Preschool children's perceptions of the role of light and chlorophyll in plants' photosynthesis

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Abstract

The involvement of infants in the natural sciences is considered necessary, because young children seem to form very early their first ideas, interpretations, theories about the concepts and phenomena of the physical world and are therefore able to approach relevant issues at a first level**.** The purpose of the present study is to investigate preschool children's perceptions regarding the role of light and chlorophyll in photosynthesis of plants. The research was carried out in a full-day kindergarten during the period of November to December 2019, where the researcher was working. The sample of the study consisted of 14 children. Activities and experiments were designed and implemented, based on the Constructive Approach. Data collection was done through semi-structured interviews, observation, and recording of users' actions. Nvivo11 software was used for the quantitative analysis of the data.

Keywords: kindergarten, perceptions, light, chlorophyll, photosynthesis

Introduction

In recent years there has been an increasing interest internationally in the education of preschool children in Natural Sciences (Gelman & Kremer, 1991; Johnson, 1998; Ravanis & Bagakis, 1998). This is due to the finding that the introduction of science in kindergarten contributes to the cognitive and mental development of infants (Trundle, 2010). Research has shown that engaging children in Natural Sciences from a very early age helps them to understand them better and later to grasp more difficult concepts (Kalleri, 2007).

Children, even before they enter formal education, have already developed some interpretive models in their attempt to understand the physical world (Koliopoulos, 2006). This is due to the innate curiosity of children to get involved in various ways in order to discover first the familiar and close natural environment.

The majority of researches on children's perceptions and environmental sensitivity are directed at older ages (Ergazaki et al., 2002; Zogza & Economopoulou, 1999; Zogza, 1998), while very limited ones refer to preschool age (Perdikari et al., 2007; Christidou & Hatzinikita, 2006).

Literature review

In Greece, the Curriculum for the early childhood (Ministry of Education and Religion, 1998) lacks a clear formulation of the teaching goals for natural sciences. However, the new Curriculum for Kindergarten in Greece (Interdisciplinary Unified Curriculum Framework, 2011) gives particular importance to the role of natural sciences and the ways in which preschool children can engage in well-organized activities, both individually and in groups. Also, for the first time, natural sciences are an autonomous and separate subject. The content of natural sciences includes selected teaching activities from various disciplines, such as Biology, Meteorology, Physics, Astronomy and Geography. Also clear is the formulation of learning objectives and teaching methodology.

Concerning the composition of the subject of Science in preschool education, important and decisive factors are the identification and codification of the learning barriers and cognitive tools that preschool children develop. Most important learning barriers are pre-existing ideas, meaning the perceptions of young children who have developed experientially within the context of their social and physical environment. Preschoolers' ideas for various physical science concepts have also been extensively studied in Greece (Hatzinikita et al., 1996; Valanides et al., 2000; Tzimogiannis, 2001). They are often referred to as prior knowledge, primary ideas and representations, initial or alternative concepts, misconceptions, etc. It is noted that empirical thinking differs from scientific reasoning (Skoumios, 2012; Halkia, 2012). It is noted that because they are products of reasoning, they are very resistant to teaching and they are often crawled along with their reoriented scientific perceptions at all levels of education, although they are influenced and re-structured during teaching activities (Kariotoglou, 2006). Sometimes children's alternative ideas are so powerful that they are not even influenced by experimental teaching (Psyllos, et al., 1993).

Perceptions of various science topics have been recorded indicating that children are interested in and build on prior knowledge on a range of issues.

Among the areas that have been well studied are students' perceptions of light and vision. Preschoolers commonly asked about light will identify it with the source or effect, and they may still identify light with the lamp or light footprint on the wall (Driver et al., 1985). Children, do not attribute autonomous properties, identifying them with light sources that produce it or the effects it produces. Indeed, this type of light-related imagery occurs more and more frequently as children are younger (Stead & Osborne, 1980; Tiberghien et al., 1980; Anderson & Smith, 1982; Eaton et al., 1984).

Also, infants can attribute to sun anthropomorphic properties as they consider it as a living organism, which at night e.g. goes to sleep or hides itself behind objects (Kalleri, 2007).

Furthermore, the natural environment is directly linked to the interests of preschool children. Their perceptions of humans, animals and plants have been issues of interest to researchers. Studies on the subject first refer to children's beliefs about the separation of living and non-living (Zogza, 2006). Hitano and Inagaki report that children have already developed a biological knowledge base from preschool age that they have built gradually through the experiences of their early years. Their research indicates that children use certain criteria to classify objects into living or non-living objects that are categorized in to behavioral criteria, morphological and functional criteria. It has been found difficult for children to first classify plants in living organisms because of lack of some criteria, such as movement (Zogza, 2006). Also, on the subject of development, preschoolers find that growing a plant means that it grows older, yielding anthropomorphic elements (Driver et al., 1985).

Photosynthesis, which is one of the essential functions for plant growth, along with the function of nutrition, is incomprehensible to young children (Zogza, 2006). Roth and Anderson (1985) found that children believe that photosynthesis is not important for plants, but for humans and animals, mainly because of the exchange of gases. As for chlorophyll, children believe it to be a food substance, a preservative, a stored product, a vital substance such as blood, something that makes plants strong or something that breaks down starch. Also, some children believe that chlorophyll attracts solar radiation or it absorbs carbon dioxide. Some other children have an anthropocentric view that chlorophyll is only there to make leaves green and beautiful. They do not understand the role of chlorophyll in the absorption of solar energy and its conversion to chemical. Most children consider the existence of light as essential for the growth of plants, without considering the existence of plants that are kept in the dark. Interviews showed that students did not understand the transfer of energy from sunlight and they used the terms "heat - warmth" and "light" indiscriminately. That is because they believed that plants use the sun's warmth as energy for photosynthesis. Many children consider the sun as a source of energy for plants, such as the

soil, minerals, the water, the air and the wind. Barker (1986) developed an introduction to photosynthesis, emphasizing the origin of sugar, starch, cellulose and wood. In addition, students tend to focus more on descriptions of the effects of light on plants or on observations than on how they use it (Christidou & Hatzinikita, 1999).

According to research, the importance of sun to plants' photosynthesis is not easily perceived by children, but they mainly refer to its warmth rather than to the light considered necessary for plant growth. In addition, there are also children who cite fertilizer as a plant food for growth. Some children who have grown plants from seed realize that leaves and other parts of the plant have grown from it, but they do not understand how the new material is made. After the age of 7 years old, they begin to mention morphological characteristics as well as plants' needs such as having roots, leaves, seeds, soil, sun, water and food (Zogza, 2006).

Method

The Current study

The purpose of the current study is to investigate preschooler's perceptions regarding the role of light and chlorophyll in photosynthesis of plants. The research questions were the following:"How do preschoolers understand the meaning of light?", "Do preschoolers understand the concept of sun light as an energy provider?", "Do preschoolers understand the role of sun light in plant development?" "Are there any pre-existing preschoolers' perceptions about the concepts of chlorophyll and photosynthesis of plants?"

Sample and Data Collection and analysis

Research was carried out in a full-day kindergarten during the period of November to December 2019, where the researcher was working. Parents' and school manager's written permission in conducting the research was obtained.

The sample of the study consisted of 14 children, aged 4 – 6 years old, of the all-day department. Of the total sample, 7 children were aged 4-5 years old and the remaining 7 children were aged 5-6 years old. Of the 14 children, 4 were boys and 10 were girls. As for the socio-cultural environment from which the children came from, 3 of them were Roma (2 aged 5 – 6 years old and 1 aged 4 – 5 years old), one child came from Bulgaria (aged 4 – 5 years old) and one had learning difficulties (aged 4 – 5 years old).

Finally, the issue of the concept of light was not developed at all in any of the 3 departments of the kindergarten, which helped to retrieve and investigate the spontaneous mental representations of infants regarding the concept of light.

The present research was a qualitative research, as it is considered more appropriate for research problems that require more exploration, understanding and description without prior knowledge of the variables (Creswell, 2011). It also studies social phenomena and focuses on differentiation, with researchers trying to understand the dynamic dimension of the phenomenon (Isari & Pourkos, 2015; Robson, 2007).

The data collection and analysis was done through questions, tape recordings, semi-structured interviews, observation and recording of users' actions. The semi-structured interview was chosen as the most appropriate method of data collection because it has the advantage of being flexible, adapts to the conditions of each school and to the different level of students' understanding, and furthermore allows the researcher to extract more in-depth information than other research tools (Cohen & Manion, 1994). The semi-structured interviews were transcribed and recorded in Nvivo 11 statistical program of qualitative analysis and the resulting material was the data of the present study.

Research hypotheses

The research hypotheses of the study, based on literature review presented above, are the following:

Concerning the research question of how children perceive the concept of light, children will not attribute to light autonomous properties, identifying it, both in meaning and concept, with the light sources that produce it or with the effects it causes. Children are also expected to attribute to the anthropomorphic properties as they view it as a living organism.

For the research question of whether preschoolers perceive the concept of light as an energy provider, they will not understand the transfer of energy from sunlight and they will use the terms "heat - warmth" and "light" indiscriminately. Children will also consider that plants use the sun's warmth as energy for photosynthesis and they will consider sun as a source of energy for plants, such as the soil, minerals, the water, the air and the wind.

In the research question about whether preschoolers perceive the role of light in plant development, they will consider the existence of light as indispensable for plant growth, without considering the existence of plants that are kept in the dark. They will also mainly refer to the warmth of the sun rather than considering light necessary for plant growth. In the research question on whether preschoolers have pre-existing perceptions of chlorophyll and plant photosynthesis, they will not understand the role of chlorophyll in the absorption of solar energy and its conversion to chemical.

Teaching Intervention

Purpose

The purpose of teaching intervention was to investigate preschoolers' perceptions of the role of light and chlorophyll in plants photosynthesis before and after teaching.

Activity 1: Emerging the concept of light

The technique of brainstorming was used in order to highlight the pre-existing ideas and perceptions of infants.

Activity 2*: The natural phenomenon of the greenhouse*

Objectives: Preschoolers to: understand the concept of "greenhouse effect" and its importance in plant growth, build their greenhouse with simple materials, understand the importance of light as energy in the proper and healthy growth of plants, learn to record in different ways their measurements, as well as to compare them, both with each other and with measurements of the rest of their classmates.

Instruments-Materials: small transparent plastic bottles, sunny window, transparent plastic glasses, scissors, cutter

Description:

The kindergarten teacher, initially, read a book titled: Phaethon and the chariot of the sun (Mandilaras, 2011). Then, after the discussion, the children were asked to draw the myth. Infants then performed the experiment described below, having already been familiar with the operation and use of the thermometer. Children planted seeds in transparent plastic glasses in soil and placed the cut bottles in some plants, like a greenhouse. In other plants they did not put plastic bottles - greenhouse. They watered their seeds daily by opening the lid of the bottle and pouring water from its mouth, as well as the plants, in which they did not place a transparent plastic bottle. They placed their small greenhouse near the window to keep their plants warm in winter.

In addition, the children planted seeds at the same time, which they undertook to take care of, but placed them in a shady place (in the kindergarten school closet), also recording through semi – structured interviews their observations regarding the growth of the plant and comparing it with that of the plants placed in the window (Figure 1).

Figure 1. We are planting ... We are putting some of our plants in greenhouse - bottles, after we have drilled a hole in their lid

In this phase, the kindergarten teacher addressed the following questions to the children: "Which plants do you think will grow faster, those with the plastic bottle, those without the plastic bottle or the plants we put in the closet?", "Why do you think that?"

When the plants grew, the children were asked again and compared their answers with the initial ones before the experiment.

Activity 3: Photosynthesis

Objectives: Preschoolers to: understand the necessity of light and chlorophyll in the photosynthesis of plants and to understand the existence of starch in plants.

Instruments-Materials: Discolored leaves, small plate, alcohol, straw, iodine tincture straw

Description: Children placed some soft light-colored leaves in a container with pure alcohol (Figure 2).

Figure 2. Experiment with alcohol on discolored leaves

The kindergarten teacher asked children "What do you think will happen to the leaves?"

Next day, the kindergarten teacher called children to check their first hypothesis, observing the color of the leaves (leaves were no longer green but yellowish).

Children in groups took some of the leaves, placed them on a small plate and threw on them with a straw a few drops of iodine tincture. The kindergarten teacher asked children, while recording their answers: "What do you observe?, "Why did that happen?"

Results

Before teaching

Preschoolers' answers to the question of what light was are listed in Figures 3 and 4.

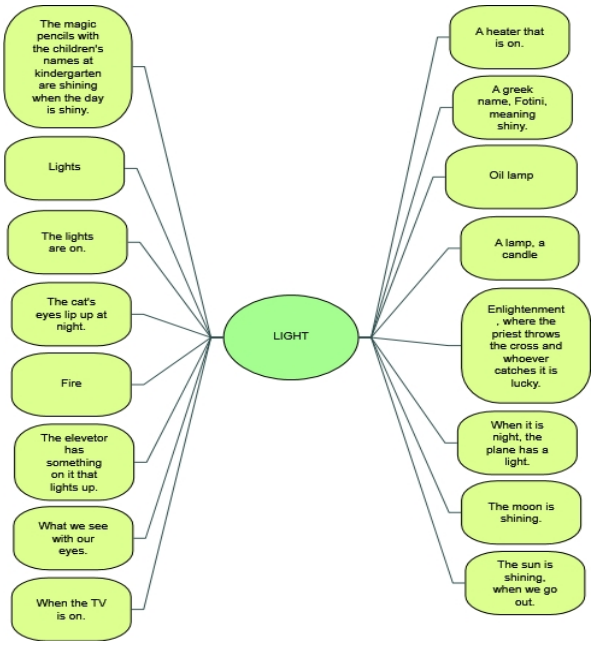

Figure 3. Mind map for the concept "light"

Figure 4. Word cloud

Children's most common answers to the question of what light is, as shown by the size of the words in the word cloud, are that light is something that illuminates, something that shines, like lights, cat's eyes at night, and lamp.

Children then planted plants that placed in the light and in the dark. A summary of children's responses to the question, about which plant would grow faster, is given in Figure 5.

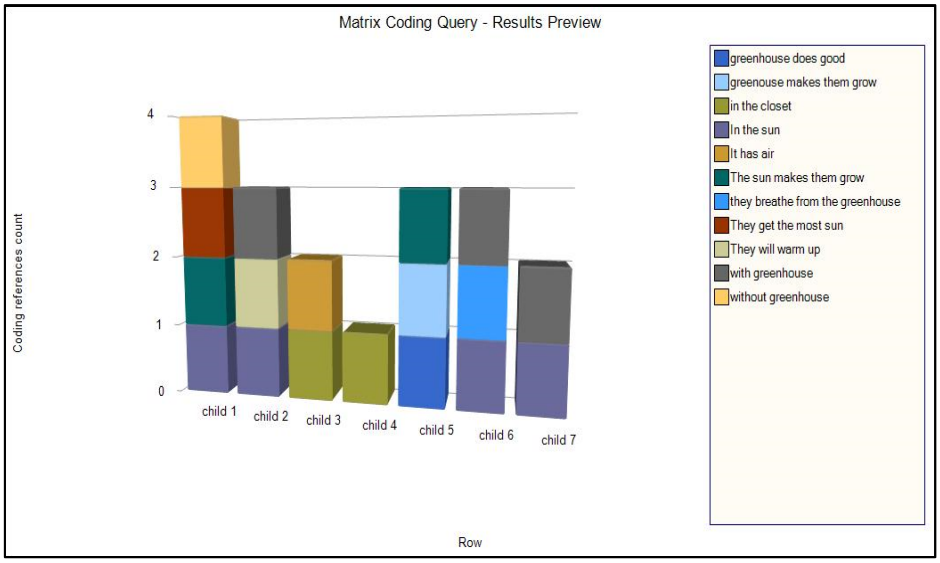

Figure 5. "Which plants will grow faster?"

Out of 7 children, 6 responded that the plants we put in the sun would grow faster. Two children responded that plants will grow faster in the sun because sun "grows them" and one child answered that plants will "be warmed up" in the sun. Two children responded that plants will grow faster in the closet, since one of them, during the interview, changed its mind and responded that plants we put in the sun would grow faster. 3 out of 7 children responded that they would grow as fast as greenhouse plants, while 1 child responded that they would grow faster than greenhouse plants because they "get the most sun".

Children placed discolored leaves on alcohol. Children's answers to the question "What do you think will happen to leaves with alcohol?" are given in Figure 6.

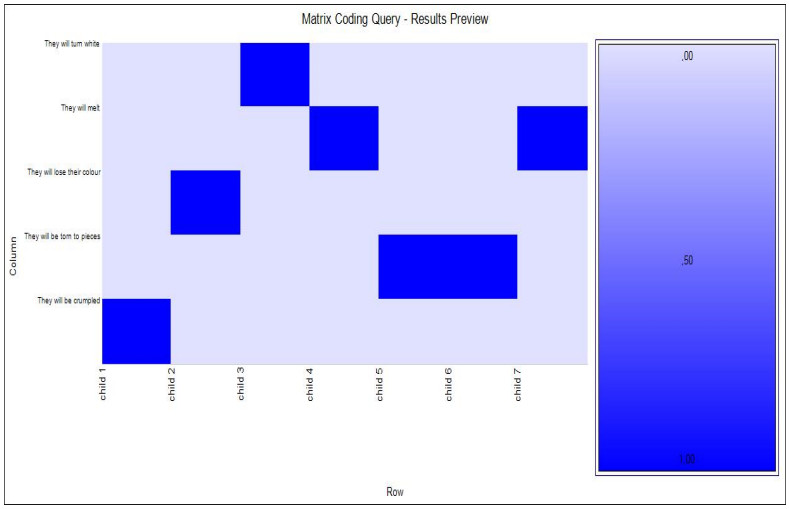

Figure 6. "What do you think will happen to discolored leaves if we put on them alcohol?"

Two children responded that leaves will melt; one child responded that they "will be crumpled", one child responded that they will "turn white because alcohol is white", one child responded that leaves "will lose their color" and one child responded that leaves will be torn to pieces.

After doing the experiment with leaves that children put in alcohol, children put iodine tincture into some leaves and the kindergarten teacher asked them "What do you think will happen to leaves if we put iodine tincture?". Children's responses are presented in Figure 7.

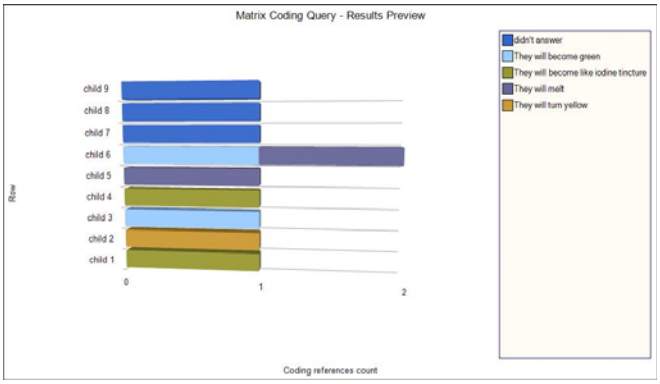

Figure 7. "What do you think will happen to leaves if we put on them iodine tincture?"

Two children responded that leaves would be molten, followed by responses that they would "become like iodine tincture" (2 children), "turn green" (2 children) and "turn yellow" (1 child). Three children did not respond.

After teaching

To the question "Which plants grew faster? Why? ", all children responded that plants were planted "in the dark" grew faster. Three children justified their response saying that plants grew faster there "because of the darkness", while two children responded that this was because plants were "looking for the sun", as well as the response of a child who said that they were "trying to pierce the closet searching for the sun to come through". Three children responded that plants grew faster in the dark because there was "dark", while one child justified its response by saying that "there was air in the closet from the little glaze that was there", meaning the slot in the closet. One child also responded that plants in the closet grew faster without justifying its response (Figure 8).

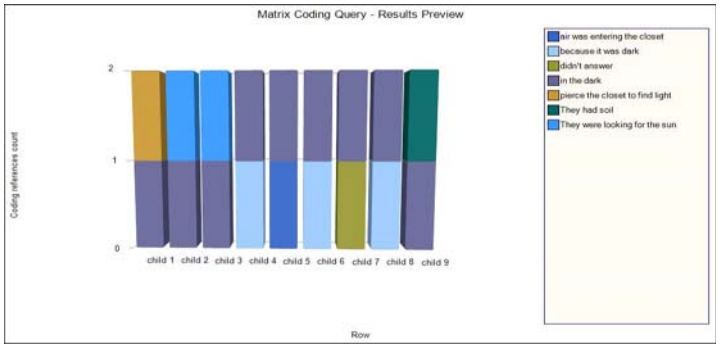

Figure 8. "Which plants grew faster? Why;"

To the question "What color do our plants that were put in the sun have?' all children responded that their color was "green". 7 children responded that the color of leaves is green "because of the sun". One child responded "because of the light", meaning the sun light and another child responded that leaves are green "because they were dried by the sun". To the question, "What color do our plants have in the dark?" the majority of children responded that leaves were yellow, while 3 children responded that leaves were white. However, none of the children justified its answer (Figure 9).

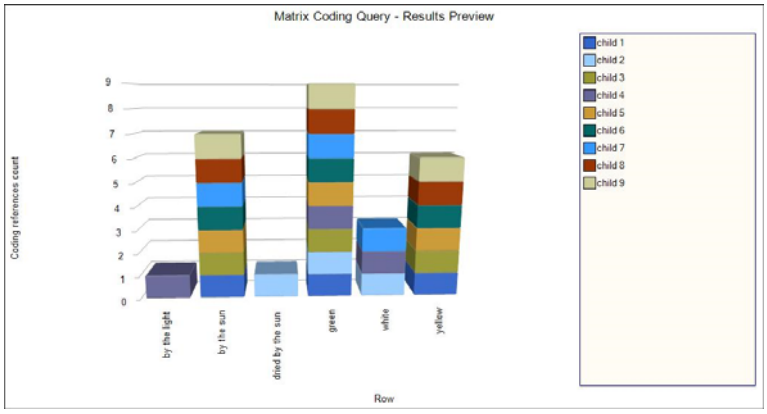

Figure 9. "What color do our plants were put in the sun have?"

After the experiment, where children put discolored leaves into alcohol, two children responded that leaves "turned yellow" and two children responded that "their color was gone." One child (child 4) gave two answers, that "were melted" and "their color was gone." One child responded that they "changed their color", while one child responded that they turned "green." Also, 3 children did not respond (Figure 10).

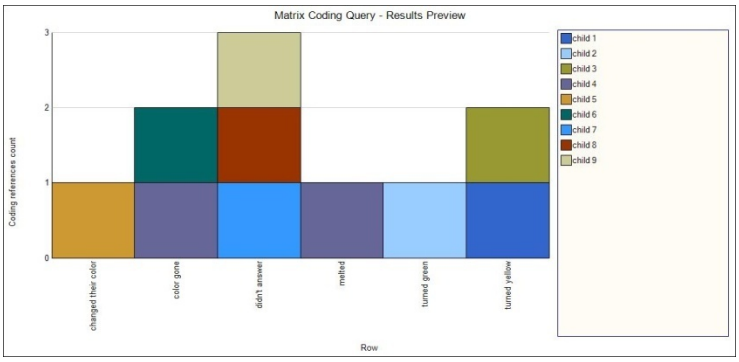

Figure 10. After the experiment with alcohol and discolored leaves

After the experiment with the iodine tincture that children put on leaves with a straw, they were asked "What happened to leaves when you put iodine tincture?" Four children responded that leaves "turned brown", 2 children responded that they "changed their color", while one child responded that leaves "turned red" (Figure 11). Three children didn't answer.

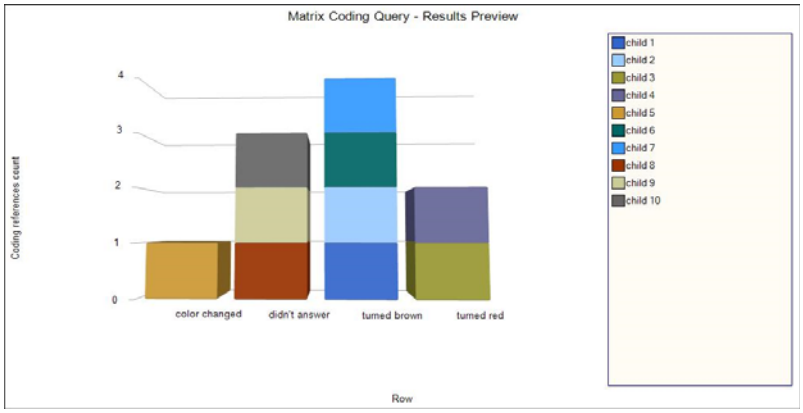

Figure 11. "What happened to leaves when we put on them iodine tincture?"

Results' discussion

In the natural greenhouse activity, children responded in the majority that plants that are in the sun will grow faster because the sun "warms them up" and "grows them", which is in line with the findings of the literature review. After the experiment, the children responded that plants that had been planted "in the dark" grew faster because "there was dark", "they were looking for the sun", "they were trying to puncture the closet", and "there was air in the closet". Children attributed the growth of plants to the predominance of darkness, while fewer children understood the need of the plant being exposed to the sun. The child, who responded that plants in the closet grew faster, seems to perceive the plant as a living organism and therefore attributed the existence of air to its growth in the closet. However, it does not understand the role of the sun in photosynthesis, since it does not mention it at all, which agrees with the literature review.

Asked about the color of plants' leaves after the experiment, children responded mainly that plants' leaves that they put in the sun were "green, because of the sun", while plants' leaves that were put in the closet were "yellow", without justifying their answer. Children understand the role of the sun in coloring plants' leaves, but they do not understand the effect of lack of sunlight on them, nor do they understand the role of chlorophyll in solar energy's commitment to their development, which agrees with the literature review.

In the activity of discolored leaves in alcohol, most children responded that "leaves will melt", and after the experiment the majority of children responded that "leaves have lost their color". However, even after the experiment was carried out, children still maintained their original perception that "leaves were melted", which confirms the durability of children's pre-existing perceptions, as stated in the theoretical part of the present study.

In the activity with iodine tincture in discolored leaves that had been left in alcohol for a day, there is a restructuring and a change of children's pre-existing perceptions, which is due to the teaching, comparing their answers described before and after the teaching intervention. So, while the majority of children initially responded that "leaves will melt" after the experiment, they responded that "leaves became like the iodine tincture".

Conclusions and implications

From time to time, various studies have been conducted on children's perceptions of the role of light and chlorophyll in plant photosynthesis. However, most of these studies were aimed at older children, because preschoolers are often considered incapable of perceiving them. This perception implies the reduced frequency of teaching these concepts in Kindergarten.

The present research shows that the investigation of preschoolers' existing perceptions of these concepts and their misconceptions, can afford to the designing of a proper educational approach of the concept of photosynthesis, with simple means and materials, based on the principles of constructivism.

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