cause is the sun, the wind or the warmth that *'spoil'* it, and (e) on the basis of humans: the cause are the humans who did not eat the apple in time.

Finally, as Leach et al reported, most of their participants were not able to understand the role of time in the phenomenon and to predict what would happen to the apple if it remained on the ground for a whole year. They mainly thought that no changes would happen, while only few of them claimed that it would disappear or become soil.

It should be noted that the difficulties encountered by preschoolers are not actually unexpected, since even children of much *older* ages are reported with a poor conceptualization of the phenomenon *as well* (Andersson, 1990; Hellden, 1995). Although they may know that organisms' residues and dead organisms undergo decomposition and rot, they seem to have difficulties in understanding how this happens and how it

results not only in 'soil' or 'mineral elements' in it, but also in carbon dioxide and water (Hellden, 1995). It is plausible that children's problems with the idea of matter transformation may be connected with their problems with regard to decomposition. As Andersson suggested (1990), teenage students' conceptions about how matter may be transformed are not strongly related to the idea of the chemical reaction. On the contrary, ideas such as 'disappearance', 'displacement' (a substance can appear in a certain place simply because it has been displaced), 'modification' (a substance retains its identity while some of its properties are changed) and 'transmutation' (a substance can be transformed even in ways that are 'forbidden' in chemistry) seem to be more popular among 12-16 year old children (Andersson, 1990).

Being a rather difficult topic, decomposition actually *needs* to be explored within a context of everyday life that could possibly make it more meaningful for the children. And it is plausible that such a context might be provided by the topic of waste management. So, what is already known about children's ideas on waste management?

It is worth noticing the most recent study where Palmer, Grodzinska-Jurczak & Suggate (2003) worked with 4-10 year old children from two different countries (England and Poland), in order to elicit what their informants knew about waste disposal, where they got their knowledge, and whether they had realized that the waste issue is very important and –as such– it should be of people's concern.

According to Palmer's et al findings, even the younger informants had *some* knowledge about the correct disposal of waste. Many of the 4-year olds were able to understand that the waste disposal follows an organized procedure. Young children had noticed the garbage trucks, heard of recycling through the media, and seen pictures of landfills with buried waste in children books. Most informants at the age of 6 were familiar with the ideas of disposing waste in special garbage bins and being able to recycle some of these. They seemed to understand the different composition of the waste and to recognize the different ways of disposal in connection with the constituting material.

Concerning the recycling of specific materials, the young children were reported to have a number of problematic conceptions, but according to the researchers they could obtain specific knowledge *if* parents and teachers encouraged and promoted such knowledge. This claim was warranted by the finding that the personal experience of children with garbage separation and recycling seemed to be strongly related with their understanding about the topic in question. Moreover, this was further enhanced by the fact that although the Polish children were generally at a lower level of awareness compared to their English counterparts - those who came from a specific region of the country where environmental education was a priority and thus had the chance to be engaged in relevant educational activities *did* show a better conceptualization of the topic.

Considering the above, the present study is concerned with tracing the ideas of 28 preschoolers about decomposition and waste management and using them to shape the objectives of a learning environment which could possibly promote a better understanding of the topic in question and thus get children engaged in environmentally responsible everyday practices.

The choice of the particular topic –decomposition and waste management– seems to be appropriate for attempting to achieve one of the main aims of environmental education, which is developing an understanding of how we, *ourselves*, can take part in the conservation of the earth's good condition by *acting* responsibly in our everyday lives.

Moreover, in a country like ours where the inappropriate waste disposal in dumps has created major environmental problems such as extensive water pollution, and the disposed garbage need to be reduced by 50% until 2050 according to the '6th Programme of Action for the Environment', educating our youngsters to start being responsible with regard to what they do with their own garbage seems to be quite urgent.

In fact, many of the environmental education programs in Greek schools seem to deal with the issue of recycling. Nevertheless, these programs usually attempt to promote recycling behaviors *without* taking into account children's previous knowledge and attitudes, and *without* creating direct links with the biological process of decomposition and the different materials' potential to undergo decomposition or not. So, it seems a good idea to deal with this missing link and at the same time attempt to make the demanding study of the biological process of decomposition gain real meaning for the young learners.

Theoretically we draw on the 'constructivist theory', which views learning as an *active* process of knowledge construction on behalf of the learners, rather than as a passive process of knowledge transmission on behalf of the teachers (Bruner, 1966; Piaget, 1970; Vygotsky, 1978). The construction of new knowledge by the learners is considered to be closely related to the knowledge they already have: learners organize their new experiences and make sense of them on the basis of their current ccognitive structure (Bruner, 1966). Thus, ascertaining the 'ideas' that children bring with them even into the kindergarten classroom is actually the necessary starting point for developing learning environments where the meaningful exploration of concepts might facilitate the course towards the development of desired attitudes and behaviors.

Finally, the questions addressed here are:

1. 'How do young children think about decomposition?'. More specifically, 'what kind of changes do they recognize when describing organic materials that undergo decomposition', 'what kind of explanations do they provide for the changes that take place', 'do they understand how decomposition progresses in time and

how it finally ends', and 'do they think that it also applies to man-made packaging materials (paper, glass, iron, aluminum, plastic)'.

2. 'What do they think about the domestic garbage and their fate after being collected by 'garbage-trucks'?'. More specifically, 'do they realize that there are two distinct types of domestic garbage', 'are they familiar with the idea that these different types of garbage need to be disposed to different garbage bins, transported to different places and undergo different treatments'.
3. 'How familiar are they with recycling as an everyday practice?'. More specifically, 'do they know what the word 'recycling' is supposed to mean', 'do they recognize the official sign of recycling', 'do they have personal experience of garbage separation at home', and finally 'do they understand what it serves?'.

Moreover, we address the question of 'how young children's traced ideas may shape a new learning environment that could possibly promote a better understanding of the topic in question and get children engaged in environmentally responsible everyday practices?'.

Thus, the objectives of this paper are:

(1) To explore young children's ideas about decomposition of organic and man-made materials, house-garbage fate and recycling.

(2) To use these ideas for shaping the objectives of a learning environment in order to meet children's needs *and* potential.

Methods

The overview of the study

The informants of the study were 28 preschoolers (age 5-6), attending 2 public kindergartens of Patras during 2008 and living in areas where different, well-indicated garbage bins have been available for quite a long time. More specifically, at the children's living areas there are 'green' bins for the organic materials and 'blue' ones for the man-made packaging materials. The content of these different bins is collected by different garbage trucks and correspondingly transported to 'landfills of hygienic burying of garbage', or to a 'recycling center' and then to special 'recycling factories'.

Nevertheless, it should be noted that our informants had never been offered *formal* learning activities about decomposition, waste management or recycling during the several months they had already spent at kindergarten. The identification of their ideas was carried out through 20-minute, individual, semi-structured interviews, conducted and tape-recorded by the 3rd researcher in quiet places of children's schools. The interviewer had previously got familiar with the children, and their own assent for participating had been asked along with their parents' informed consent.

The interview protocol

Taking into account the previous studies and the topic's conceptual analysis, we developed a two-part interview protocol.

In the first part, we attempted to trace the ideas of our informants about the decomposition of organic materials, and then about the decomposition of man-made ones, showing them concrete items (fruits and packaging materials).

a) Decomposition: organic material (fruit)

Children were first presented with two real tangerines. The first one, which was fresh, was supposed to have been picked up from a tangerine-tree in the interviewer's garden; the second one, which had just started undergoing decomposition, was supposed to have been found lying at the soil underneath the tangerine-tree in the interviewer's garden. After identifying the differences between the two fruits, children were asked to describe the fruit that was found at the soil and explain how it might have become like this. Moreover, they were asked to predict what might happen to the fresh fruit that was picked up from the tree *if* it was left at the soil for a long time. Those children who predicted a possible reduction in the size of the fruit or even the fruits' disappearance were additionally asked where the missing fruit material might have gone.

Finally, children were presented with a third tangerine being at a further stage of decomposition, were informed that *'a child of another school told the interviewer that fruits and vegetables become like this because of very small animals that are called germs'* and were asked to give their own opinion about the other child's idea. Those children who found this idea plausible were additionally asked what germs may actually do to the tangerine and make it look like that.

b) Decomposition: man-made packaging materials

First, children were presented with a series of empty bottles (a paper-made milk bottle, a glass-made bottle of refreshment, an iron-made tin of evaporated milk, an aluminum-made can of refreshment and a plastic-made bottle of water) and were asked if they knew the different materials that these bottles were made of and the different origin of these materials, as well.

For instance, when shown the paper-made bottle of milk or the glass-made bottle of refreshment, children were asked to name the material that each bottle is made of (paper or glass) and also the material that the bottle's material is made of (wood or sand). Those children who couldn't respond were given the following question: *'Have you ever heard that something is made of paper (or glass)? Is there such a thing in your classroom? Can you show it to me? From what material do you think paper (or glass) is made of?'*.

After tracing the children's capability of distinguishing the different packages of everyday products on the basis of their structural materials, we proceeded with trac-

ing whether they think that decomposition can also happen to such materials. For instance, with the paper milk-bottle or the glass refreshment-bottle in front of them, children were asked whether these bottles would change or not if a child just threw them empty at the soil and left them there for a long time.

Finally, children were required to make a *direct* distinction between organic and man-made materials with regard to their potential of undergoing decomposition by having to make the following prediction: *'If we went in the school's backyard, buried all these stuff we have here (tangerines and different bottles), left them buried for a very long time, and finally came back and dig to see what happened, do you think that we would find them? How would they be? Would they be changed or not?'*. Those children who responded that we wouldn't find the buried stuff again were additionally asked where they think it would have gone or what would have happened to it.

In the second part of the interview protocol, we are concerned with children's ideas about the domestic garbage, their fate after being collected by the garbage trucks, and the practice of recycling in particular.

More specifically, the children were asked what sort of things there are in the house-garbage, where do we dispose our full garbage bags, who takes them and where to, and what happens to them at their final destination. To ascertain children's ideas in more detail, we asked them if they noticed that there are garbage bins of different colours, why they think is that, what sort of garbage we throw in the green bins and what in the blue ones, whether it's good to throw different sort of garbage in different-colour bins, whether the garbage trucks take the garbage of the green and blue bins to different places and what happens there.

Moreover, the children were asked whether they had any personal experience of garbage separation at home and if they understood what this might serve. They were also engaged in thinking what they would do if they were at home and all these fruits and bottles used for the interview were their own garbage which they would have to throw away. In particular, they were asked whether they would gather all this stuff in the same bag or not. And if not, how would they separate them in different bags and why. Furthermore, they were required to show the interviewer what exactly they would do with the different garbage and the different garbage bags, and inform her whether we could use again some of them according to their opinion.

Questions about having heard the word 'recycling' and knowing its meaning, or recognizing the recycling sign were made at the closure of the interview.

The 28 tape-recorded interviews were transcribed and children's responses were coded at a series of 'categories' that highlight their alternative views, as shown in the section that follows.

RESULTS

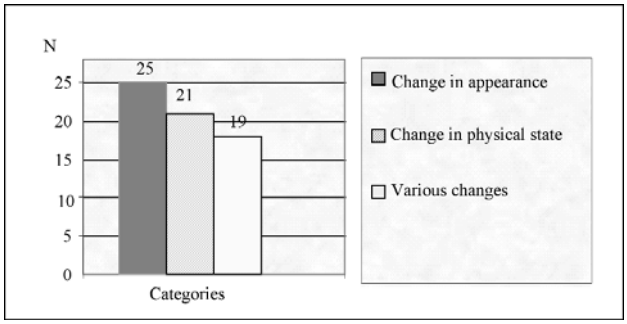
Concerning the Ist research question

The analysis of our data in regard to our 1st research question, namely children's ideas about the decomposition of organic materials and man-made packaging ones, showed the following.

1.1. Describing the decomposing organic material (fruit)

In order to describe the decomposing fruit, children referred (a) to changes in the fruit's appearance, (b) changes in the fruit's physical state, and (c) various other changes which were actually irrelevant to the decomposition itself (Fig. 1). It is noted that our informants recognized more than one type of change for the decomposing fruit.

FIGURE 1



Description of the decomposing organic material (fruit)

The stated changes in the fruit's appearance had mainly to do with its colour and shape. More specifically, most of the children (25/28) referred to the *colour* of the fruit, although in some cases such references were rather superficial and had actually little to do with the process of decomposition itself. Change in the fruit's size was mentioned by only one child, but it was explained in a 'mechanical' way; namely, it was attributed to the fruit's falling off the tree and its hit on the ground. It is worth noticing that even those children who claimed either a reduction in the fruit's size or the fruit's disappearance or even transformation to soil later on in the interview, did *not* refer to changes in size at this point as this was not so obvious from the presented items upon which they seemed to focus.

Many children (21/28) described changes in the fruit's physical state with expressions like *'it is rotten', 'it dries out', 'it melts', 'it blackens inside', 'it is spoiled', 'it is rusty', 'it has expired', 'it is useless', 'it is bad'*. However, it should be noted that these expressions

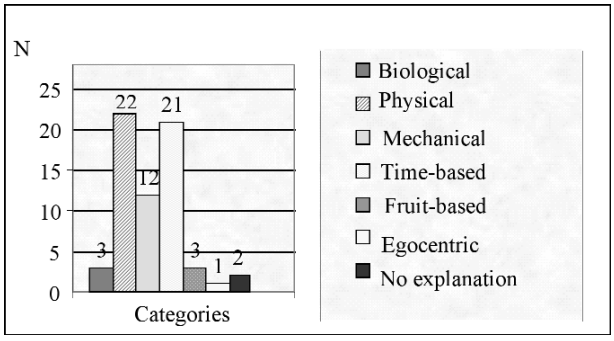
are not necessarily loaded with their adult meaning when used by young children. For example, it seems possible that the expressions *'it dries out'* or *'it is rotten'* merely describe changes in the fruit's appearance when coming out our informants' lips, although when used by an adult they could very well be a reference to the *process* of the fruit's decomposition. Similarly, expressions like it is *'spoiled', 'useless' or 'bad'* seem to have been used for indicating that the fruit in question is dirty and unhealthy for people.

Finally, many of our informants (19/28) recognize changes in *both* the fruit's appearance *and* physical state in their descriptions, while *'various changes'* – actually irrelevant to the decomposition itself (i.e. 'it is dirty', 'it has soil or grass over it', 'it has something white it') – are mentioned frequently as well.

1.2. Explaining the changes in the decomposing organic material (fruit)

Our informants provided different kinds of explanations for the changes in the decomposing fruit, which we coded as *'biological', 'physical', 'mechanical', 'time-based', 'fruit-based'* and *'egocentric',* taking into account the categorization proposed by Leach et al (1996b). It is noted that our informants provided more than one types of explanation for the decomposing fruit, while only 2/28 children came up with *'no explanation'* at all (Fig. 2).

FIGURE 2



Explanation of the changes in the decomposing organic material (fruit)

More specifically:

- The *'biological explanation'* had to do with *living organisms* feeding upon the organic material in question and thus causing its decomposition. In this category, we included only those children who referred *themselves* to visible organisms (dogs, cats, mice, insects, worms) or invisible ones (germs) as the causal agents of the observed phenomenon, without taking into account those who merely accepted this kind of explanation when it was suggested by the interviewer later in the interview. As

shown in Figure 2, the biological explanation was provided only by 3 children. It is also noted, that all 3 of them provided a mechanical explanation as well.

- The *'physical explanation'* had to do with environmental factors acting on the organic material in question and thus causing its decomposition. So, in this category we included those children who attributed the changes in the decomposing fruit to factors like sun, water (rain, snow or ice), cold and soil - mud, with the last being the most frequently mentioned.
- The *'mechanical explanation'* had to do with mechanical factors acting on the organic material in question and thus causing its decomposition. In this category, we included the children that attributed the changes in the decomposing fruit either to the fruits' falling (sometimes because of the blowing wind) and hitting the ground, or to the action of humans or animals that might have stepped on it, scratched it or dropped it.
- The *'time-based explanation'* was based on the idea that time is the key-factor for either the mechanical damage of the decomposing fruit or the changes in its physical state. It has been used by 21/28 children.
- The' *fruit-based explanation'* was based on the idea that decomposition is a natural step in the fruit's 'life': being cut off the tree, the fruit comes to an end through its decomposition, since it cannot meet its food-water needs any more. 3/28 children came up with an explanation like this.
- The *'egocentric explanation'* had to do with human beings and their failure to consume the fruit in question on time and was used only once.

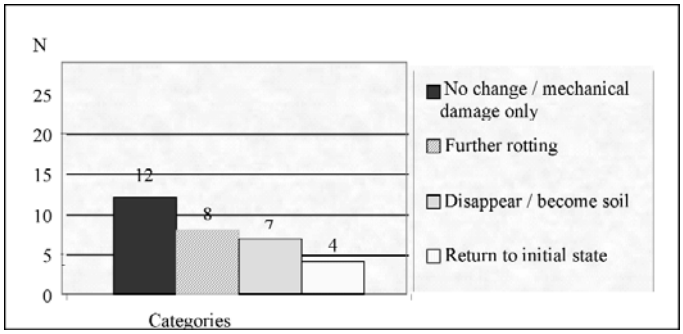
As shown in Figure 2, the most frequent kinds of explanations are the *'physical'* (22/28) and the *'time-based'* (21/28) ones, with the *'mechanical explanation'* following (12/28) and the *'biological'* one being quite rare (3/28).

Nevertheless, it should be noted that the children's *'physical explanations'* may actually be incompatible with the scientific ones. For instance, our informants seem to consider the low temperature ('cold') – instead of the high – as causing decomposition, claiming that nothing would happen to the fruit *'if it was summer time'*. Moreover, it is worth noticing that some of the children's *'physical explanations'* may also have a rather *'mechanical'* dimension. For instance, when changes in the decomposing fruit are attributed to environmental factors such as snow or ice, or even soil and mud, this attribution may be underlied by the idea that the fruit's coverage by the above gives a chance for a mechanical action to take place upon the fruit: *'if the tangerine stays for long time on the ground, snow and ice will melt it'*.

1.3. Predicting the course of the organic material's decomposition

When asked about the fate of the decomposing fruit if it was buried, our informants came up with a series of predictions ranging from *'nothing would happen to the fruit'* to *'the fruit would be converted into soil'*. More specifically, 12/28 children predicted that either no change or just *mechanical* damage would occur, while 4 of these 12 children *also* predicted that the fruit might return to its initial state. The fruit was thought to be *'rotting further'* by 8/28 children, while 7/28 managed to go all the way and state that it might *'disappear'* or *'become soil'*.

FIGURE 3



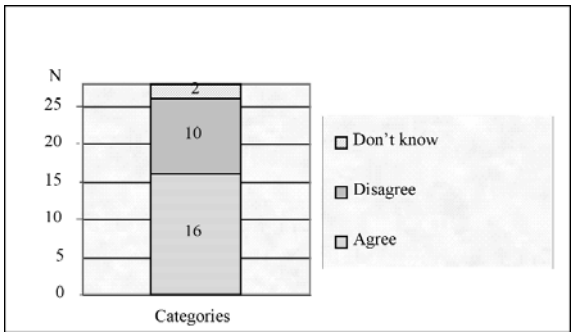
The course of the organic material's decomposition

1.4. Evaluating the germ-based biological explanation

Although 16/28 children actually *agreed* with the suggested biological explanation of the fruit's decomposition (Fig.4), only 2 of them claimed that the fruit *is eaten* by the germs when they were asked to come up with ways in which germs may possibly act upon the fruit. Germs were thought as *'melting'* or *'spoiling'* the fruit by 6 of 16 children in agreement with the suggested explanation, while 4 claimed that *'germs make tangerines get sick'* by probably reasoning in a *'personifying'* way on the basis of their knowledge about human disease (Inagaki & Hatano, 2006). Finally, germs were thought as *'making tangerines dirty'* (2/16) and since dirt was identified as a causal factor of decomposition, the same was considered to be valid for germs as well.

According to the above, it seems that a great effort would be required for the construction of the germ-based biological explanation on behalf of the children within a learning environment about decomposition. This is also indicated by the fact that an informant who had earlier come up with a biological explanation by attributing the decomposition of the fruit to visible organisms such as insects, did *not* even agree with the suggested germ-based explanation in question.

FIGURE 4



Evaluating the germ-based biological explanation of the fruit's decomposition

But what do our informants think about the decomposition when it comes to man-made packaging materials of everyday products such as milk, refreshments or juice? And first of all, are they capable of recognizing the material that makes up each package in question *before* they predicted its fate?

1.5. Recognizing the materials making up the packages in question and their origin

The bottle of milk was correctly recognized as being made of paper by 19/28 children, while 7/28 thought that it was made of other materials (i.e. plastic, 'paper & glass', 'paper & aluminum'), and finally 2/28 just stated that they didn't know the answer. The bottle of refreshment was easily identified by almost all the children (27/28) as made of glass. Iron was identified correctly as the structural material of the tin of evaporated milk by 16/28 children, while 12/28 children failed to come up with the right identification. Our informants seemed to have serious difficulties with the aluminum-made can of refreshment, since only 2 of them were able to identify correctly its structural material, while the others thought that it was made of iron (11), glass (5), plastic (2) or other materials (6), and 2 just stated that they didn't know the answer. On the contrary, the material of the bottle of water was easy for the children to identify: 24/28 succeeded in recognizing the plastic as the bottle's material, 1 failed and 3 just stated that they didn't know the answer.

Finally, a significant number of children (19/28 children) *did* mention wood as the origin of paper, while a small one (6/28) appeared to know the origin of iron. On the contrary, our informants didn't seem to know much about the origin of glass, plastic, or aluminum as it was expected.

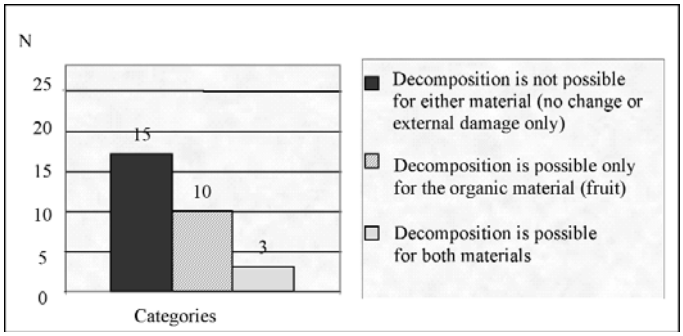
1.6. Predicting the packages' fate

Most of the children believed that the man-made package materials in question would *not* be decomposed. The predictions made by them are the following.

The paper-made bottle of milk was predicted to 'get away' either with some damage or no change at all by 24/28 children, while predictions of its disappearance or conversion to soil or compost were made by the remaining 4 children. Changes to the packages were generally predicted by very few children. More specifically, conversion to soil is predicted by 1 child for the glass-made refreshment bottle, 2 children for the iron-made tin of evaporated milk, 2 children for the aluminum-made can of juice, and also 2 children for the plastic-made bottle of water. It is worth noticing that these change-predictions for the packages were made by the same – totally 4 – children, 2 of which had earlier predicted the same for the decomposing tangerine.

1.7. Differentiating between organic and man-made materials on the basis of decomposition
As shown in Figure 5, reasoning in the context of the 'burying stuff in the backyard'-task 10/28 children were able to differentiate directly between the fruit and the packages by recognizing that the decomposition is possible only for the fruit and 3 of them claimed that the fruit disappears at the end of the process. On the contrary, all the remaining informants failed in making the target-differentiation, since they claimed that decomposition was either possible or impossible for both the fruit and the packages.

FIGURE 5



Differentiating between organic and man-made materials on the basis of decomposition

Concerning the 2nd research question
Moving to the findings of our analysis in regard with our 2nd research question, namely children's ideas about the domestic garbage and their fate after being removed from the house and collected by 'garbage-trucks', we note the following.

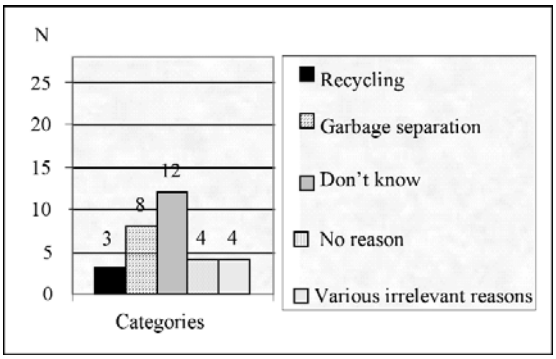
2.1. Garbage disposal: house - different garbage bins
All our informants knew what sort of things may be found in the house-garbage, but they didn't seem to realize that these things actually belong to two different groups

(organic and man-made ones). As it was expected, they also knew where we dispose our full garbage bags to get rid of them and had already noticed the blue and the green garbage bins at their neighborhoods.

Nevertheless, as shown in Figure 6, most of the children did *not* know what these different bins are supposed to serve (see 16/28 at the categories 'don't know' & 'no reason'). In fact, they thought that any kind of garbage can be disposed at any kind of bin.

The remaining 12 children *did* offer an explanation for the existence of the different bins, and sometimes more than one. 8/28 children referred to the separation of garbage and 3/28 to recycling in particular, but even those appeared to have serious difficulties in deciding what kind of garbage should go to what kind of bin. In fact, only 2/28 children linked the green bins exclusively to the organic garbage, and 3/28 linked the blue bins exclusively to the man-made ones (product packages). Finally, 4/28 children provided various irrelevant reasons for the existence of different bins, like having aesthetic value or making more space for the garbage disposal.

FIGURE 6

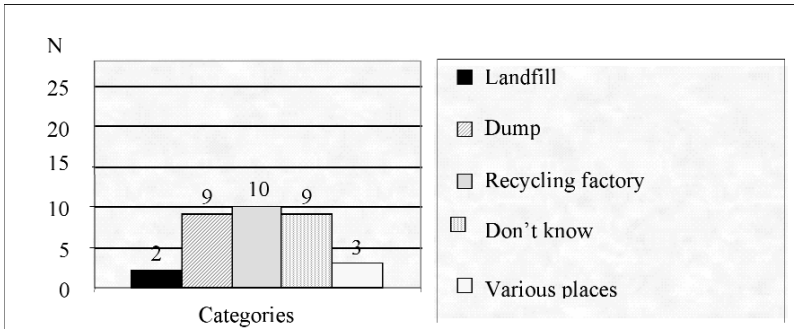


Reasons for having green and blue garbage bins

2.2. Garbage disposal: different garbage bins - different garbage destinations

As shown in Figure 7, our informants suggested several destinations for the house-garbage. These range from places like *'other bins', 'next to the grass', 'river'*, to landfills where garbage get buried, dumps or *'places full of garbage'* where garbage are just left in piles, and several factories or labs. It is noted that some children gave more than one possible garbage-destinations at the same time. This explains why there *seems* to be a number mismatch in Figure 7, but does *not* imply that the children were familiar with the idea that these different places where the house-garbage end, have very much to do with the different garbage-bins (green or blue) from which they were collected.

FIGURE 7



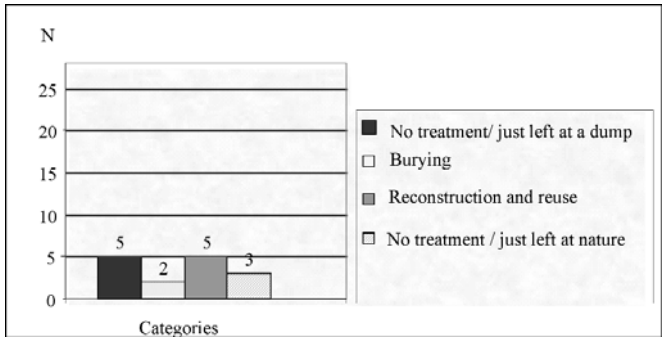
House-garbage destinations

2.3. Garbage treatment: different garbage bins - different garbage treatments

4/28 children claimed that there are different treatments for the garbage of the different bins and came up with the assertion that the contents of the blue bins are transported to recycling factories or labs to become *'as good as new'* and be reused by people, while the contents of the green bins are transported to landfills where they get buried or to dumps where they are left in piles. On the contrary, 9/28 appeared to know nothing about that.

Finally, the remaining 15 children suggested that there is a common treatment for the garbage of both types of bins. As shown in Figure 8, this common treatment may range from the simple deposition of the garbage at the natural environment or at a dump –in other words, from no actual treatment– to garbage burying, reconstruction and reuse. Some of them gave more than one possible garbage-treatments at the same time, but this had actually *nothing* to do with the idea that these different treatments

FIGURE 8



Common treatment of the garbage of all bins

at the different destinations of the garbage concern the contents of the different garbage-bins. In fact, this is an idea with which most of our informants seem to be rather unfamiliar.

Concerning the 3rd research question

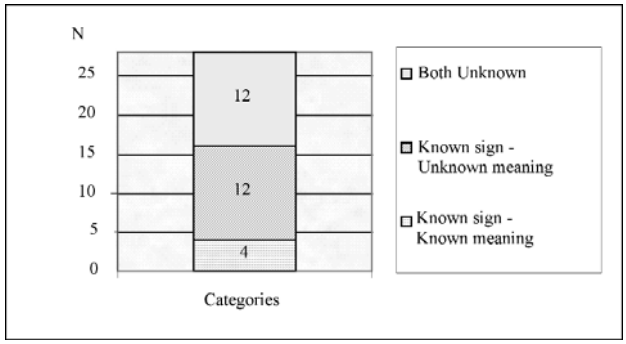
Finally, the analysis of our data concerning the children's ideas for recycling in particular, showed the following.

3.1. Recycling

7/28 children had a personal experience of garbage separation at their home, but only 2 of them were actually able to justify this practice by appealing to *'the different kind of garbage put in the different bins'* and the different treatment of the packaging materials, namely the fact that *'they're reconstructed and reused'*.

As shown in Figure 9, 4/28 children were aware of *both* the sign of recycling *and* of what it stands for, 12 children were aware of the sign but they did *not* know what it stands for, and the remaining 12 were *not* aware even of the sign itself.

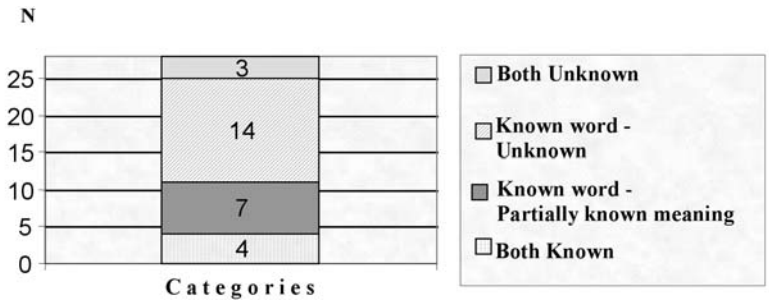
FIGURE 9



The sign of 'recycling'

The sign of recycling may not be known by many children, but what about the word 'recycling'? Our findings showed that more children knew the word than the sign. Nevertheless, being aware of the word does *not* necessarily indicate that our informants are aware of the word's meaning as well. It seems that 14 of the 25 informants, who had actually heard the word 'recycling' many times, do not understand what it means. On the contrary, 11 of these 25 children *did* show an understanding – or at least a partial one – of the word by (a) referring at least to a few or even to several recyclable objects, (b) considering at least either garbage reconstruction or garbage reuse as carried out through recycling, or even both of them, and (c) recognizing the exclusive

FIGURE 10



The word 'recycling'

relationship of recycling at least with some special bins (i.e. bins for batteries') or even the green garbage-bins only.

In summary, the children's knowledge about garbage management and recycling as a part of it, is fragmented and does not comprise a coherent and uniform mental model. Thus, our informants *do* encounter serious difficulties in explaining the existence and usefulness of the different garbage-bins, and in suggesting different garbage-destinations and different garbage-treatments. Moreover, they do not really see the need and consequently they do not have a strong motive for developing an environmentally responsible everyday attitude such as recycling.

DISCUSSION

Having already presented our informants' initial conceptions of decomposition, garbage fate and recycling in particular, we proceed to defining the specific objectives of a learning environment aiming at supporting children towards a conceptual refinement as well as an active involvement in environmentally responsible practices like recycling. In other words, we deal with our last research question.

1. Decomposition

1.1. Describing decomposing organic materials

Taking into account that the children's descriptions of the decomposing fruit had mainly to do with its colour and shape whereas the size changes had been mostly overviewed, as well as that the expressions they used for the changes in the fruit's physical state did not actually referred to the very *process* of decomposition, we claim that it would be purposeful:

- To emphasize the changes in the *size* of an organic material during the process of its decomposition. The observation of the material's size getting smaller and small-

er may be of key importance for introducing more effectively the idea of the material being eaten by tiny living organisms – 'biological explanation' – and help children to understand the final 'disappearance' of the material as its *almost* full consumption by these organisms.

- To help children build a stronger relationship between the changes in the material's *colour* and the process of decomposition. In other words, to help them attribute these changes to the fact that the material is being decomposed.
- To help children build a stronger relationship between the changes in the material's physical state and the process of decomposition. In other words, to help them reformulate the meaning of expressions such as *'it is rotten', 'it dries out' or 'it is spoiled'* by shifting from the state level to the *procedural* one

1.2. Explaining the decomposition of organic material (fruit)

Our findings with regard to the children's explanations for the changes in a decomposing fruit, suggest that we should attempt:

- To introduce the biological explanation of the phenomenon, thus to help children get familiar with the idea that tiny living organisms – both visible and invisible – cut the organic materials in very small pieces and use them as their food – while the invisible 'left overs' of their 'meal' in the soil may be taken and used by the plants.
- To help children reconsider the role of 'time' concerning decomposition. More specifically, to grasp time *not* as being *itself* the causal agent of decomposition, but as being a key factor for the action of the *real* causal agents, the living organisms. Thus, the target reasoning strand may be shaped by the idea of 'tiny living organisms being really *slow* eaters and also spoil their food during their long meals', which may explain quite easily why the observed changes in the material's appearance and physical state *do* need some time to occur.
- To reconsider the role the 'environmental factors' for the phenomenon in question. More specifically, to grasp the environmental factors they refer to (i.e. water, soil, temperature) *not* as being the causal agents of decomposition *themselves*, but as being key factors for the action of the *real* causal agents, the living organisms. Thus, the target reasoning strand may be shaped by the ideas of tiny living organisms 'having their home at soil', 'needing water all the time' and 'being more active if *not* getting cold', which may explain quite easily why the observed changes take place at soil when there is plenty of water and high temperature.

1.3. Predicting the course of the organic material's decomposition

According to our findings, we should help children:

- Predict the time order of the different snapshots of a decomposing material based on the gradual changes in its appearance (colour, shape and size) and physical state.

- Realize that the course of decomposition is irreversible. In other words, that a decomposing fruit cannot return to its initial state. The mediating idea may be that the tiny living organisms that feed very slowly upon organic materials like fruits, 'mess' with them so much *as soon as they begin* their meal, that these materials can never again have a similar look with the one they had before the organisms begun their long meal.
- Build on their own suggestion that *'the fruit would be converted into soil'*, by introducing the idea of the 'cycling of matter'. Namely, to help them understand that although they seem to always finish their meal (some children *did* say that the fruit disappears), the tiny living organisms in question actually *leave* some invisible pieces of their own food into the soil and these may then be taken and used by the plants.

1.4. Differentiating between organic and man-made materials on the basis of decomposition
The objective here is:

- The construction of a consistent model that would differentiate between the fate of the organic materials and the fate of the man-made ones. Namely, the grounding of the idea that man-made materials such as product packages do *not* undergo similar changes with the organic materials such as fruits, because they are *not* included in the food preferences of the tiny organisms which are feeding upon organic materials only.

Moreover, it would be purposeful to help children recognize the different sort of materials that make up the product packages in question and classify the empty product packages on the basis of their constructing material (paper, glass, plastic, aluminium and iron). Extra attention would be needed for the children to become capable of differentiating between aluminium-made cans and iron-made ones, as suggested by their traced difficulties. A key difference to be used could be the different behaviour of these materials to magnets.

2. House-garbage and their fate: house - different garbage bins - different destinations - different treatments, recycling

The objectives suggested by the findings of our analysis are to help children:

- Understand that the different things within the house-garbage belong to two different groups: (a) 'organic' like our food residues, which are food for tiny soil organisms as well, and (b) 'man-made' like empty product packages, which are *not* food either for us or for *any* other organism. So, children need to be able to classify the garbage items to these groups, in order to separate them in their every day lives.
- Link this garbage-separation with their disposal at different bins ('food residues → green bins', 'product packages → blue bins') and thus start to understand what the different bins are for.

- Identify the sign of recycling on both the blue bins and the recyclable packages, and realize that the word 'recycling' means the transformation of waste materials to materials that can be used again (reconstruction & reuse).
- Link the different garbage-bins with specific destinations for the house-garbage and specific treatments: (a) 'food residues → green bins → landfills', and (b) 'product packages → blue bins → recycling factories'. In other words, help children understand that landfills should be the destination for our food residues, but *not* for our product packages as well, by getting familiar with the idea that when buried in a landfill, our food residues are eaten by tiny soil organisms living there, while our product packages are *not* eaten by any organism and thus stay there for ever. Children should also be supported in understanding that recycling factories should be the destination for our empty product packages and *not* for our food residues as well, by getting familiar with the idea that our product packages can be reconstructed from their materials (paper, glass, aluminum or plastic) and thus reused, while our food residues obviously cannot.
- Recognize the space problem that originates from non separating our garbage and sending them all to landfills: 'non-separation of the garbage → all garbage to green bins → all garbage buried to landfills → product packages are not eaten by the soil organisms and they become more and more until the landfill is full → we need to create new landfills all the time → nature becomes a garbage-place '.
- Recognize the resources problem that originates from non separating our garbage and not sending the recyclable ones to recycling centers: 'non-separation of the garbage → all garbage to green bins → no garbage to blue bins → empty product packages are not transported to recycling centers to be reconstructed → if we don't reconstruct the empty packages, we have to construct new ones all the time → this requires new structural materials from natural resources (i.e. if we need more and more paper, we have to use more and more wood and thus cut more and more trees) → these resources are not endless and we won't have them if we use them so much'.
- Realize that they can be part of *both* these problems' solution by taking everyday action. In other words, give them a strong motive to be engaged in garbage-separation and appropriate disposal in their everyday lives, as well as in reducing the consumption of several products like refreshments or non-fresh juice.

Having presented the main objectives of the learning environment as shaped by the results of the tracing phase of the study, it is worth noticing a few things about its content as well.

As indicated by our theoretical framework, this strategy was based on the *active* participation of the children in several tasks and their meaningful interaction with the teacher (Ravanis & Bagakis, 1998). These actually ranged from 'creative tasks' with

some emotional involvement (making drawings, creating stories or engaged in role-playing), to 'inquiry tasks' (making predictions, providing possible explanations and checking their validity by observing the course of the decomposition 'experiments'), as well as to 'authentic tasks' like integrating the practice of recycling at the every day life of the kindergarten, reducing the consumption of products like refreshments or non-fresh juice, or reusing packages like the plastic bottles that can be reused.

The full description of this evidence-based learning environment, its 2-month implementation with the 28 preschoolers, and the exploration of its learning impact are going to be presented elsewhere.

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