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Sciences Activities in Preschool Education: Effective and Ineffective Activities in a Piagetian Theoretical Framework for Research and Development

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Abstract: This paper presents two researches in which children 6 years of age approximately, participated in activities organized according to pagetian strageties. In the first research children detect magnets and their properties and in the second they discover the factors that friction depends on. Furthermore, the findings from two preliminary studies conducted, concerning the content of the activities in principle, determined the educative designing of the two researches. Namely, although the activities of two researches are oriented to pagetian framework, they have different educative content which leads to different level of progress in children's thought.

Keywords: Piagetian Framework, Preschool Education, Effective Science Activities, Ineffective Science Activities, Material Objects

Theoretical Framework

THE SIGNIFICANCE AND necessity as well as the interest in developing science activities in preschool classroom is the topic of systematic discussion about both Preschool Education and Science Education (Ravanis & Bagakis 1998, Zogza & Papamichael 2000, Fleer & Robbins 2003, Robbins 2005, Zogza & Christopoulou 2005, Kampeza 2006, Ergazaki & Andriotou 2007). Therefore, activity programs of preschool education, regardless of their orientation, almost always include activities related to sciences.

A category of programs includes activities and research based on the Piagetian perspective on knowledge construction (Ravanis 1994). This concerns a framework created by pedagogues who accept the basic principles of Piaget's theory and work in the field of preschool education. In other words, this amounts to a specialized teaching strategy, which we call "Piagetian". Although one of the basic targets of this approach is the construction of physical knowledge, it has not had so far any interaction with Science Education research, especially with respect to preschool education. In this context, and according to research results, the proposed activities help children interact with the selected pedagogical material in appropriately designed educative environments. Thus, children are helped in the construction of physical knowledge (Kamii & DeVries 1993). For example, Kamii (1982) proposes elementary activities for preschoolers with main objectives the transposition and transformation of objects. A similar approach from Crahay & Delhaxhe (1988a, 1988b) proposes the introduction of preschool children to basic properties of certain objects (such as spirals, magnets and inclined planes). However, given that the teacher mainly plays a supportive and encouraging role and that the pedagogical material should be such that children themselves could act upon it, the Piagetian perspective on developing activities has got certain limitations.

As far as we know, a basic point of Piaget's epistemology is that the development of human intelligence is the result of the constitution of intellectual structures through the activity of the subject on the objects of the material world and not of the shapeless, sensory perception of data of the physical and social environment (Piaget 1967). Therefore, it is natural that didactic approaches based on Piaget's theory should lead to strategies which provide children with the possibility of manipulating material objects and experimenting with them, that is, the possibility of intellectual activity leading to the assimilation of physical knowledge. In particular, with respect to the constitution of physical knowledge, the educational procedures suggested for preschool children have the above mentioned characteristics. At the center of these procedures stands the free but carefully supported initiative of the children, with the nursery-school teachers playing a particular, encouraging and analyzing part in the activities.

Kamii (1982) and Kamii & De Vries (1993) express the opinion that at preschool age we should juxtapose the "activities of physical knowledge" with the "teaching of science". The teaching of Physics focuses on the object to be taught, the laws of Phys-

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ics, scientific terminology and research methodology. On the contrary, the activities of physical knowledge focus on the progress of the child's activities and its discoveries. Kamii (1982, 14-29) and Kamii - De Vries (1977, 410) suggest a frame of educational principles based on Piaget's theory. In this context they suggest the development of acts corresponding to the different phases of the activity's evolution, as follows: 1) preparation of the activity and formation of questions, according to the kind of action on the object, 2) introduction of an activity in a way which maximizes the child's initiative, 3) starting with games not requiring any kind of social co-operation; every child is provided with its own material so that individual work with the child can in principle be effected, 4) comprehension of what the child thinks and reaction of nursery-school teachers accordingly, 5) encouragement of interaction among the children, 6) choice of the activity which takes into account the general intellectual development of the child and 7) encouragement to the child in thinking about its own activities.

While studying, within a similar theoretical framework, the free activity of nursery-school children in an environment rich in educational material, Crahay and Delhaxhe (1988, 9-13) observed that the approach to the objects of the physical world is always achieved by the children in a constant order. Children set goals on the basis of which they organize activities and get some results. These goals were either set at the beginning or during the haphazard use of the objects. Thus, educational planning suggests a series of actions including the following phases:

1. *Predictions of the nursery-school teacher prior to the activity.* At first, the nursery-school teachers are responsible for the choice of the field of activities. Therefore, they are also responsible for determining the character, quality and quantity of the material to be used, as well as the classrooms required or their arrangement. The chosen didactic objects should offer the opportunity of experimental interaction with specific material and should not be taken at random from daily life. As soon as the teacher chooses the objects and the material, s/he should attempt some predictions about the quality level of the children's activity or the possibility of their shown initiative, so as to be in a position to encourage their own plans, help them transcend any failures and propose new activities. That is, s/he should formulate a predictive plan for each child on the basis of which s/he will observe the whole process.
2. *During the activity.* Nursery-school teachers present the working material (such as magnets and springs) to the children, without showing them how to use it. As soon as the children become familiarized with these materials, they start organizing simple patterns, that is, small constructions, representations of objects, etc. At this phase the nursery-school teacher notices and observes the activities of the children and records their activities, difficulties and failures as objectively as possible. The teacher asks them about their goals and encourages them if they succeed in achieving a desired result. When the teacher finds out that they fail in achieving their goals or when the teacher judges that intervention by adults is necessary in order to set more complex goals, s/he intervenes according to either the plans s/he had predicted or an unexpected development. On completion of the pattern, the children often ask to repeat the same activity in spite of their initial success. They are very possibly motivated by the satisfaction achieved by this success and the encouragement and appreciation of the teacher. From the didactic point of view, the repetition of these activities is also most important because the order of the activities demands a coordination of a number of particular acts, which should not be considered achieved despite the fact that the child has attained the desired goal. It quite often happens that children fail when they try to repeat the same activity. The repetition of activities stabilizes cognitive coordination and prepares the thought of the child towards the achievement of further similar coordination.
3. *Analysis after the activity.* After the teacher has collected observations on the children's activities, with or without his/her intervention, s/he may then analyze, for each child or for groups of children, those observations trying to answer questions like "how did they act?", "which actions did they perform?", "which are the most important difficulties they encounter?". As soon as the teacher analyzes the free activities, s/he should locate the results of his/her own attitude, whether this consists of encouragement or questioning or of specific intervention. This analysis is facilitated when the teacher attempts to answer questions of the following kind: "did the child change its manner of reaction?", "did it show any initiative?", "did the child face some insurmountable difficulties?", and "was the child led to any new actions?". This analysis obviously leads to exact findings as far as the possibilities of the children are concerned and allows the teacher to repeat and expand the activities which in any case cannot be developed at one go. In addition, teachers have the opportunity to both evaluate their own actions and locate the students which present the greatest

difficulties as well as the kind of difficulties concerned. After they are fully aware of the difficulties, they may try to systematically deal with them. Such interventions lead the children to successful activities as regards both the results of their actions and their intellectual formation.

It is obvious that the strategies of Kamii-De Vries and Crahay-Delhaxhe move in the same direction, since, on accepting Piaget's theory, they plan their activities around the supported, yet autonomous, interaction of the child with the material world. We will give here two examples of research in which, children approximately 6 years of age participated in activities oriented to Piagetian strategies. In the first one, where children work in order to detect elementary magnetic properties, the results are quite satisfactory. In the second study, where the goal is the discovery of factors that friction – developed when an object slips on a horizontal plane – depends on, a small number of children achieve sufficient progress. In our approach, the achievement of cognitive progress constitutes the criterion according to which we deem the activities effective or ineffective. And what we mean by cognitive progress is the transition from reasoning which is incompatible with elementary school knowledge of Physics, to reasoning which is compatible.

In these two research cases, different methodological perspectives have been followed, because of the early findings extracted from specialized preliminary studies we conducted. With respect to these studies, we realized that in order to fully comprehend the potential changes in children's thought, we had to follow two kinds of research. In a preliminary study about magnets, children collaborate satisfactorily, communicating, showing initiative and manipulating the educational material adequately. In the second preliminary study, the children work mainly individually, experimenting with the material and not exchanging their thoughts. On the basis of these findings, we made our methodological choices which led to the two kinds of research. However, although in the two researches the analysis is completely different, the activities during teaching interventions follow the typical characteristics of Piagetian strategies.

After investigating various other concepts, we selected as our examples the concepts of magnetism and friction, because in both of these the differences which may lead to effective or ineffective activities are clearly discernible. In terms of their role in the development of activities, they differ. Discovering magnetic properties is not as difficult for children as friction is, being an abstract concept. However, in this case, we do not bring the children directly in contact with the concept of friction, but rather with the factors on which it depends. This dimension does not create problems in comprehension in the minds of small children.

Two Examples: Magnetism and Friction

The Discovery of Elementary Magnetic Properties

Research Questions

On the basis of the above strategies, we tried to research the success of the effort to organize activities of children working with magnets, the aim being their understanding of the properties of magnets (Ravanis 1994, 2000). We chose magnetic materials because they present peculiarities as compared with common materials and, as a result, create an environment which might turn out to be significant since it might become a source of new experiences for preschool children. In fact, the attractive forces exerted at a distance by magnets on some non-magnetic materials as well as the mutual attractive or repulsive interactions between magnets that are not in contact with each other could appear magical to the child.

This is exactly what we attempted to do in our research project. The hypotheses we formulated were that during the activity the children:

1. will discover the attractive forces exerted by magnets on certain materials,
2. will distinguish materials susceptible to magnetic forces from materials not susceptible to such forces,
3. will discover the mutual attractive and repulsive action of magnets.

Sample

Forty-one children from 5.5 to 6.5 years of age (average age 5 years and 8 months) attending nursery schools in Patras (city of Greece), in regions of the same social characteristics, participated in the research process. The children's parents had not received any special education in science. The children worked in three-member and four-member groups. In their classes they did not participate in activities with magnets until the moment of the research process. The participating educators were aware of the aims of the research but had no specialized knowledge of Physics.

Process

Materials: We gave each group of children a number of disk-like and rod-like magnets as well as some materials attracted by magnets and some not attracted (such as short metallic rods, clips, drawing pins, plastic pen caps and small pieces of paper). These materials were presented one by one by a nursery school teacher at the beginning of the process and handed over to the children for familiarization.

Design: We precisely explained the "game" we were to play to the children. The teacher asked the children to take the materials on the table and play with them. The children used their initiative and effected various constructions (such as small airplanes and bridges), which they characterized as such either on their own initiative or in response to the teacher's questions. Whenever the children failed in their constructions, the teachers intervened in order to help them execute their plans. Certain subjects lacking good psychomotor coordination were not able to manipulate the materials as they wished, thus resulting in their encountering practical obstacles which, at times, they could not overcome single-handedly.

The teachers also attempted to intervene when the children abandoned their occupation or when they started to play by using the rest of the material without the magnets. Interaction between children was desired, so we allowed and encouraged it. That is, we let the children observe the work of other children and urged them to cooperate in both the creation of a common construction and the exchange of the material they selected. Each group worked for approximately 20 minutes. The whole procedure did not take place in a classroom but in a specially arranged "laboratory" in the nursery school. This "laboratory" was a small room usually used as an office by the teachers. In this room there were no factors, such as objects, nor apparatuses, while the presence of persons was not involved in the relevant "experimental" procedure, which would disturb the subjects' activities. For the purposes of the research the room was arranged in a specific way; all the children belonging to the same group worked on the same table in the presence of a teacher. The researcher was in the room in a position from which s/he could observe the activity without disturbing it.

The efforts of 2 groups (seven subjects) were recorded and the videotapes analyzed. From this analysis we arrived at an observation protocol on the basis of which we recorded the activities of the 34 remaining subjects which participated in the "experimental" procedure.

Results

The analysis of the results has a qualitative character. We attempted to examine not only the frequency of a specific achievement, but also the development of the activity as well as the recording and analysis of the circumstances under which the research took place. The axes on the basis of which we recorded our comments are the following: a) random discoveries by the children, b) execution of activities based on children's constructions, c) new patterns after the discovery of magnetic properties, d) completion of constructions with the help of nursery-school teachers and e) resumption of initiatives after the intervention of teachers.

We considered our hypotheses confirmed when the children, in cooperation among themselves or with the intervention of the teacher, succeeded in discovering magnetic attraction by distinguishing between magnetic and non-magnet materials and by locating the mutual attractive and repulsive forces between the magnets.

Discovery of the Attractive Properties of the Magnets on Non-magnetic Material

At first 31 out of 41 children accidentally discovered the attractive magnetic property. That is, by using a magnet they accidentally attracted a metal object. They usually pulled it away and placed it in a position where the magnet attracted it again. After experimenting a few times and failing to detach it definitively from the magnet, they discovered that they had to remove it at a much longer distance. It is interesting here to note the surprise of the children when they discovered this property. For example, after she found out that the magnet "stuck", Laura was surprised to touch the end of the magnet and look at her hand, while immediately afterwards she checked to see if the magnet "stuck" to her face. In this case, Laura attributes magnetic attraction to some kind of "glue" which she tries to find by the touch. As Peter accidentally moved a magnet bar, the bar attracted some drawing pins. Looking at the end of the magnet, he said: "We have got a lot of glue here ... our hands will get stuck". Seven of the rest of the children did not show any initiative; either because they hesitated or because the material did not suffice as the children who were playing had used it up. But they were very impressed; they carefully observed the activities and we can conclude that they understood exactly what was happening because later, while they were playing, they only made slight attempts to confirm the predictions they seemed to be making, while afterwards they worked on or easily used the attractive properties of magnets by organizing and applying constructions on the basis of this property. For example, Helen, after observing the activities of the other children for ten minutes, without being active at all, she took a disk-shaped magnet, chose objects attracted by it and, having placed them at the one side of the magnet and in response to a relevant question of the teacher, she said that she had made a cake with its tail.

The last 3 children did not seem to be able to recognize the attractive properties of the magnets. They used the magnets and the other materials without differentiating between them, while in their constructions they did not utilize the attractive properties of the magnets in spite of the interventions of the teachers, who attempted to lead the children towards this discovery.

Differentiation between Magnetic and Non-magnetic Materials

As soon as the children discover the attractive properties of the magnets, they start attracting various objects - usually the objects which happen to be near them. Thus, they make various attempts in this direction. In this way, they have the chance to discover that the drawing pins or clips are attracted by the magnet, while a plastic box, for example, is not attracted despite repeated efforts. This process of recognition is repeated several times and it obviously has the character of trials. Immediately afterwards or at the same time, the children conceive some patterns and try to execute them. In reality, this constitutes the main phase of the activity. The children start to use the whole material in their attempt to promote their plans. For example, by supporting a metallic bar vertically to the one pole of the magnet bar they form an "axe"; by placing drawing pins at the end of a magnet bar they form a "ventilator" and by using clips they make a "light". In the course of time the patterns multiply and we now have a set of several diverse activities with the same materials: "streets", "knives", "shops" and "tables" as well as a number of undefined forms. It is important to note that the more the number of patterns grows, the more the children choose magnetic materials, that is, they gradually abandon non-magnetic materials. We also observed that certain children, motivated by the novel behavior they had discovered in their materials, showed a strong interest in using magnetically attracted objects, even when they had no specific plan of action. Alexander, for instance, made a big construction out of such objects. When the teacher asked him to explain what he had made, after thinking for a while, he answered: "I don't know. But it is beautiful".

In addition, the more complex the patterns become, the more chances of co-operation the children have. Thus, whenever some children get tired and abandon their efforts, but go on watching the activities of the other children, they intervene by giving advice and making corrections. In a number of cases the teachers have the opportunity to become involved in the process. For example, Sotiris builds a "bridge" by placing two small metallic bars in an upright position and supporting a magnet on their ends. When he tries to put supports at the foot of the bridge, he uses matches which do not "stick", as he discovers after a few failed attempts. The teacher then urges Sotiris to use clips so as to complete the task he has planned. In another case, Laura puts a few drawing pins pinned to small pieces of paper in a box and pulls them out of the box with a magnet. The teacher urges her to repeat this activity using only the pieces of paper, thus leading Laura to failure and to the distinction between material capable of being attracted and material less capable of doing so.

After a sufficient number of activities, it became obvious that 36 children had distinguished the materials capable of being attracted by magnets since they had selected them and used them without any particular difficulty.

The Discovery of Mutual Attractive and Repulsive Forces of the Magnets

While some children are using two magnets they discover that the magnets "stick" together. They are not particularly impressed by this fact since they already know the attractive property. But when two ends of magnets of the same magnetic pole accidentally come into contact and are repulsed, the children are impressed. At first they insist on "sticking" together the two poles which are repulsed. Vassilis, for example, after trying in every possible way to join two cylindrical magnets which repulse each other, seems to be giving up this idea. Accidentally, however, as the one magnet turns in his hand, he achieves his goal. That is, he succeeds and at the same time distinguishes between attraction and repulsion, because when he later attempts to repeat his original plan, he immediately rotates the magnet in order to change the pole as soon as he perceives the repulsion. From the very beginning Peter used two rod-like magnets and discovered their mutual repulsion by chance. Because he was surprised by this kind of interaction he repeated the same activity a number of times. Then, after laying down the magnet he was holding in his right hand, he began to bring various objects close to the magnet in his left hand trying to recapture the phenomenon of repulsion. He attempted this at first with various metallic objects, although he already knew that these were attracted to the magnet; however, he very soon gave up such attempts. He then used various plastic and wooden objects - naturally without success. Finally he used a cylindrical magnet and once more observed the phenomenon of mutual repulsion. "Only this can [do it]" he said and went on playing with the two magnets.

After the initial discovery of repulsion, 38 children organized plans in which we observed the use of both the attraction and repulsion of magnetic poles. The children's interest was so intense that none of their plans was abandoned and the teachers did not need to intervene. We, thus, observed children constructing "trains" with "wagons" of magnets attracting each other, "police" hunting "thieves" by using the repulsive powers of magnets or even "dancing" magnets. The rest of the children who did not try to work with two magnets carefully observed with great interest the relevant activities of other children. The teachers tried to urge these children to work with two magnets but when the children used two or more magnets they still could not distinguish attractive from repulsive forces. Therefore, we cannot claim that they discovered repulsion.

What Factors does Friction depend on?

The Research Questions

The interaction between two objects in contact, sliding with respect to each other, can be described as the resultant of the parallel to the common surface force, which is called friction, and the force that is vertical to that surface. The appearance of the frictional force depends on a number of factors, most of which play a role in certain cases. Usually, in science education the force of friction is studied in relation to two factors: the vertical force and the nature of the surfaces in contact. When the whole problem is limited to the movement of an object on a horizontal and fixed surface, then the force exercised by that surface on the object is equal to the weight of the object and therefore we can assume as such a factor the weight of the moving object.

Thus the attempt to develop a precursor model for approaching the friction focuses on the construction of two factors affecting the motion of an object projected on a horizontal surface, and which can be related to distance travelled by the object: (a) the estimated weight of the moving object on a qualitative scale 'lighter - heavier' and (b) the nature of the surfaces in contact assessed on a qualitative scale as 'smoother - rougher' (Ravanis, Koliopoulos & Hadzigeorgiou, 2004).

Sample

The sample of the study consisted of 34 subjects (ages 5 to 6, average age 5 years and 6 months) who were children attending public kindergartens of Patras. All children had already attended one year in the kindergarten, and had become familiar with teaching interactions taking place in the classroom setting. All children could use without difficulty the concept of distance ('far - near'). As in the previous study, the participating educators were aware of the aims of the research but had no specialized knowledge of Physics.

Process

Design: The study was conducted in three phases (pre - test, teaching intervention and post - test). The data of the study consisted of children's responses and explanations to two tasks used during both the pre - test and post - test and were collected through individually structured interviews which took place in an especially arranged space of the kindergartens. The pre - test took place 10 days before the teaching intervention and the post - test 15 days afterwards. The analysis of the data was based upon the recorded discussions (between children and the researches) and individual observation protocols.

Materials: Throughout the study a simple projecting apparatus, as seen in figure, was used. The apparatus consists of a mobile part, which (a) is released through a lever, (b) is pushed up to a certain position by two springs and (c) strikes objects placed on a fixed point. The immobile part of the apparatus consists of a track, which can be covered with various materials. Objects can move and come to a stop on the track due the frictional force developed between it and the moving objects. This apparatus was used because in a preliminary study we found that several children attributed the changes in the distances covered by the moving objects when pushed to the different magnitude of the initial force applied on these object. It is well documented by research that, often, intuitive thinking can lead even older children to infer that 'the quantity of motion is proportional to the quantity of the force'. When this apparatus was used all children of our sample accepted that the applied force remained always the same. For both the pre - test and the post - test three cardboard cubes of equal dimensions were also used. The first cube (cube 1) was quite light and covered by a smooth paper, the second cube (cube 2) was much heavier than the first one and was covered with the same material (as was cube 1), while the third cube (cube 3) had the same weight as the first cube but it was covered with sandpaper so its surface was rougher.

Figure: The Projecting Apparatus

During the teaching interventions the following materials were used:

1. Two dolls, one bigger and heavier than the other. We chose dolls of different size since for children a difference in size often means a difference in weight.
2. A cardboard box inside which the two dolls were placed, one at a time, and which is to move along the track. The use of the box was justified on the grounds that both dolls could move in the same way, since they did not fall and since the factor of 'surface of contact' with the track, remained constant.
3. Two strips, one made of smooth plastic and the other one of carpet, which were laid on the fixed part of the projecting apparatus, in order that the motion of the object could take place under conditions of different coefficient of friction.

Tasks used in the pre - test and post - test: At first we presented children with the projecting apparatus and explained its function: *'We have made this machine that pushes with the same force every time we use it. By pulling this (piece of iron), the machine hits all objects placed on it with the same force. So when we use the machine we all hit the objects with the same force'.* Subsequently we asked children to comment on the action of constant force and continued when we were certain that their explanations were satisfactory. We then gave each child three cubes and urged him/her to hold it in his/her hand and play with them so that s/he discovered and became familiar with their differences.

As soon as the researcher made sure that each and every child had become familiar with the cubes and their differences, she asked children to give her 'the shining and light cube' (cube 1) and predict the point on the track it would stop, if stricken by the moving part of the apparatus. She encouraged children to mark that point (by placing a peg).

Task 1. We asked children to predict and mark the point on the tract that cube 2 (which is heavier than cube 1) would stop. As soon as children did that we asked them to explain why they believed that it (cube 2) would reach the position they marked in relation to cube 1. With this task we tried to probe children's thinking in regard to the distance travelled on the same track by the two objects of different weight. This way we could determine whether children relate the distance to the weight of the object, that is, whether they recognized the greater weight as a cause of the difficulty in the motion of cube 2 in relation to the motion of cube 1.

Task 2. Finally we asked children to predict and mark the position cube 3 (of the same weight as cube 1 but with rougher surface) would stop. When each and every child pointed to the predicted position for cube 3, we asked their explanations with reference to the predicted position for cube 1. With this task we tried to ascertain children's thinking when a comparison was made between the distances travelled by cubes of the same weight and the differences in the roughness of the material that covered them. Given that during the projection and movement of the two cubes the only variable was the material of their surfaces, we could judge the causal relationship between different distances travelled by cubes 1 and 3 and the nature of their surface.

Teaching intervention: Teaching intervention took place individually. The researcher explained again to every child the function of the projecting apparatus and discussed the idea of the constant force exerted by the machine on the projected objects. The children were given two dolls, and as soon as they became familiar with them, they identified in the course of a discussion with the researcher the lighter and heavier doll. Subsequently the researcher gave children two strips, one consisting of smooth plastic material and the other of carpet and discussed with them the different nature of those materials. The two strips would cover the track on which the box with the doll on would move.

The researcher asked each child to place the box with the light doll in it on the plastic track and pull the level. Thus the system (box and doll) was projected up to a point that the child marked by placing a peg on the wall of the track. She then asked the same child to replace the plastic material with the carpet, to place the box with the same doll in it on the same starting position and a chocolate where the peg was *'so that the doll would take it'.* As soon as the child placed the chocolate, the researcher asked him/her whether *'the box with the doll would stop, before the chocolate, or past it'*; she also asked the explanation of the child's prediction. Immediately after that the researcher pulled the lever and the box stopped covering a smaller distance than before. The researcher they asked the child: *'why did it go there and not to the same point as before?'*. Subsequently the researcher asked children to place the plastic track on the apparatus and in using the box with the light doll in, to pull the lever. After they marked the position reached by the box, they repeat the process, using this time the heavy doll. The researcher, just like before, asked each child why the box reached that position and did not go where it did before.

When the child made reference to the change in the nature of the material with which the track of the apparatus was covered or the child mentioned the difference in the weight of the second doll, a discussion for ascertaining whether the child attributed the observed change to the difference in the nature of the materials or the weight took place.

When children's answers were not satisfactory the researcher simply encouraged them to manipulate the different material of the track, or feel the different weights of the two dolls and discussed with them until she was certain they recognized those differences and the importance they attached to those differences. The children manipulated the materials and some of them asked for more information about their nature and their characteristics while they kept on manipulating them.

Results

In the first task involving the weight of the moving object as a variable, children's responses and explanations fell into two categories:

1. In the first category belong the responses (2 at the pre-test and 11 at the post-test), which took into account the weight of the cubes as a factor influencing the distances traveled by the cubes (before they come to a stop). For example, *'the other cube (that is, cube 2) will arrive nearer because it is heavier…whereas the first one (cube 1) was lighter'*. Included in this category are a small number of responses which considered the role of the weight but it was not clear whether the distance the lighter or heavier cube would travel was attributed to the role of that variable. For example *'it will not go to the same position because it is lighter (cube 2)…it will go nearer…no…farther ……I don't know …I am not sure but it will go elsewhere'.* Such responses were included in this category given that what interested us in the case of the first task were not simply the 'correct' responses but whether children ascribed significance to the factor of 'weight'.
2. In the second category belong those responses (32 at the pre-test and 23 at the post-test), which did not take into account the weight of the cubes as a factor influencing the distances they cover when moving on the track. Included in this category are responses in which the explanations were not based on the factor of the weight, regardless of whether or not the children made the correct prediction about the distances traveled by the cubes. For example, *'since the boxes are identical they will go to the same position', 'this box (cube 2) will arrive where the other one (cube 1) will, because the machine pushes them the same'.*

In the second task involving the nature of the surface as a variable, children's responses and explanation, also fell into two categories.

1. In the first category belong the responses (0 at the pre-test and 3 at the post-test), which considered the nature of the surface in contact as a factor influencing the distances traveled by the cubes on the track (before they come to a stop). For example, *'this box (cube 3) will stop nearer than the other (cube 1) because it cannot slide well…it is not shining…', 'no this one (cube 3) will not arrive there (where cube 1 did) because …it has outside that black paper (sandpaper) which is not slippery'.*
2. In the second category we included those responses (34 at the pre-test and 31 at the post-test), which did not consider the differences in the nature of the surface of the cubes for estimating the distances traveled by the cubes, irrespective of the 'correctness' of the responses. For example, *'this (cube 3) will arrive nearer…this is what I believe as I hold it', ' it (cube 3) will reach the end (the child points to the end of the track), because that is where the road ends'.*

Discussion

In these two studies, we tried to create educative environments where children of preschool age can work mainly with materials. That is to say, to reveal to children the properties of materials, to act with them in understanding their performance, to formulate and execute plans, to predict and look into their predictions according to the effects of their own action.

Nevertheless, according to the results of our research, successful changes in children's thought occur only in the case of magnetic properties; children achieve the objectives in high percentages (76% to 93%). Indeed, children's effort as regards the factors that affect the motion of bodies on a horizontal plane was not satisfactory at all. Only 9% in the one task and 26% in the other task make progress at the end of the activity. Of course, the activities that were developed in the two cases are different, but it is suggested that a detailed approach to their essential characteristics could help lead to certain forms of interpretation of effective or ineffective Piagetian activities for the construction of physical knowledge.

The main difference between two perspectives might be the educative designing in terms of children's manipulation of the materials. This not only gives children the opportunity to become involved with material objects in a different way, but it also attributes new roles to teachers-researchers. In the activity with magnets, since children recognize the materials, they use them as they wish, they invent and execute their own plans of action, they move from individual work to collaboration both with other children and adults. Researchers observe the activities, encouraging children only when it is necessary. In the activity concerning the factors on which friction depends, although the children participate in a structured activity, in which the typical aspects of Piagetian frameworks are recognized, they do not have the opportunity to develop individual plans of action since they are confined by the stories of the doll and of the chocolate. Furthermore, researchers, without providing any solutions for the problems that the children are faced with, propose the alternation of materials and the breaking of the activity into steps.

One more interesting difference between the two activities concerns the kind of materials used. The materials which allow children to identify magnets and their properties are commonly used in children's daily life; during the activity, children use them with or without their conventional properties, consistent with their plans and their imagination. The materials used for the study of the factors that friction depends on, have been constructed exclusively for the demands of the research. On the one hand they have interesting properties which children can easily discover, but on the other hand they have limited alternative uses. This fact prevents children from seeing objects as tools and from using their properties in relation to the motion of bodies on the horizontal plane.

If we try to see what lies behind the success or the failure of the activity – that is to say which is the element that crucially determines the rest of the activity – it seems worthwhile to investigate the content of the activity in connection to the subject's cognitive constitution; namely, in which precise field we intend to achieve cognitive changes in the thought of children of preschool age. If the content of the activity allows us to organise activities in an environment similar to that concerning magnets, it seems that we have many chances of succeeding. However, as soon as we move away from these conditions, other strategies which do not emerge from Piagetian frameworks can be more fruitful in the approach of preschool children's thought in the physical world (Ravanis, 2005).

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