CHILDREN'S IDEAS ABOUT THE INTERNAL STRUCTURE OF TREES: Cross–age studies.

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ABSTRACT

Trees are important to the environment owing to their ecological services. However, many aspects of their form and function are poorly understood by the public. From their earliest years, children have an elementary knowledge about plants which they gain from their everyday observations, their parents and other people and from their kindergarten and primary schooling. However, studies carried out in Brazil and England have shown that many children hold a number of alternative conceptions about the internal structure of trees. The goal of this research was to investigate Polish children's understanding of trees' internal structure. This cross-age study involved 5-year-old children from kindergarten (n=57, 26 boys and 31 girls) and 7-year-old children (n=105, 57 boys and 48 girls) and 10-year-old children (83 children, 36 boys and 47 girls) from primary school. Participants were asked to draw the internal structure of a tree. The results of the study showed that there were some significant differences in the responses between age groups and between the genders. Nevertheless, there were some ideas that were shared among all age groups indicating that they might be resistant to change. The study also identified some alternative conceptions about the internal structure of plants and the influence of the media on children's ideas. These ideas, which to some extent replicate findings from England and Brazil, might be crucial for shaping pro-environmental attitudes of pupils in central European farmland countries where plants are important organisms not only for environmental but also for economic perspectives.

Key words: children's understanding, school children conceptions, mental models, tree

INTRODUCTION

People are familiar with plants in their surroundings. These organisms (especially trees) play an important role not only in the environment (as a producers, providing other organisms with organic matter and oxygen), but also in human economy and culture. In different countries, trees have been regarded as symbols of power, growth, justice, life, enlightenment, knowledge and immortality (Ferguson and Ferguson 1959; Becker 2000). Even today these large plants are quite often treated as sacred, for example the Bodhi tree or the holy forest in Arshan (Kopalinski 2007). From a biological point of view, trees are important parts of many ecosystems because of the ecological services they render (Bolund and Hunhammar 1999).

In Poland, many children grow up in agricultural areas and from the earliest years they are aware of plant-related issues such as irrigation problems (Lachowski 2009). Students also learn that conserving water is an important issue (Grodzinska-Jurczak et al. 2006) and they can gain hands-on experiences through activities such as cutting trees (Lachowski 2009). Across the world children have been found to hold alternative conceptions about plants and particularly trees (Gatt et al. 2007; Tunnicliffe and Reiss 2000; Tunnicliffe, Rybska, and Sajkowska 2014). Since it has also been shown that there is a linear relationship between interest and prior knowledge (Tobias 1994), we assume that this lack of scientific knowledge of plants may also indicate a lack of interest in trees and plants. In multicultural studies carried out by Hatano and co-workers (1993), it was found that many children had problems in regarding plants as living organisms. Examples of misconceptions about plants mainly involve photosynthesis such as that plants take in carbon dioxide and change it to oxygen or that plants get their food from the soil (Tekkaya 2002). Other misconceptions are that photosynthesis is the process whereby the plants breathe, or that only green plants can carry out photosynthesis. Some students think that soil provides energy for plants or that seeds do not need nutrition for germination (Lin 2004). In Barmann and co-workers' (2006) study, students thought that plants, like animals, are provided with sunlight, water and food externally and that sunlight may warm up plants or helps to produce food by giving energy and heat. In the same study, students claimed that trees and grass were not plants.

In many countries, plants also seem to be neglected in both the science curriculum and in biology textbooks compared to the coverage allocated to animals (Honey 1987; Schussler et al. 2010). For example, in research carried out by Shussler (2010), a selection of elementary school textbooks (provided by Harcourt Science and Macmillan McGraw-Hill Science), were analyzed. Both series of textbooks from class 1 to 5 (ages 6 to 10) were compared according to the content they provide to students. In the Harcourt series there was no mention of adaptation of the plants and in the McGraw-Hill series it was only 4% of content. In the Harcourt books, 15.8% of the information was about plant parts and 12.3% about plants' needs whereas 3% of the content was about animal parts but about animal needs there were 22.8%. In the Macmillan series the greatest differences were between the different types of plants (7.9%) and animals (21.4%). Thus students may presume that plants do not have to, or cannot, adapt to different or changing environments (Schussler et al. 2010). This observation is also true for the curriculum and textbooks in Poland.

Trees are present in the Polish curriculum from kindergarten to high school but this presence is hidden. For example, the kindergarten curriculum mentions trees twice when describing children's behaviour. Firstly, people are not supposed to shelter under trees during thunderstorms, and, secondly, children will observe that people use wood. The curriculum for the early school education mentions plants once noting that pupils are supposed to recognize some species. However, neither the number nor the names of the species are provided (Curriculum 2011, p.42).

One of our goals as teachers is to promote pro-environmental attitudes among students (Pe'er, Goldman and Yavetz 2007) including attitudes towards living organisms such as trees. Such a goal seems to be difficult to achieve when the curriculum provides only a list of content to be covered during lessons and is written in a non-constructivist way, such that children do not discuss whether plants are alive or not or even consider what is meant by life.

As many research shows the way science, the environment and, in particular, organisms are perceived seems to be gender related. Osborne and co-workers (2003) noted that boys tend to be more interested in physics while girls tend to be more interested in biology. In relation to animals, Herzog (2007) showed that, on average, women show higher levels of positive behaviors and attitudes towards animals while men have higher levels of negative attitudes and behaviors. In the area of visual imagery the differences between genders are also observed. During the activity of drawing, girls tend to prefer colorful and detailed images of people, plants and animals, while boys prefer images that imply action danger or rescue (Rogers 1995).

It was also shown that interests in science are age-related (Osborne, Simon, and Collins 2003). In the work of Prokop, Prokop and Tunnicliffe (2007) it was found that significant differences exist between students' interests in biology lessons and their age. For example the grade 6 (age 11-12 years), students showed the highest interest in biology. What is more important is that interest towards biology decreased after the age of 11-12. The authors also found that students claim that biology and science related areas are not attractive in terms of future careers.

As children grow, their ways of looking at the world change as does their curiosity about living organisms and their development (Tunnicliffe and Reiss 1999). Usually, before they are seven years old, children do not look beyond superficial cues which they can observe (Gelman, Coley, and Gottfried 1994; Piaget 1964). Thus, young children are said to be essentialists. Later, they are considered to develop logical, more abstract ways of thinking (Tunnicliffe and Reiss 1999). Even though plants seem to be interesting to young children, they tend to lose this interest as they grow older and their attitudes change (Schneekloth 1989). Plant-blindness, an inability of humans to notice plants in their environment, has been described by Wandersee and Schussler (2001). On the other hand, as Zoldosova and Prokop's (2006) research suggests, children's participation in fieldwork may influence their mental models and attitudes towards plants. Bearing those findings in mind, we consider that it is important to explore students' understanding and attitudes towards the environment, biological objects and, specifically in this case, towards trees.

When students are learning science, three main situations may occur: 1) they may not have any prior knowledge about the subject and learning involves adding new information; 2) they may have some correct prior knowledge, usually incomplete, thus learning might be considered as gap-filling; and, 3) students may have some ideas (mental models), that are in conflict with the target concepts (Vosniadou and Verschaffel 2004; Chi 2008). Knowledge acquisition in this third case has been described as conceptual change (Chi 2008). Children come to school with pre-existing knowledge and pre-existing mental-models (Cohen, Eysenck, and Le Voi 1986) and these models are often resistant to change (Taber 2000).

The process of forming a mental model is a personal activity and serves as an expression of personal knowledge. But what we, as outsiders, can observe through talking or drawing is the learners' expressed model. A mental model is understood here as:

"a special kind of mental representation, an analog representation, which individuals generate during cognitive functioning, and which has the special characteristic that it preserves the structure of the thing it is supposed to represent." (Vosniadou 1994, p.48)

Mental models are, thus, the end result of perception, imagination and the comprehension of discourse (Johnson-Laird 1980). They are dynamic and can be manipulated mentally in order to provide causal explanations of some phenomena and to make predictions (Vosniadou 1994; Duit et al. 1996).

The goal of the present study was to examine students' conceptions of the internal structure of trees, according to age and gender and to investigate the mental models which they appear to hold. The results for the group of 5-year-old children have been presented in Rybska, Tunnicliffe and Sajkowska (2014). In this study, a cross–age analysis was conducted. It was presumed in devising the study that some of the students' ideas about the internal structure of a tree would be shared among all age- groups suggesting that the shared ideas are resistant to change.

METHODS

For many years, researchers have gathered data using children's drawings together with interviews (Osborne and Gilbert 1980; Ehrlén 2009; Bartoszeck and Tunnicliffe 2013). Ehrlén (2009) points out that an analysis of children's drawings may serve as a tool for collecting information about their conceptions but the data have to be supported with explanation of the meaning that children give to their own drawings by signing the elements of it. Every drawing is then an individual concept of the student and may represent a mental model about the object.

The children who participated in this study attended two state schools and two kindergartens located in Poznan, a city in north-western Poland. Poznan is known for its green areas, parks and for the nature reserves located within the city. In recent years, the region has had a water shortage and the challenges facing farmers have been mentioned frequently in the media. The researchers worked with students from three age groups; the first aged five – three kindergarten classes (57 children), four classes of students aged seven (the first class of primary school, 105 children) and four classes of students aged 10 (the fourth class of primary school, 83 children). None of the classes had participated recently in lessons about trees but as a motivation, a picture of a tree was shown to them and they had a very short discussion about where we can find trees and what differences they could observe between tree species.

The participants were asked to draw a representation of what they thought was inside a tree on a blank A4 sheet of paper individually. They were allowed to draw for up to 20 minutes. Each child was asked to label what they had shown in the drawing. Children who were not able to write labels were assisted by the researchers. In each case, the researchers paid special attention to write the exact names or words used by the children. This process was more commonly used with the younger children who were not yet able to write. An analysis was carried out on the drawings taking account of the children's comments. Finally, 18 children (six of each age group, chosen at random) were interviewed about what they had drawn. Each child was interviewed individually and children were picked at random – two from each class. The interviews were carried on with children who held their drawings.

The drawings were analyzed using a rubric – a scale of categories that was constructed based on those used in studies of children's understanding of biological organisms (Bartoszeck, Machado, and Amann-Gainotti 2011; Bartoszeck, Rocha da Silva, and Tunnicliffe 2011; Reiss and Tunnicliffe 2001).

The first used rubric scale was based on cited literature, and after the first analysis of drawings it was modified to made it more accurate for drawings of children. External features as well as ecological surroundings were also coded and analyzed. Each category had subcategories created earlier following initial scrutiny and analysis of the drawings. The scale used to allocate a grade to the drawings is shown in Table 1.

INSERT TABLE 1 about here

Analysis of the drawings

After the data collection had been completed, the drawings were collected, numbered and coded according to the age and gender of the child. For example, one of the 10-year-old girls was scored 2pad, 3lg, 4bomi (which meant that for the internal parts of the tree we observed such structure as p – 'pipes or tubes', a – 'age' and d – 'hollow'; 3 – for external parts of the tree observed: l – 'leaves' and g – 'branches'; 4 – for ecological views: b – 'bird', o – 'insects', m – 'mammals', and I – 'other animals' (Fig. 1).

INSERT FIGURE 1 about here

Each drawing was scored separately by three of the authors who then met and discussed the scores until they reached an agreement on the score allocated to each drawing. The 'artistic' value of the drawings was not considered in this research nor was any notice taken of the students' age during the scoring. The frequency of drawings assigned to a particular category was tested using the G test (http://elem.com/~btilly/effective-ab-testing/g-test-calculator.html). Differences between the age of particular groups of students' drawings assigned to particular category were analysed using Exact Fisher's Test for Count Data and Chi-squared test in R software and tested for goodness-of-fit.

Innovation in methods of analysis

Looking at the children's pictures and the text of interviews, the authors had a strong feeling that there is something more than one might read from them apart from their biological knowledge. Basing on the literature the authors would distinguish four types of reasoning: essentialist, essentialist reasoning, inductive reasoning and scientific reasoning (Zimmerman 2000; Gelman et al. 1994). Data received by the authors will alow to indicate the type of reasoning which particular children is using. Such analysis was conducted only in case of the students which were both drawed and interviewed about internal structure of the tree.

FINDINGS

Drawing analysis

Analysis of the differences in the representation of categories in the drawings – the arrow shows statistically significant differences.

The null category, that is, no representation of trees for 5-and 7-year-old groups showed similar proportions (respectively 3.16% and 3.96%) and did not show differences between the groups (G(1)=1.97,df=3 p=0.2). However, for the 10-year-old group, the proportion of no representation was significantly lower (0.85%) than the 5-and 7-year-old groups (G(1) = 3.21,df=3 p = 0.034, Figure 2). At category one, the proportion of drawings were similar for all age groups (respectively: 19%, 19% and 21%) and did not differ between particular groups (G(2) = 0.37,df=3 p = 0.63). On category two (some internal parts of a tree indicated), we did not find differences between drawings for 5-year-olds (34%), 7-year-olds (31%) and 10-year-olds (36%) (G(2) = 1.99,df=3 p = 0.44). It was the most strongly represented categories in all age classes and these drawings were actually attempting the task as instructed. At the third category (external parts of a tree indicated) the proportion of drawings for all age groups were, respectively, 26%, 33.4% and 25.7%. The results of statistical analysis demonstrated little difference between the two older age groups (G(2) = 1.11,df=3 p = 0.047). At category four (ecological and habitat views associated indicated) for all the age groups, the proportions of the drawings were quite similar (respectively 15.5%, 12.3% and 14%) and were statistically insignificant (G(2) = 0.67, df=3, p = 0.49).

Analysis of the differences between genders

We analysed gender differences between particular categories. Subcategories were associated with categories 2, 3 and 4. At category 2 (internal parts of a tree), five subcategories were observed: P – 'tubes/pipes/roots', H – 'like human have', J – 'juices', A – 'Age/timber' and D – 'hollow'. At category 3 (external parts of a tree), five subcategories were observed: L – 'leaves', F – 'fruits', B – 'bark', G – 'branches' and S – 'seeds'. At category 4 (Ecological and habitat views associated), four subcategories were observed: B – 'birds', O – 'insects', M – 'mammals', and I – 'other animals'.

For the five-year-old groups, we did not find significant differences between all categories and gender (all p>0.05, G-test). However for the seven-year-olds, differences were observed in two categories: 'fluids', which boys drew more frequently than girls (G(1) = 3.07,df= 3p = 0.007) and 'branches and mammals' were more often drawn by girls than boys (G(1) = 1.02,df=3 p = 0.049). For the ten-year-olds there were only differences of drawings in 'wood' and 'birds' which in both cases involved boys drawing them more frequently than did the girls (G(2) = 2.16,df=3 p = 0.003).

Analysis of differences between age classes

We found significant differences between the categories 'fluids' and 'roots' in particular age groups (respectively: X2=12.4;df=3; p<0.01 and X2=8;df=3; p=0.02) where 7-year-olds drew them more often than the 10-year-olds group. In turn, the oldest investigated group drew animals more frequently (X2=5.4; p=0.07) than the others. For the five-year-olds group, the most frequent interior feature drawn in the trees was a hollow (G(1) = 1.06,df=3 p = 0.045). The percentage of responses in each category are shown in Figure 2.

INSERT FIGUE 2 about here

Some of the pictures would fit to more than just one category, for example some of the pictures will contain elements from cathegory 1, some would contain cathegory 1 and 2, some would contain elements from cathegory 1, 2 and 3, etc. The percantage was counted for all the answers from particular age group.

Interview analysis

Shortly after making the drawings, six children from each group were selected for an interview. All of them were interviewed separately. The following examples are presented in age order. For this publication the authors have chosen the most illuminating and explanatory responses (authors selected examples that help to explain why students used this most common characteristic).

5-year-old children's explanations

One child explained that inside a tree was a hollow and that he had seen it many times in the park near his home. The next most frequent category referenced at this age was 'internal fluids' (or gases) of which many different kinds were listed, including water, maple syrup and oxygen. One girl explained her reasoning:

Girl: 'You know trees take in water and it comes inside it up to the top.'

Researcher: 'How do you know that it comes to the top?'

Girl: 'Grandmother told me, she also said that it has roots somewhere in the ground.'

Other children said that water kept the tree alive. Another child pointed out that he saw that water went inside a tree in a cartoon on the television.

Some pupils (n=13) drew human organs inside a tree. One girl said: 'If this is alive, the tree has to have a heart, like me.' Perhaps surprisingly, four children labelled a 'soul' as a part of an internal or even an external feature of the tree.

For many children, trees served as a home for other organisms. One five-year-old boy explained that the tree itself was just timber, but was used by other organisms such as spiders and ants for a home.

7-year- old children's explanations

The most frequent internal structure mentioned by seven-year-olds was 'fluids' such as water (n=47). But quite often timber (n=30) or age (n=33) also occurred. During the interview, one child said, 'Well inside a tree is inside', to which the interviewer asked, 'What do you mean by that?' to which the child responded, 'You know a tree, timber and the age, you might see the age inside the tree – like me, seven-years-old'. The other child said, 'There's nothing inside." The interviewer asked, "So you mean it's empty?" Another child responded, 'No not empty … but nothing … nothing more than an age'. The researcher asked, 'What do you mean by age?' The child answered, 'You know how old is the tree … those lines are there'. A ten-year-old boy said that he had seen a cross-section of a tree many times and it looked like his drawing.

A seven-year-old girl, when asked why she drew honey, answered, 'I saw it in the book. Mummy was reading to me'. The researcher asked, 'Which one, do you remember?' The girl responded, 'Winnie the Pooh, there were bees and honey inside the tree, and Winnie was trying to get the honey.' Honey appeared in three pictures in the whole group and two in the group of seven-year-olds and one in 10 years old. One seven-year-old mentioned amber, which is traditionally found in Poland, for example, deposited by the sea.

10-year-old children's explanations

The most frequent internal organs drawn by the group of 10-year-olds was 'tubes, pipes or roots' (n=37). The group of 10-year-olds, surprisingly, often used the human body as a template (n=15): there was no such observation in the group of seven-year-olds. A mixture of botanical and human-like features of a tree was provided by one child who explained that in the trunk there was a special box with green pigment that gave all the leaves their colour.

Researcher: 'Why is it in the trunk?'

Child: 'Because only leaves needs to be green … leaves are the most important part of the tree – they also have nerves that are responsible for tree's senses or feelings.'

One 10-year-old girl also explained that she drew the entire inside of a tree green, 'because there is greenery inside, from which all the fluids goes to the leaves.' Another child said that inside a trunk there was 'A place where leaves begins, so … they are green and some kind of dye is located in this place of leaf initiation.' A girl explained her drawings and said that she drew a brain, mouth and special holes for breathing:

Girl: 'A tree is alive, so it has to feel and have all those structures that we have.'

Researcher: 'Have you ever seen those structures on the tree?'

Girl: 'No, but just because we don't see them doesn't mean they don't exist, our science teacher told us, the people a long time ago didn't know that every living creature was composed of a cells, and now we know the cells are there even if we don't see them.'

General outcomes from interviews and drawing analysis

Some children pictured tree as non-living or 'partially living' organisms and this statement was supported in the interviews. Students' seemed to think that the most important 'essence' of a tree is its wood. The most frequently-mentioned internal element in each group was some kind of pipe, link or root that went up the trunk. This assumption would be the most appreciated as it indicates that tree as an organisms have their own processes. One seven-year-old boy who was interviewed said that there were 'Links to raise water up; the tree is a plant and needs water'. Quite often children called those lines 'roots' (n=10), explaining that, 'Roots are for taking water from the ground and giving it to the tree, so they start in the ground, go all the way through the trunk and give this water to the leaves'.

In each group, insects were the most frequently drawn animals that were thought to be 'inside' a tree. The groups of 5-and 7-year-olds mentioned that the next most frequent animals were mammals (mostly squirrels), however a different result was found in the group of 10-year-olds. The older group tended to put different organisms in the tree, sometimes without giving the species a name (calling them 'parasites', or 'bacteria', or 'snails'). Those types of tree pictures would show a more holistic view of a tree as a part of ecosystem, and some relationship with other organisms.

DISCUSSION

Children's conceptions of plants and 'the inside of a tree' were found to have something in common when comparing data from Brazil (Bartoszeck and Tunnicliffe 2013), England (Tunnicliffe 1999), Poland (Rybska, Tunnicliffe, and Sajkowska 2014) and the current study. This commonality – such as drawing pipes inside a tree, or marking just bark or wood, drawing animals inside or outside the tree – might suggest that some children's conceptions about the internal structure of a tree are not only resistant to change as time passes but are also shared across different cultures. Some of those ideas seem to be an example of common-sense reasoning; for example, a tree having inside pipes that suck up water or that serve as shelter for animals. Such common sense reasoning that is supported by everyday experience and socialisation was described by Driver and co-workers (Driver et al. 1994). Other ideas observed in the present research seem to follow the scheme described as naive biology by Hatano and Inagaki (1994). Students would use an expression such as 'like humans have' – using the human body as a template (Hatano and Inagaki 1994). An example in the present study would be picturing a tree as having a heart or other human internal organs. Such results are in agreement with data obtained in Brazil (Bartoszeck and Tunnicliffe 2013) and England (Tunnicliffe 1999).

The present research study is one of a number which have analyzed students' drawing in a cross-age context. In some cross-age studies, the observation was made that there are conceptions which appear to be resistant to change and which are shared by students across a range of ages. Yen, Yao, and Chiu (2004) found misconceptions about a cricket identified by participants as a reptile in students from primary school to university, without significant changes. In other studies conducted by Prokop et al. (2007) the change of students' conceptions may also depend on the topic involved. For example, conceptions about skeletons were resistant to change but the ideas about organ systems changed with age. Furthermore, what is interesting is that differences observed in drawings between age groups were noticeable but not extreme. The conceptions constructed by age five will not be changed significantly even by the age of 10, after over four years of school education. Children's conceptions and the shaping of their pro-environmental attitudes appear to begin at the very first moment when pupils become explorers investigating the nature which surrounds them (Wandersee et al. 1994; Tanner and Allen 2005). On the other hand, as Tunnicliffe (1999, p.3) wrote, 'Children take what they know and apply it to new situations'. For many of the participating children, it was not an easy task to draw what was inside a tree. A few of them failed to do it at all. Of those who were able to draw the tree we may observe a variety of concepts: non-living creatures to house-like environments in which squirrels and birds live. However as Lachowski (2009) observes, when children have an experience with cutting a tree they may know the difference between wood and timber. In the Polish language, the words 'tree' and 'timber' are very similar in pronunciation ('drzewo' and 'drewno'). Quite often it happens that very young children cannot differentiate between those two words. In this case, it appears to be a semantic issue similar to one described by Villalbi and Lucas (1991). As one child said, 'Trees give us furniture and the furniture comes from timber that makes a trunk'. Identifying timber inside a tree was also noted in a study by Bartoszeck and Tunnicliffe (2013). Some of the students' ideas were some distance from the biological explanation (such as boxes with green dye or places that serve as a source for leaves), but they indicated a student's way of explaining their observations. The children shared a common concept of a tree as an organism, although some were not sure if this organism was alive (even when they drew age rings in the tree). Bell (1981) reported that children from New Zealand did not consider trees to be plants. Another common observation in the present study was that more boys than girls drew the wood inside the tree, a finding that corresponds with Gatt and co-workers' (2007) research in which boys were also more aware of tree issues then were the girls. Lindemann–Matthies (2005) showed that children believed plants to be lifeless. As was mentioned above, the two terms are confusing in the Polish language and children tend not to be able to distinguish between the terms 'tree' and 'timber'. Since timber is not alive, some children were not sure if trees are alive since people made furniture from them.

As the age of the participating students increased, their conceptions of non-plant-specific concepts (such as animals and bacteria being present and plants as habitats) become more sophisticated, while plant concepts became narrower. From this point of view, trees are seen as organisms in an ecological context, having relations with other organisms, offering some services to them. Two interviewed children who were 10-years old stated that trees have feelings – for them there was no doubt that these are living organisms. As Saka and co-workers (2006) noted: 'year by year as students gain new information and as knowledge gets more complicated, students may forget some of the previously learned superficial knowledge and may develop alternative concepts'.

Although it has been shown in some research that plants are neglected organisms in the curriculum (Tunnicliffe 1999), in textbooks (Honey 1987; Schussler et al. 2010) and even in students' minds (Gatt et al. 2007; Patrick and Tunnicliffe 2011), teachers may benefit from considering that students have their own explanations of plant structure, physiology and life functions contained in their mental models. In order to teach about biological phenomena effectively, teachers may benefit from paying special attention to plants and to the way students see and interpret them. Establishing children's existing conceptual understanding is essential for educators to build suitable teaching strategies (Mintzes 1984).

Schools and teachers are concerned about the incorporation of scientific knowledge into students' mental models. This outcome is usually undertaken by helping the learner understand the accepted science knowledge and incorporate it into their mental model (Gilbert, Boulter, and Rutherford 1998). To be successful, teachers need to understand mental models of natural phenomena that their students possess.

As a research technique, drawing is a useful tool to probe students' ideas about scientific phenomena (Bartoszeck, Rocha da Silva, and Tunnicliffe 2011; Reiss and Tunnicliffe 2001). The technique, however, has some disadvantages such as difficulties in recognizing what has been represented (Novak and Musonda 1991; Osborne and Gilbert 1980; Salmon and Pipe 2000). The other issue is that pictures may not always show all the knowledge that a child has, or they may show mental models of more than one child when they copy a picture from each other. On the other hand, drawings are quite a popular way of representing the world among young children at kindergarten levels and early years at school. Drawing as a method of visualization is important in science education and it might help to enhance engagement, to learn to represent or to reveal understanding (Ainsworth, Prain, and Tytler 2011).

Media influence

In this research it was evident that the media influenced students' understandings of a number of issues such as water conservation. Most participants were aware of the significance of water for trees and for all plants. A 10-year-old girl said that, 'We have to protect water, since plants might not survive without it, and if they won't we don't get any oxygen'. She added, 'You know, we might run out of water if we won't save it'. Water conservation is a common issue in the Polish media and is often discussed in schools and kindergartens. Also, the role of Polish agriculture is not without influence. Poland is one of central Europe's farmlands where agriculture and environment connect and are still an important issue in the economy. Citizens of this developing country are frequently provided with environmental information which they may not understand. The number of decisions to be made by the public are rising because of the new challenges which this century's economy has brought to farmers (Munroe 2001).

Children's reasoning

Young children's judgments about the properties of living objects are influenced by similarity-based interferences (Carey 1985, 1988) what also means that such ideas are influenced by their culture perception especially in the degree of similarity between the target entity and the best-understood living thing – mostly human being (Hatano et al. 1993). Looking at the children's pictures, the authors had a strong feeling that there is something more than one might read from them apart from their biological knowledge. Drawings are used in science for many reasons: from describing scientific phenomena to a source of student conceptions and misconceptions. In the following research it is shown that research with drawings and interviews at the same time may deliver more specific information about thinking and the inferences of children. In this research we observed four types of situation: essentialist, essentialist reasoning, inductive reasoning and scientific reasoning. To the best of our knowledge there is no research which has analyzed drawings in this way and would indicate that drawings might also be useful as a tool to discover children types of scientific reasoning.

In analyzing the drawings, groups of children can be identified who recognize trees from an essentialist angle (first category). Children who were asked for an explanation of their drawings could only tell that inside there is wood, and indicate at the same time that the tree is a non-living organism (Fig. 3).

INSERT FIGURE 3 ABOUT HERE

Elements of essentialist reasoning can be observed when: 'children have an early, powerful tendency to search hidden, non-obvious features of things… and when children spontaneously construct concepts and beliefs that reflect essentialist bias.' (Gelman 2009, p. 7). Essentialist reasoning can be observed when children draw pipes for pumping the water to the top of the tree (Fig. 4) – probably on the basis of their own experience of drinking water using a straw – as it was explained by one 7year old students during an interview.

INSERT FIGURE 4 ABOUT HERE

Other examples which were observed concerned inductive reasoning (Carey 1985; Inagaki and Hatano 1989) when students used the human body as a template. Almost 11% of all drawings seemed to be in this category (found in the 5-year old group and the 10-year-old group). During the interviews, one of the girls said that 'plants live, but it is a different life'. Taking into account the differences between plants and animals, it seems reasonable to assume that plant are less prone to this kind of student reasoning than animals (Rybska et al. 2014). In our research, examples of inductive reasoning were observed in 37% of the drawings.

In this study it appeared that few drawings showed scientific reasoning, that is, 'encompass[ing] the reasoning and problem solving skills involved in generating, testing and revising hypotheses' (Morris et al. 2012). An example of this hypothesis might be the drawing represented below (Figure 5) where the child thinks that that green colour of the leaves 'obviously is not coming from vanity but since it is observed just at the top part of the tree - there has to be container with green dye'.

INSERT FIGURE 5 ABOUT HERE

CONCLUSION

In each age group investigated, the children imagined pipes to transport water, or a heart as if using a human analogy, or the tree as a shelter for animals. In each group, children saw a tree as part of the environment (as a habitat of another living creatures) – they put animals inside the tree. Children from all age groups had little understanding of the internal structure of a tree, quite often they did not consider trees as a living organism. For a teacher who is trying to teach a holistic view of living things, knowing the conceptions that children possess seems to be the first step to helping them construct a deeper understanding of the accepted biological view. In discussing the topic we would recommend highlighting differences between organisms representing the animal and plant kingdoms, making comparisons of similar life functions that are carried out in different ways – such as the transport of nutrients inside the body. What is more, teachers usually plan their lessons based on the curriculum without knowing children's conceptions about the topic. The authors would like to highlight that another practice should take place – in which teachers would plan biology lessons on the basis of students' ideas/pre-existing knowledge about the phenomena.

EDUCATIONAL IMPLICATIONS

By better understanding students' conception of trees we may influence their appreciation of the environment and may affect their pro-environmental choices in the future (Pyrovetsi and Daoutopoulos 1999). The findings might also be considered by schools and teachers or included in textbooks and curriculum (for example, by including them and their role in the environment in the curriculum). One of the major implications coming from this study is that teachers could consider preparing hands-on activities that would directly address student conceptions. These activities might include:

1) Planting a small branch, watering it until it grows into a tree (the teacher might want to try different species of tree branches with one being a willow);

2) Putting a branch with buds into water and observing the buds turning into leaves and also noting that roots grow from the branch underwater;

3) Making a model of a plant/tree;

4) Taking a field-trip to a commercial forest and observing trees of different ages, examining the tree-trunks after the tree was cut down;

5) Preparing activities that would allow students to compare the life processes of plants and animals.

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