Learning about Environmental Issues with the Aid of Cognitive Tools

Mikael Jensen
Department of Applied Information Technology
University of Gothenburg
SE-412 96 Göteborg, Sweden
Tel: 46-317-862-985 E-mail: mikael.jensen@sskkii.gu.se

Received: July 27, 2011 Accepted: August 15, 2011 Published: December 1, 2011
doi:10.5539/enrr.v1n1p92 URL: http://dx.doi.org/10.5539/enrr.v1n1p92

Abstract

When looking at the issue of learning about environmental problems many difficulties stem from their inherent abstractness which causes difficulties because humans have a problem understanding information that is not directly perceivable. We primarily create our lives on perceivable information and by imitating other people. This paper will examine the limitations of the human mind and it will discuss environmental problems that we can't grasp, but on the other hand it will discuss our cognitive capacities and the kind of tools we can use, and how these might be handled by educators. The tools discussed are: models and miniatures, metaphors and analogies, tracking, key questions, and (participatory) stories. The cognitive science approach is just one way of looking at the issue but it can be useful when dealing with educational challenges.

Keywords: Learning, Cognitive tools, Environmental problems, Stories, Educational challenges

1. Introduction

Most environmental problems today are abstract and embedded (e.g. Holmberg, 1995; Kollmuss & Agyeman, 2002; Jensen, 2009a). Thus, it makes it hard for humans in general and pre-school children and students in particular to understand what the problems really are. Fortner (2001, 25), for example, believes that "key concepts for understanding climate change are very abstract and are beyond the mental preparation of elementary students". This paper is not particularly discussing climate change but will argue that there are educational tools that can be of help to make these issues accessible for elementary students as well as adults. Not in an accurate way as we believe that experts understand abstract problems but as a starting point in a growing understanding. Bruner (1960/2003, 17) ones wrote: "Learning should not only take us somewhere; it should allow us later to go further more easily".

The purpose of this paper is to look at our potential and limitation as humans, and especially children, when it comes to understanding abstract knowledge related to environmental issues. The paper's focus is on issues concerning environmental problems related to everyday life, approached through cognitive science which has much to offer educators struggling with abstract phenomena. Instruction, learning and cognitive tools will be discussed and the arguments are leading towards the storyline method (the development of a story based on important key questions where the students participate as characters) that may include other tools in a complementing way.

First we need to look at what kind of problems we, especially children and young people, face in everyday life. The following examples can be used as a starting point to discuss environmental and related problems. For example: (1) we use huge quantities of paper and other products originating from wood pulp. It is fun to draw or write on a sheet of paper and it doesn't seem to harm our environment in any way, especially not to the child or student. (2) We use vehicles to move from one place to another which we find comfortable and convenient and the environmental consequences are largely hidden from us. (3) Children of today, in Sweden, have about five times as many toys as children had just three decades ago (Nelson & Nilsson, 2002). Again, it is fun to play with toys but no child really knows what they are made of, how they are made, where they are made and the conditions under which this takes place and eventually, what will happen when the toys are no longer wanted. (4) Clothes are a part of our culture and are also a way to get shelter from wind, rain, heat and cold. We take those pieces of fabric for granted and have little idea of where the cotton, for instance, is produced or the amount of chemicals used during the process. We know what colours we like to wear but normally we know nothing of how unhealthy colouring agents can affect our bodies. (5) Finally, we have to eat but eating is a behaviour that is separated from our knowledge about how food is produced. How can a child, as well as an adult, know whether a particular meal is produced in a way that affects our environment negatively? What we see here is that our continuing everyday living will have effects on other people and on the planet's capacity to support life, even if we do not know in detail what forms these take, and hence how we can change our way of living to mitigate these. This is not a very positive picture but the paper attempts to show why that is and how we might handle it. There is a potential solution which is more or less already known.

The following parts of the paper will examine our cognitive limits and capacities, and identify the cognitive structures and components that might help us understand problems related to environmental issues. The guiding questions are: What are our cognitive limitations and weaknesses? How can we deal with them? What are our cognitive possibilities and strengths? How can we use them? How do we best learn? How can we create instructional processes based on the way we learn? What kind of cognitive tools are there? How can we use and combine them? How is all this related to the understanding of environmental problems? In what ways can we explore environmental problems with the use of cognitive tools? The last question is discussed in the last section of this paper.

2. Limitations of the human mind

The human cognitive system has its limits. The major ones are listed here:

1) The perceptual systems react to *changes in the environment* (e.g. it is darkening fast, it is getting colder, something is roaring nearby, something is moving) (Norman, 1993; Bateson, 1972/2000; Smith, 1998; Jensen, 2009a). These changes must be perceivable, otherwise they cannot be appreciated.

2) The human visual system is "adapted to 'middle-sized objects' lying somewhere between planets and atoms" (Meltzoff & Moore, 2001, 221) which excludes a great deal of surrounding material.

3) We are unaware of most of our actions (Baddeley, 1999; Rovee-Collier et al., 2001; Bauer, 2004; Hayne, 2004; Nelson & Webb, 2003). It is a relief not having to be aware of our every action as the mind would be occupied with acting and would have no room for thoughts or other processes that need awareness. Routine actions or habits are a way to be more efficient but as a result of that we don't always think of what we are doing, why we are doing it or what effects it may cause. Changing a habit demands effort and awareness (Chen, Gärling & Kitamura, 2004; Jensen, 2009a).

4) Many of our actions are imitations, that is, we imitate people in our environment including movies and commercials. We imitate from the first hour of life (Meltzoff & Moore, 1983; 1997; Kugiumutzakis, 1998; 1999; Heimann, 1998; 2001; 2002). Though this behaviour is reduced after two years of age (Nadel, 2002) we keep on doing it as adults too (Meltzoff & Moore, 1997). Imitation can explain why our everyday living replicates itself. We often do things the same way as others do. This is both a weakness and strength. The weakness is that we imitate without critical thinking. The strength is that imitation is an efficient way to learn.

5) When a (young) person confronts a risk she looks for guidance in the emotional expression of a human nearby. If the human is calm or smiles the situation is safe. If the human signals fear or anger the situation means danger (see Hobson, 2002). This is a fundamental way for the child to learn about environmental risks. But, this is the problem, when the risk is not perceivable neither the child nor the adult will react.

6) "Without concepts, there would be no thoughts. Concepts are the basic timbre of our mental lives" (Prinz, 2004, 1). Prinz argues that concepts are created by what we perceive. At the same time, already infants can understand that the sounds we use as words function as *essence placeholders* (Xu, 2002). Objects or essences are framed by the word which helps humans keep track of it even though it is out of sight. An *essence placeholder* (imagine a container with a label on it) might be able to hold an unseen essence, like oxygen, in the mind. There is a problem however if we never come to know the placeholders (the words) for certain essences because then we won't be able to know the evidences themselves. If much of the world that affects us is made up of non-perceivable essences, we need words or visualizations of some kind to be able to think of them. Otherwise they won't be in our minds.

This gives us some kind of understanding of the challenges we are facing as teachers.

2.1 Typical environmental problems and challenges of the mind

Most of us have never perceived any of the many greenhouse gases, for example: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF6) (www.ipcc.ch). We hear a lot about carbon dioxide but what about the others? Do we know how they are contained in the artefacts (e.g. electronics or shoes) we use and the effects they have? We cannot because we can't perceive most of them and have no (or minimum) knowledge of them (see Jensen, 2009a; Kollmuss & Agyeman, 2002). Hence, we find it hard to relate to the problem of global warming which these gases are causing.

What do we know about ozone? Some associate ozone with the stratospheric ozone layer. They understand that the ozone layer is protective of life on earth. But how can anyone know such a thing when no one has seen the ozone layer? Humans are not equipped with such abilities. So how is it possible for us to have knowledge and understanding about it? Well, there are experts who, with the aid of sensitive instruments, can report their findings. Parts of the ozone layer happen to be thinner which increases the risk for life on earth. If we can, we should adapt our way of life to such findings. But we would know nothing if the experts didn't find out, and tell us. We, in this way, have become dependent on experts (Beck, 1986/1992; Giddens, 1991; Jensen, 2009a).

But we also have ozone near the surface of the earth as a result photochemical reactions between air and the exhaust gases from the internal combustion engine. Ozone is in this context hazardous as it causes allergic reactions in the eyes, nose, throat and lungs. Both humans and other animals are affected, as are plants. Up to 10 percent of crops, in exposed areas, are lost every year because of ground-level ozone. It is not possible for a human to understand all these connections by perception (we cannot sense it), emotional communication (we cannot detect fear in others) and imitation (we keep on doing the same as the rest) alone.

As we know from Rachel Carson's (1962/1986) groundbreaking research, many artificial chemicals have a negative impact on biological systems. In this tradition Krimsky (2000) has shown that some rather commonly used chemicals and heavy metals affect both the endocrine system (hormones) and the nervous system (neurotransmitters) in ways that can change our biological functioning including our emotional reactions and cognition (e.g. memory, concentration and attention). The main problem here is that biological systems as well as ecological systems are negatively affected by such chemicals if they are embedded in daily used products (e.g. Holmberg, 1995) and we can't possibly perceive these risks (early argued by Beck, 1986/1992). This needs to become visible to us in some way.

The point stressed here is that our perceptual and cognitive abilities can't help us if we don't get information from scientists (experts). Scientists provide educators with necessary concepts and educators have to, in a clear and graspable way, instruct students about environmental issues that concern their everyday life.

3. Possibilities through language and social cognition

So what are humans good at? In what ways are our cognitive systems handling abstract and complex information? The strongest attribute of human capacity is our ability to use symbol systems, primarily language. Humans are symbol-minded from about three years of age (DeLoache, 2004). We soon learn to understand that one thing can represent something else (Perner, 1991). Already at two, children can understand that a picture represents something other than itself. At about the same age children understand that a word represents something in the world other than itself and three year olds can use miniatures and models to reason about what they represent. The use of representations, whether symbolic or iconic (see below), can be developed as tools for learning.

Generally, the main keys to abstract thought are language and concepts. Another important key is the capacity to distinguish types or groups from each other and infants can distinguish living kinds from dead kinds and natural kinds from artificial kinds. They can distinguish animals from plants, they can count, and they can categorise (Gardner, 1991; Perner, 1991; Gopnik & Meltzoff, 2002; Wynn, 1992; Dehaene, 1997; Feigenson, Dehaene & Spelke, 2004; Quinn, Eimas & Tarr, 2001; Mandler, 2004). When they come to this point they may reason that one category is visible objects and events, and another category is non-visible. This is where essence placeholders (see above) come in; that is, we have words for things that are not present. To talk about non-visible things make us believe that they actually can exist. Even though there may be doubts.

Language is extended in time, it is temporal. Schank and Abelson (1977) argue that understanding is best developed in a temporal frame, that is, as an experienced event or as a story. This is why we should use and develop instruction processes as events and stories.

Human emotions are intertwined with the human memory system (Damasio, 1998). To put it simply, when we are in a joyful state we are more open to remembering new facts and events, and when in a state of fear we close ourselves to new knowledge, except the knowledge of avoidance of situations that scare us. An emotionally motivated person will remember the newly learned knowledge for a long time (Damasio, 1994; 1999; LeDoux, 2003; Spitzer, 1999; Rolls, 2000; Panksepp & Smith Pasqualini, 2005). This is also, or even more, important when we deal with abstract and complex information. If the teacher can make the students emotionally engaged and motivated they will be cognitively open to difficult stuff. Joyful activities, humour and teacher immediacy are well known ways to motivate students (McCroskey, Richmond & McCroskey, 2006; Witt, Wheeless & Allen, 2006; Martin, Preiss, Gayle & Allen, 2006; Powell & Powell, 2010). Role-play or storyline may be just the right kind of activity to motivate students.

Humans are social beings (e.g. Bråten, 1998; Perner, 1991; Jeannerod, 2002; Gazzaniga, 1985) and the quality of being social depends on the development of social cognition which can be understood as the capacity to respond to others´ *emotions* (Hobson, 2002), to respond to and understand others´ *intentions* (the use of a specific means to attain a specific goal) (Tomasello, 2003; Meltzoff, 1995), to respond to and understand others´ *desires* (wants) (Wellman, 2004), to respond to and understand others´ *beliefs* (how we understand objects and events in the world) (Perner, 1991; Wellman, 2004), and to develop *empathy* (to be in one emotional state and at the same time take the view of another individual's different emotional state) (Thompson, 1998; Gopnik, Meltzoff & Kuhl, 2001). Taken together, this means that a child, from the age of four, is capable of taking others´ views and to be engaged when she hears a fictive or autobiographical story; she can even take the role of an animal.

Many of these capacities are needed to take part in a story and to think abstractly. It makes it possible to develop tools that rely on those capacities. Section 5 will discuss some of the known tools.

4. Instruction and learning effects

What can teachers do to help students learn and understand? Research on instructional processes has tried to find answers to this question. These are suggested best ways to promote learning in an efficiency order:

1) One-on-one instruction. Teacher or peer instruct student. Imitation is possible. This is suggested to be the most efficient way to learn. The student learns more and remembers longer (Ohlsson, 2011).
2) Cooperative learning. Learning during peer cooperation in small groups. This is effective, more than students themselves believe (Allen & Plax, 1999). A less traditional way of cooperative learning is role-play or storyline (see below).
3) Collaborative learning. For example a discussion led by teacher. The teacher can use questions to direct the content of the discussion (Allen & Plax, 1999). Especially high-order questions (often open ended questions; see below) used by the teacher are said to promote student learning as well as critical thinking (Gayle, Preiss & Allen, 2006; Jensen, 2009b). Generally, this way of learning is not as efficient as the two ones above.
4) Traditional lecture. The teacher is presenting information on a black board/white board, on a power point, by reading out loud or by telling some kind of story. How efficient students learn depends on a lot of factors. Clarity is probably the most important single factor on cognitive learning (McCroskey, Richmond & McCroskey, 2006; Powell & Powell, 2010).

There are primarily two ways to achieve clarity: (1) to organize the material to be presented and (2) to use cognitive tools to present complex and abstract concepts. Some tools are also organizers at the same time. These are some basic ways to organize ideas to create a foundation for clarity (Beebe, Beebe & Ivy, 2009):

- Organizing ideas chronologically. The best ways are to use some kind of timeline or a story. This is used to communicate in what order things happen and how events are related in time, and maybe also how one event causes another.
- Organizing ideas according to complexity. From simple to complex or from complex to simple. To understand the process of the whole biosphere you can start with the simpler biosphere in a bottle (see below). You can also start with a simple question and make the following questions more advanced the longer you inquire a topic. Tools like metaphors and analogies can be used to approach the complex.
- Organizing ideas spatially. Things are related in space even though they are not visible to us. You can visualize large things, small things, fast events or slow events as a map or a model or a miniature (see below).

Some research suggests that learning and memory retrieval becomes more efficient if the information is presented with both words and visualizations, and even the possibility to touch, at the same time (Shapiro, Kerssen-Griep, Gayle & Allen, 2006; Young, 2011; Paivio, 2007). The tools in the following sections can be used that way.

5. Tools to bridge the gap

There is a gap between our experience of everyday life and the problems that we need to grasp, and this section will provide examples of tools to bridge this gap and enable non-experts to come to think about expert (i.e. not directly perceivable) knowledge. These first steps towards understanding abstract environmental issues are not meant to be accurate but accessible to the student. The discussion of misconception (see e.g. McBean & Hengeveld, 2000; Boyes & Stanisstreet, 2001; Fortner, 2001) is not relevant here since we all have misconceptions of some degree, especially students and teachers (see e.g. Fortner, 2001). It is about giving the students a set of beliefs to better act, in every day life, in accordance with today's scientific knowledge. It is also about laying a ground for further learning. If this ground can't be a result of perceived experience we need to use cognitive tools (Bruner, 1960/2003).

5.1 Models and miniatures

Humans have the capacity to use external representations (Norman, 1993) which can be understood as *icons* or *symbols* (following Peirce, 1998). An icon is a representation which resembles what it represents, for example a photo. A symbol is an arbitrary representation that doesn't do this, for example a word such as *cat* which doesn't look like a cat. Most models and miniatures are iconic but quite often they have symbolic parts. A map is an external representation of a territory (see Korzybski, 1958). The map represents the territory, mostly in an iconic way, although there are symbols on maps. You can look at the map as well as the territory which is what makes it external. An internal (mental) representation is not directly perceivable; it is the result of a stored perception. We use external representations for facilitation.

A molecule is too small to perceive so a model of a molecule will help us grasp the concept (see Gardner, 1999). The earth is too big so a globe, a miniature, will help give us an overview of our planet. In these cases we are dealing with special representations which we here call *proxy representations*. For example, when you are going to a city for the first time you might have a map of the city with you, which is an external representation representing the real place. As you have no actual information of the place you are going to, the map is standing as a proxy giving you some knowledge to relate to.

The same thing goes for the molecule model and the globe. You will never see a molecule with your own eyes; hence, the model stands as a proxy. Most of us will never have the opportunity to view Earth from space. Our concept of Earth is a proxy given to us via a globe. One of the best used miniatures, when it comes to environmental understanding, is the biosphere in a bottle (figure 1). It describes life in its most basic form: a plant, micro-organisms, earth, water, light, warmth, oxygen, carbon and other things. To view real life in this closed room enables you to wonder: What is life? What does it depend on?

The pedagogical benefit of a closed biosphere is that it can be used in the early years of school. The complexity of it is best understood by teenage students but younger children can make sense of it too. For example, if you put it in a sunny window for a long time it will get too hot inside and experience global warming on a small scale. If you put a blanket over the bottle for a long time to exclude light the lifecycle will stop. One conclusion here is that a plant can live without the aid of humans, in this closed room, but it can be damaged by inappropriate human behaviour and choice. Teenagers can get an idea of the circulation of molecules and the regulation of energy in the bottle to sustain life.

5.2 Metaphors and analogies

The concept of *lifecycle analysis* is a metaphor. Such analyses are about products' creation, life and demise, and since products are not actually alive lifecycle in this context must be a metaphor. When dealing with abstractions it is helpful to use a metaphor which we do all the time (Lakoff & Johnson, 1980/2003). "Environmental issues are frequently described by metaphors" (Lake, 2001, 54).

A greenhouse is a concrete concept even if we can't always explain the processes going on inside. An analogy is often used to explain an unknown process by the aid of a well known process. In this case, the process of a greenhouse is transferred to the earth's biosphere giving rise to the concept of *greenhouse effect*.

Both metaphors and analogies are a special kind of proxy-representations. When it comes to metaphors, they are proxy-representations in a superficial way. A superficial quality is transferred into a new context to give it a notion of this quality. For example "Her ego is very fragile" (Lakoff & Johnson, 2003, 28). An ego is a psychological entity, but here the fragile quality tells us something about the person because we have experienced fragile objects. We also say that some ecosystems are fragile. Although we would never see the ecosystem break (like a vase) this language conveys a notion of how easily an ecosystem can be affected by disturbances.

An analogy uses a deeper structure or process (Gardner, 1999) as a proxy-representation. It is the knowledge of this deeper structure or process that is transferred to a new context. Let's take a greenhouse as an example again. We know, because experts tell us, that photons pass through the glass and enter the greenhouse worming up the content, with the heat then becoming held inside the greenhouse. The greenhouse gases in the Earth's atmosphere do a similar thing. Sometimes this rather different but easily understood type of inference is called abduction (see Sebeok & Danesi, 2000); something known is used to explain something unknown (e.g. the structure of the solar system, the known, was suggested by Ernest Rutherford to be similar to the atom structure, the unknown).

Humans are well prepared to understand metaphors and analogies as cognitive tools (Gardner, 1999; also Norman, 1993) and the development of this ability seems to be a part of the early development of language (Tomasello, 2003). Thus, it can be used with small children but the trick is to find a suitable level. Metaphors and analogies are very useful tools for explanation but they can also be used inappropriately (Simon, 1962). To find the right metaphor or analogy can be difficult and because we use metaphors and analogies all the time (according to Lakoff & Johnson, 2003), the use of them can become trivial. First we have to make the process explicit in order to understand why they are so useful, and only then can we create our own, new metaphors and analogies.

In this creation we encounter problems about what metaphorical terms to choose. For example, should we say global heating in stead of global warming or carbon investment instead of carbon sink (Lake, 2001)? Global warming may be understood as something pleasant while global heating is not. Carbon sink, according to Lake, may cause a misleading association while carbon investment is a more appropriate description. Therefore we need to take emotive associations in account.

5.3 Tracking

Any artefact has an embedded timeline, but when you buy it you will only experience some part of this. It has a history before you bought it and it will have a future when you no longer have it. This history and future is not just in time but also in space. The artefact will have moved through several places as figure 2 shows.

Tracking is a method inspired by lifecycle analysis (see Jensen, 2009a). The basic idea of tracking is to start at the user phase and track the product backwards. How many times was it transported? In what was it transported? How many times was it wrapped up? In what material was it wrapped up? What happened to the packaging? Eventually you track the product to the production phase and think about the raw materials and chemicals used, discussing what type of energy source the industry uses and what the waste products (residual products) may be.

When you no longer need the object you have to look at the timeline into the future. If you have put it into the dustbin or the recycling box, how will it be transported and what will happen then? If it is made of plastic and/or contains chemicals it may well cause problems later on. This gives you a lot to think about, especially how all this can affect the environment. When you use an object you don't think of the problems it may have already caused or will possibly cause. But if you associate a product with its whole lifecycle or timeline it may be possible to see it from a different perspective.

5.4 Doubt and questions

When most of your way of life is built on habits and you are unaware of most of your behaviours, it doesn't really matter if those acts lead to environmental problems or not. You just don't think about the consequences your behaviour will cause if you don't know there are possible effects from it. To analyze this we can turn to a theory by the philosopher Charles Sanders Peirce (1839-1914) (see Jensen, 2009b). If you, for example, are in a situation when your usual way of handling it doesn't work, you experience a state of doubt. It is not pleasant to be in this state so you will try to find out how to act. This Peirce calls an inquiry. It is a method (you can choose from several methods depending on what will fit your task best) that enables you to leave the state of doubt and form a new habit (or belief as Peirce also called it).

Doubt → Inquiry → Belief

Peirce (1992; also 1998) thought that this is the way we form beliefs and habits in everyday life. If you question a person's beliefs or habits you may well put this person in a state of doubt. In order to do this you have to work out one or several key questions (see below). The next step is to provide the person with a helpful method so the inquiry can result in a steady new belief/habit.

You can ask (hypothetical) questions such as:

- Can a shoe be an environmental problem?
- What would we do if all cars broke down at the same time?
- Who do birds sing for?
- For whom are flowers so beautiful?
- Is waste useless?
- Can you watch TV or use a computer without energy?

The questions are meant to be used as open ended questions to start an inquiry and to involve the students in a group discussion (cf. Jensen, 2009b; Axelsson, 2004; Fortner, 2001).

5.5 Stories

Stories are marvellous means of summarizing experiences, of capturing an event and the surrounding context that seems essential. Stories are important cognitive events, for they encapsulate, into one compact package, information, knowledge, context, and emotion (Norman, 1993, 129). Norman argues that we need stories to be able to cope with everyday life. Stories provide means other than logic. Logic generalises and offers global judgements, while stories particularise and offer a personal point of view. The greatness of stories is that we use them to explain things to other people, but more importantly, we use stories to explain things to ourselves, to make everyday life more coherent (Schank, 1990; Schank & Abelson, 1977). Storytelling is a much older way of memorising and understanding our world than logic. As we are well equipped to handle sequences such as words, sentences, events and temporal structures, the use of stories fits us humans well (Norman, 1993; Bruner, 1990; 2003; Tomasello, 2003).

So, how are stories and memory related to each other? In order to remember words (e.g. names or facts) or pictures, we seem to recall these better if they are integrated into a story, rather than being in a list. The best result comes from creating our own stories, doing our own organising, using new names, facts, pictures and events. The parts that are best integrated into the story are also most readily recalled (Baddeley, 1999; Poulsen et al., 1979; Delaney & Knowls, 2005). Neither storytellers nor audiences have an accurate recall when it comes to details in a story. We recall the structure of the story and the central facts (Norman, 1993; Schank & Abelson, 1977). The more central the facts are to the story the better the facts will be recalled (Thorndyke, 1977).

5.5.1 Learning from stories

A very interesting finding is that listeners/readers don't usually admit that they have learned new facts from a story, when they obviously have. They persist in claiming that they knew the facts prior to the story even though the facts were novel or false, fabricated and integrated into the story (Esbensen, Taylor & Stoess, 1997; Marsch, Meade & Roediger, 2003). Behavioural knowledge, on the other hand, is acknowledged as having been explicitly learned (Esbensen et al., 1997). When taking part in a story children and adults enter into a state of *fictional absorption*. That is, they temporarily adopt a point-of-view situated inside the story world. The closer our point-of-view is to the main character in the story the faster we will recall and the more affected we will become afterwards (Harris, 1998). We remember more emotional parts of a story than non-emotional parts (Davidson, Luo & Burden, 2001) which might have something to do with our memories being interconnected to emotional contents. We are emotionally evoked by emotionally charged scenes, and develop empathy towards the main characters, unless we repeatedly convince ourselves that what we are experiencing in the story is not reality (Harris, 1998). From a neuroscience perspective, stories must be very central to our lives as the neural structures activated during story comprehension are the same structures used by working memory processes (consciousness and attention) and theory-of-mind processes (how we understand minds) (Mar, 2004; also Vogeley et al., 2001). To adopt a point-of-view in a story is much the same as adopting a point-of-view in real life.

5.5.2 Stories, knowledge and storyline

The sequence of a story is most often causal. This means that we need to understand the causality if we are to grasp a story (Tomasello, 2003). There is also often a moral end to a story and when we hear stories about our own social group it is always us making the right moral choices and others making the wrong ones. When we hear stories about heroes we tend to identify with the good guy. We construct stories of our own social group, culture or society. We construct stories of ourselves, including stories about who we are (Bruner, 2003; Hylland-Eriksen, 2002). Our lives are stories.

 ISSN 1927-0488 E-ISSN 1927-0496

Stories are powerful tools to understand abstract events and changes over time, and when it comes to environmental issues there are several ways to use a story. We will look at three examples here. The evidence provided by science education suggests that narratives play an important part in a teacher's repertoire and that this medium has been used successfully in the classroom to convey scientific knowledge in an accurate, attractive, imaginative, participatory and memorable way (Negrete & Lartigue, 2004, 123). Novels, short stories, movies or comic strips all work as stories to make it easier to grasp scientific subjects. One way is to read stories about environmental issues to children or, when old enough, let them read by themselves. For those who don't read so well a comic strip might work better. This is a very traditional way but we sometimes forget how useful it is. Drama is a kind of participatory story which is "*a physical system separate from the audience allowing participation in a fictive story*" (Gander, 2005, 81). When participating, you are allowed to engage, reflect and react in a different way from when you just listen, watch or read. Inside the story you are more capable of feeling sympathy for, and empathy with, other people and organisms. The context offers role-taking, alternatives and a chance to discuss the problem (McNaughton, 2004).

A related method is the storyline method (see e.g. Creswell, 1997; Falkenberg, 1994). The idea is to make up a story together in a group. All the group members participate as characters in the story. The story is driven by a theme and one or several key questions. A teacher is there to structure the development of the story using key questions. It is useful to create models of the story environment or invent characters (that may be drawn or represented as a doll). The members of the group have a chance to reflect by doing their own drawings or by participating in discussions. One story used in some Swedish schools is about a man (called Commuter Karl) who drives his car to any place he goes even if he is just going to the next street. The theme is environment and traffic and a human sized doll is used to give the main character a real shape. Along the storyline the group discussed how this behaviour affected the environment.

A rather common story is about living on an uninhabited island (see Falkenberg, 1994). The idea is to create a social life based on the primary human needs and social behaviour. Key questions in this case are whether or not it is possible to build a store, listen to music or watch TV. What will we need to survive? What can we construct by ourselves? A good idea is to build a model or draw a map of the island (some schools just use the island-model to discuss environmental issues without the storyline). Afterwards you can discuss the differences between the life on this fictive island and the real life we are living. What are our primary needs? What is unnecessary? Why do we need unnecessary things?

The storyline method offers multiple tools. You may use models and miniatures, you may use metaphors and analogies, you may use tracking afterwards (in the island story you make your own fictive food and clothes), you may use key questions to put the group members in a state of doubt, and finally, it is a story built on concepts, emotions, participation, cooperation and a need for problem solving.

6. Discussion

A set of tools such as these, discussed above, are in many cases best used if they complement each other. If you begin by asking a question, for example: is a sheet of paper an environmental problem? Don't see this as a normative question, because we really do want to find out. The first step is tracking (figure 2), in which we have to ask: where did we buy this sheet of paper? How did we transport it here? If it was by car, for example, we have to discuss the problems with cars and how they disturb the greenhouse effect and give rise to global warming. This may be illustrated by a globe and/or a biosphere in a bottle or we can imagine the Earth in the bottle. For the older students you can create a CO_2 account. You add every source during the line and sum it up to get some idea of how much CO_2 one single object have caused. This approximation demands advanced mathematics.

We have just begun the tracking backwards and in doing this we immediately stumble on big environmental issues. A methodological question is being raised. Shouldn't we explain the greenhouse effect and global warming before we start this journey? The quick answer is yes. The real problem, however, is that everyday life seems to be one thing and environmental problems another. If we don't integrate them children/students will understand them separately. This type of question may show that everyday life is intertwined with the environmental problems. I suggest that it is possible to introduce the consequences of greenhouse gases if it shows that it is caused by everyday action but it might as well be introduced as a phenomenon (in part) caused by this object I hold in my hand, as the object I hold in my hand has an embedded history and future that is part of the real cause.

If we choose to discuss a shoe instead, it can be perceived as an environmental problem but it can also be discussed as an introduction to human rights and child labour. By tracking backwards we may find out that the shoe is made by a child in a remote, poor country. By tracking forward we may find out that the shoe will leak SF6, the worst known greenhouse gas (www.ipcc.ch). How can we justify the use of such an object?

That is not the main problem, however. This is that most of us don't know there is a need for justification concerning this everyday artefact. Wherever we start, this ought to be done with a key question because if we don't ask the questions there will be nothing to find out. With an interesting question the next step is to find the method to search for the answer. The teacher has the key role of providing different methods. Some of them need tools like those above. If you ask a child where bananas come from they might answer: the store. That is a good start but now you have to question this child's understanding. The tracking backwards begins.

Tracking is a detective job and you're not satisfied until you can answer the questions: (1) Where does the object originally come from? (2) Who made it? (3) What is it made of? If these are the main questions then you may use different methods of finding out the answers. Perhaps the best method is to tell a story or look at a map. You might find lots of living creatures along the line. What happened to them? Are they well? Did they suffer?

The question justifies the means but there are other aspects to consider. If you want the whole group to take part in the inquiry, the storyline or something like it is a terrific means of achieving this as the story engages the participants, and they will come to know more than they did before and other tools are used as well. Thus, you start with a question and end up with a whole story.

Finally, what is there to say about the use of these cognitive (and in many cases emotive) tools? Are there positive results to report? In a school on the largest Swedish island teachers worked both with an island-model and the biosphere in a bottle. Since they live on an island the island-model was a good way to gain ecological knowledge concerning their own lives. The teachers found out that an island as an ecosystem is a better way to understand the circulation of material (for a relevant discussion see MacNeill, Winsemius & Yakushiji, 1998) than it is to discuss it at a larger scale. At this school they used the models and other artefacts in an interdisciplinary way. This, they claimed, was the only way to give the students the whole picture. Many years later the teachers met students who remembered the whole idea because they had grasped the environmental problems that were presented during the course (Jensen, 2000).

In another Swedish school some of the teachers used key questions frequently. One question that gave a better result than first imagined was: "Who do birds sing for?" The students (about ten years old) went out in the woods to find out by themselves. This resulted in new thoughts about anthropocentric and biocentric views. Do birds sing for us or for other birds? Do they live for our sake or for their own sake? The use of a closed bottle gave rise to a similar discussion.

Teachers who have tested the storylines made by the Traffic and Public Transport Authority (in Gothenburg, Sweden), for example about Commuter Karl, believe that their pupils have felt a great degree of involvement in the story and its characters and have been able to re-enact courses of events that would otherwise have been alien to them (see www.trafikforlivet.nu). Many reports on these storylines come to the same conclusion: the pupils are motivated and engaged in a positive way which in turn promotes learning and understanding.

There is still a lot to investigate. The general research on learning and instruction tells us that we are on the right track but we need more research on the use of these particular tools dealing specifically with environmental issues. Most of the tools can be used on every level of education, since they are general cognitive tools used by humans everywhere. The educator has to adapt the use of the tools to fit the present student level.

Acknowledgements

The author would like to thank Adlerbertska forskningsstiftelsen for financial support; Helge Malmgren, and members of the Swedish ESD-network for their comments on earlier drafts of this paper.

References

Allen, T. H., & Plax, T. G. (1999). Group communication in the formal educational context. In F. R. Lawrence (ed.). *The handbook of group communication theory & research*. London: Sage Publications.

Axelsson, H. (2004). Dare to learn for a sustainable future – A study of teachers as learners. In P. Wickenberg et al. (eds.), *Learning to change our world? Swedish research on education & sustainable development*. Lund: Studentlitteratur.

Baddeley, A. D. (1999). *Essentials of human memory*. East Sussex: Psychology press.

Bateson, G. (2000). *Steps to an ecology of mind*. Chicago: The University of Chicago Press. First published 1972.

Bauer, P. J. (2004). Getting explicit memory off the ground: Steps toward construction of a neurodevelopmental account of changes in the first years of life. *Developmental Review,* 24, 347-373. http://dx.doi.org/10.1016/j.dr.2004.08.003

Beck, U. (1992). *Risk society: towards a new modernity*. London: Sage. First published in 1986.

Beebe, S. A., Beebe, S. J., & Ivy, D. K. (2009). *Communication. Principles for a lifetime. Volume 4: Presentational speaking*. Boston. Pearson.

Boyes, E., & Stanisstreet, M. (2001). Plus ca change, plus c'est la même chose? School students' ideas about the "greenhouse effect" a decade on. *Canadian Journal of Environmental Education,* 6, 77-101.

Bruner, J. (2003). *The process of education*. Cambridge, MA: Harvard University Press. First published in 1960.

Bruner, J. (1990). *Acts of meaning*. Cambridge, MA: Harvard University Press.

Bruner, J. (2003). *Making stories. Law, Literature, Life*. Cambridge, MA: Harvard University Press.

Bråten, S. (ed.) (1998). *Intersubjective communication and emotion in early ontogeny*. Cambridge, UK: Cambridge University Press.

Carson, R. (1986). *Silent spring*. Middlesex: Penguin Books in association with Hamish Hamilton. First published in 1962.

Chen, C., Gärling, T., & Kitamura, R. (2004). Activity rescheduling: reasoned or habitual? *Transportation Research*, Part F 7, 351-371. http://dx.doi.org/10.1016/j.trf.2004.10.003

Creswell, J. (1997). *Creating worlds, constructing meaning: the Scottish storyline method*. Portsmouth: Heinemann.

Damasio, A. R. (1994). *Descartes' error : emotion, reason, and the human brain*. New York: G.P. Putnam.

Damasio, A. R. (1998). Emotion in the perspective of an integrated nervous system. *Brain Research Reviews,* 26, 83-86. http://dx.doi.org/10.1016/S0165-0173(97)00064-7

Damasio, A. R. (1999). *The feeling of what happens: body and emotion in the making of consciousness*. London: Heinemann.

Davidson, D., Luo, Z., & Burden, M. J. (2001). Children's recall of emotional behaviours, emotional labels, and nonemotional behaviours: Does emotion enhance memory? *Cognition and Emotion,* 15, 1-26. http://dx.doi.org/10.1080/0269993004200105

Dehaene, S. (1997). *The number sense. How the mind creates mathematics*. London: Penguin Books.

Delaney, P. F., & Knowles, M. E. (2005). Encoding strategy changes and spacing effects in the free recall of unmixed lists. *Journal of Memory and Language,* 52, 120–130. http://dx.doi.org/10.1016/j.jml.2004.09.002

DeLoache, J. S. (2004). Becoming symbol-minded. *Trends in Cognitive Sciences,* 8(2), 66-70. http://dx.doi.org/10.1016/j.tics.2003.12.004

Esbensen, B. M., Taylor, M., & Stoess, C. (1997). Children's behavioural understanding of knowledge acquisition. *Cognitive Development,* 12, 53-84. http://dx.doi.org/10.1016/S0885-2014(97)90030-7

Falkenberg, C. (1994). *Storyline-metoden: "den skotske metode": undervisning på fantasiens vinger*. Vejle: Kroghs forlag.

Feigenson, L., Dehaene, S., & Spelke E. (2004). Core systems of number. *Trends in cognitive sciences,* 8(7), 307-314. http://dx.doi.org/10.1016/j.tics.2004.05.002

Fortner, R. W. (2001). Climate change in school: where does it fit and how ready are we? *Canadian Journal of Environmental Education,* 6, 18-31.

Gander, P. (2005). *Participating in a story. Exploring audience cognition*. Lund: Lund University Cognitive Studies 119.

Gardner, H. (1991). *The unschooled mind. How children think and how schools should teach*. New York: BasicBooks.

Gardner, H. (1999). *The disciplined mind: what all students should understand*. New York: Simon & Schuster.

Gayle, B. M., Preiss, R. W., & Allen, M. (2006). How effective are teacher-initiated classroom questions in enhancing student learning? In B. M. Gayle, R. W. Preiss, N. Burrell & M. Allen (eds.). *Classroom* *communication and instructional processes. Advances through meta-analysis*. Mahwah, NJ: Lawrence Earlbaum Assosiates, Publishers.

Gazzaniga, M. S. (1985). *The social brain: discovering the networks of the mind*. New York: Basic Books.

Giddens, A. (1990). *The consequences of modernity*. Cambridge, UK: Polity in association with Blackwell.

Gopnik, A., & Meltzoff A. N. (2002). *Words, thoughts, and theories*. Cambridge, MA: A Bradford Book. Third printing. First printing 1997.

Gopnik, A., Meltzoff, A. N., & Kuhl, P. K. (2001). *The scientist in the crib. What early learning tells us about the mind*. New York: Perennial. First published in 1999.

Harris, P. L. (1998). Fictional absorption: emotional responses to make-believe. In Bråten, S. (ed.). *Intersubjective communication and emotion in early ontogeny*. Cambridge, UK: Cambridge University Press.

Hayne, H. (2004). Infant memory development: implications for childhood amnesia. *Developmental Review,* 24, 33–73. http://dx.doi.org/10.1016/j.dr.2003.09.007

Heimann, M. (1998). Imitation in neonates, in older infants and in children with autism: feedback to theory. In S. Bråten (ed.), *Intersubjective communication and emotion in early ontogeny*. Cambridge, UK: Cambridge University Press.

Heimann, M. (2001). Neonatal imitation – A “fuzzy” phenomenon? In F. Lacerda, C. von Hofsten & M. Heimann (eds.), *Emerging cognitive abilities in early infancy*. Hahwah, NJ: Larwrence Erlbaum Associates, Publishers.

Heimann, M. (2002). Notes on individual differences and the assumed elusiveness of neonatal imitation. In A. N. Meltzoff & W. Prinz (eds.), *The imitative mind*. Cambridge, UK: Cambridge University Press. http://dx.doi.org/10.1017/CBO9780511489969.005

Hobson, P. (2002). *The cradle of thought*. London: Macmillan.

Holmberg, J. (1995). *Socio-ecological principles and indicators for sustainability*. Göteborg: Chalmers tekniska högskola.

Hylland Eriksen, T. (2002). *Ethnicity and nationalism*. London: Pluto Press.

Intergovernmental Panel on Climate Change (ICPP) <www.ipcc.ch>. A table on greenhouse gases and their global warming potential. [Online] Available: http://www.ipcc.ch/activity/tables/t0206.pdf (January 2006).

Jeannerod, M. (2002). Naturalization of Mental States and Personal Identity. In A. M.Galaburda, S. M. Kosslyn & Y. Christen (eds.). *The Languages of the Brain*. Cambridge, MA: Harvard University Press.

Jensen, M. (2000). *Allting sprider sig. En etnografisk skildring av några svenska skolors miljöarbete*. (Everything will spread. An ethnographic study on environmental education in some Swedish schools). Göteborg (Sweden): The department of education, University of Gothenburg.

Jensen, M. (2009a). Lifestyle: suggesting mechanisms and a definition from a cognitive science perspective. *Environment, Development and Sustainability,* 11(1), 215-228. http://dx.doi.org/10.1007/s10668-007-9105-4

Jensen, M. (2009b). *När frågan är svaret (eng. When the question is the answer)*. Report 4:2009. Department of education and behavioural science. Borås, Sweden: University of Borås.

Kollmuss, A., & Agyeman, J. (2002). Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behaviour? *Environmental Education Research,* 8(3), 239-260. http://dx.doi.org/10.1080/13504620220145401

Korzybski, A. (1958). *Science and sanity: an introduction to non-Aristotelian systems and general semantics*. The International Non-Aristotelian Library Publishing Company.

Krimsky, S. (2000). *Hormonal chaos: the scientific and social origins of the environmental endocrine hypothesis*. Baltimore: Johns Hopkins University Press.

Kugiumutzakis, G. (1998). Neonatal imitation in the intersubjective companion space. In S. Bråten (ed.), *Intersubjective communication and emotion in early ontogeny*. Cambridge, UK: Cambridge University Press.

Kugiumutzakis, G. (1999). Genesis and development of early infant mimesis to facial and vocal models. In J. Nadel & G. Butterworth (eds.), *Imitation in infancy*. Cambridge, UK: Cambridge University Press.

Lake, D. C. (2001). Waging the war of the words: global warming or heating? *Canadian Journal of Environmental Education,* 6, 52-57.

Lakoff, G., & Johnson, M. (2003). *Metaphores we live by*. Chicago: The University of Chicago Press. First published in 1980.

LeDoux, J. (2003). *Synaptic self. How our brains become who we are*. New York: Penguin Books.

Mandler, J. M. (2004). *The foundations of mind*. Oxford: Oxford University Press.

Mar, R. A. (2004). The neuropsychology of narrative: story comprehension, story production and their interrelation. *Neuropsychologia,* 42, 1414-1434. http://dx.doi.org/10.1016/j.neuropsychologia.2003.12.016

Marsch, E. J., Meade, M. L., & Roediger, H. L. (2003). Learning facts from fiction. *Journal of Memory and Language,* 49, 519-536. http://dx.doi.org/10.1016/S0749-596X(03)00092-5

Martin, D. M., Preiss, R. W., Gayle, B. M., & Allen, M. (2006). A meta-analytic assessment of the effect of humorous lectures on learning. In B. M. Gayle, R. W. Preiss, N. Burrell & M. Allen (eds.). *Classroom communication and instructional processes. Advances through meta-analysis*. Mahwah, NJ: Lawrence Earlbaum Assosiates, Publishers.

MacNeill, J., Winsemius, P., & Yakushiji, T. (1998). The shadow ecologies of western economies. First published 1991. In K. Conca & G. D. Dabelko (eds.), *Green planet blues. Environmental politics from Stockholm to Kyoto*. Oxford: Westview Press.

McBean, G. A. & Hengeveld, H. G. (2000). Communicating the science of climate change: a mutual challenge for scientists and educators. *Canadian Journal of Environmental Education,* 5, 9-25.

McCroskey, J. C., Richmond, V. P., & McCroskey, L. L. (2006). The role of communication in Instruction: The first three decades. In B. M. Gayle, R. W. Preiss, N. Burrell & M. Allen (eds.), *Classroom communication and instructional processes. Advances through meta-analysis*. Mahwah, NJ: Lawrence Earlbaum Assosiates, Publishers.

McNaughton, M. J. (2004). Educational drama in the teaching of education for sustainability. *Environmental Education Research,* 10(2), 139-155. http://dx.doi.org/10.1080/1350462042000198140

Meltzoff, A. N. (1995). Understanging the intentions of others: Re-enactment of intended acts by 18-monthold children. *Developmental Psychology,* 31(5), 838-850. http://dx.doi.org/10.1037/0012-1649.31.5.838

Meltzoff, A. N., & Moore, K. (1983). Newborn infants imitate adult facial gestures. *Child Development,* 54, 702-709. http://dx.doi.org/10.2307/1130058

Meltzoff, A. N., & Moore, K. (1997). Explaining facial imitation: a theoretical model. *Early Development and Parenting,* 6, 179-192. http://dx.doi.org/10.1002/(SICI)1099-0917(199709/12)6:3/4<179::AID-EDP157>3.0.CO;2-R

Meltzoff, A. N., & Moore, K. (2001). “Discovery procedures” for people and things – the role of representation and identity. In F. Lacerda, C. von Hofsten & M. Heimann (eds.), *Emerging cognitive abilities in early infancy*. Hahwah, NJ: Larwrence Erlbaum Associates, Publishers.

Nadel, J. (2002). Imitation and imitation recognition: Functional use in preverbal infants and nonverbal children with autism. In A. N. Meltzoff & W. Prinz (eds.) *The imitative mind*. Cambridge, UK: Cambridge University Press. http://dx.doi.org/10.1017/CBO9780511489969.003

Negrete, A., & Lartigue, C. (2004). Learning from education to communicate science as a good story. *Endeavour,* 28(3), 120-124. http://dx.doi.org/10.1016/j.endeavour.2004.07.003

Nelson, A., & Nilsson, M (2002). *Det massiva barnrummet: teoretiska och empiriska studier av leksaker*. Malmö: Research studies, department of education, university collage of Malmö, Sweden.

Nelson, C. A., & Webb, S. J. (2003). A Cognitive neuroscience perspective on early memory development. In M. De Haan & M. H. Johnson (eds.), *The Cognitive Neuroscience of Development*. New York: Psychology Press.

Norman, D. A. (1993). *Things that make us smart. Defending human attributes in the age of the machine*. Cambridge, MA: Perseus Books.

Ohlsson, S. (2011). *Deep learning. How the mind overrides experience*. New York: Cambridge University Press. http://dx.doi.org/10.1017/CBO9780511780295

Paivio, A. (2007). *Mind and its evolution. A dual coding theoretical approach*. Mahwah, NJ: Lawrence Earlbaum Assosiates, Publishers.

Panksepp, J., & Smith Pasqualini, M. (2005). The search for the fundamental brain/mind sources of affective experience. In J. Nadel & D. Muir (eds.), *Emotional development*. Oxford: Oxford University Press.

Perner, J. (1991). *Understanding the representational mind*. Cambridge, MA: A Bradford Book.

Peirce, C. S. (1992). *The essential Peirce: selected philosophical writings.* Volume 1(1867-1893). Edited by Kloesel, C. J. W. & Houser, N. Bloomington: Indiana University Press.

Peirce, C. S. (1998). *The essential Peirce: Selected philosophical writings,* Volume 2(1893-1913). Edited by: the Peirce Edition Project. Bloomington: Indiana University Press.

Poulsen, D. et al. (1979). Children's comprehension and memory for stories. *Journal of experimental child psychology,* 28(3), 379-403. http://dx.doi.org/10.1016/0022-0965(79)90070-5

Powell, R. G., & Powell, D. L. (2010). *Classroom communication and diversity. Enhancing instructional practice*. 2nd edition. London: Routledge.

Prinz, J. J. (2004). *Furnishing the mind. Concepts and their perceptual basis*. Cambridge, MA: A Bradford Book.

Quinn, P. C., Eimas, P. D., & Tarr, M. J. (2001). Perceptual Categorization of Cat and Dog Silhouettes by 3- to 4-Month-Old Infants. *Journal of Experimental Child Psychology,* 79, 78-94. http://dx.doi.org/10.1006/jecp.2000.2609

Rolls, E. T. (2000). Memory systems in the brain. *Annual Review in Psychology,* 51, 599-630. http://dx.doi.org/10.1146/annurev.psych.51.1.599

Rovee-Collier, C., Hayne, H., & Colombo, M. (2001). *The development of implicit and explicit memory*. Amsterdam: John Benjamins Publishing Company.

Schank, R. C. (1990). *Tell me a story: A new look at real and artificial memory*. New York: Scribner.

Schank, R. C., & Abelson, R. P. (1977). *Scripts, plans, goals and understanding. An inquiry into human knowledge structures*. Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Sebeok, T. A., & Danesi, M. (2000). *The forms of meaning*. Berlin: Mouton de Gruyter.

Shapiro, E. J., Kerssen-Griep, J., Gayle, B. M., & Allen, M. (2006). How powerful is powerpoint? Analyzing the educational effects of desktop presentational programs in the classroom. In B. M. Gayle, R. W. Preiss, N. Burrell & M. Allen (eds.). *Classroom communication and instructional processes. Advances through meta-analysis*. Mahwah, NJ: Lawrence Earlbaum Assosiates, Publishers.

Simon, H. A. (1962). The architecture of complexity. *Proceedings of the american philosophical society,* 106(6), 467-482.

Smith, D. C. (1998). *On the origins of objects*. London: MIT.

Spitzer, M. (1999). *The mind within the net. Models of learning, thinking and acting*. Cambridge, MA: MIT press.

Thompson, R. A. (1998). Empathy and its origins in early development. In S. Bråten (ed.), *Intersubjective communication and emotion in early ontogeny*. Cambridge, UK: Cambridge University Press.

Thorndyke, P. W. (1977). Cognitive structures in comprehension and memory of narrative discourse. *Cognitive Psychology,* 9(1), 77-110. http://dx.doi.org/10.1016/0010-0285(77)90005-6

Tomasello, M. (2003). *The cultural origins of human cognition*. London: Harvard University Press. Fourth printing. First printing 1999.

Traffic and Public Transport Authority (in Gothenburg, Sweden). [Online] Available: www.trafikforlivet.nu (September 2005).

Vogeley, K. et al. (2001). Mind reading: Neural mechanisms of theory of mind and self-perspective. *NeuroImage,* 14, 170-181. http://dx.doi.org/10.1006/nimg.2001.0789

Wellman, H. M. (2004). Understanding the psychological world: developing a theory of mind. In U. Goswami (ed.), *Blackwell handbook of childhood cognitive development*. Oxford: Blackwell publishing. First Published 2002.

Witt, P. L., Wheeless, L. R., & Allen, M. (2006). The relationship between teacher immediacy and student learning: A meta-analysis. In B. M. Gayle, R. W. Preiss, N. Burrell & M. Allen (eds.), *Classroom* *communication and instructional processes. Advances through meta-analysis*. Mahwah, NJ: Lawrence Earlbaum Assosiates, Publishers. http://dx.doi.org/10.1038/358749a0

Wynn, K. (1992). Addition and subtraction by human infants. *Nature,* 358, 749-750.

Xu, F. (2002). The role of language in acquiring object kind concepts in infancy. *Cognition,* 85, 223-250. http://dx.doi.org/10.1016/S0010-0277(02)00109-9

Young, R. O. (2011). *How audiences decide. A cognitive approach to business communication*. London: Routledge.

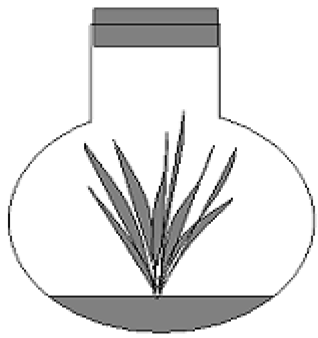

Figure 1. A biosphere in a bottle (also known as closed bottle; closed ecosystem; biosphere 3)

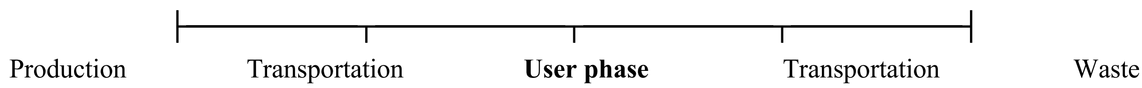

Figure 2. Timeline of a product