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Creating a simple electric circuit with children between the ages of five and six

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This paper presents a study of how preschool-aged children go about creating and operating a simple electric circuit (wires, light bulb, and battery), and how they view the elements that comprise it, particularly how they view the role of the battery. The research involved 108 children aged between five and six, who were individually interviewed. The results of the study show that the children have already begun to form representations which link the battery, the light bulb and the wires to electrical functions, and that the majority of children are able, with or without help, to successfully create a simple electric circuit. Moreover, their involvement in the process of creating and operating such a circuit leads many children not only to a comprehensive viewing of the circuit, but also to the creation of a pre-energy thought-form in which the battery is acknowledged as the distribution source of an entity which is responsible for the luminescence of the light bulb.

Keywords: preschool-aged children; representations; simple electric circuit

Theoretical Framework

In the context of science education and the various branches of psychology that have to do with learning and the epistemology of knowledge, an important research topic is the study of students' representations of entities and phenomena from the natural world, as well as natural sciences concepts (Coleman, Stears & Dempster, 2015). The scientific discussion on representations was initiated by intensive research carried out by Piaget (Piaget, 1926) and argues that people idiosyncratically construct their own meanings from sensory and social inputs, and that the differing conceptions so commonly found are the outcomes of this individual construction process (Gunstone, Gray & Searle, 1992; Ravanis, 2005). Especially with regard to preschoolers, a wide range of studies have shown that these representations are not conscious, are dominated by a persistent focusing on the objects, their properties and functions, and are apt to change in different circumstances (Fleer, 1996; Fragkiadaki & Ravanis, 2015; Hadzigeorgiou, 2002; Herakleioti & Pantidos, 2015; Kambouri, 2015; Panagiotaki & Ravanis, 2014). However, despite these difficulties, when children aged between five and six become involved in teaching activities geared to overcoming the obstacles created by their representations, researchers observe not only cognitive progress, but also the creation of thought-forms which display stability in different situations and compatibility with certain aspects of natural science models that have been created for the education of older children (Canedo-Ibarra, Castelló-Escandell, García-Wehrle & Morales-Blake, 2010; Delserieys, Jégou & Givry, 2014; Gallegos Cázares, Flores-Camacho & Calderón Canales, 2009; Ntalakoura & Ravanis, 2014). In working with children of this age, therefore, and trying to transform their representations into thought-forms compatible with the natural sciences thought-forms used in school, this study will attempt, during an initial phase, to register and classify these representations. Such an orientation would allow researchers to understand the way in which children, even in early childhood, begin to tackle the natural sciences, and thus would create insight into the conditions for effective teaching environments, built around pupils' actual difficulties (Stears & Gopal, 2010). Such a prospect would allow natural sciences education to contribute to the dissemination in society of a scientific culture, while also helping to shape children with positive attitudes and good performances. This would facilitate the selection of executives with a strong scientific and technological background, which in turn would lead to economic growth (Boilevin & Ravanis, 2007).

Literature Review

The problems that arise in the thinking process of older children when faced with a simple electric circuit have been studied systematically for many years (Dupin & Johsua, 1985; Koumaras, Kariotoglou & Psillos, 1994). The main explanatory schema used by pupils aged 9-18 regarding the functioning of a simple electric circuit (battery – wires – light bulb), is based on the representation of a natural entity, which is stored in the battery and which is recognised as "electricity", "energy" or "current". This entity is transported to the light bulb through one or more wires and is "consumed" there.

While studying the question of how eight-year-old children tackle simple electrical phenomena, Shipstone (1984) observed the great difficulty they had in differentiating between basic concepts, as well as difficulties in their effort to turn on a light bulb when they were given a battery and connection wires. Before being involved in teaching activities, the children perceive the battery as an "active factor-source" and the rest of the circuit as a "consumer-receiver", even though what is being consumed is unclear to the child's mind. However, from the first phases of a typical teaching session, the children focus on the electrical power, quickly attributing to it properties of "storing" and "consuming".

A study by Fleer (1991) examines the difficulties involved in teaching the concept of electricity to children aged between three and five. In this research, special significance is given to children's experience and everyday language, with the study being designed based on a teaching intervention regarding the operation of a torch using batteries, light bulbs and wires. During the teaching intervention, taking into account the children's representations, language and communication context, the teachers support the children's reasoning, suggesting starting points for the discussion, ways of using the materials, and alternative solutions. The results of this study were satisfactory, given that the children successfully tackled the structure and operation of a simple electric circuit and the role of its components, forming an adequate representation on the level of a description of electricity.

Tackling the concept of electric current and the operation of electrical appliances has been the object of a study involving preschoolers by Solomonidou and Kakana (2000). The results of this study showed that while children perceive electric current as a static entity, the majority are familiar with identifying electrical appliances. Furthermore, many children seem to believe that home appliances store "electric energy" inside themselves, so that when one buys an electrical appliance, one also buys the electric current. Children also do not link batteries or battery-operated toys to the idea of electric power, perhaps because they cannot see the external components (wires, plugs), which are supposedly required for providing electric energy.

In another study of the representations of children aged between five and six regarding electric circuits, it was observed that children express a variety of views on the connections required to create an electric circuit, suggest different kind of explanations and display varying levels of ability in building a circuit (Glauert, 2009). The relationship between children's predictions, explanations and practical work on a circuit is not always satisfactory, since, for example, children who have similar abilities when it comes to working on the circuit give completely different explanations. This study focuses on the children's predictions and explanations regarding the circuit, and observe that the reasoning they formulate falls under the same framework as that expressed by older children or adults with similar experiences.

Koliopoulos, Christidou, Symidala and Koutsiouba (2009) studied the reasoning of children aged between five and six as they tried to explain the movement of a toy car equipped with a battery. After talking with the children, the researchers saw that they were able to give explanations in which the battery was recognised as an external cause for the car's movement. Also, in certain cases, in the explanations they gave, the children recognised the phenomenon of an entity being distributed from the battery to the car.

Finally, after observing that preschool aged children have formed certain initial representations of electricity and of the concept of electric current, Kalogiannakis and Lantzaki (2012) tried to compare the results of teaching interventions both with and without the use of educational software. Despite not finding differences between the two approaches, clear progress was observed in issues such as the children recognising electrical appliances and the necessary components needed to build a simple electric circuit.

It appears then, given the researchers' findings in the existing literature and the extremely limited number of studies to have been carried out on the subject with respect to preschool aged children, that there is a significant field of study which is still unexplored. In the study presented here, three research questions have been posed regarding how children aged five to six approach the creation of a simple electric circuit:

1. What are children's representations of the main components and the building of a simple electric circuit?
2. Are children able to build a simple electric circuit, either alone or with help?
3. After completing a rudimentary wiring, what ideas do children express about certain operational components of the circuits?

Research Methodology

Design

The data of the study were collected through individually semi-structured interviews that took place in a specially arranged area in the pre-primary school. In Greece, pre-primary school is attended by children between four and six years old. The Greek pre-primary curriculum sets clear aims with regard to familiarising children with the concepts and phenomena of the natural sciences and technology (Vellopoulou & Ravanis, 2010). The interviews between the researchers and the children were tape-recorded and special protocols including non-verbal reactions were also observed. The conversations were held once with each child and each one lasted approximately 20 minutes.

The interviews were composed based on the three research questions in three distinct phases:

- In the first phase, the children were presented with the wires, the battery and the light bulb and were asked to describe them, provided they recognized what they were. Immediately afterwards, they were asked if they could make something with them, and what that might be. If they did not know that they could be connected, the idea was suggested to them. After that, the researchers spoke with them about what would happen if they were connected.
- In the second phase, the children were given the objects and were asked to connect them in order for the light bulb to light up. If they were faced with a substantial or technical difficulty, they were given help. If they did not try or if it was impossible for them to make the connection, the researchers did it for them.
- In the third phase, after the circuit had operated and the light bulb had been turned on, the interviews

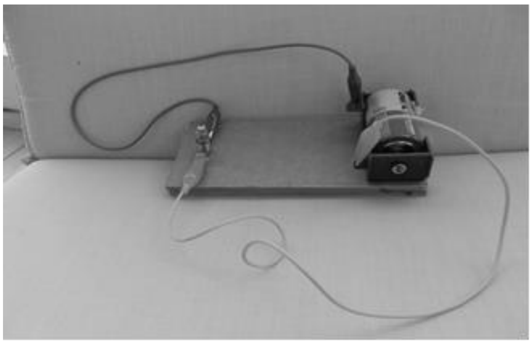
concluded with questions about what made the light bulb light up, and what the particular role of the battery was.

Sample

The research sample included 108 children (57 boys and 51 girls) of the same middle socio-economic background, with an average age of five years and six months (Standard Deviation (*SD*): two months), from two classes of a public pre-primary school. The children were randomly sampled among those willing to cooperate. All children had already attended one year of pre-primary school, and had become familiar with teaching interactions taking place in a classroom setting. The children that took part in the research had not previously attended any organised discussion or teaching activity on electrical phenomena.

Materials

The components used in the research were: connection wires, a battery, a little light bulb and a base on which to assemble all of the above (Photograph 1).



Photograph 1 The simple electric circuit

Results

The results of the analysis of the interviews with the children are presented below in three parts, according to the three research questions.

First Research Question: What are Children's Representations of the Main Components and the Building of a Simple Electric Circuit?

Question 1: Each child is shown the wires, the battery and the light bulb and is asked to tell the researchers what each object is.

The children's answers to this question were classified into two categories:

1. Answers in which all three components are recognised.
2. Answers in which certain ones of the three components are recognised.

Table 1 shows the frequency of the children's answers.

As can be seen in Table 1, the majority of the children recognised the three components necessary to create a simple electric circuit. Some children named these components using words from their daily environment, like calling the wires "cables" and the light bulb a "torch".

Question 2: Can something be done with these components and if so, what?

This question was aimed at observing whether the children were able to spontaneously link the components to some type of electrical function, irrespective of the kind of choice or how correct their suggestion would be. The children's answers were classified into three categories:

1. Answers in which the children suggested connecting the three components and/or linking them to various electrical functions. For example, "let's make the battery work" (Subject 1); "let's put the wires in the TV and the battery in lamps that aren't working" (S. 3), "you put the wire in the socket" (S. 11); "let's put the battery on its own side and the light bulb on own its side" (S. 17); "if we connect the wire then the battery will work and the light bulb will come on" (S. 18); "it shows us we should put the light bulb in its place" (S. 19); "Let's put the battery in the computer, the light bulb on the light bulb and the wire into the socket" (the words "computer" or "socket" are used to describe the assembly base) (S. 22); "we put the battery, then the wire and then the light bulb … all together…" (S. 66); and "we light the light bulb" (S. 108).
2. Answers in which the children do not link the components to electrical functions. For example, "let's make a little house; the green wire is the garden, the yellow one is the sun, the battery is the garbage bin, the base of the battery is a boat, the lamp is an anchor and the wooden base is the sea" (S. 2); "a task" (S. 7); and "these things are for children to play with…" (S. 89).
3. Answers in which children say "I don't know" or reply with vague or contradicting statements. For example, "[…] like toys lighting up […] when we play with other children […] I don't know when […] many days…" (S. 67).

Table 1 Frequency of the children's answers to Question 1

	Subjects	*F*	%
Recognised all components	1, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 30, 32, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 47, 48, 49, 50, 51, 52, 54, 55, 56, 57, 58, 60, 61, 62, 63, 64, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 78, 79, 81, 82, 84, 85, 86, 87, 88, 91, 92, 94, 95, 96, 97, 98, 100, 101, 103, 105, 107, 108	85	78.7
Recognised certain of the three components	2, 3, 4, 5, 16, 29, 31, 33, 34, 46, 53, 59, 65, 77, 80, 83, 89, 90, 93, 99, 102, 104, 106	23	21.3

Table 2 Frequency of the children's answers to Question 2

	Subjects	*F*	%
Connecting the components and linking them to electrical functions	1, 3, 10, 11, 14, 15, 16, 17, 18, 19, 21, 22, 23, 25, 26, 27, 28, 30, 32, 35, 36, 37, 39, 40, 42, 43, 44, 45, 48, 50, 51, 56, 57, 58, 63, 64, 66, 68, 70, 71, 73, 76, 78, 81, 84, 85, 86, 87, 91, 94, 95, 96, 97, 100, 101, 103, 104, 105, 107, 108	60	55.5
Not linking them to electrical functions	2, 5, 7, 13, 29, 46, 53, 59, 60, 65, 69, 72, 77, 88, 89, 92, 98, 102	18	16.7
No answer, vague or contradictory answers	4, 6, 8, 9, 12, 20, 24, 31, 33, 34, 38, 41, 47, 49, 52, 54, 55, 61, 62, 67, 74, 75, 79, 80, 82, 83, 90, 93, 99, 106	30	27.8

Question 3: What do you think will happen if we connect them all together?

The children's answers were classified into three categories:

1. The first category includes answers in which the children recognise that the connection of the components will lead to the light bulb lighting up. For example, "let's turn on the little light" (S. 13); "they'll work and they'll give us current and light" (S. 18); "an electric system … an electric battery … we'll light the light bulb" (S. 19); "this little lamp right here will light up…" (S. 71); and "the little lamp lights up and we can see at night" (S. 97).
2. The first category includes answers in which the children's references are not related to the function of a simple circuit, although reference is often made to the function of electrical appliances. For example, "we'll be playing, the TV will be on … the toys" (S. 1); "an alarm" (S. 7); and "it'll be a little train of things" (S. 81). A small number of children in this category was reserved, as it wished to try to connect the components: "I'll see what happens" (S. 6).
3. The children whose answers were included in the third category did not suggest anything specific, usually answering "I don't know". For example, "we'll put them all … together … because we want to play? I don't know…" (S. 44).

Table 3 Frequency of the children's answers to Question 3

	Subjects	*F*	%
Functioning of the light bulb	10, 13, 16, 18, 19, 22, 25, 26, 28, 30, 32, 42, 48, 50, 63, 66, 71, 78, 81, 84, 91, 94, 96, 97, 100, 108	25	23.1
Other references	1, 2, 6, 7, 27, 33, 34, 45, 46, 53, 55, 56, 60, 65, 69, 73, 75, 79, 81, 85, 92, 95, 98, 101, 102, 103, 105, 107	28	26
No answer	3, 4, 5, 8, 9, 11, 12, 14, 15, 17, 20, 21, 23, 24, 29, 31, 35, 36, 37, 38, 39, 40, 41, 43, 44, 47, 49, 51, 52, 54, 57, 58, 59, 61, 62, 64, 67, 68, 70, 72, 74, 76, 77, 80, 82, 83, 86, 87, 88, 89, 90, 93, 99, 104, 106	55	50.9

Second Research Question: Are Children Able to Build a Simple Electric Circuit, Either Alone or With Help?

Question 4: Each child is given the components of the circuit and is asked to connect them in order for the light bulb to light up

The children's answers were classified into three categories:

1. The first category includes the actions of those children who connected the simple electric circuit without any help (Photograph 2).
2. The second category includes the actions of the children who needed substantial or technical help (Photograph 3).
3. The third category includes the actions of the children who couldn't connect the components or ask for the proper help (Photograph 4).

Table 4 Frequency of the children's answers to Question 4

	Subjects	*F*	%
Connection without help	1, 3, 6, 10, 12, 13, 18, 20, 21, 22, 25, 26, 28, 32, 36, 37, 42, 44, 45, 48, 50, 52, 56, 62, 63, 66, 67, 70, 71, 84, 91, 94, 96, 100, 101, 103, 107, 108	38	35.2
Connection with help	4, 5, 9, 11, 14, 15, 16, 17, 19, 24, 27, 33, 34, 35, 38, 39, 40, 43, 46, 49, 51, 53, 55, 57, 58, 61, 64, 65, 68, 72, 74, 76, 77, 78, 80, 83, 85, 86, 88, 89, 90, 93, 95, 97, 99, 102, 104, 105	48	44.4
Connection by researcher	2, 7, 8, 23, 29, 30, 31, 41, 47, 54, 59, 60, 69, 73, 75, 79, 81, 82, 87, 92, 98, 106	22	20.4

As can be seen, 38 children were able to connect the components on their own, without any help (Photograph 2), while 48 children connected them with the help of the researcher. This help involved mainly the technical handling of connecting the wires (Photograph 3). Finally, 22 did not know how to go about making the connection, and either asked, or it was suggested to them, how the connection could be made, upon which the connection was carried out by the researcher (photograph 4).

Photograph 2 Children connecting the circuit on their own

Photograph 3 Connecting the circuit with help from the researcher

Photograph 4 Connection of the circuit by the researcher alone

Third Research Question: After the Completion of a Rudimentary Wiring, What Representations do the Children form in Regard to the Functioning of the Circuit?

Question 5: What is it that made the light bulb light up?

Through this question, an effort was made to focus on the way in which the children view the circuit as a whole and/or the special role its separate parts play in the circuit's function. The children's answers were classified into three categories:

1. The first category includes answers in which the creation of the circuit with all its components is recognised. For example, "we put wires, a light bulb and a battery" (S. 2); "the battery gives current and the wires give current and it goes to the light bulb" (S. 18); and "the battery gives electricity […] and it goes through the wires and it lights up the light bulb…" (S. 66).
2. The second category includes children's answers in which separate references are made to the components of the circuit. For example "because we put

the battery" (S. 1); "battery, socket and current" (S. 24); "we put the wires to the little lamp" (S. 48); and "the battery lights up the little lamp […] only the battery can light torches" (S. 99). Another child referred to the connection of the wires thus: "…these shouldn't cross over" (S. 13).
3. This category includes answers in which the children say "I don't know" or give vague and contradictory answers. For example "After we turned it on…" (S. 55).

Table 5 Frequency of the children's answers to Question 5

	Subjects	*F*	P%
Building an entire circuit	2, 6, 10, 16, 18, 25, 26, 28, 32, 37, 38, 42, 45, 50, 52, 66, 70, 71, 74, 91, 94, 95, 96, 100, 103, 108	26	24.1
References to components of the circuit with an emphasis on the battery	1, 4, 5, 8, 11, 13, 15, 17, 19, 21, 22, 24, 27, 30, 31, 33, 35, 36, 39, 40, 43, 46, 48, 49, 53, 56, 57, 58, 59, 61, 64, 65, 67, 68, 69, 72, 73, 76, 77, 78, 80, 83, 84, 85, 86, 87, 89, 90, 93, 99, 101, 102, 105, 107	54	50
"I don't know", vague, or contradictory answers	3, 7, 9, 12, 14, 20, 23, 29, 34, 41, 44, 47, 51, 54, 55, 60, 62, 63, 75, 79, 81, 82, 88, 92, 97, 98, 104, 106	28	25.9

Question 6: Did the battery give something to the light bulb and what was it?

By means of this question, the researchers endeavoured to discover whether the children attributed any certain role to the battery, and to determine what exactly this role might be. The children's answers were classified into three categories:

1. Answers in which references to energy are made with regard to the role of the battery. For example, "it gave it light" (S. 1); "it gave it current" (S. 13); "energy to the wires and so it goes to the light bulb and lights it up" (S. 15); "…power and its current" (S. 17); and "it gave it something that made it light up […] it gave it energy" (S. 78).
2. Answers in which references to parts of the circuit are made. For example, "the wires" (S. 4), "it was the battery […] that's why it's lighting up" (S. 64).
3. Answers in which no particular role is attributed to the battery. For example, "…it gave it what it needed…" (S. 2); "nothing" (S. 9); "it doesn't give anything to the battery" (S. 54).

Table 6 Frequency of the children's answers to Question 6

	Subjects	*F*	P%
References to energy	1, 3, 6, 8, 10, 13, 15, 17, 18, 19, 22, 23, 24, 25, 26, 27, 28, 32, 36, 37, 39, 42, 43, 44, 45, 48, 50, 51, 55, 56, 58, 62, 63, 66, 70, 71, 74, 78, 79, 85, 86, 88, 91, 94, 96, 100, 101, 103, 108	49	45.3
Circuit components with a reference to the battery	4, 5, 7, 11, 16, 21, 30, 31, 33, 34, 46, 49, 52, 57, 59, 61, 64, 65, 67, 69, 72, 77, 80, 83, 84, 87, 89, 90, 97, 99, 102, 105, 107	33	30.6
No reference to the role of the battery	2, 9, 12, 14, 20, 29, 35, 38, 40, 41, 47, 53, 54, 60, 68, 73, 75, 76, 81, 82, 92, 93, 95, 98, 104, 106	26	24.1

Discussion and Conclusion

In this research, an attempt has been made to explore how children aged between five and six tackle the components of a simple electric circuit, their connection and the luminescence of a light bulb as a result of being connected to wires and a battery.

Through the first question, the study tried to ascertain whether and what the children know about the main components, and the creation of a circuit. As was observed, eight in about 10 children recognise the battery, the light bulb and the wires. But when the children are asked "to do something with them", only six out of 10 suggest connecting them to one another. Moreover, only two out of 10 clearly acknowledge that were they to be connected, the bulb would light up. Therefore, it appears that the children have begun to form representations which link the battery, the light bulb and the wire to electrical functions, but a very small percentage can verbally express representations of creating a simple circuit.

In the second question, it was observed that 35% of the children are able to create a simple electric circuit without needing help, and also that approximately 44% can achieve this with prompts from the researcher. This finding is not commensurate with the findings of Shipstone (1984) from England, in whose study children aged eight failed in their efforts to light a bulb when they were given a battery and wire. It is possible that the difference in these two cases is related to the general framework within which the children are asked to operate, or perhaps cultural differences between the two samples led to different approaches to a technical task. Indeed, the fact that our own research conducted in Greece at a period when the pre-primary school curriculum includes a significant number of activities in technology and science, may have played a decisive role. This hypothesis seems to be confirmed by the results of a series of studies which have already been mentioned (Kalogiannakis & Lantzaki, 2012; Koliopoulos et al., 2009; Ntalakoura & Ravanis, 2014).

By means of the third question, the researchers endeavoured to discover what kind of representations children are led to by their involvement in the process of creating a simple electric circuit, in terms both of its overall function and the role of the battery. First of all, it was observed that only a few children are able to attribute the luminescence of the bulb to the circuit as a whole. This problem is common in existing literature and may affect even older children. In this respect, it is especially interesting that about one in four children at such an early age avoids focusing on the circuit's individual components. On the contrary, in their effort to explain how a light bulb that was turned off was then turned on, they focus their thoughts on different circuit components, ignoring the overall process of creating it, in which they participated. Of course the problem of focusing their thoughts on specific parts of an experimental situation is a familiar one in research carried out on preschoolers (Ravanis, 1998; Ravanis, Christidou & Hatzinikita, 2013).

But when the conversation turns to the possible special role played by the battery, about 45% of the children recognise that a certain entity (current, energy, power) originates in the battery and fuels the light bulb. Here, even though the study of electricity presents this classic misconception, one could hypothesise that the children are beginning to entertain a causal explanation based on a "preservation" representation. This is consistent with findings which, in other experimental processes, identify a form of pre-energy reasoning, in which the children recognise an entity which is transported between objects in an electrical connection (Koliopoulos et al., 2009).

Based on the results of this research, it appears that children aged between five and six without any previous teaching intervention on the issue of a simple electric circuit, did have certain representations of simple electrical phenomena and the components that make up the circuit, as has been observed in other related studies (Glauert, 2009; Kalogiannakis & Lantzaki, 2012). Their involvement in the process of creating and operating a simple electric circuit led several children not only to an overall viewing of the circuit, but also to the creation of a pre-energy precursor model with respect to recognising the battery as the distribution source of an entity which is responsible for the bulb's luminescence. Weil-Barais has noted, "these precursors are cognitive constructions […] generated by the educational context. They constitute the moulds for subsequent cognitive constructions, which without their help, would be difficult, or impossible" (2001:188). According to our findings, the initiation of children into certain aspects of the technological and natural world is possible even from the preschool age, as long as preschoolers are supported and facilitated in constructing a precursor model of the simple electric circuit, which is compatible with the descriptive characteristics of scientific models. Some results of the relevant research tend to support a wider hypothesis concerning the ability of constructing precursor models for science and technology from early childhood (Canedo-Ibarra et al., 2010; Gallegos Cázares et al., 2009; Ravanis, 2005).

It is also remarkable that, when interviewed, 15 children (14% of the sample) gave answers consistent with the school model for teaching electricity. This observation allows the formulation of a hypothesis, according to which initiation into the function of a simple electric circuit, i.e., into an organised experience by which a child is introduced to electricity, is possible at a pre-school age. Therefore, it is important for children to be involved in such activities of creation and experimentation in pre-primary school. As was found, the dynamics of the interactions between the researchers and the children favoured the cognitive progress of the latter. However, the entire organisation of the activity is too far removed from the actual conditions extant in a pre-primary school, no matter how compelling the results of this study may be. However, this 'distance' had been deliberately planned, since it was a conscious choice that offered certain possibilities. This choice can indeed allow us to assess preschoolers' cognitive ability to construct a representation compatible with the scientific, though in a particularly favourable educational environment. If we find that children are able to approach the cognitive parameters of a simple electric circuit, we can subsequently design instructional processes which will gradually approach the actual conditions found in a pre-primary class. In such a study, which is now being planned, the interactions between a preschool teacher and a small group of children appear to produce learning results that are of interest.

Another important issue concerns the development of curricula which support scientific literacy and teacher training programmes (Edwards, 2010). Such a prospect would lead to the creation of citizens who are informed with regard to science and technology, while also helping to produce scientists who might contribute to the societal advancement. This is the orientation according to which this continuing research is being forwarded.

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