Sciences Activities in Preschool Age: The case of elementary magnetic properties

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ABSTRACT
This article presents the results of a research relating to the construction of elementary magnetic properties in preschool children. Five to six-year-old children, in small groups, had at their disposal different types of magnets as well as diverse objects which could be attracted by them. The proposed hypothesis is that by performing various activities (playing) with them, the children on the one hand would discover the attractive force exerted on certain metallic materials and on the other would distinguish the objects which were not thus attracted. We also formed the hypothesis that the children would discover the mutual forces of interaction by using the magnets. The teachers observed the activities, encouraged and questioned each child and intervened in order to help the children to co-ordinate their activities which were becoming more and more complex. The analysis of the protocols gave us results which seem to confirm the hypotheses.

Indexing terms/Keywords
Elementary magnetic properties; preschool age and education
INTRODUCTION AND 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 (Paulu & Martin, 1992; Conezio & French, 2002) and Science Education (Fleer & Robbins, 2003; Ravanis & Pantidos, 2008). 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, 2000, 2005). 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, 1982; 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 & Delhaixe (1988) and Ravanis (1994) 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 Physics, 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) and Kamii & De Vries (1977) 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 & Delhaixe (1988) and Ravanis (1994) 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 preschool 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, Crahay-Delhaxhe and Ravanis 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 here give an example of research in which children about 6 years old participated in activities within the framework of Piagetian strategies, aiming to understand elementary magnetic properties.

The 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. 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.

METHODOLOGY

Subjects

Forty-one children from 5.5 to 6.5 years of age (average age 5 years and 10 months) attending nursery schools in Russia, 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 research procedure

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.

1. Discovery of the attractive properties of the magnets on non-magnetic material.

At first 31 out of 41 children by chance 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", Aksana 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 leg. In this case, Aksana attributes magnetic attraction to some kind of "glue" which she tries to find by the touch. As Kiryl by coincidence moved a magnet bar, the bar attracted some drawing pins. Looking at the end of the magnet, he said: "There must be glue that sticks ....... things".

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, Galina, 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.

2. 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: "beds" "roads", "knives", 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. Edik, 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 think it is a great thing".

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, Fedor 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 Fedor to use clips so as to complete the task he has planned. In another case, Aksana 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 Aksana 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.

3. 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. Cheslav, 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 Kiryl 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 rod-like magnet and once more observed the phenomenon of mutual repulsion. "When I get this ...... I can do" 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.

DISCUSSION

The success of the example we gave shows that Piagetian strategies may be a highly favourable environment for the development of effective activities in physical sciences with respect to preschool education. Respect towards both autonomy and the individual rate of little children’s development, encouragement of curiosity and creativity, effective implementation in preschool classes as well as teachers’ systematic activity are important advantages of these methods.

However, this methodological approach presupposes activities in which the children may easily and safely handle the pedagogical material, as it is obvious that methodology focuses on the properly supported, yet autonomous, action of the children on the objects they are provided and surrounded with. In addition, the comparison between the effectiveness of Piagetian strategies and other strategies, such as socio-cognitive or socio-constructivist approaches, in which a systematic teaching attempt to transform them, after the children’s mental representations of various physical phenomena and concepts have been inquired, are of particular interest. Indeed, the comparison between the results of these strategies and Piagetian strategy demonstrates the most suitable strategy for the cognitive progress of little children (Ravanis, Papandreou, Kampeza & Vellopoulou, 2013; Ravanis, Christidou & Hatzinikita, 2013).

In any case, before they are incorporated into some curriculum, the suggested activities should have been previously tested through research processes in both experimental environment and actual preschool classes.

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